

## Boat No. 074 - Build Instructions Book Five

### SECTION 45 - MAINMAST

#### 45.1 Timber

45.1.1 Timber for spars needs to be lightweight, strong, straight grained and free of knots and other defects.

45.1.2 North American Silver Spruce (*Picea Stitchensis*) is the ideal timber but it is expensive and sometimes difficult to obtain. Its average weight is 430 g/m<sup>3</sup>. European spruce is not suitable.

45.1.3 Douglas Fir (sometimes called British Columbian Pine) is a good substitute. Its chief disadvantage is its weight - about 530 g/m<sup>3</sup>. It is available in good long, clean lengths.

45.1.4 Russian Redwood if available in long clean lengths is also a good timber for spars and has a slight weight advantage over Douglas Fir at about 510 g/m<sup>3</sup>.

45.1.5 The timber needs to be dry - preferably kiln dried down to 12%.

45.1.6 If timber of sufficient length is not available for the various mast component then it can be scarphed up into boards of suitable lengths. Use a scarph length 10 times the board thickness and WEST bond the scarph, wetting out very thoroughly as usual.

45.1.7 It is usual to arrange the scarphs to come in different places on the finished spar.

#### 45.2 Equipment

45.2.1 To glue the spars up on, you will need several stools spread over about 5700mm set up so that their tops are dead straight (and preferably level, though this is not vital). Check for straightness with a taut line or an accurate straightedge if you have one long enough.

45.2.4 Fix a length of timber along the tops of all the stools to bridge them and tie them together to form a firm base. The length of timber should be, say, ex 150 x 50 planed up square and straight. This will form a good base for cramping to.

45.2.5 You will need lots of cramps and cramping pieces. The mainmast will need pairs of cramps on cramping bars, spaced at no more than 400 between each pair - which would be about 30 cramps, plus the same number again to cramp across the spar, plus some spare in case some intermediate cramps are needed.

45.2.6 A good alternative to cramps (at least for cramping top-to-bottom) can be pairs of cramping bars pulled together with a bolt at each end. A suitable size of timber would be about 50 x 40, of sufficient length so that the bolts run clear of the spar being glued up. About 200mm long with bolts about 150mm apart would be about right for the mainmast.

45.2.7 The spars are WEST/#403 bonded together and you should use slow hardener to give yourself sufficient working time.

#### 45.3 General principles

45.3.1 The mast is basically a hollow box

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with chocks in the internal corners so that the wall thickness is maintained when it is rounded up.

45.3.2 Externally the finished mast is a straight taper from Ø85 at 600 above the heel to Ø65 at the hounds (at 4375 above the heel) and then a sharper straight taper from the hounds to Ø55 at the head (at 5380 above the heel). The first 600mm from the heel are left square to fit in the tabernacle. Above the head there is a parallel section at Ø51 for 100mm length (for the upper mast band) and then another parallel section at Ø30 to take the truck.

45.3.3 The wall thickness also varies in proportion to the outside diameter to produce internal diameter tapers. Thus there is a straight taper from Ø50 at 600 above the heel to Ø37 at the hounds and then a sharper straight taper from the hounds to Ø31 at the head (at 5325 above the heel)

45.3.4 There are solid sections at the top and bottom of the mast.

45.3.5 The mainmast is made square, then planed to an octagon and then rounded up to a circular section.

45.3.6 In the instructions that follow for the mainmast and all the other spars we shall give finished sizes to get the various items of timber out to. In most cases these will be the actual finished sizes of the spar. When planing the timber to size you should keep just full of the given sizes to allow for losses in rounding up and sanding. By “full” we mean no more than 1mm, perhaps a little less.

