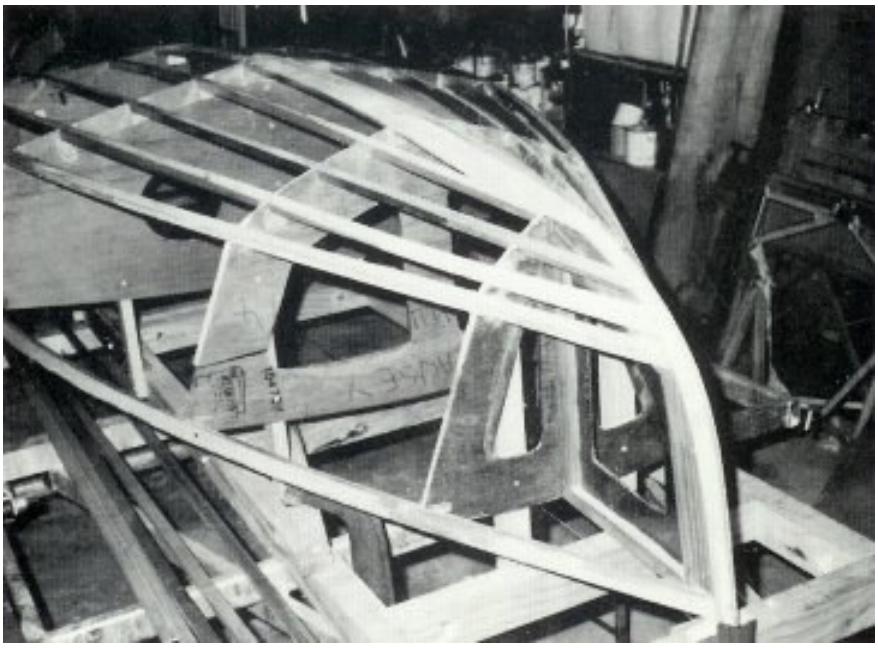
STARLING BUILDING GUIDE



Materials
Building base - 100 x 50mm radiata (or larger if available)
2 - 2900mm and 1 - 1830mm

Cedar, clear radiata or white pine.			**Lineal quantity**
Centreboard	300 x 18mm	dressed two sides	1070mm
Rudder and tuck	240 x 19mm	dressed two sides	1670mm
Stem doublers	150 x 12mm	dressed four sides	1060mm
Deck stringer, mast support and braces	38 x 19mm	dressed four sides	10 metres
C'case frame and posts	32 x 19mm	dressed four sides	4.25 metres
Gunwales, chines, carlines Etc	25 x 16mm	dressed four sides	8 - 3.05 metres
Stringers	14 x 19mm	dressed four sides	4 - 3.05 metres
Marine plywood 6mm	4 – 2400 x 1200mm sheets		
or	2 – 2400 x 1200 and 2 – 3000 x 900mm sheets		

Fastenings: Surefix screws 6 gauge x 5/8"
8 gauge x 1"
8 gauge x 11/2"
(Packs of 50 for each size would be sufficient as all screws are removed after the glue has cured.)

Glue: Epoxy resin, 4 litres.

West System and *International 9000* are brand names for epoxy resin products that can be used as a resin, glue or as a hull faring medium. The base resin has the mixed consistency of thick paint and provides excellent sealing qualities for interior and exterior hull surfaces. By adding the glue powder, the resin becomes an extremely strong gluing agent. Alternatively, if powdered micro-balloons are added to the resin, an easily sanded fairing product is obtained that makes filling hollows in the hull easier and lighter than previous

generation products. With all the requirements for gluing, sealing and filling in one 'package', the multi purpose epoxy resin is a very versatile product and ideal for Starling construction.
Caution: Epoxies can cause severe skin reactions in some people. It is highly recommended that epoxy compounds and epoxy thinners should **NEVER** come in contact with skin. Always use vinyl medical examination gloves when handling these products. Retail outlets selling epoxy also stock individual gloves. Alternatively, New Zealand Safety sells boxes of gloves. Buy the box because in the course of building a boat, many gloves are used.

