Boat Building Notes

For High School Students

Bruce Heyer

Wet Paper

Father and son

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Boat building notes

For High School Marine Studies Students

Bruce Heyer

Wet Paper
Marine Education

Contents

"A uniting bond was generated amongst the students in this group. The boat, built for school use, was considered by them to be 'theirs.' "

To those who always wanted a boat but could not afford it.

Somebody once said something about building a better mouse trap and the world will wear a path to your door.

The same applies to boats. Find a better, simpler, quicker method and everyone wants to know about it.

This publication is the result of building boats over thirty years , teaching high school for over twenty years and a constant hammering from Bob (Moffatt) for the last five. I hope it is of some help.

Bruce Heyer.

'A good boat is a thousand jobs done right"

Allan H Vaitses
International Publishing Co, Camden, Maine, 04843.

Chapter 1

Basic boat building materials

The preson who invented the wheel was a Johnny-come-lately because the boat was invented years before and has done at least as much to benefit humankind. The boats of primitive people were made of primitive materials but occasionally their design was quite advanced. Primitive boats would include the coracle, the dug out canoe and the bark canoe.

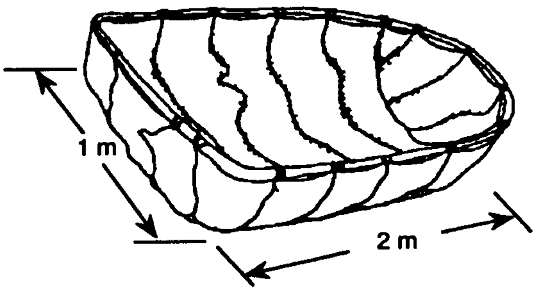


Fig 1.1: The Coracle. This was a light dinghy or skiff with a light wooden or wicker frame covered with hides and water proofed with tar. It was typical of boats made in Wales or Ireland.

As early man was a 'tool user' it was merely a matter of time until his tools became more specialized and of course his finished product became better. The oldest sea going vessels known to our society have their origins with the Egyptions, the Polynesians and the Vikings. The Japanese and Chinese had some rather large vessels but were for calm weather only. The Vikings were the first rulers of the sea with various other nations having their moment of glory through history.

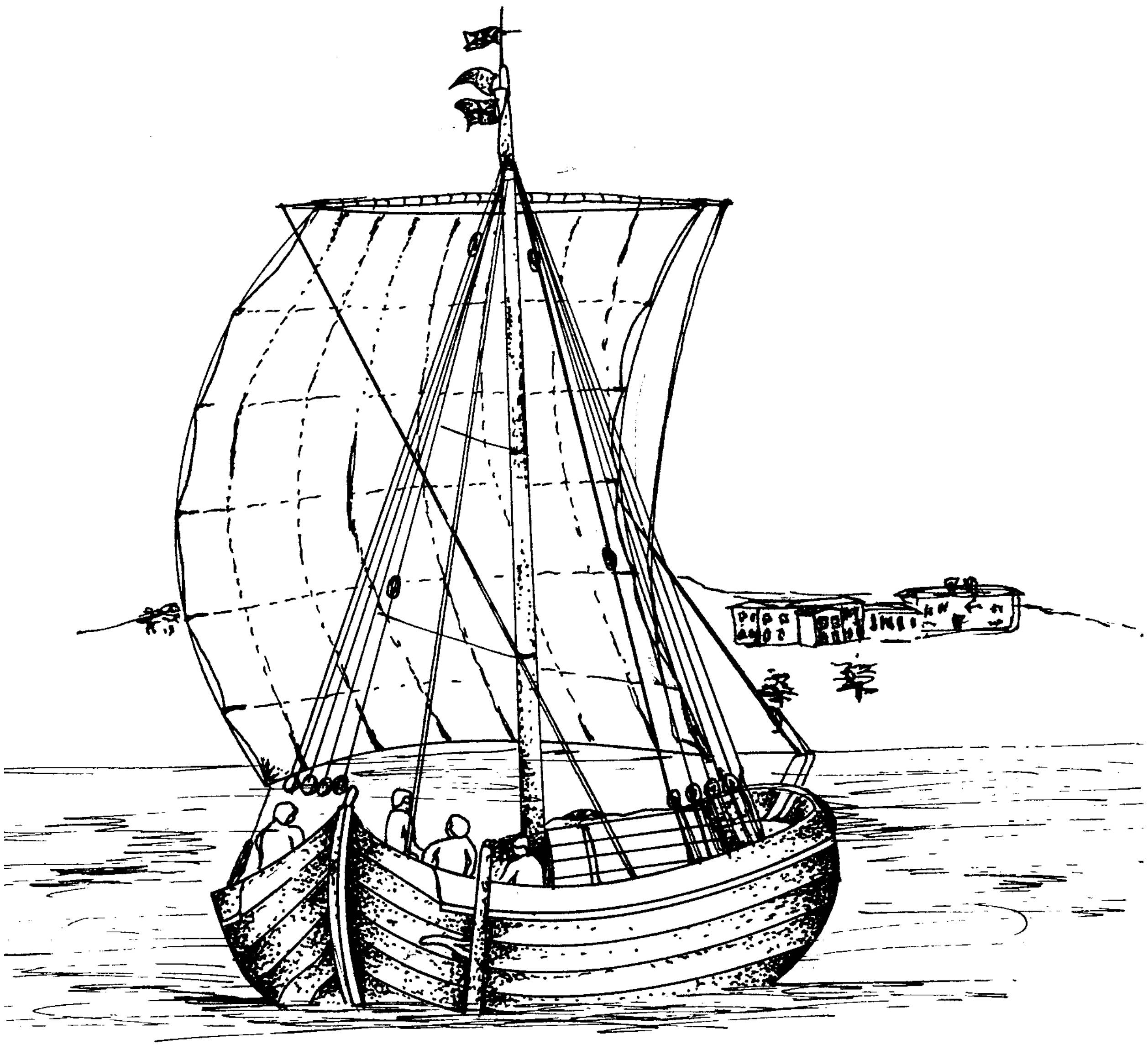


Fig 1.2: A drawing of a Viking deep sea trading vessel (knar) 'Saga Sigla' in Sydney Harbour in 1985. A Norwegian skipper named Ragnar Thorseth sailed this vessel with his wife and family from Norway to Sydney passing by Canada and the USA to prove an old design can make a good 45° to windward and capable of out pacing some of todays yachts.

The remains of five Viking ships were discovered in the late 50s by the Danish National Museum in the muck in the bottom of Roskilde Fjord. After studying the construction techniques used in the wrecks, modern boat builders built the 'Saga Siglar', she is considered by the Museum to be 99% correct. The Viking ships were built to go anywhere and are thought to have at least crossed the North Atlantic.

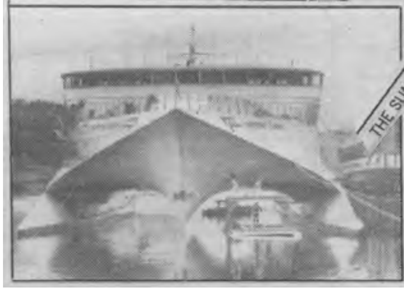
There have been many types of boats and ships built over the years; all from timber until relatively recently when in the late nineteenth century steel mills became popular.

In recent times a great many materials have been used. These materials include steel, aluminium, concrete and fibre reinforced plastic. The boating enthusiast of today can either build or buy one ready made. His choice of materials is quite large.

To build an effective boat from timber, the builder must use materials that are resistant to the suns rays, water, and attack from insects, borers and rot. Some of the better known timbers to be used in this often harsh environment are shown in the table below.

Softwood	**Hardwood**	**Origin**
Oregon pine		North America
Western red cedar		North America
	Crows ash	Australia
	Spotted gum	Australia
	Silver ash	Australia
	Fraser Is. Turpentine	Australia
Heron pine		Australia
Meranti		Eastern Pacific Rim
	Teak	S.E. Asia

Fig 1.3: This boat was made from 6mm marine ply, stitch and glue method with F.R.P. sheath.



Robert Clifford — lifetime dream. LEFT: the *Christopher Colombus*.

THE Australian domination of English Channel crossings, set by our swimmers, is set to continue via the jet engines of one of the world's biggest catamarans.

Revolutionary Australian "wave piercing" catamarans, with a top speed of 40 knots and the ability to handle 6m seas, signal a new era in passenger ferries and a multi-million dollar export industry for Australia.

The *Christopher Colombus*, the first of the new breed, is to begin service with the British Hoverspeed Company in June.

As quickly as International catamarans, the Hobart-based manufacturer, can make them, the giant boats will go into service all over the world.

The catamarans are the culmination of a lifetime's work for 47-year-old boat builder Robert Clifford.

Dynamic ferry set for lift-off

By ANNE SIMPSON

AN all-Australian company based on the Gold Coast has set out on the high seas of boat design and development with a revolutionary new vessel.

Booth and Wilson Marine Services Pty Ltd has joined with naval designer John Lund to develop and build a high-speed passenger ferry.

Called the Stolkraft, it is unique because the hull relies on a combination of hydrodynamic and aerodynamic lift.

"It is as efficient as a hydrofoil yet it doesn't have the same complications," technical director for Stolkraft International John Lund said.

A 7.5m craft now being built in the Booth and Wilson factory will be able to achieve up to 40 knots in service.

It is expected this vessel will be launched early next month.

Mr Lund said there was a large market for fast, stable, smaller boats.

He said the secret of the design was in the shape of the hull which allowed air and water to be sucked under it as it skimmed along the surface.

"There is a cavity under the centre of the craft which forces the boat to elevate above the water as the air and water is forced into the area.

Development

"The air also acts as a lubricant for the boat's underside and friction is greatly reduced."

