SECTION 1 – LINES

1.1 The Lines

1.1.1 The “lines” are a means of looking at the 3-dimensional object that is the boat in a variety of 2-dimensional shapes.

1.1.2 Traditionally, the designer gave the builder a “lines plan” and a “table of offsets” which the builder drew out full size (called “lofting”, or “laying off”). The builder made sure the lines ran true and fair and adjusted them as necessary (called “fairing”). Much of the ‘shape’ information for building the boat was obtained by the builder from the full size lines.

1.1.3 We design on a computer and we use a surface generating programme for the hull shape. Thus we have a complete 3-dimensional surface and the 2-dimensional shapes are derived from it. This is a complete reversal of traditional lofting, where the 3-dimensional shape was built up from 2-dimensional lines.

1.1.4 We still need most of the 2-dimensional shapes to actually build the boat. However instead of the builder having to derive them from the lofting, the designer can give them direct to the builder, drawing the information from the 3-dimensional shape that exists within the computer programme.

1.1.5 We still use much the same views and the same terminology for these views, so it is worthwhile just going through these so that you are conversant with the terms and what they mean.

1.2 Reference Points

1.2.1 The Datum Water Line (dwl) is a horizontal line from which heights are measured. It should not be confused with the Load Water Line (LWL) which is the line the boat floats at when loaded. The dwl is usually approximately the same place as the LWL but the two are quite separate.

1.2.2 The Zero Point is the point from which longitudinal measurements are taken. On your boat it is the forward extremity of the boat. In fact it is not quite the forward extremity because the top edge of the bow transom is cambered (curved) so, because the transom leans forward, the top projects beyond the Zero Point. We take the forward extremity to be at the sheer edge because otherwise a change to the transom camber would cause a change to the Zero Point, which would be a nuisance.

1.2.3 The Centreline is the fore-&-aft centreline of the boat and is the line from which all widths are measured.

1.2.4 “Positions” are measured longitudinally from the Zero Point. Positions aft of the Zero Point are negative. So Position -600 means 600mm aft of the Zero Point.

1.2.5 “Offsets” are widths measured out from the centreline. So Offset 260

means 260mm out from the centreline. Both sides are positive - if it is necessary to specify side then Port and Starboard are used. Port is the left hand side of the boat when you are facing forward; Starboard is the right hand side of the boat when you are facing forward. Port and Starboard are constant, so if you turn around and face aft, the Starboard side of the boat will now be on your left hand.

1.2.6 "Heights" are measured above or below the dwl. Heights below the dwl are negative. So Height -64 means 64mm below the dwl.

1.2.7 So any point on the boat can be identified by its Position, Offset and Height (usually in that order). These are often grouped together in tabular form, somewhat confusingly know as a "table of offsets", although it contains heights and positions as well as offsets. Also somewhat confusingly, the dimensions themselves taken collectively are known as offsets. Thus we shall talk about the "offsets" of an object (perhaps a frame) to refer to the Position, Heights and Offsets which identify that frame and its shape.

1.3 Sections

1.3.1 Sections are vertical athwartships slices through the boat - like slices off a loaf of bread.

1.3.2 Sections are designated "s" and are known by their position. Thus "s -600" means a section 600mm aft of the Zero Point.

1.3.3 On your boat we are using sections for the frames and floors.

1.4 Waterlines

1.4.1 Waterlines are horizontal longitudinal slices through the boat.

1.4.2 Waterlines are designated "wl" and are known by their height from the dwl. Thus "wl -100" is a waterline 100mm below the dwl.

1.4.3 Waterlines above the dwl are often called "level lines" and are designated "ll". We have used this convention on your boat. So "ll 100" means a level line (i.e. a waterline) 100mm above the dwl.

1.4.4Waterlines are useful for getting the shape of things like bunk tops and similar horizontal flat bits of the boat.

1.4.5 On your boat we are using waterline offsets to give the shape of the frames above the chine line.

1.5 Buttocks

1.5.1 Buttocks are vertical longitudinal slices through the boat.

1.5.2 Buttocks are designated "b" and are known by their distance out from the centreline (i.e. their offset). Thus "b 250" means a buttock line 250mm out from the centreline.