Selection of Timber

Use cedar, clear radiata or white pine *(kahikatea)*. Cedar is the lightest of these woods and can be sourced in most major urban centres. Select timber that is straight and not twisted or warped.

Plywood: This must be 6mm thickness. Starlings can be built to the minimum weight if the plywood used is carefully selected with weight in mind. It pays to visit the supplier with a set of scales (bathroom ones are ideal) and choose your own sheets. A weight of less than 10kg per sheet (2400 x 1200mm) is essential (preferably less than 9kg per sheet). Availability of suitable plywood varies throughout the year and from supplier to supplier. Some satisfactory plywood species available are – Gabon, Klinki, Moranti, Queensland Maple and Australian Red Cedar.

Rule Tolerances

Before starting building it is worth remembering that the Starling Rules allow tolerances of up to **plus or minus 6mm on all plan dimensions**. If building a Starling to dimensions other than those provided on the plan, it is recommended that the class rules be thoroughly examined and dimensional changes not be made to these limits. Allow leeway for building and measuring inaccuracies. When pushing the boundaries of the class rules, it is essential to dimension and construct the boat very accurately. **Deviation from the plan is at the builders' peril.** It is worth getting the hull checked in a GBC approved measuring jig before painting.

A master-measuring jig and three duplicates have been constructed to ensure hull compliance. These have been designed to fit over a boat built to the maximum permitted hull form. The front of the centre-case opening is the **datum point** for the location of this jig, and its positioning is fixed and unable to be moved. The minimum hull tolerances are then checked on the jig templates between the jig and inner sight lines. The jig templates are fixed at the location of the bulkheads as dimensioned on the Starling plan. If a builder utilizes tolerance limits on bulkhead dimensioning, it is important that these bulkheads are located exactly as per plan otherwise it is likely the boat will not pass measurement. Bulkhead location is especially critical at A and B frames.

Some commercially available computer-cut framing currently available can be a time saving advantage. However extreme caution must be exercised in using these as some of the dimensions have been taken to the edge of the class tolerances and a number of boats built using these frames have failed their first measurement and required major rebuilding before presentation for re-measuring.

It is the builders' responsibility to comply with both the spirit and the intent of the class rules, and additional fees may be charged by the Glendowie Boating Club for the repeat re-measurement of out of tolerance boats.

Frames and Tuck

Note: the rules of the class allow a tolerance of up to 6mm in the frame shape from chine to keelson aft of Frame B at Frames C, D, E and Tuck. Making a slight convex curve through this section of the hull may help to stiffen the surface of the hull, but it does create problems in fairing the hull for an inexperienced builder. The use of stringers through the hull provides sufficient stiffness and unless the builder has had some experience, curving the surface and maintaining a fair hull and an even surface on each side of the hull is a difficult exercise. The directions given in these notes assume that the surface between keelson and chine is flat from Frame C aft.

On the ply sheet draw full sized frames A, B, C, D, E and the bow section using the dimensions shown on the plan. Carefully mark in the centre lines and grid lines. Mark the frame dimensions from the centre and grid lines. Join these lines up using straight edges and a flexible batten for the curves. **CHECK ALL DIMENSIONS AT LEAST TWICE**. An error at this point may result in a boat unable to pass measuring.

Mark all checkouts for chines, gunwales, carlines, deck stringers, deck beam and keel. . Cut ply doublers 38mm wide to fit the top and bottom at the forward side of frame C and the after side of frame E and glue them in position. These will provide the important waterproof seal and additional strength required for the cockpit at these points. It is also recommended to glue 6mm ply doublers at all checkout points on the forward side of frames A, B, and D. Mark and cut air vent ports in frames A and B and the side of D and