He said the design was constantly being improved.

The Stolkcraft, recently a subject on the *Beyond 2000* television program, was the idea of Leo Stolk who died before he could realise the concept.

Mr Lund has worked on the design and commercial application of the Stolkraft hull since 1981.

He said the hull created minimal wash and had excellent speed, power and seakeeping characteristics.

"We envisage the craft being used in the tourist ferry market, for police and Customs patrols, by the military, as crew boats, and as fast leisure craft." he said.

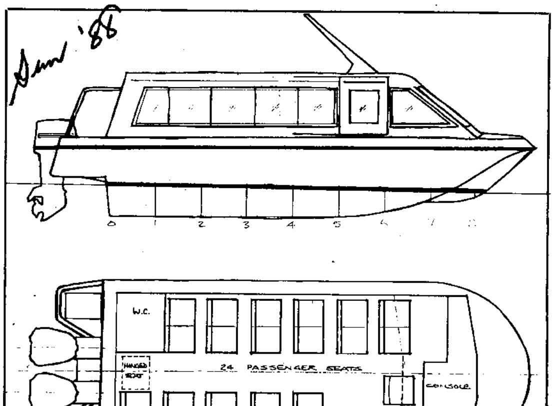
"Already Stolkrafts are being used for water taxis on the Gold Coast.

"One would shortly be used as a tourist ferry at Port Macquarie on the NSW north coast.

"We have had inquiries from all over Australia and overseas, especially south-east Asia."

At a price of $280,000 for the 7.5m size craft, the Stolkraft could well become a major income earner for Australia.

It is fully patented in most major countries.



The layout of the 7.5m Stolkraft-design ferry which will carry 24 passengers.

Fig 1.4: Significant changes to boat design have occurred in recent years. These articles courtesy of Sun Newspapers.

Plywood, a reconstituted timber developed this century, has been used extensively in the production of boats, particularly home built boats. Good quality boats can be built from marine ply and if given average care and protection will last for many years.

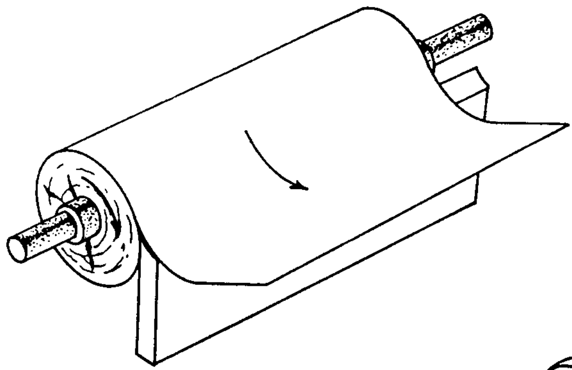
Plywood has an uneven number of veneers glued one on top of the other so that each veneer has its grain running at 90 ° to the previous one. There are numerous grades of ply, but the one suitable for boat building is 'marine ply'. The veneers of marine ply are treated with insoluble salts of copper, zinc, tin and sometimes arsenic and then glued together with a water proof glue.

Vereers of timbers are cut by one of two methods viz:-

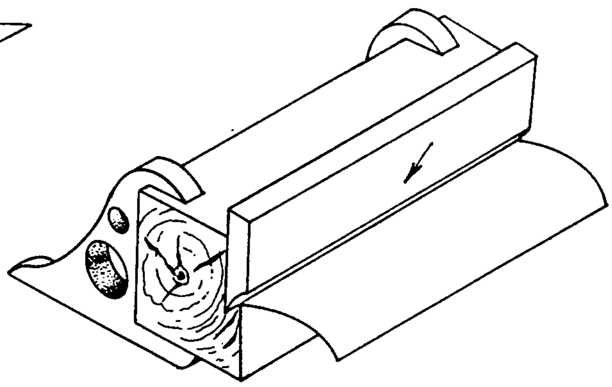
1. Rotary method. In the rotary method a pre-steamed log is turned in a lathe and a continuous veneer is pealed off as the lathe rotates.

2. Slicing method. In the slicing method a pre-steamed flitch is held securely and a guillotine type blade is lowered with a slicing action to cut off sheets of veneer.

The continuous veneer is the most efficient, however the sliced sheets produce a sheet of veneer that has a 'true to life' grain pattern.



Rotary Method



Slicing Method

Fig 1.5: Two common proceedures of cutting veneer are the rotary and slicing methods.

Fibre Reinforced Plastic (F.R.P.) is a more correct term than fibre glass and has been increasing in popularity since the mid fifties. During this time the proportional cost of F.R.P. has decreased and its' versatility increased. The earliest fibre reinforced product to be used commercially was for electrical insulation. The fibre was mostly cotton waste and the plastic was ureaformaldehyde.

To produce fibre glass, continuous filaments of glass are drawn mechanically and staples (short lengths around 60mm) are produced by blasting air or steam over the newly formed group of filaments. The long filaments are spun into thread which is subsequently woven into cloth. Glass fibre is an excellent thermal, electrical and sound insulating material, but is used primarily as a construction material for products ranging from tubing to aircraft and bridges.

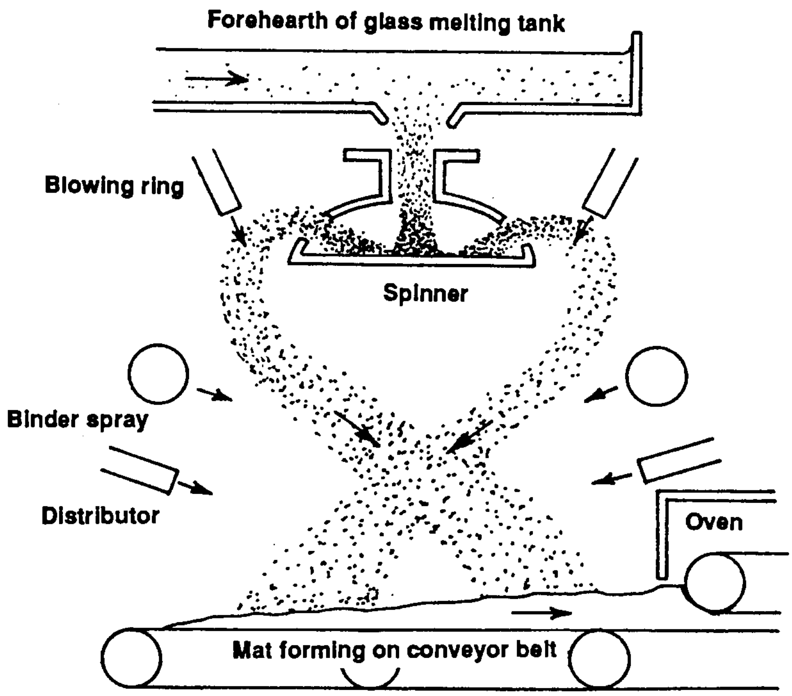


Fig 1.5: **Making fibreglass by the crown and wool process.**

Glass fibre is supplied in a number of forms. There are cloth, matt, woven rovings and continuous rovings.

Cloth is just as the word implies, however, the weight and size of the threads that make up the cloth vary greatly. The lightest form is made of threads of around .3mm. The heaviest is the woven roving with the roving being a number of threads making up a strand around .3mm thick and 6mm wide. The matt is a blanket of randomly placed staples of glass roving of about 50mm in length that is available in various weights. The matt is the strongest form glass reinforcement.

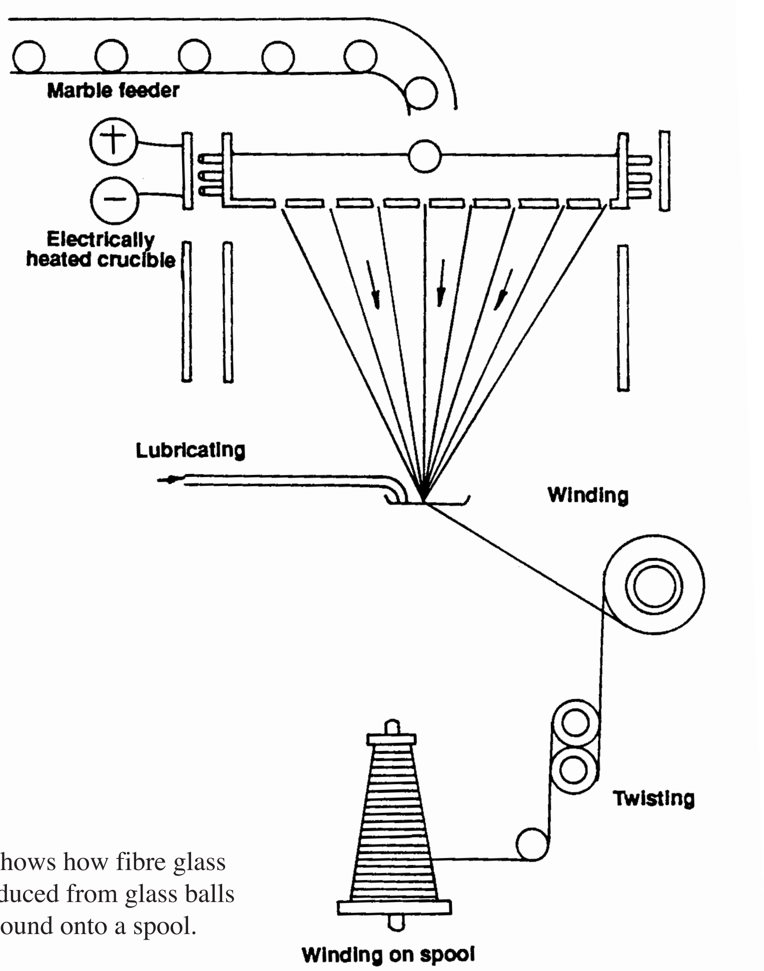


Fig 1.6: This shows how fibre glass is produced from glass balls and wound onto a spool.