### 45.4 Side planks & chocks

45.4.1 Get out the two side planks planed up to 25 thick by 101 wide by say 5600 long. Scarph the timber up if necessary, arranging for one scarph to come towards the top end and one towards the bottom. Note that we need a minimum of 25 thick to ensure that the 95 square can be maintained up to 600 from the heel - if the planks are only 22 thick (their final thickness at the heel) they will not make 95 at 600 up because of the taper. Similarly, they need to be 101 wide to make 95 at 600 up

45.4.2 Mark a centreline down the side planks, both inside and outside.

45.4.3 Now mark the line of the inside taper on the inside faces of the side planks. These lines will be spaced 50mm apart (measured 25 each side of the centreline) at the heel, 50mm apart (25 each side of the centreline) at 600 above the heel, 37mm apart (measured 18.5 each side of the centreline) at the hounds and 31mm apart (15.5 each side of the centreline) at the head.

45.4.4 Join these points up with straight lines from the 600 above the heel to the hounds and straight lines from hounds to head.

45.4.5 Mark the bottom 600 parallel (at 27 each side of the centreline. From the head to the top continue the hounds-head taper.

45.4.6 Now get out the triangular chocks to fit in the internal corners of the spar. These should be left triangular for the moment, the

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inside faces can be hollowed out once they are bonded to the spar side planks.

45.4.7 The chocks will have 25mm arms at 600 tapering to 18mm (neglect the 0.5mm) at the hounds and then tapering again to 15mm at the head. Allow them to run on at 25mm to the heel and 15mm to the top.

45.4.8 In practice the chocks can be made in several pieces with short scarphs (say 6:1) joining them together. To plane a chock to a taper, first get it out parallel. Mark the line of the taper on the two arms, measuring from the 90° corner towards the hypotenuse face. Rest the chock in some vee-blocks on the bench with the 90° corner downwards and the hypotenuse face upwards. Then plane off the hypotenuse face down to the taper lines, starting at the end which is to be the smaller and working back to the larger. The taper doesn't have to be dead perfect, but the two 90° faces want to be good and straight.

45.4.9 Now try the chock sections on the side planks. When the chocks are laid on the planks with their inside corners touching, the inside width lines should in theory just be visible. If the chocks have to be drawn apart a mm or so in order to get to the lines, then this is fine. Otherwise, adjust the chocks as necessary.

45.4.10 At the top and bottom the spar is solid. We shall make these solids to run into the spar for about 100mm greater depth than the solid depth shown on the drawing, to allow the inner ends of the solids to be hollowed out a little to provide a reasonably gradual transition from solid to hollow. The

chocks will also house up into the solids for 200mm length.

45.4.11 So at the top, the chocks will end 300 below the head and at the bottom they will end 700 above the heel

45.4.12 Before finally fitting the chocks together and bonding them to the sides, we have to induce the upper taper into the sides. Because the walls are parallel thickness at the moment we can work from the internal diameters. If the heel to hounds internal diameter taper were continued to the head, then head internal diameter would be 34mm. In fact it is 31mm which is 3mm less (or 1.5mm less on each side).

45.4.13 So, on the set-up plank on the stools that we are going to glue the mast up on, mark the heel, hounds and head positions. At the head tack a 1.5mm thick strip across the plank. Half way between the hounds and the head tack a 0.75mm thick strip across the plank. Now cramp one of the side planks down to the set-up plank so that it takes up the correct shape with the slightly sharper upper taper.

45.4.14 Now the chock sections can be finally scarphed together and WEST/#403 bonded to the spar side plank, making sure that they remain accurately the correct distance apart. With softwood you do need to wet the bonding faces out really thoroughly.

45.4.15 Allow the WEST to cure well before removing from the set-up plank. Then repeat the process for the other side plank.

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45.4.16 Hollow out the inner faces of the chocks so that they approximate to the core radii of the spar. Where the chocks will house into the solids (the top and bottom 200mm) they can be left triangular, without any hollow.

### 45.5 Solids

45.5.1 The top solid will start off at least 430 long and will start in the mast at 300 below the head.

45.5.2 The solid will taper from bottom to top. So measure the inside diameters at 300 below the head and at the top of the mast and make the solid to these dimensions (but square in section of course).