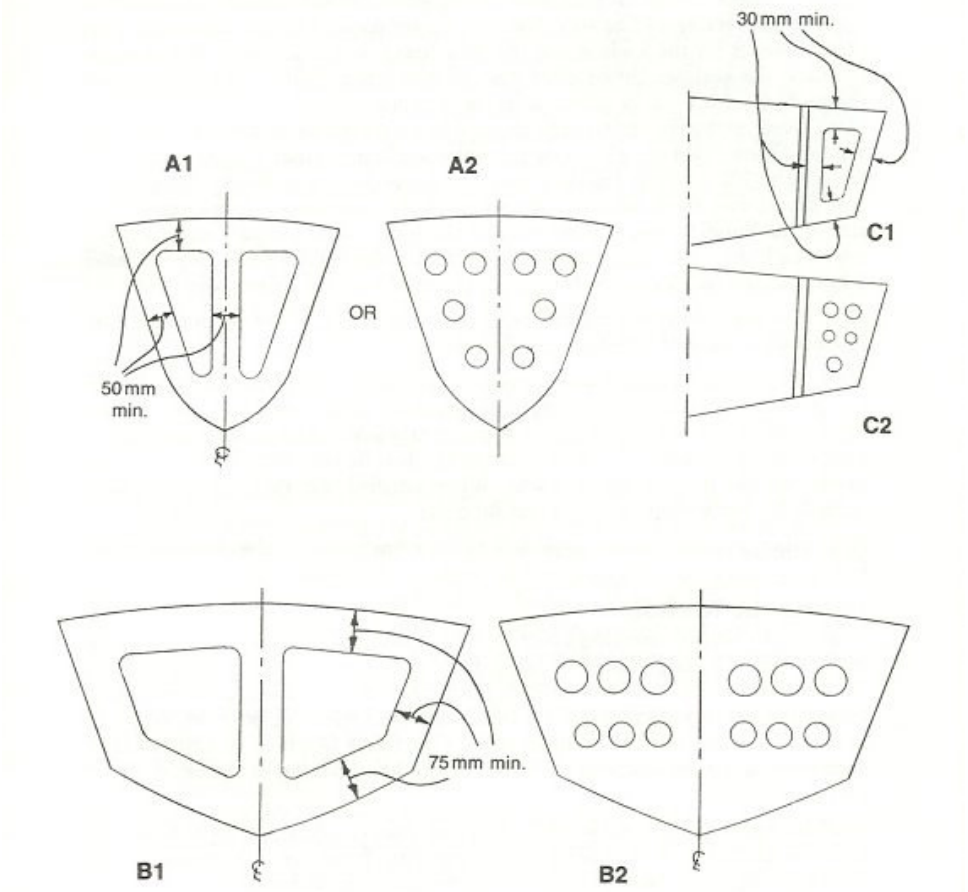


Fig. 1 Frame Cut Outs

E.

In frames A and B there may be a series of small holes or two larger cutouts. (The larger cutouts are recommended). Leave plenty of timber at the side and down the centre for strength. This should be not less than 50mm on Frame A or less than 75mm on frame B. (*see Fig 1*). At the side of D and E frames a centre cutout leaving at least 30m at all side is best (*see fig.1*). *Note:* Hollowing in excess of these guidelines is not allowed.

Mark and cut holes for inspection ports in frames C (each side) and E (centre). (Buy the ports first and cut holes to suit.) Mark and cut the tuck from 19mm timber. Allow an extra 5mm at the top for the angle at which the deck ply meets the tuck. Mark the checkouts in the tuck in the same way as the frames.

Bow Section
Draw in the grid line on 6mm ply bow profile. Cut an air vent hole after marking the position of all doublers. Glue 76 x 12mm doublers to either side of the bow profile. Clamp and glue these – don't nail. Roughly shape – don't take off too much. Glue 19 x 19mm doublers at the frame joint and the deck line. Dress and make sure connecting faces are square before attaching to A frame. Glue and screw the bow section to A frame making sure that it is square with the frame, and that the grid lines join.

The building jig
The plan details the use of a 100 x 50 mm build jig. In practice this is suitable if it is secured to additional structure or to the floor to ensure the frame does not flex or twist during the boat's construction. Any movement may result in a twisted boat. If larger dimensioned timber is used for the jig construction, then the chances of build twist will be reduced.