Continuous roving is a continuous strand of glass fibres supplied in a 'cheese' similar to a 'cheese' of rope. Continuous roving is used with a 'chopper gun'.

A 'chopper gun' is a spray gun used in commercial f.r.p. (fibre glass reinforced plastic) factories that sprays resin from one nozzle and catalyst from another. Directly above these side by side nozzles is an opening of 40 x 25 that has chopped roving sprayed from it.

The 'chopper' part of the gun is similar to an electric planer however it is driven by compressed air. Compressed air is also used as the vehicle to deliver the staples of roving to the job. As the resultant pattern is the same as the 'matt' its strength is the same.

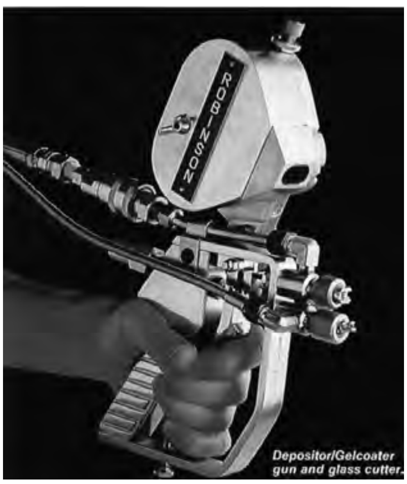


Fig 1.7: A chopper gun. Photo courtesy Robinson Industries.

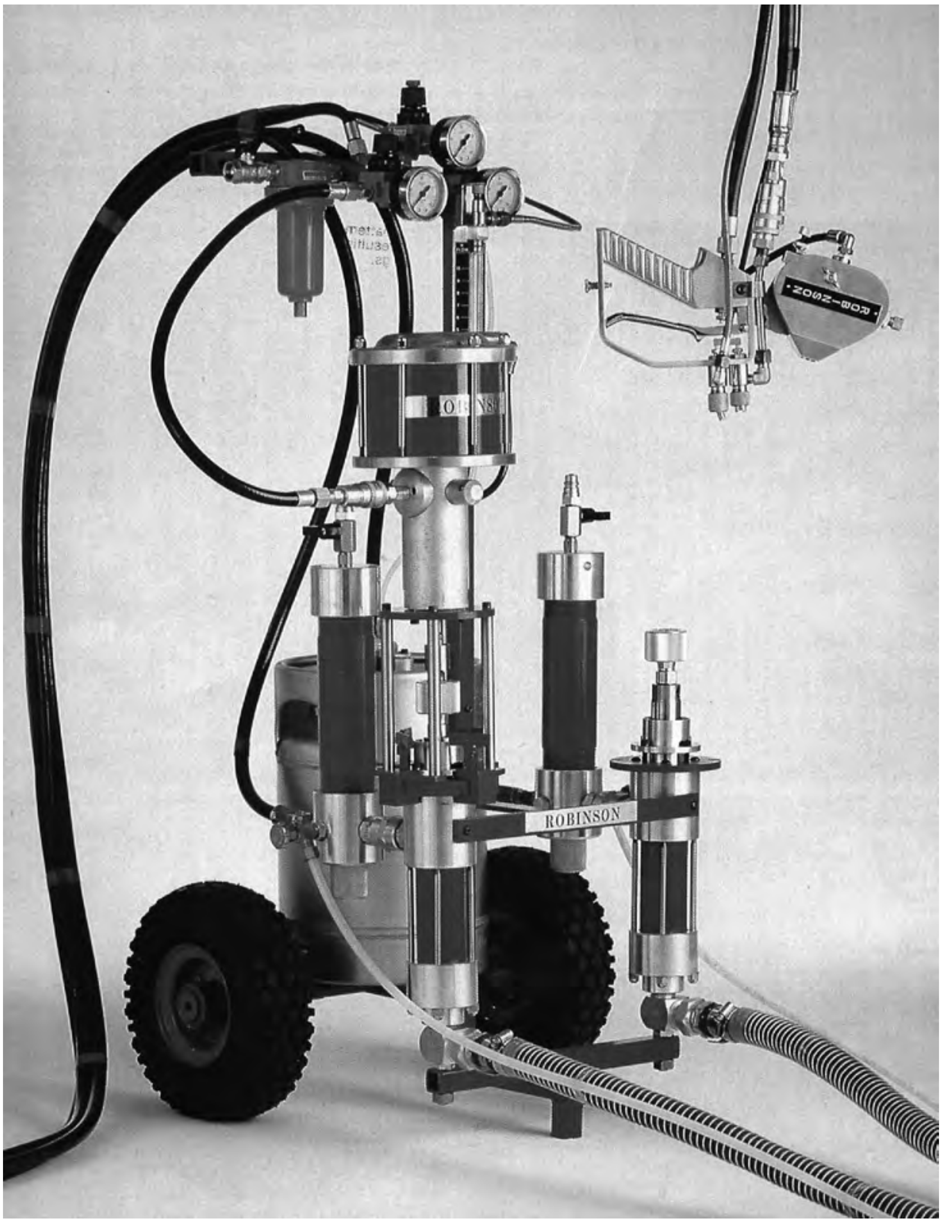


Fig 1.8: The chopper gun delivers resin, catalyst and chopped strands of glass roving to the job surface.) Figure courtesy Robinson Industries.

There are a number of fibres other than glass that are used to reinforce plastics. The most common of these are carbon and kevla. Glass is used because of its strength (ten times the tensile strength of steel) and its relative low cost. Carbon is used because of its low weight and strength to weight ratio. The strength to weight ratio of carbon is much higher than that of glass.

Kevla, the 'marvel' fibre is approximately 35% lighter than glass but with around 5 times the strength. Kevla is 30% more expensive than glass. Kevla is currently being used for flack jackets and soldier's battle helmets.

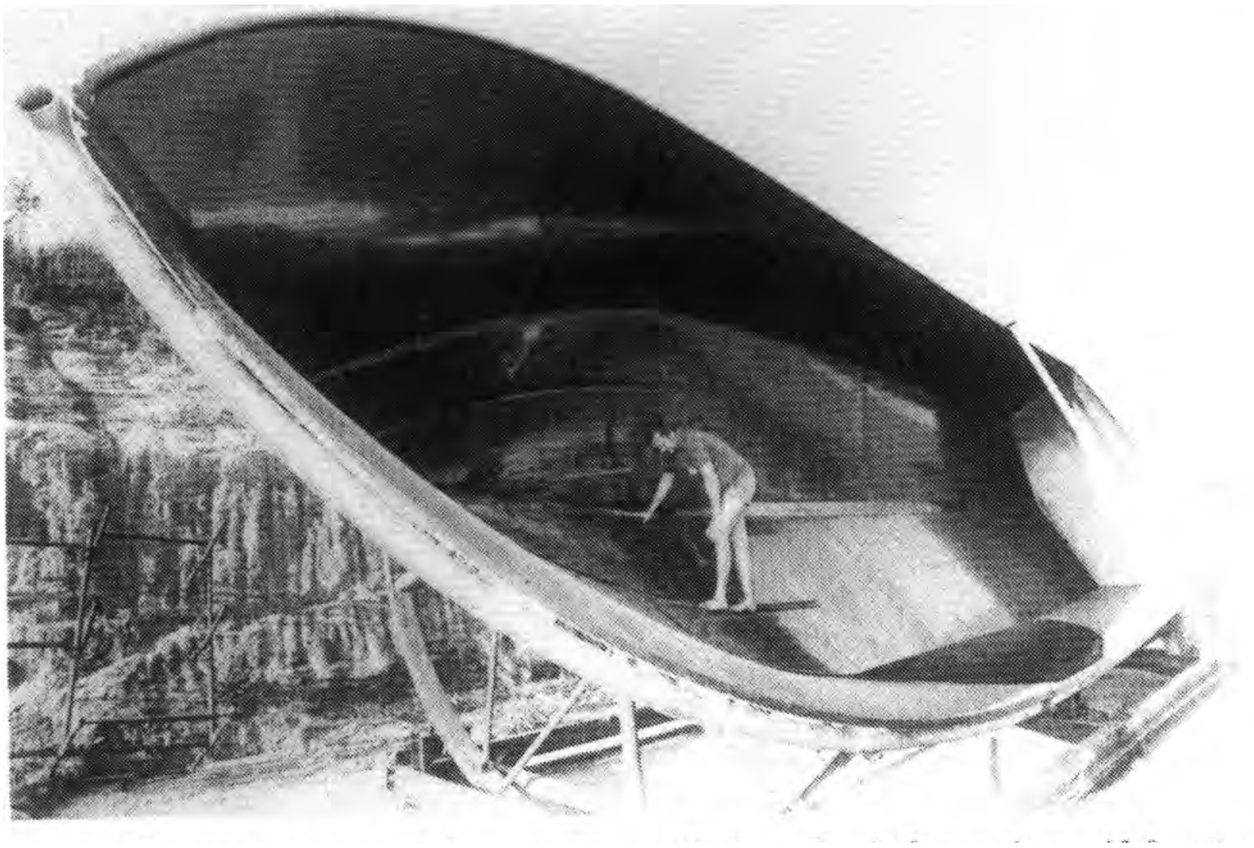


Fig 1.9:   A 12.8 metre mono hull mould (Photo courtesy Sunshine Coast Kevlacat)

If kevla is substituted for glass in a boat the total weight reduction allows for a lighter trailer to be built and a smaller engine to be used. The consequence is that while the hull may cost a little more, the cost of the trailer, the engine and fuel to power such a vessel is much less.

All fibre reinforcing is sold by the weight per area and as most reinforcing fibre is produced in America, (a non metric country), it is usually sold by the pound with the glass being manufactured in weight per pound.