1.5.3 Buttocks are useful for getting the shape of things like bunk fronts and similar vertical flat bits of boat, that are parallel to the centreline.

1.5.4 On your boat we are using buttock heights to give the shape of the frames and floors under the chine line.

1.6 Diagonals

1.6.1 Diagonals are angled longitudinal slices through the boat. But we are not using any of these on your boat.

1.7 The Sheer

1.7.1 The sheer is the outer top edge of the hull of the boat.

1.7.2 Because the sheer is curved in two directions, it needs a position, offset and height to identify a point on it.

1.8 The Chine

1.8.1 The chine is the join of the topsides and bottom planking.

1.8.2 Like the sheer, the chine is curved in two directions and thus needs a position, offset and height to identify a point on it.

1.9 The Centreline

1.9.1 In this context, the centreline is the profile of the boat, really from the bottom tip of the bow transom to the bottom tip of the stern transom.

1.9.2 The centreline is only curved in one direction (its offset is always zero), so it only needs a position and height to identify a point on it.

SECTION 2 – FRAMES

2.1 The Grid

2.1.1 The grid is used to mark out the frames and to check that they have been assembled correctly.

2.1.2 The grid is shown on the frame drawing. You will see that it consists of the centreline, the dwl, buttock lines and level lines.

2.1.3 The grid is best marked on a flat, smooth surface - a sheet of chipboard will do fine. Make sure that it is flat. You are going to join up the frames and floors on this surface, so if it is twisted, so will they be. We will call this surface the “floor”, like the loft floor when laying off.

2.1.4 Paint the floor white - emulsion is best. Mark the grid lines in thin pencil, or better in fine ball point, so they don’t get rubbed out so easily.

2.1.5 Draw the centreline and the dwl, truly at 90° to each other. It is most important that these lines are really square to each other as they will control all the remainder.

2.1.6 A triangle, the sides of which are in the ratio 3:4:5 will be right-angled. So to check that the dwl is square to the centreline, measure a multiple of three (say 600mm) from the intersection of the two lines up the centreline and tick off at the 600 mark. Now measure the same multiple of four (800mm) from the intersection of the two lines along the dwl and tick off. Measuring from one tick to the other (along the hypotenuse of the triangle) should give the same multiple of five - in this case 1000mm. Check this carefully and be satisfied that the two lines are at right angles.

2.1.7 Now draw in the buttock lines at 100, 200, 300 and 400 offsets, parallel to the centreline. draw in the level lines at 100, 200 and 300 heights above and parallel to the dwl. Try to get these lines as near parallel as possible. Don't measure from one to the next (i.e. in 100 steps) but measure the full dimension each time from the centreline or dwl, as the case may be.

2.1.8 If you draw a line wrong, just emulsion over it and draw it again. Make the lines long enough to make the biggest frame on.

2.2 Marking out the Frames

2.2.1 The frames are made from 16mm sided material. Sided means the measurement from side to side - the thickness. This is opposed to moulded which means the depth from top to bottom. There are four main parts of the frame - the a topsides futtock (the sections from which a frame is made) each side and a bottom futtock each side. The "topsides" is the area of the hull above the chine. The "bottom" is the area of hull below the chine.

2.2.2 At the chine the futtocks are joined together as shown and the joint is reinforced by a 16mm sided chock in the "corner".

2.2.3 At the centreline in the bottom, the futtocks are butt joined and the join is reinforced by a 16mm sided doubler.

2.2.4 We might as well start with Frame -600. The nominal position of the frame is at -600 and this is the centre of the frame. As the frames are 16mm sided, the fwd face will be 8mm ahead of this (-592) and the aft face 8mm astern of this (-608). Look at the "Table of Offsets" on the drawing, under the drawing of the frame.

2.2.5 Dimensions (heights and offsets) are given for the forward face of the frame (at position -592) and the aft face (at position -608). As this frame is well ahead in the boat, the aft face will be the larger - but be careful because the sheer height will be larger on the fwd face.