It is very important to ensure the centre line, bulkhead location points and the grid lines are accurately defined. It is important to locate the bulkheads using the dimensions from the plan and use **C frame as the starting datum,** since this is the point used for measuring the boat.

Secure the frames to the build jig by screws that can be removed when the upturned hull is covered with plywood. It may be easier to use strong G clamps to hold A frame in place.

Fitting the keelson, chines, gunwales and carlines.
Fit the keelson, first checking the distance between the bulkheads has not moved. It is easy for the flexible 6 mm ply to bend a few mm with the load from securing the keelson. (Consider cutting two slots in the keelson for the centre case opening prior to fitting. If a table saw is available these cuts are more easily made now than when the hull is assembled.) Lay the chines around the sides of the frames into the checkouts. Again, check the distances between the frames at the chines. There is even more of a tendency for the frames to pull out of position as the chines are loaded into the checkouts.
If your measurements are correct, the chines will lie fair without any forcing into place or distortion. Adjust any checkouts, making sure that the chines remain parallel with the sides of the frames. This will prevent the need to fair off the sides later.

The chines should be shaped sufficiently at the bow to allow each chine to follow evenly forward and then bevel into the bow piece. Fasten the chines at the bow and at each frame with removable surefix screws. Before gluing check by eye to see that the chines are laying evenly on each side of the boat. Remove one at a time and glue and re-screw them into position. The gunwales are fastened similarly to the chines. Remember to check the distances between the frames at the gunwale and to see that the gunwales lie parallel with the sides of the frames. When the glue is dry, remove the screws.

An alternate method of fitting the 19 x 32mm chines and gunwales is to use two 9.5 x 32mm lengths of timber each side. After dry fitting to the frames, these are removed, glued together and then while still wet, glued to the frames. The advantage of this method is that for the softer timbers like cedar, it reduces the chances of the timber splitting during fitting and it creates a stronger gunwale for the subsequent plywood fastening process. It also loads the frames up less than had a single piece of timber been used.

Fit the cockpit side stringers and the two floor stringers on each side. Be careful that these lie fair. This can be achieved easily by ensuring that the timber used is straight and that the slots in the frames are cut to allow the stringers to slide slightly when fitting. Consider using denser timber for the floor stringers as repeated friction from general cockpit wear and tear can damage or wear away soft woods like cedar.

Note: The cockpit side stringers are laid at the angle of the cockpit sides and faired later. The cockpit floor stringers are laid at right angles to the floor and should require very little, if any, fairing except at the bow.

The plan shows all stringers carried forward to frame B and optionally carried to the bow. It has been found preferable to carry the stringers to the bow as this provides an even bend in the stringers between A and B frames. It also allows for easier fairing of the bow section and if the joining the bottom plywood is by scarfing at the bow (as described later) the stringers provide an excellent joining surface.

Making and fitting the Centrecase

Using 32 x 19mm timber make doublers by scribing and planning two pieces 560mm long to the shape of the keelson aft of frame C. Put aside. Cut ply sides of case to the plan dimensions. Allow these to be 254mm deep. Cut kingposts and doublers for the top from 32 x 19mm timber and glue and nail to the sides. *Note:* The forward kingpost extends 100m above the case top. Measure the width and length of the box section formed and cut a slot to suit in the keelson aft of frame C. *Note:* The slot in the keelson will be a little shorter than the length of the centre case. Square the aft corner of the case to fit. Push the centre case into the slot so that the top of the case lies at a point 76mm below the grid line. Check the centre line of the forward kingpost with the centreline of frame C. Sight through the case to the centre line cord to ensure that the case is straight in the boat.

Glue and fasten the centre-case to frame C and the keelson. Wedges through the slot will force the ply side to the keelson and ensure a good join. Glue and fasten the doublers (scribed and planed earlier) along the keelson against the case. These will extend approximately 100mm past the case. Later, glue a piece of timber between these. (These can be fitted after the hull is completed and if the boat is underweight, heavier timber can be used i.e. jara.) Round the inside corners of the keelson from the aft end of the centre case doublers to Frame E. Cut the excess off the centre case to the bevel of the keelson.