Of the many kinds of resins currently being produced there are three that are more commonly used. These are epoxy, polyester and vinylester.

INDUSTRY

SPACE AGE BOATS LAUNCHED

A Sunshine Coast company has met with considerable success building a range of power boats from a new space age material.

A director of the firm, Kevlacat Pty Ltd, Mr Jack Temminck, said: "The product that we are using, kevlar, is a super-strong woven material found in applications such as bullet-proof vests.

"Although it is probably not timely to talk about it at the moment, the material was also used in construction of the cone of the recent ill-fated space shuttle.

"Basically a short time ago, my partner and I felt the possibilities for using the material in boat building had never been fully explored.

"Research conducted by the Civil Engineering Department of the Queensland Institute of Technology however, showed that our application was 100 per cent stronger than normal fibreglass. It was also only half as thick.

"This allows us to lay up a boat much lighter, which means less horsepower to run it, and consequently a huge savings in fuel costs."

Mr Temminck said Kevlacat's most popular boat at the moment was a 6.1 metre model which is generally powered by a 270 horsepower motor. "It's a good all-round fishing boat, but we have found it has received quite a deal of acceptance in the pleasure boat market as well.

"Business is very brisk and currently we have a lot of orders. There are enough boats in the water now to prove the usefulness of the product," he said.

Kevlacat produces mono hulls, designed by Len Randell, in 10.6 metre, 12.8 metre and 16.7 metre sizes. Catamarans, made to the company's own designs, are produced in 3 metre, 6.1 metre and 7.9 metre lengths.

Mr Temminck said his partner, Mr Paul D'auria, was a professional fisherman before he entered the boat building business. "He wanted a cheap boat to run and therefore undertook a lot of investigative work before deciding kevlar was the complete answer."

Mr Temminck said although his company put a lot of faith in a new material for its boats, he was firmly committed to using as much local talent as possible in their design and construction.

Kevlacat Pty Ltd, Shed 5, Lot 3, Page Street, Kunda Park Q 4556. Phone (071) 453 444.

Comparison: Epoxy Resin is about twice the price of polyester resin with the cost of vynilester resin falling between the previous two. It has the greatest adhesive ability of the three resins and will not degenerate polystyrene foam bases. However polyester resin will degenerate polystyrene, reducing it to a shapeless slop. Epoxy resin does not suffer from osmosis, polyester does (absorbs water) vinylester is used in conjunction with polyester to waterproof the casting. Because of its lesser cost, most commercial boat producers use polyester resin. ***NB.*** *Before using any liquid resins or their accompanying fibres, a study of the manufacturers information pamphlets and fact sheets is recommended. These companies are usually very helpful..*

Aluminium alloy is an extremely good boat building material for craft of all sizes, but particularly so for craft up to 4.8m. Aluminium is produced from a red powdery soil called bauxite which is found in vast quantities in North Queensland.

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This powder is treated with caustic soda to produce alumina and this in turn is smelted to produce aluminium. High amounts of electricity are required to produce aluminium in an electrolytic process hence alumina plants and aluminium smelters are located in areas producing low cost electricity. The alloy used in boat manufacture is predominantly aluminium with small amounts of copper, magnesium, manganese, silicon, and iron added. Aluminium alloy is popular because it resists corrosion, is light weight, has good appearance and receives painted finishes well. There is however some difficulty in maintaining a good appearance when electrical circuits are used in alloy craft. No matter how much care is used, small electronic circuits are set up and evidence of the electrolysis is soon seen.

Concrete Most people are familiar with the method of building a concrete path in the garden - form work all around, at least 100mm deep, steel reinforcing mesh in the middle; its easy! It's easy alright, but try doing it without any form work and in mid-air. That is what it takes to build a concrete hull. Steel rods are fashioned to the sectional shape of the hull, both horizontally and vertically. These shapes are then fitted together, wired and then welded. This skeletal frame then has 10mm or 12mm chicken mesh wired securely to it. The concrete is made with stones no larger than 6mm to a fairly thick consistency and is plastered all over the hull in-side and outside until the hull is at least 100mm thick. Provision for propeller shaft and rudder mounts must be made before the concreting is commenced.

Steel is a more refined form of iron. Steels' strength and resistance to corrosion can be tailor made with the addition of elements such as nickel, chromium, copper, silicon and manganese during its molten stage. 316 marine grade stainless steel would make a good hull but the cost prohibits construction from this material. Mild steel plate is used for steel hulls and edges that are susceptible to wear through the painted surface are often made of 316 stainless. Steels' susceptibility to rust, demands that much attention be given to the hull surface and the finish applied. Most steel hulls are currently having epoxy paints applied to them to seal out the salt and water. The epoxy paints appear to be the most successful used to date. Steel is generally used for hulls of more than 12m. in length.

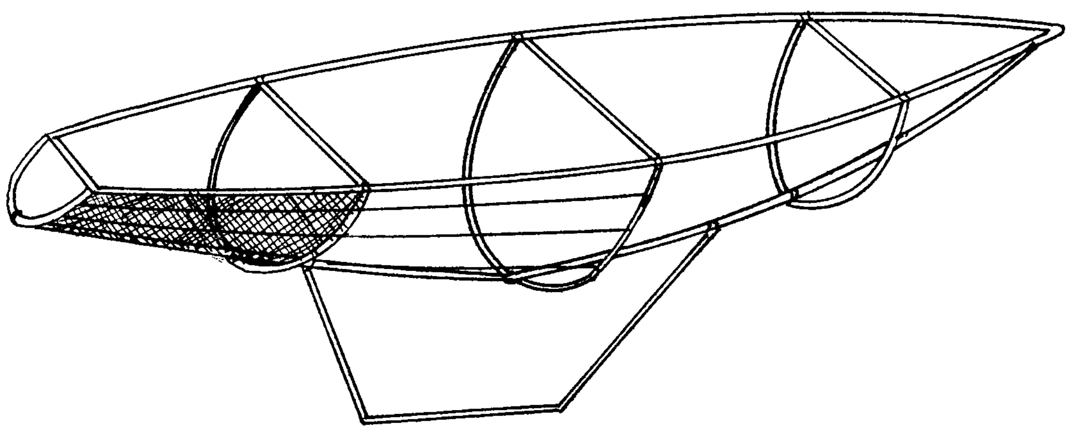
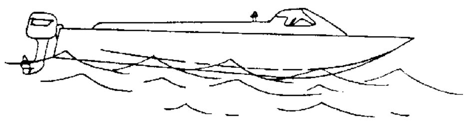


Fig 1.10: This shows a skeletal hull for a ferro-cement hull

Chapter 2 Boat building terms

There have been many different types of hulls developed. The shapes of hulls relate directly to the purpose for which the craft is required and to the type of materials available. The frame work for example, in a carvel hull is more complicated and takes more time to build than the frame of plywood hull.



Planing hull

Displacement hull

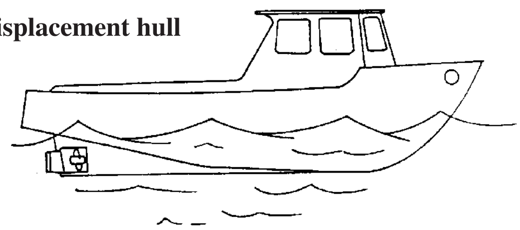


Fig 2.1: This shows the difference between planing and displacement hulls

In building a boat there are some terms that need to be understood in designating the appropriate parts.

Clinker-built

This refers to the method of planking. The first plank is laid next to the keel and the next one overlaps it. Each plank is fastened to the frame and to the previous plank with copper rovings.

Carvel-built

The planks are sawn and fitted edge to edge with a small gap left between. This is calked with a cotton or hemp and filled with a linseed oil - red lead putty.

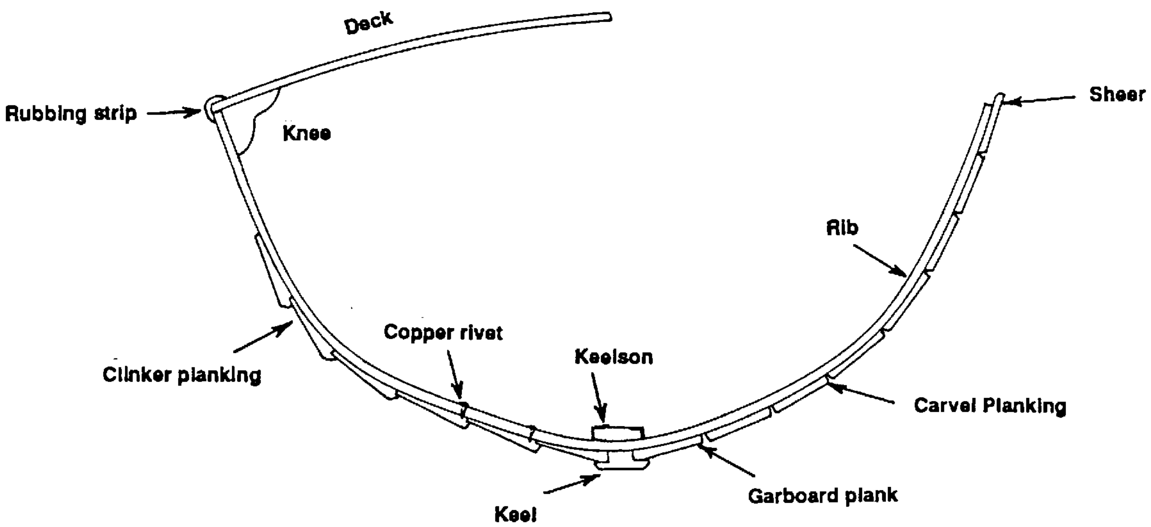


Fig 2.2: Summary of boat planking details

Garboard plank

This is the first plank laid, the one next to the keel.