2.2.6 So, run your eye down the table of offsets and tick the dimensions that will give the larger outline. This can be a bit confusing on heights because a smaller height on the same offset will give a larger outline. So, for example at buttock 300, the boat is 16mm above the dwl on the aft edge and 19mm above the dwl on the fwd

edge. 16mm being nearer the dwl will give the bigger outline. The same applies to negative heights: -22 (on the centreline) will give a bigger boat than -20 - in this case because it is further down from the dwl. It is mostly fairly obvious because you naturally know which edge of the frame is likely to be the larger - but around amidships it can change from one face to the other . This is because not all the lines of the boat change from getting bigger to getting smaller at the same point.

2.2.7 So, we will go right through this frame, just to be sure. Measure first 22mm down from the dwl on the centreline (see "Centreline" - Aft Edge in the table of offsets). Tick this off.

2.2.8 Now on b 100 measure and mark 15mm down from the dwl. Do this both sides. On b 200 measure and mark 2mm down from the dwl on each side. On b 300 measure and mark 16mm up from the dwl and at b 400 measure and mark 39mm.

2.2.9 Now measure 435mm out from the centreline and draw a short vertical line (from about 45 to 55 heights) parallel to the centreline at this offset. Measure 48mm up from the dwl and mark this height on the vertical line. This is the chine.

2.2.10 Disregard the dwl offset - we shall generally not use the dwl offsets where the chine is above the dwl.

2.2.11 Now mark an offset of 452mm on ll 100, an offset of 481mm on ll 200 and an offset of 505mm on ll 300.

2.2.12 For the sheer we need the larger offset and the larger height. So mark an offset of 517mm at a height of 364mm

2.2.13 Use a batten to join up the bottom marks and the topside marks. The batten can be about 15mm wide x about 10mm thick and only needs to be about 1000mm long. Clean softwood is best for this. Plane it up straight and smooth. Drive a small nail (about 25mm length) into the floor on each of the bottom marks (from the centreline to the chine). Bend the batten around outside the nails and draw the outline of the bottom of the frame. Repeat this on the topsides section. Mark the outline of both sides.

2.2.14 Now mark in the inside edges of the frame futtocks. These measurements will be found on the drawing itself.

2.2.15 Mark an offset of 485 at a height of 369 for the top inner corner of the topsides futtock. Mark an offset of 383, parallel to the centreline. Where this line crosses the outline of the bottom is the bottom inner corner of the topsides futtock. Join these two marks with a straight line for the inner edge of the topsides futtock.

2.2.16 Mark a height of 24 on the centreline. Mark a height of 76 parallel to the dwl. Where this crosses the inner edge of the topsides futtock is the top corner of the bottom futtock. Join these two points with a straight line for the top edge of the bottom futtock.

2.2.17 The chock at the chine can be similarly marked out. The cut-outs for the shelf, hog and chine are best made when the frame is assembled.

2.2.18 The frame doubler will grow bigger than the frame because its aft face is 16mm further aft than the aft face of the frame (aft in the boat, the double will get smaller). The doubler can be marked out directly on the timber, using the heights and offsets given.

2.2.19 The other two frames are marked in exactly the same way - but we shall make this frame first, before marking them out or else we shall get confused lines. If you do want to mark them all out at once then use different coloured ball point pens.

2.2.20 The floors, which only have bottom futtocks, are marked out in the same way - but we do not need these until after the boat is planked and turned right way up.

2.3 Making the Frames

2.3.1 The frames are made from 16mm mahogany (or similar hardwood). Choose material with a nice straight even grain. 16mm is the finished thickness - after planing.

2.3.2 Check the greatest width that is required - it will be about 50mm or a little more - and saw the timber to this width, plus an allowance for fitting - say 15mm. Cut a suitable length for the first futtock (say the topsides futtock). Leave the timber about 100mm longer than needed.

2.3.3 There are many ways of transferring lines from the floor to the timber. I think that, in this instance, I would proceed as follows:

2.3.4 We are starting with the topsides futtock. Draw a line parallel to the inner edge, such that when the timber is laid on the floor against this line, the outside line of the frame is just all visible (it will be closest at the top and bottom corners). Fix the timber in place with heavy weights so it does not move easily. Have some spare timber sticking over each end.