45.5.3 Chop out the housings for the chocks in the bottom 200 of the solid and try the solid down on both side plank assemblies - the housings can be a fairly free fit over the chocks because any gaps will be filled with WEST/#403.

45.5.4 Bore a series of holes in the inner end of the solid angled in to the centre and about 100mm deep, and chisel and gouge these out to provide a reasonably gradual transition from solid to hollow

45.5.5 Make the bottom solid in a similar way.

45.5.6 The solids are bonded in when the whole mast is bonded together.

### 45.6 Fwd & aft end planks

45.6.1 Get the end planks out (scarphed if necessary) at 25 thick by 50·5 wide (say 51). Mark the centreline down these. As with the side planks, we need a minimum of 25 thick to ensure that the 95 square can be maintained up to 600 from the heel - if the planks are only 22 thick (their final thickness at the heel) they will not make 95 at 600 because of the taper.

45.6.2 Mark out the widths of the end planks: from 51 wide (25·5 each side of the centreline) at 600 above the heel. to 37 wide (18·5 each side of the centreline) at the hounds in a straight taper; then another straight taper to 31 wide (15·5 each side of the centreline) at the head. Let the top end just run on at the same taper. The bottom end will be 51 parallel.

45.6.3 Cut and plane the end planks to the tapered widths.

### 45.7 Assembling the spar

45.7.1 Lay one of the spar sides on the stool set-up (with the strips still in place for the upper taper). Fit the top and bottom solids. Stand the end planks in place and then lay the other side on top

45.7.2 Lightly cramp the whole spar up making sure that the ends slide fully in to touch the chocks bonded on the sides. Check the joints for a good tight fit. You can check the overall widths of the spar, remembering that at the moment the wall thickness is a constant 25mm. So at the heel the mast should be 101 square (51 + 25 + 25), at the hounds the spar should be 87 square (37 + 25 + 25) and at the head it should be 81 square

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(31 + 25 + 25). Make any adjustments necessary.

45.7.3 Now disassemble the spar and WEST coat the inside of all the components 3 coats - but only coat the outside faces of the triangular chocks and the other bonding surfaces one coat to avoid a build-up of WEST.

45.7.4 We can run cables inside the spar, or we can run a plastic conduit top to bottom to allow cables to be drawn in later on. In either case the cables or the conduit must be firmly clipped to prevent them working loose in the future (when it will then tap very irritatingly).

45.7.5 We have to be a bit careful about the exit points of cable. Through the side of the spar makes cleaning off very difficult and the cables tend to get chopped off during the process. Probably the best way is to use plastic conduit curving it round at the bottom in a channel in the solid to exit above the pivot bolt hole on the fwd face. At the top the cable can out through the top - so bore a hole through the solid.

45.7.6 Fit the conduit in place and brush a coat of WEST over the conduit & clips to seal any pin holes round the clip fastenings. You can leave a draw string through the conduit.

45.7.7 Finally glue the spar up using WEST/#403, drawing all the cramps and cramping bars in gradually so that all the components get fully home.

45.7.6 Allow a week for the spar to cure fully, though you can move it off the stools after a day or so.

### 45.8 Finishing the spar

45.8.1 Plane the edges of the side planks off flush with the end planks, so that the spar is square for its whole length. Make sure that the heel is square to the sides and ends.

45.8.2 Remark if necessary the principal positions: 600 above the heel; the hounds at 4375; the head at 5380 and the top at 130 above this. Cut off the top to length. Remark the centreline on all four sides.

45.8.3 Plane the bottom 600mm to be 95 square and parallel (it doesn't matter if it's marginally different from this as long as we get a free fit in the tabernacle. The change from square to round won't be sudden as the drawing shows but will be faired in (a spokeshave is the tool for this) as the spar is rounded up.