Sheer plank

This is the last plank laid and is around the deck edge.

Transom

The transom is the back end or stern of the vessel. The transom should be of strong construction as it supports the rudder or outboard engine.

Keel and keelson

The keel runs the length of the vessel on the outside or bottom of the hull. The keelson runs the length of the vessel on the inside bottom of the craft. Both these members are important as they play a major roll in the fastening of the planks or sheeting. Sometimes a false keel is used merely as a rubbing strip to protect the bottom of the boat.

Sheer

The sheer is that member of the frame that marks the gunwale. The top edge of the vessels side is also referred to as 'the sheer'.

Chine

The chine is the corner formed by the intersection of the bottom and sides. A hard chine describes a corner that is around 90°. Soft chine and multi-chine vessels are more obtuse of angle.

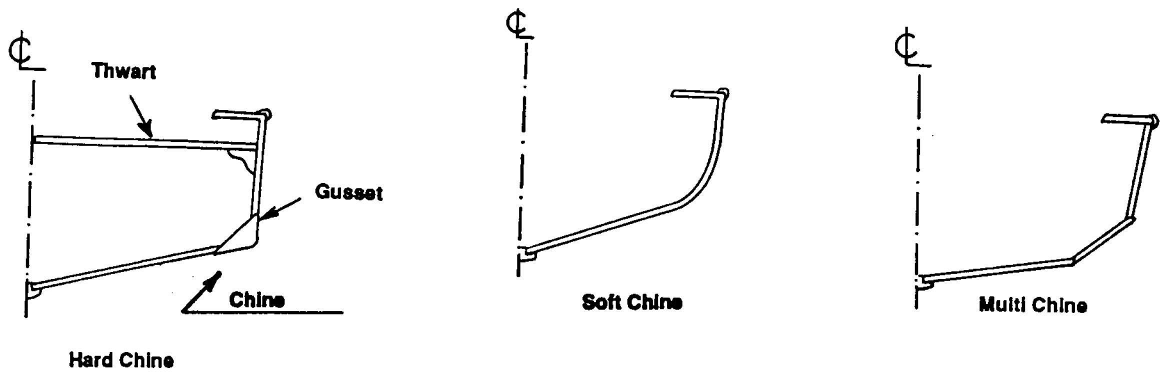


Fig 2.3: Summary of chine types

Thwart

A thwart is any member in the frame work that runs from side to side to assist in stiffening the hull. A seat in a dinghy serves as a thwart.

Bow

The bow is the front of the boat. Most vessels have their shape sharpened toward the bow. If the vessel is not intended to cut heavy seas, there is no reason for the interior space not to be enlarged and not to have a snub nose bow.

Knee

Corner joints are supported and strengthened by shaped pieces called 'knees'. Knees are shaped from 'crooks' of wood that has the grain running with the shape of the knee. The gnarled buttress roots of trees are used for 'crooks'. Mangrove trees produce buttress roots that are good for this purpose. Laminated plywood is also used extensively for knees.

Ribs

Ribs are used in planked hulls and are usually made from timber that allows steam bending. Spotted gum is good for this purpose. Ribs run from gunwale to gunwale over the keel. Planks are riveted to ribs with copper nails.

Deck

The deck is the covered part of the hull. The deck keeps out water and stiffens the hull.

Hatch

A hatch is a water resistant, removable cover over holds etc.

Rubbing strip

A rubbing strip is a sacrificial piece of timber fitted along the gunwale to protect the hull.

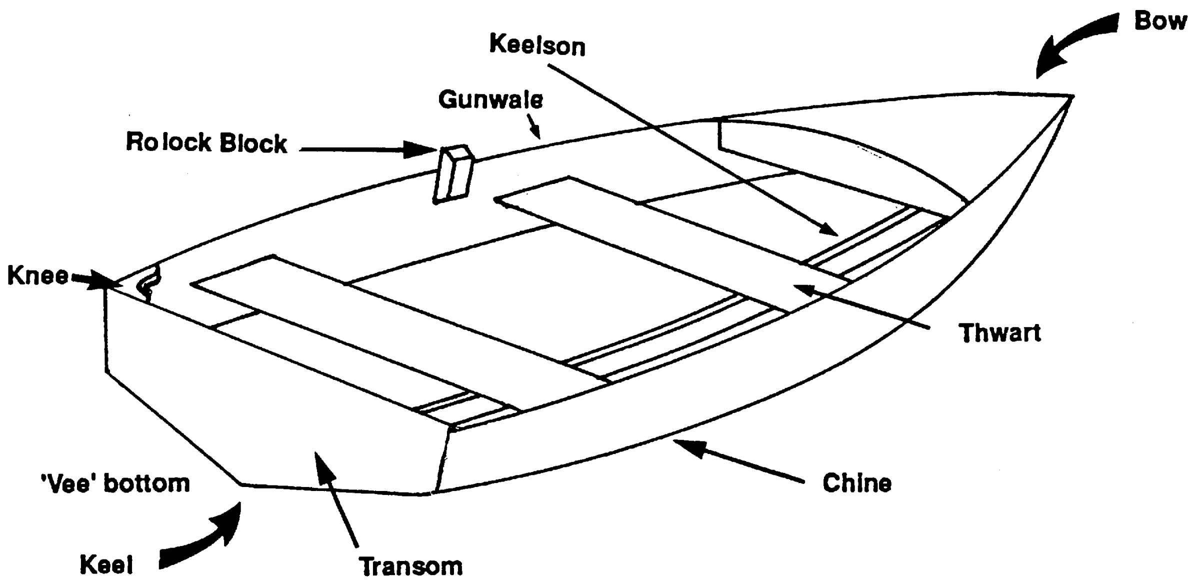


Fig 2.4: Summary of boating terms

Frames

Frames are the internal support of a vessel. Small light weight dinghies and planked yachts usually have temporary frames that are removed when the hull is completed. Plywood hulled vessels usually have the frames retained.

Station Points

Station points are the longitudinal positions of the frames.

Stem

The stem is a shaped or laminated piece of timber that forms the nose or bow of the boat.

Strakes

Strakes are small sectioned pieces of timber fastened to the outside of a hull longitudinally to improve the steering capabilities. They are usually used on planing hulls.

CHAPTER 3

Building a simple dinghy using the stitch and glue method

Most boats are first built as a model to a scale of one tenth.

To save time, only one side is made. The half model is then fastened to a flat surface and accurate measurements are made to prepare drawings from which the craftsman may translate the designers vision into reality.

Fig 3.1: To build a small dinghy suitable for a tender or a spot of fishing is not really difficult.

A half model allows the designer to see the finished shape. It is made as a half model merely to save time. Measurements are taken from the model with callipers and gauges and are reproduced to scale on paper or full size on the loft floor.

The chalk lines on the loft floor become the patterns and finally the ribs of the vessel. A half model design method may even be used even for large ships.

Very few amateur builders begin with a model but purchase proven designs from which to build their dream. Plans for large boats are rarely supplied full size, however some of the smaller sailing dinghies have plans supplied full size.

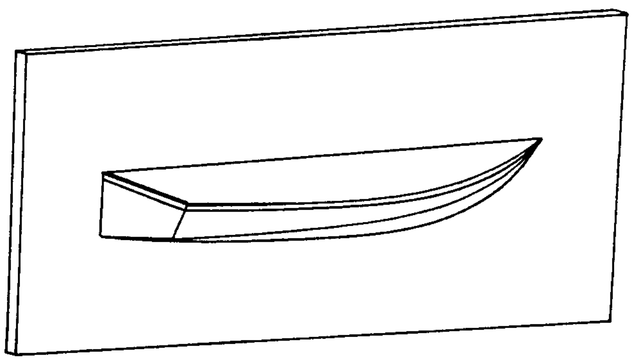


Fig 3.1: A half model

Generally plans are based on frame size and station points (position of frames). Boat plans can appear complicated to the novice but an hour or two studying the plans will clear many perceived difficulties.

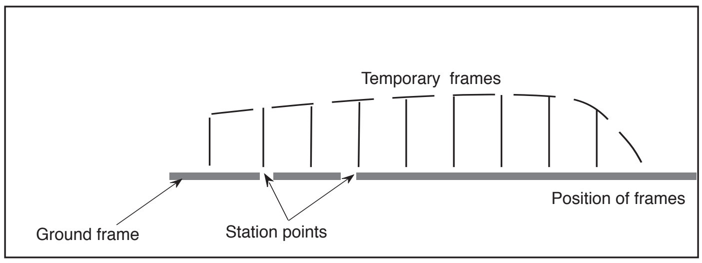


Fig 3.2: Ground frame and station points

To build a 3.0m (10 feet) dinghy suitable for a tender or a spot of fishing is not really difficult.

The following is a procedure for building a small boat that can be carried out by the non-professional boat builder with a minimum of tools.

Procedure

1. Make a cardboard model to one tenth of the finished size. On a blank sheet of paper, draw a series of one cm squares.

Dismantle your cardboard model and lay the pieces over the squared paper and carefully draw the outline. It is necessary to draw only one of the components that have pairs. The shapes found, may be transposed to your sheets of ply by drawing 10 cm squares on the ply and transferring the information from paper to the ply.

Alternatively, if your neighbour has a dinghy and he is willing to let you copy it, you can obtain full size paper patterns by draping large sheets of paper over the up turned vessel carefully marking off the side, the bottom and the transom. Check also measurements for width and length of boat and position seats.

2. The transom of a 'tinny' may have the sides curved. This curve is usually too much for the forming of ply wood and may have to be reduced, or even made to a straight line.