Alternatively, the centre-case can be fitted after the hull is completed allowing the use of suitable weight timbers, depending on how close to minimum weight it is estimated the boat will be at completion. If the case is fitted after the bottom ply is attached, do not run the plywood case sides through the keelson.

It is worth fibre glassing or at least resining the inside faces of the case before assembly, as this is a high wear area of the boat and impossible to maintain once the boat is in use.

Fairing Up

Fair the bottom starting with the keelson. Plane carefully so that the bevel is true with the angle of the frames. Bevel the frame edges to suit the keel rise but do not take too much

off. Be sure that the frame edge is not hollowed. Using the frames as a guide, mark a fair line along the outside edge of the chine. Bevel from the inside edge to this line. Don't take off too much at a time and check with a straight edge across the boat from keelson to chine as you go. Use a straight timber batten approx. 19 x 6mm or a strip of aluminium or steel approx. 19 x 3mm to check the fairness fore and aft along the boat. When placed fore and aft over the frames and pulled tight, it should touch every frame and lie true along the bevel of the chine.

Finish fairing by sanding. Use a piece of straight timber approximately 1 metre long by 50 to 70mm wide and 20 to 25mm thick. Cut a strip of 80 grit sandpaper paper the same width and a little longer and place on the board. Turn the ends and fasten to the ends of the board by using tacks or staples. Lay the board across from keelson to chine and carefully sand back and forth from the tuck to frame C. Check with a piece of 6mm plywood over the surface. It should lie true at all points. From frame C to the bow use a piece of thin ply – 5mm or less – or heavy cardboard to check your fairing. Be especially careful at the bow.

Note: The fairer the surface, the easier it is to fasten the plywood and the better the resulting boat.

Fair the sides by using a plane where necessary and finishing with the sanding board. If the chines and gunwales have been laid parallel with the frame sides, very little fairing will be necessary.

At this point, cut limber (drain) hole notches in each of frames A and B at each side of the keelson and at the chine side of the floor stringers. Repeat the same process beside the bulkhead cleats in frame D and E.

It is a good policy at this stage to check with a straight edge all flat sections on frames A, B and D that lie between the stringers. The bulkheads must not be proud of the stringers, chines or keelson as this may result in hard spots or bumps in the finished bottom surface.

Planking

Bottom – using 2400 x 1200mm sheet.

Using a whole sheet of ply, cut as shown in *Fig 2.* Fit and clamp the bottom section onto the boat and mark the keel centre. Plane this to fit. Mark the chine. Cut this to leave an overlap of approx. 10mm. The end of the ply will lie between A and B frames. Take the off-cut and fit this to cover the bow section allowing a 50mm overlap (*see fig.2*). Don't overlap the pieces less than the 50mm suggested. For a satisfactory scarf joint the ratio of the ply thickness to the width of the joint should be a great as possible. In this case the ratio is 1 to 8, which is the minimum recommended. (Some steaming of the piece may be necessary when finally fitted, depending on the ply used.) Mark carefully. Remove the ply. Lay the bow piece back on to the larger piece at the join point and clamp together, (*see fig. 2*). Plane the bevel carefully. Fit the two sections and check the join. Fit the other side in a similar way. The bottom ply will be butt joined along the keelson centreline to A frame where it will have to be overlapped. Fit and glue one side. Bevel the bow section piece when the glue has set. Fit and glue the other side allowing the bow section piece to overlap at the keel line.

Notes:

The two sections of each side can either be joined and glued on the boat or glued before fitting. If the scarf joint is to be joined on the boat, use plenty of glue at the scarf joint. If the stringers have all been brought forward to the bow as suggested earlier, a good stiff surface is provided for the join. When gluing, check that the join is true. A few staples through the ply into the stringers may be needed.

If the scarf joints on the bottom sheets of ply are glued prior to fitting on the boat, the bow section will require fore/aft saw cuts to be made half way through the ply to enable bending around the A frame area. Using a hand saw, make cuts parallel to the keelson edge, 10mm apart, running aft to between A and B frames on the inside face of the plywood bottom.