2.3.5 Transfer the level lines to the top face of the timber.

2.3.6 Now measure the furthest distance from the outside line of the frame to the timber and round this to a convenient number - let us say it is 15mm.

2.3.7 Stand a joiners square on the outside line of the frame and measure the 15mm distance (or whatever the distance chosen is) in from the square to the timber and mark this point on the face of the timber. Do this at the chine point, the level lines and the sheer point. Join these marks up with the batten and this should be the outside line of the frame.

2.3.8 Plane the edge of the frame to this line; lay it on the floor again and check to

see if it fits. Make adjustments as necessary until the outer edge of the futtock fits the line on the floor. Lay the futtock on the floor and mark by ticks on the edge, the bottom edge of the futtock (i.e. the outline of the bottom). Square these ticks up to the top face and join them up. Cut the bottom of the futtock. Repeat this process at the top and cut this to length.

2.3.9 Now mark the top and bottom of the inner edge of the futtock on the ends of the futtock timber, square these marks up to the face, join them up and plane the inner edge to the correct line.

2.3.10 Once you are satisfied that the futtock matches its outline on the floor, the futtock timber for the other side of the boat can be marked from it.

2.3.11 Repeat the process with the bottom futtocks.

2.3.12 Cut out the chine chocks.

2.3.13 Mark the doubler out directly on the timber, using the offsets table and the dimensions on the drawing to calculate the size. The bottom edge will be bigger than the frame (3mm bigger at b 100 and 2mm bigger on the centreline).

2.3.14 Now screw short chocks (about 75 long x 50 wide x 20 thick) at the sheer, each side of the chine and each side of the centreline - on both sides of the frame. These are to cramp the frame futtocks to. If you don't have many cramps, then screw chocks just clear of the inside of the futtocks and use shallow wedges between these and the futtocks. Keep the inner chocks clear of the chine chock. It is necessary either to wax the floor and the chocks, or cover them (or the relevant areas) in parcel tape or wide selotape). This is to prevent the frame becoming glued to the floor or the chocks.

2.3.15 Assemble the futtocks and check that you can cramp or wedge them up without them twisting off the floor and that the chine and centreline joints are tight. If they twist up off the floor, screw a piece of timber across two chocks and wedge the futtock down to the floor. Fit the chine chock and make a chock screwed to the floor so that this can be wedged firmly into place. Hold this down to the floor with a wedge in the same way as mentioned above for preventing twist.

2.3.16 Put the doubler in place and drill off for two 1" x 8g countersunk screws each side into the bottom futtocks. Use a Stanley "screwsink" combined drill and countersinker for this job.

2.3.17 At this point, you will need to start using WEST™. We are assuming that you have a copy of the WEST™ manual, or the book "The Gougeon Brothers on Boatbuilding" which contains all the technical information about mixing and using WEST™ system materials. If not, ask me for a WEST™ system fact sheet.

2.3.18 We shall generally have a "dry

run" before gluing up components to ensure that everything works alright and that all the necessary tools are to hand etc.

2.3.19 Once you a are satisfied that the system works well and that you have all the cramps, wedges etc. that you need, the frame can be glued up.

2.3.20 Mix a small amount of resin/hardener (about 1 or 2 pumps if you are using the WEST pumps) Wet out the end grain of the bottom futtocks and the chine chocks with unmodified resin/hardener and leave for 15 minutes. Add #403 microfibres to the resin and apply to all the joints. Assemble the frame and wedge tight. Fit the chine chocks and wedge tight. Screw and glue the doubler in place. Clean off as much excess glue as possible. Leave for the glue to go off for at least 15 hours at minimum 15°C.

2.3.21 Once the glue (i.e. WEST/#403) has gone off, remove the frame from the floor and store it flat for several days for the resin to reach full strength. You can now proceed to mark out and make the next frame.