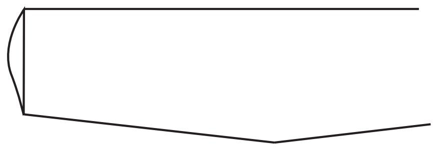


Fig 3.3: The transom of a 'tinny' may have the sides curved

3. The sheets of marine plywood you have purchased are shorter than the boat and therefore have to be spliced together to obtain the lengths required. Place the sheets on the saw stools, one on top of the other as shown.

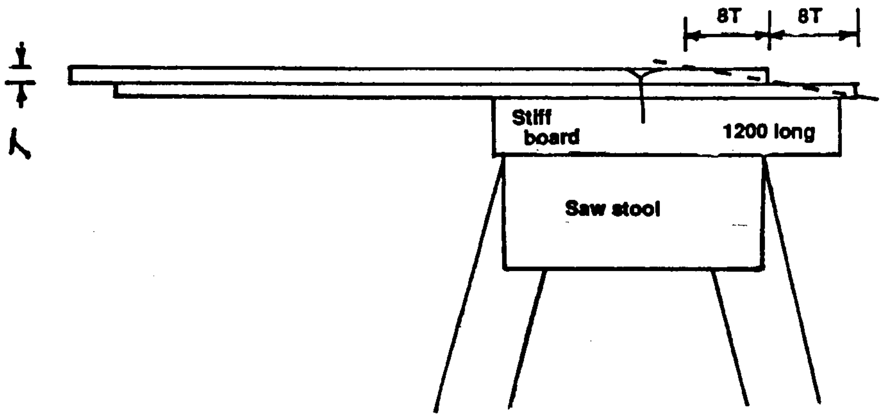


Fig 3.4: Place the sheets on the saw stools, one on top of the other to prepare scarf joint

Fasten the sheets to the saw stool with screws. (Screws are easier to remove than nails). Note that the sheets are off set by eight time the thickness of the ply. Using a smoothing plane remove the material indicated by the dotted line. Finish with disc sander. Take particular care to obtain a fairly good finish here. Mix your epoxy glue according to the manufacturers directions, apply to the 8:1 tapered surface.

Remove screws, flip the top sheet over and place a straight stiff board under the ply and fasten together as shown below. Twenty-four hours later the screws are removed and with help of a disc sander and block sander, the faces of the ply are cleaned up to a good finish.

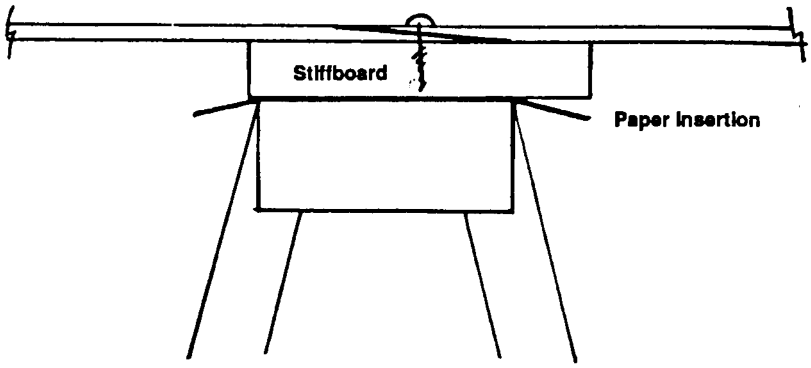


Fig 3.5: Sheets in the "glued -up" position.

4. Lay your paper pattern out over the sheet of ply to work out the best position for cutting. Fasten the two sheets together with screws. Paste or tape the pattern in place and proceed to cut around the pattern with a portable electric jigsaw. If you have drawn the shape onto the plywood you won't need the paper pattern.

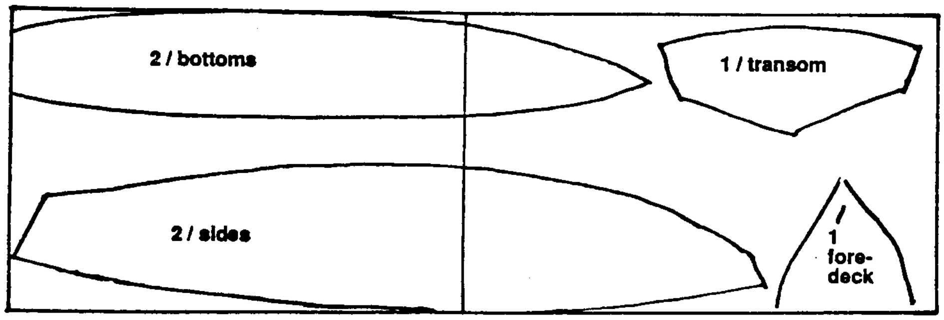


Fig 3.6: Pattern ready for cutting.

By cutting two sheets together both left and right hand parts will be exactly the same. Smooth any irregularities in shape with a smoothing plane while the two parts are still together.

5. Take a piece of 75mm wide material and mark positions for the stitch holes. Drill the holes taking care not to drill holes on the transom or other parts that fit to the transom or the top edge of the sides.

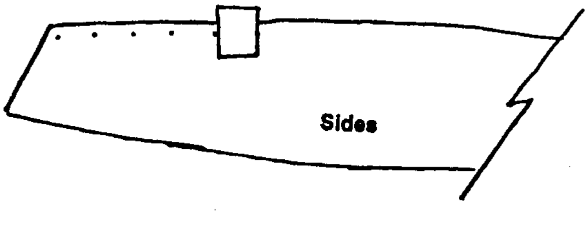


Fig 3.7: Drilling the holes.

6. Put the copper wire ties in place along what will be the middle seam. Begin to twitch the wire but do not tighten yet. Remove the screws holding the two bottom pieces together and allow the ply to fold out on the wire ties. Tighten four or five ties at the back, two or three in the middle and then watch the shape of the boat begin.

Sometimes you may have to release the tension on some of the ties, therefore it is a good idea not to tighten them completely until **all** the components have been laced together.

Tip: Don't try to fasten more than one pair of holes with one piece of wire. I've tried it. It is not worth the hassle.

7. By this time you should have all the ply and components laced together and it should look 'something' like a boat with no back in it.

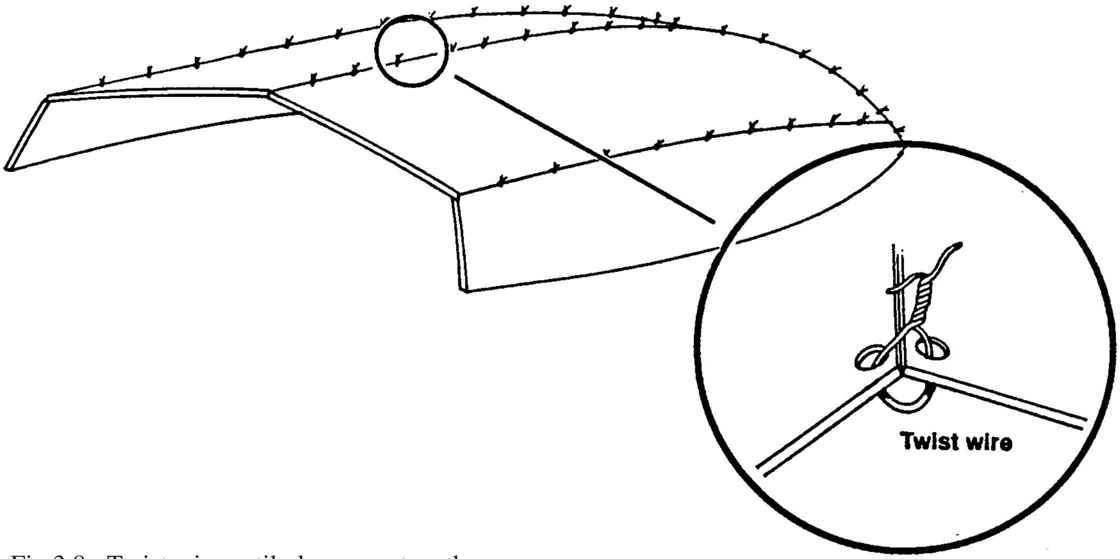


Fig 3.8: Twist wire until ply comes together.

Check the transom to ensure that it will fit, also check the transom for symmetry.

Fig 3.8: The ply components laced together.

8. Now is a good time to take stock of the remaining material. You are going to need a fore-deck which will be roughly triangular in shape with a median length of about 700mm give or take 100 so allow enough material for this now.

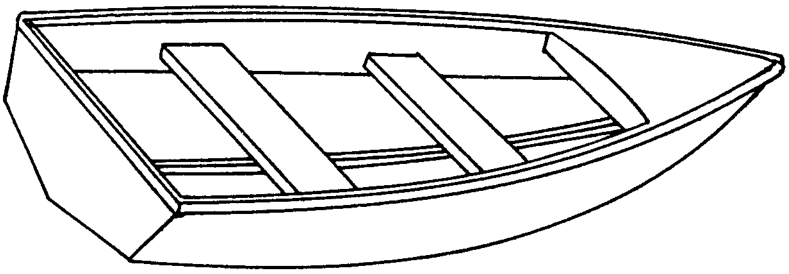


Fig 3.11: Positioning of the seats

You will also need two seats, 300 mm wide and as long as the width of the boat. Allow material for these now. If you are running short of material it is better to have a join in the seats than the fore-deck.