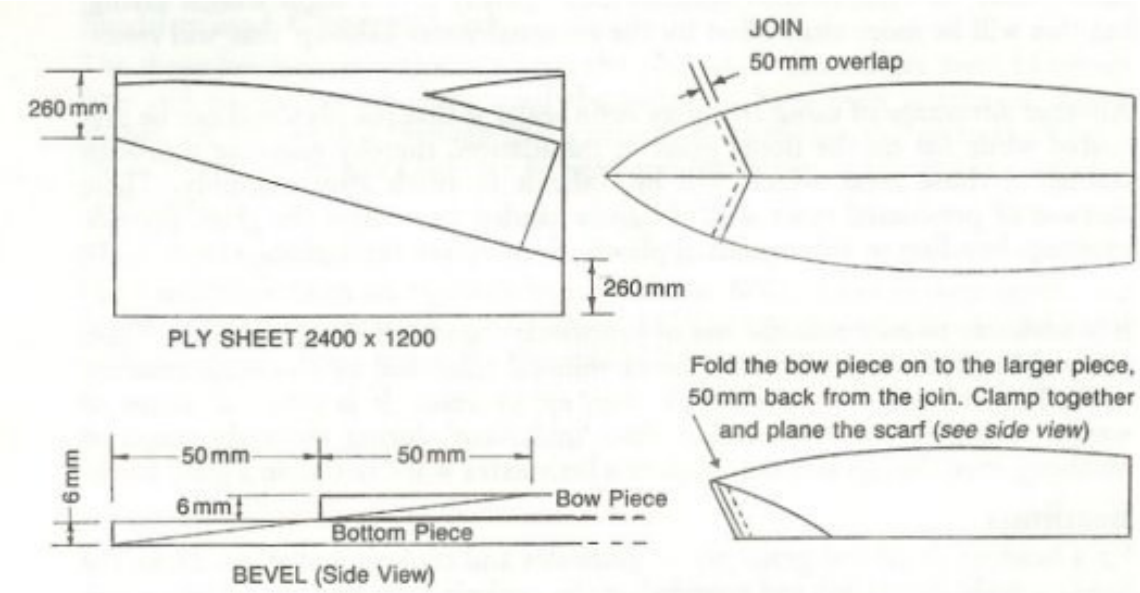


Fig. 2 Scarf Joint Method for Bottom Planking

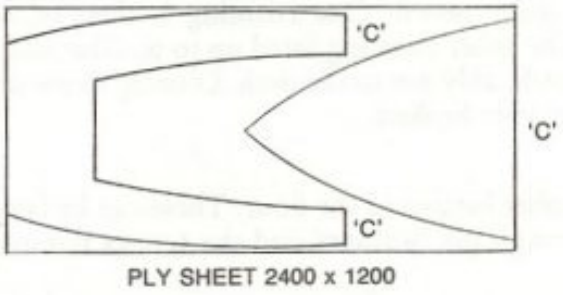


Fig. 3 Method for Cutting Deck from 1200 x 2400 Ply Sheet with Joint at 'C' Frame.

Leave the first side on and fit the other side. Make sure that the centre line is a good join. Allow the ply to overlap forward of frame B. Take off both sides. Drill small holes from the inside along the marked cleat positions. These will allow you to locate the cleats easily when fastening the ply. Glue and fasten the first side. Use surefix 5/8 screws where there is little tension and 1" screws where there is more tension e.g. the bow. Fit and glue a section of ply to each side from frame E to the tuck.

Note: If the cleat at frame E has not been continued to the chine, a piece of plywood can be fitted over this section of the joint.

Regardless of the method used, don't forget to clean out the glue from the limber holes after the bottom sheets of plywood have been fastened and before the glue curers.