45.8.4 Now mark out the taper of the spar from 85 at 600 to 65 at the hounds, and then to 55 at the head (allow the head taper to run through to the top), measuring the half-widths each side out from the centrelines.

45.8.5 Plane the spar down to the square tapered sizes. Remark the centrelines on all four faces

45.8.6 To get to a round, we next plane the spar up to an octagon. The sides of an octagon which is 85 across flats are 32mm . For 65 across the flats we need 27mm sides

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and for 55 we need 23mm sides.

45.8.7 So at 600 above the heel measure 16 each side of the centreline on all four faces; at 4375 measure 13.5 each side of the centreline and at 5380 measure 11.5 each side of the centreline. Join these lines up as usual. Then plane off the corners of the spar down to the lines until it is nicely octagonal.

45.8.8 Now plane off the corners of the octagon but retaining the centrelines on all four sides.

45.8.9 Then sand the spar up round. If you cut a length of 60 or 80 grit abrasive paper (off a 100mm wide roll) about 600 long and fix a ply handle each end, this makes a good preliminary sander. Pull the sander back and forth slightly diagonally across the spar, gradually working along and around the spar. You can feel bumps with you hand best of all. Once the spar is reasonably round move to sanding by hand along the length of the spar gradually using finer paper until you have a really good finish. You can use an electric sander but beware of sanding flats on the spar and the little circular sander marks made by bits of dust trapped in the paper. From time to time try the 4-eye band at the hounds on to the mast - to ensure that you don't make the mast too small in this area so the band is loose and wants to drop further down the spar

45.8.10 Once the spar is all rounded up and smooth mark the hounds position lightly and try the 4-eye band on the mast again to make sure that it will tap down to the hounds position and be a good tight fit. Don't tap it right down for the moment - it should just

pull tight about 30mm or so above the hounds position.

45.8.11 Make the chocks to be housed and bonded into the mast at the hounds. These are to prevent the 4-eye band pulling down the mast under the shroud and stay load. Check the chocks into the mast neatly and WEST bond them in place. Sand round the mast immediately above the chocks with a narrow strip of abrasive paper until the 4-eye band will tap gently down on to the chocks. Remove the band.

45.8.12 Round up the top of the mast above the head so that the 2-eye head band (or you can fit a 4-eye band if you intend to use runner backstays) will just tap down on to the shoulder formed at the head of the mast. Then round up the final section of mast to take the truck.

45.8.13 Make the truck (on a wood turning lathe if you have one or have access to one) with a hole in the centre to fit closely over the final top section of the spar. Make a slot out near the edge of the truck to take a tiny sheave for the burgee halyard (this is usually set to stbd). The truck is not bonded to the mast as otherwise the bands could never be removed etc. Usually the truck is just a tight drive fit over the mast, but you can screw a small plate across the top with one screw into the mast and one into the truck to retain it in the correct orientation.

45.8.14 Cut the heel of the mast to suit the tapered wedge in the tabernacle.

45.8.15 Bore off for the copper tube for the

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pivot bolt and WEST bond the tube in place. Fit the cleats - these should be checked into the mast 3mm to take the sheering load off the screws and make sure that the cleats stay tight under load. Remove the cleats while the mast is being WEST coated.

45.8.16 WEST the mast one coat and sand smooth. WEST two further coats and sand smooth ready for varnishing. You can incorporate a section of fine woven glass cloth at the gaff jaw position if you wish to prevent any wear on the spar. Make this about 300 long, 150 above & below the centreline of the jaws.

45.8.17 Fit the 4-eye band at the hounds and the 2-eye (or 4-eye) at the head.

45.8.18 Draw the cable through the conduit. Seal the exits using Sikaflex 221 or similar (not silicones).

45.8.19 Varnish the mast 3 or 4 coats using a good quality UV resistant varnish, sanding between coats as usual. Fit the truck.