2.4 Bevelling the Frames

2.4.1 The outside edges of the frames are planed off to a bevel (an angle) to suit the angle of the hull.

2.4.2 Clean the frame up with a very sharp plane or spokeshave; clean off all excess glue etc. If the grain is contrary and tears up, a Stanley cabinet scraper is a very good tool - this is a tool like a large spokeshave but with a cabinet scraper blade which you bend by turning a thumbscrew in the body of the tool - it is a very effective tool indeed for this job and will clean up the most contrary material. Try the grain etc. on a piece of scrap frame timber first to see how it planes etc..

2.4.3 Lay the frame on the floor so it fits its outline and transfer the level lines and the buttock lines to both face of the frame. Mark lightly or else you will have a job to clean the lines off when you come to sand the frames up.

2.4.4 The amount of bevel can be found by looking at the table of offsets for the particular frame. So, if we look at the table for Frame -600, we can see for example, that the offset at ll 300 is 505mm on the aft edge (the size we have made the frame to) and 501mm on the fwd edge. So the amount of bevel to come off is 4mm (505 - 501). Mark the bevel amounts on the appropriate face (in this case all on the fwd face except the sheer height which is on the aft face). Bevels are marked along their line - that is a bevel on a level line is marked horizontally along that line; on a buttock line it is marked vertically. On a chine, height bevels are marked vertically and offset bevels horizontally, from the point of the chine.

2.4.5 Join the bevel lines up with a batten. Plane the edges of the frame so that the bevel lines are *just* visible. Be careful not to take material off the other edge. If you run a pencil line down the

edge of the frame about 1mm in from the face that has no bevel to come off and leave this line *just* visible also, you will know that you have not touched the edge itself.

2.4.6 The doubler is bevelled from its given dimensions on its aft edge (-624 in the case of Frame -600) to the dimensions of the aft edge of the frame as made.

2.5 Cutting the Notches

2.5.1 The notch for the hog is 75 wide and 16 deep (depth measured on the centreline) The sides of the notch will be vertical and square to the faces of the frame but the bottom of the notch will be bevelled - use the same amount of bevel as the centreline has (a total of 5mm over the 32mm siding in the case of Frame -600)

2.5.2 Mark the notch out and cut down the sides with a tenon saw and chisel the relevant piece out - or cut it out entirely with an electric jig saw. Mark the bottom bevel and chisel this off. If you have a small block plane (a plane in which the blade comes right to the edge) you can use this here - but you are planing or chiselling across the grain so be careful of splintering. Marking the line of the bevel deeply with a sharp marking knife will help to prevent this.

2.5.3 The chine is shown in detail on the frame drawing. The notch will match this.

2.5.4 Measure the chine angle and bisect this (you don't have to be accurate to the degree). Measure 20mm up the bisecting line from the point of the chine (on the larger face of the frame). Mark a line off square to the bisecting line at the 20mm distance in. mark the sides of the notch but only 20mm each side of the bisecting line rather than the full 25mm shown.

2.5.5 Cut out the chine notch. There will be a bevel on the bottom face of the notch and there will be bevels on the side faces. These are difficult to establish accurately at this stage and are best left until the frames are fixed to the jig, at which time a batten can be run round the frames and the accurate bevels established.

2.5.6 Mark the shelf notch (16 x 40) on the big side of the frame and cut it out. But remember the height bevel may be the reverse of the offset bevel - in which case do not cut the notch full height by the amount of the bevel (i.e. if the bevel is 1mm, cut the notch 39mm, not 40). The bevels follow those for the sheer.

2.5.7 You can now run a chamfer around the inside edges of the frame - say about 4mm on each corner. Sand the frame up - sand with the grain and use fine paper. Make sure there are no pencil marks left. Don't sand off the sharp corners along the outside edges. WEST the frame 3 coats. You don't need to WEST the outer edges and notches at this stage. Lay the frame back on the floor and transfer the centreline and the dwl line to the aft

face of it - it is best to stick some masking tape on the frame and make the marks on this.

SEE NOW BOOK TWO:

MAKING THE TRANSOMS
MAKING THE JIG
SETTING UP THE FRAMES
FITTING THE HOG
FITTING THE SHELVES
FITTING THE CHINES
PLANKING