Sides

Plane off excess plywood along the chine, to a point just forward of frame B. (see plan). At this point the joint changes from a lap to a butt joint. Cut the bottom ply along the centre of the chine to the change point. Scarf-joint plywood for the side so that you have 3050mm in length. Lay the ply for the side along the boat starting at the bow, and tack in position. Mark along the butt joint on the chine from the bow to the change point. Remove and cut. Place in position. Make sure that the butt joint is close and that the ply lies fair. Mark along the chine and gunwale and at the frame positions. Remove and cut along the chine and gunwale leaving a little excess. Glue and fasten using surefix screws as for the bottom.
Trim off the excess ply along the chine and stern. Once the glue has cured, remove all screws. Sand the bottom and sides keeping the chines and stern edges sharp. Epoxy resin mixed with micro balloons can be used where necessary for fairing the hull. Fairing is much easier done while the boat is secured to the building base.

Side Bulkhead and Deck

Remove the hull from the building base and turn it over. Make a building cradle and consider fastening the hull securely to it, making sure the hull is not twisted in any way. Alternatively, simply use the alloy beach trailer as a build cradle and accept a little more movement during the subsequent building.

Fit the mast support and centre deck stringer. Fit the deck carlines. Cut out D frame between the deck carlins and the cockpit side stringers. Fit 16mm x 16mm cleats for the cockpit sides to C, D and E frames. Using heavy paper, make a template for the cockpit sides and mark onto plywood. Cut out and fit into the cockpit. Glue in place. Fit backing blocks for the chain-plates, stacking-straps and deck fittings. *Note:* Chain-plates are better bolted through than screwed.

Fair off the deck, planning gunwale and carlines carefully to avoid hollows. A straight edge placed along the deck parallel with the centre line should touch at all frame points. Lay the deck plywood on with one end at the bow and tack it in place. (see fig 3 for layout guide). Check that a good joint is made at the gunwale. Mark around the gunwale and inside the cockpit. (This can be achieved by coercing a child to lie in the cockpit and mark underside of the ply around the cockpit edge.) Mark the end of the ply sheet on the boat. Remove the ply. Cut just outside the gunwale line and around the cockpit. Fit a doubler – approx. 25mm wide on each side deck to take the ply joint.

Note: If ply longer than 2400mm sheet is being used or if you scarf joint the ply first, this doubler is not needed.

Mark the position of the gunwales, cockpit sides, centre-deck beam and carline and frame C and E cleats on the inside of the deck ply. Drill small holes from the inside along the beams listed above. These will form marking points for nailing the ply on. To reduce the damage from nails on a clear finished deck, consider removing the nails after the glue has dried. Pre-nailing each nail through a 10mm x 10mm square of 6mm ply and using these to nail down. When the glue has dried the 10x10 block can be carefully knocked out and the nail extracted. This leaves a hole considerably smaller than had the nail and its head been countersunk into the deck.

Alternatively the deck ply may be stapled on. A large staple gun with 13 or 14mm staples is needed. If stapling, place a thick cardboard square (20mm x 20mm) or timber veneer over the fastening point and staple through it. This provides protection for the ply surface. The staples and the removal of the staples later will mark the cardboard or veneer and not the deck.

If a fastening-free clear finish is desired, consider the more laborious technique of temporarily fastening 15mm x 20mm stringers to the outside of the gunnels from bow to stern. Repeat the same process around the top inside edge of the cockpit. Ensure the inside and top edges of these temporary stringers have first been taped over with a plastic glue-proof tape. When gluing the deck to the hull, use these temporary stringers for fastening while the glue is drying. When dry, remove the screws that fastened the temporary stringers to the deck, hull and cockpit sides. The temporary stringers should then fall away leaving the overhanging deck plywood to be planned off.

Sealing the inside

The boat must be watertight and the timber sealed on all inside surfaces **BEFORE** the deck ply is fastened. Long-term benefits can be gained from applying two or more coats of a special purpose sealer such as the International brand *Evedure*, to all interior surfaces. Alternatively one coat of epoxy resin such as *West System* resin will suffice. Particular attention should be paid to those areas that will be poorly ventilated such as watertight compartments.