### SECTION 46 - MAIN BOOM

#### 46.1 General principles

46.1.1 The main boom is basically rectangular, with the corners radiused off.

46.1.2 The boom is a hollow box section with constant wall thickness.

46.1.3 The top face is straight but both the depth and width vary, with a maximum section, tapering in both width and depth to

the ends. Note that the maximum section of the boom is not in the middle but aft of middle at 2050 from the fwd end.

46.1.4 The boom has solid sections at both fwd and aft ends.

#### 46.2 Making the boom

46.2.1 The boom can be glued up on the stool set-up used for the mainmast, but with the taper strips removed. You will need to cover the set-up plank with polythene to prevent the boom becoming bonded to it.

46.2.2 Get out the two side panels. These start off at 14 thick by 90 wide. The top edges remain straight. The bottom edges are curved. Mark out the widths - 65 at the fwd end; 90 at the deepest point; and 75 at the aft end. Remember that the deepest point is 2050 from the fwd end. Join the three points with a batten and mark in the curve of the bottom edge. Cut and plane the bottom edges to shape.

46.2.3 Get out the top and bottom panels. These start off at 18 thick by 37 wide.

46.2.4 Mark a centreline down the top and bottom panels. Then set out the widths - 17 at the fwd end (8.5 each side of the centreline); 37 at the widest point (18.5 each side of the centreline); and 27 at the aft end (13.5 each side of the centreline). Remember that the widest point is 2050 from the fwd end. Join the points with a batten as usual; cut and plane the curved shapes of the top and bottom panels. Be sure to plane the edges square to the faces and flat across so that you

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get a good glue line.

46.2.5 Make the fwd and aft end solids - it's not necessary to fair these in to the hollow although you can on the depth if you wish by making the solids about 75 longer than shown and cutting a v-shaped notch in the inner ends. You can obtain the taper of the solids by measurement from the the side, top and bottom panels. Remember that the top is straight so all the depth taper is on the bottom edge.

46.2.6 To help keep the boom components stable while gluing up you can make, say, three ply bulkheads to fit the inside dimensions. Place one of these at the deepest point and the others half way between the deepest point and the inner ends of the solids. The deepest point bulkhead will be 54 high (90 - 18 - 18) and 37 wide (65 - 14 - 14). The sizes of the other two can be established by marking their positions on the panels and taking measurements (deducting the top and bottom panel thicknesses from the height). The bulkheads can be 12mm ply or similar.

46.2.7 To assemble the boom, lay the top panel on the set-up plank on the stools. Fit the end solids and the three intermediate bulkheads - these can have a little cleat (say 10 x 10) each side on the top panel to locate them and hold them in place. Then the solids and bulkheads can be WEST bonded to the top panel.

46.2.8 WEST coat the inside of the top panel and the bulkheads (all three coats) - don't WEST the bonding surfaces more than

one coat. WEST coat the inside face of the bottom panel 3 coats. WEST coat the inside faces of the side panels 3 coats

46.2.9 Try the bottom panel and the side panels in place to make sure that the solids and bulkheads are the correct depth and width. Make any adjustments necessary.

46.2.10 Bond the bottom panel to the solids and bulkheads, making sure it remains accurately square over the bottom panel (you can cramp some side pieces up each side at the ends and perhaps the mid-bulkhead).

46.2.11 Bond the side panels to the top and bottom panel, the solids and the bulkheads.

46.2.12 Once the WEST has fully cured (leave it about a week before working on the boom), clean the boom up, radius the corners, square off the ends, sand smooth and WEST 3 coats. Sand smooth and varnish as usual. In practice the fittings are best fitted before the final WEST coat and varnishing.

### SECTION 47 - MAIN YARD

#### 47.1 General principles

47.1.1 The main gaff is rectangular in section and hollow.

47.1.2 Construction is exactly the same as for the boom, but with different sizes as shown on the drawing.

END