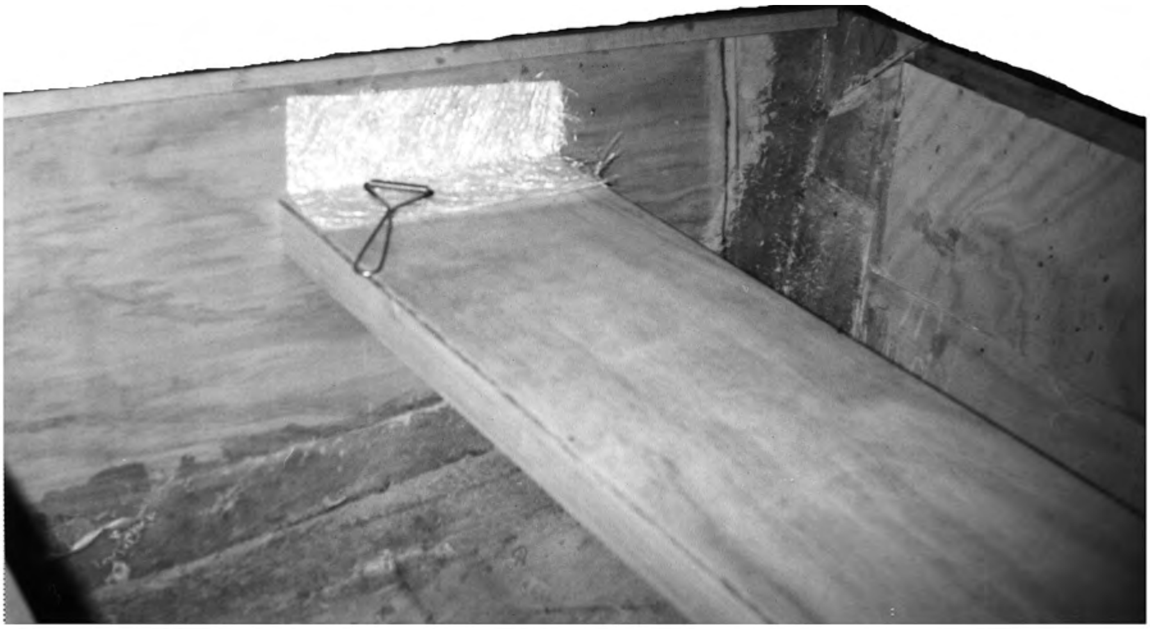


Fig 3.12: Seats ready to glue in

The remaining material can now be used to make up the transom and various knees. The transom is layered with extra pieces of ply securely glued to make a sandwich type construction that will be 18mm thick at the thickest part.

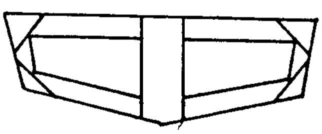


Fig 3.13: How to make-up transom

9. When the glue is dry and the excess trimmed, the transom is ready to put in place. Position the transom and secure temporarily with steel nails. Remove transom after having made some nail holes that will make life easy when the glue is applied.

Mix the epoxy glue and apply to edge of transom. Put the transom in place and fasten with silicon bronze nails. The silicon bronze nails can bend very easily and you may find it easier to first make a slightly smaller than necessary nail hole with a steel nail.

10. An inner keel should be planed to shape from the 75 mm X19 mm piece of timber and fixed in place with screws/nails and resin.

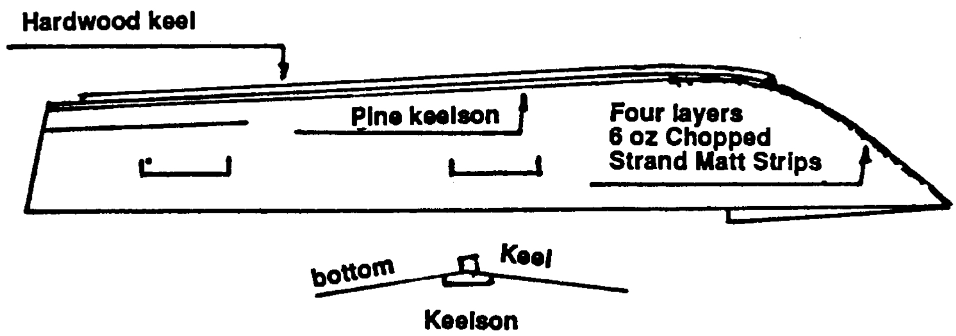


Fig 3.14: Fitting the inner keel

The boat should now be upside down. Before beginning the fibre glass work we apply expoxy glue to the joints, pushing the glue down firmly with an ice-block stick or similar. Gaps may be filled with a filler made by adding talcum powder to the mixed glue until the desired thickness is acquired. Allow to dry (24 hrs.).

11. First turn boat right way up. Second fit a temporary spreader at about the widest part of the boat. 42 mm X 19 mm should be sufficient for the spreader. Finally bend the copper ties to conform with the shape of the boat.

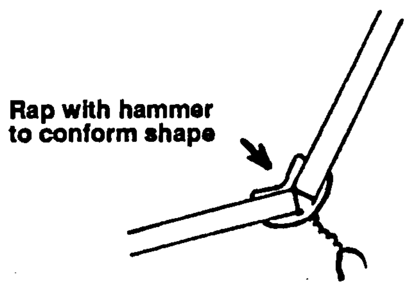


Fig 3.15: Bending the copper ties

Sand off any bumps or dags of glue with a coarse sand paper. Cut the mat glass into strips of about 100 mm wide.

Mix the polyester resin and apply to the inside of the seams spreading the resin at least 60mm each way. Lay on glass, apply more resin and 'wet out' the fibres. A jabbing or dabbing technique is better for wetting-out these fibres than the dragging technique usually used with a brush. Two layers of chopped strand matt are required.

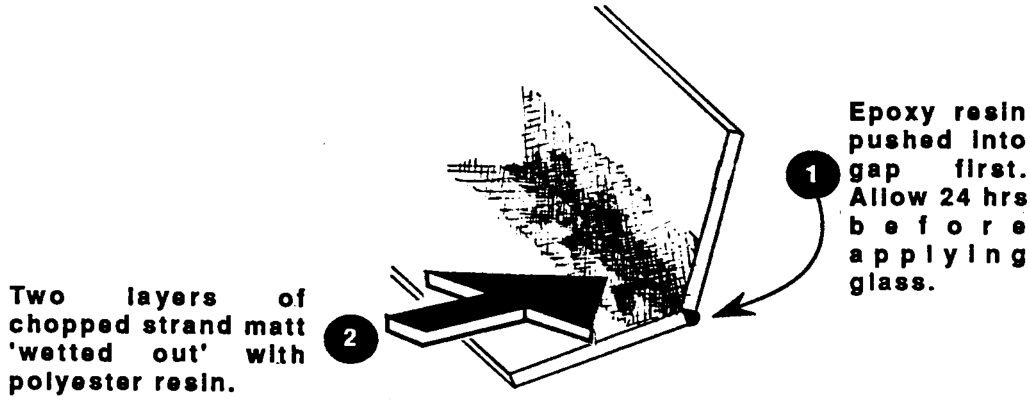


Fig 3.16: Applying the fibre glass

12. The top edge of the sides will be floppy or unsupported. This is rectified by forming the gunwale on the top edge. The gunwale is formed by gluing a 42mm x 12mm strip of timber along the inside and the outside of the ply.

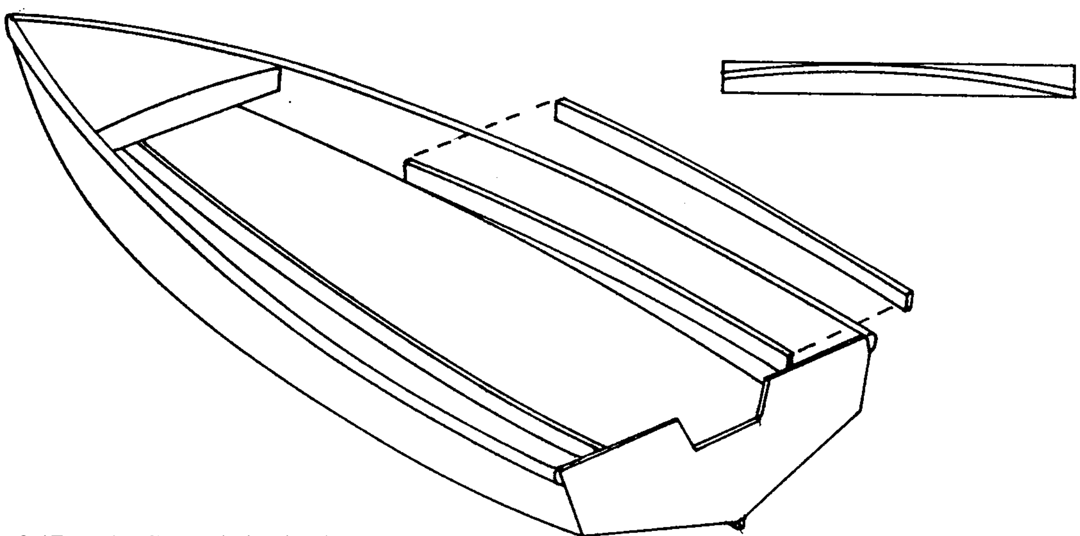


Fig 3.17: The Gunwale is glued on

Because of the compound curve formed at the top edge of the ply a piece of timber 150mm wide is needed to obtain the strip 42mm wide.

First clamp a 150mm X 12mm piece of timber to both sides of the boat (attack both sides at once to maintain symmetry).

Draw a pencil along the top edge. Remove timber from boat. Cut along this line with a jigsaw. Smooth the edge and with a marking gauge or adjustable square mark a line 50mm away from but parallel to the new edge. Cut away the waste and smooth the edge. Use a marking gauge or adjustable square to mark 42mm down from the top of the sides.

This line is a guide to gluing the gunwale in place. The boats gunwales are made up from 4 pieces on the outside and 4 on the inside.

After the glue has dried the top edge of the boats sides and therefore the gunwales should be planed and sanded to a smooth finish. The permanent spreader which forms the back part of the foredeck should now be prepared and fitted. A camber of about 30mm should be sufficient. A central rib would be of advantage as shown in figure 3.16 below.