An advantage of using epoxy resin as a sealer is that the underside of the deck can be pre-coated while flat on the floor, prior to installation, thereby ensuring thorough sealing of those areas which will be impossible reach after assembly. These surfaces of pre-coated resin will require light sanding to remove gloss and ensure glue adhesion to the deck framing. Alternatively, the deck underside can be resined and prior to the resin curing (within 12hrs), glue and fasten the deck to the hull. This negates the need to sand as the uncured resin and the glue mix will chemically key together.

Beadings

It is advised, but not mandatory to fit a beading to all end grain deck plywood – gunwales and cockpit and stern. Beadings can be made up to 25mm wide. When rounded at the gunwale adjacent to the cockpit and in the cockpit, it provides a ‘softer’ corner for the sailor when stacking out. Inside the cockpit some builders route out the deck/cockpit interface and insert solid timber. This enables corner rounding without the weight of additional timber being fastened to the inside edge of the cockpit.

Coamings

The centre knee is first shaped, bevelled and glued into position. Take the angles and bevels from the plan. One at a time the roughed out coamings are fitted against the knee and scribed onto the deck with a sharp pencil. One coaming is then mitred and trial fitted to the deck. Rub a chalk stick on the mitred bottom face and rub the coaming against the deck. Where the chalk rubs off the coaming, either sand or spoke-shave off the surplus timber. Repeat this process until the chalk rubs off the coaming evenly across the entire length. Glue the coaming to the knee and the deck.

Floor Battens

Fit plywood or timber battens to the floor. These can be fastened with staples or screwed down through ply ‘washers’ and the screws removed when the glue is dry.

Centre- case Brace

The fitting of a brace to support the free end of the centre-case is strongly recommended. This can be glued to the aft end of the centre-case and fitted to the stringers or extended to the side of the cockpit. Be sure that while fitting the brace, the bottom of the boat is not distorted by pressure on the stringers. Make sure adequate provision is made for water movement fore and aft of the brace.

Mast Block

The mast block should be made fairly large to take deck blocks etc, associated with outhaul, downhaul and kicker. Unless previously planed for, there are no doublers or supports beneath the deck at this point to provide an alternative fastening. The measurement at the deck, from the aft face of the mast circle (excluding track) is an important one; 610mm +/- 6mm to the fwd cockpit bulkhead. Care must be taken to place the mast step exactly. If it is planned to locate the mast pin forward of the centre of the mast, an allowance must be made for the rotational location of the mast circle. Be sure also that the mast step is centred exactly on the centre line of the boat.

Rudder and Centreboard

The shapes for these are optional within the plan sizes. The rudder must be tip-up type and should not be made until the rudderstock has been designed. The rudder gudgeon pintals should be bolted through the transom. For new, inexperienced or lighter sailor it is recommended to make the rudder to the maximum depth from the deck centreline of 840mm and no narrower than 230mm. As the sailor becomes more experienced, a smaller lower drag rudder can be fitted.

Be sure that the surfaces of both centreboard and rudder blade are straight and the section is fair and the same shape on both sides. A smooth even radius on the leading edge is important.

Mast and Boom

The required sections are available from A. Foster & Co. Ltd and their agents. For corrosion prevention, it is recommended that the mast and boom should be anodised or painted. Closely study the class rules before cutting the mast or boom, as errors may be impossible to rectify.

It is recommended that cutting off the sail track at the gooseneck area of the mast be avoided as the track assists mast stiffness at this heavily loaded region. Gently prize open the track above the gooseneck where required for the insertion of the sail.

If the stays are fitted to the outside of the mast, the attachment compliance point is measured from the upper bearing face of the saddle. If a tang is used the intersect point with the mast becomes the measurement point. In the case of a slotted ‘through the mast hook’ type system, the bearing face at the mast slot is the measurement point. For stays fixed to a through-bolt inside the mast, the measurement point is taken from where the stay exits the mast.

In all cases these dimensions must include any washers or pivot sheaves used between the mast base and mast step. The mast pin is not included in these dimensions.

The boom has a minimum track requirement. Be careful not to cut too much off.

Glendowie Boating Club
October 2005