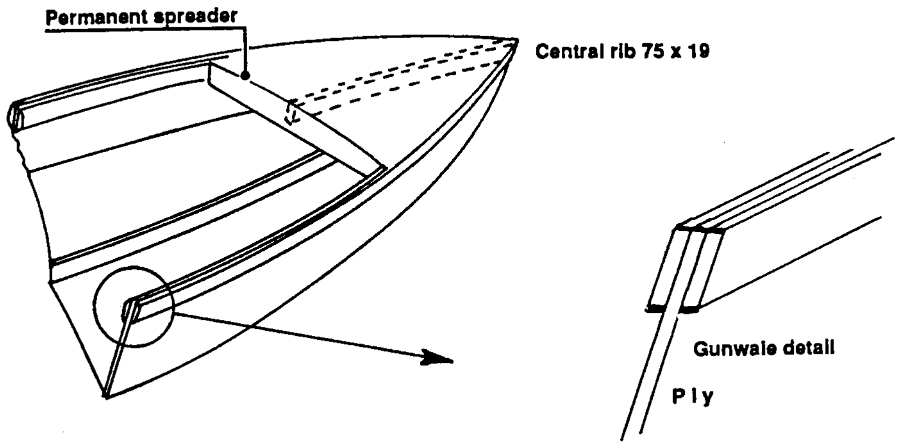


Fig 3.18: The permanent spreader and central rib are added.

The foredeck has the edge prepared smooth before it is glued onto framework. The overhanging edge on the sides is cleaned off after the glue has dried. The nails used here are 20mm silicon bronze. The seats (or thwarts) are our next consideration. They are prepared as shown in figure 3.14 below.

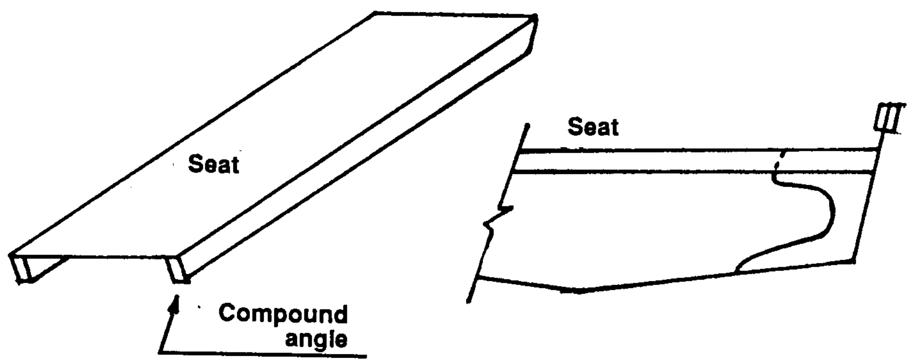


Fig 3.19: The seats

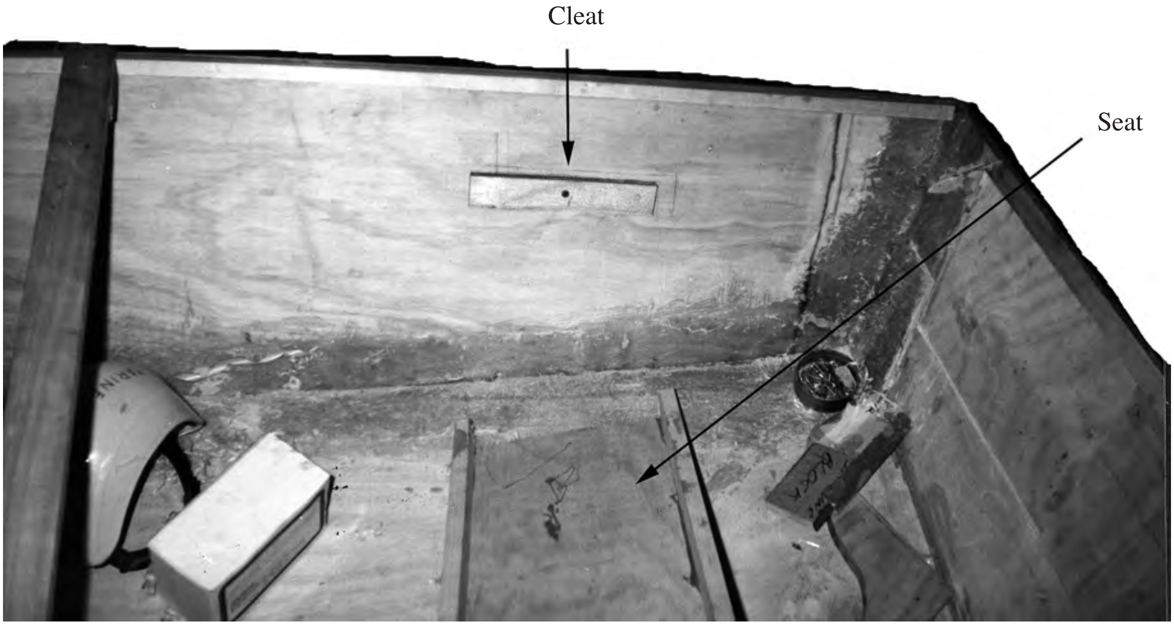


Fig 3.14: Cleat in place ready to receive seat. See also Figure 3.12

Fig 3.15: Fitting knees

When fixing the seats, be sure to leave sufficient space at the back for a fuel tank.

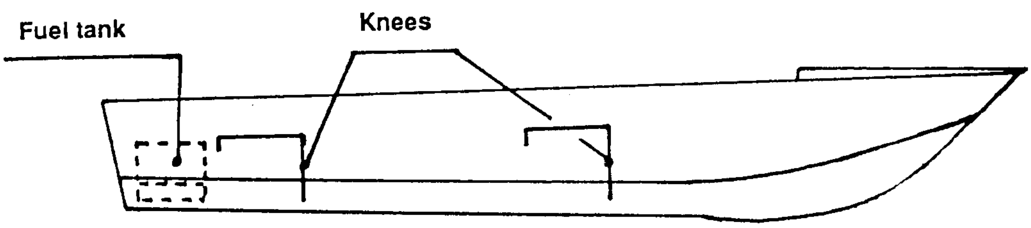


Fig 3.16: The knees and fuel tank

13. After the internal fittings have been fitted the interior is given a final sanding. All holes or gaps are filled with an epoxy filler. Turn the boat over. Cut off all the tails of wire and sand ends of wire down with a disc sander.

Do not attempt to hit wire ends down with the hammer as this will damage the fibreglass on the inside. Fill all holes and gaps with an epoxy filler. Apply one layer of glass cloth and resin to the seams and the transom, sanding when cured.

The scarf joints may also be glassed. Sand all work areas to a fine finish. Fix an extra ply piece to the transom as shown. This piece should be disposable and may need replacing every two years, or so.

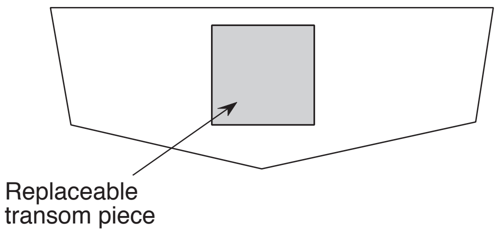


Fig 3.17: Add extra ply for strength to support outboard engine

NB. Polyester resin may be applied over epoxy resin and the adhesion will be quite good.

Epoxy over polyester does not give good adhesion unless the cured resin has been cleaned with a solvent and all gloss is sanded off.

The reason for the above anomaly is that polyester resin, when curing, produces a wax that inhibits sound adhesion of a dissimilar plastic.

14. A hardwood keel of about 19mm X19mm should be fitted to the underside to give steerage and as a buffer strip for beaching.

Do not run this to the absolute back of the boat as it may interfere with steerage when using an outboard engine.

Fig 3.18: Who wants first go?

The tools you will need to build a small dinghy are:

(a) **Portable Jig Saw**
(b) **4" Angle Grinder with sanding pad or electric drill**
(c) **Hand saw**
(d) **Smoothing Plane**
(e) **Pliers**
(f) **Side cutters**
(g) **Hammer**
(h) **10 or 12 quick release G clamps**
(i) **Two saw stools**
(j) **A battery screwdriver**

Other items you need are:

* **4 or 5 plastic ice cream containers**
* **4 or 5 'el cheapo' paint brushes, approx. 25mm**
* **Micro spheres ('el cheapo' talc will do for this)**
* **Mixing sticks**
* **Measuring cups and spoons**
* **150 150mm pieces of 1mm copper wire.**

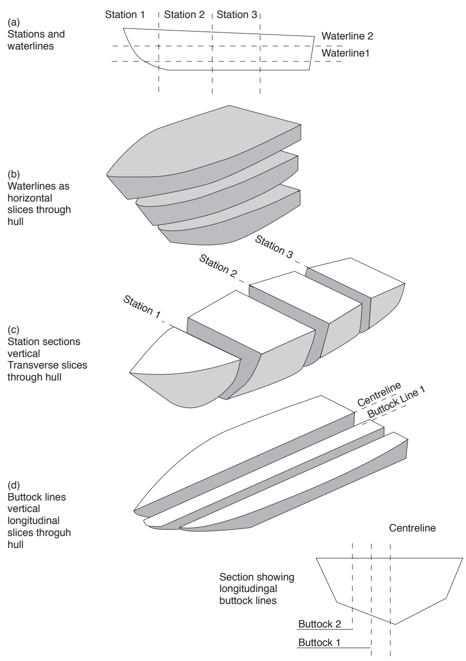
The materials needed for stitch and glue method: **(All measurement are in mm.)**

(a) **4/2400 X 1200 X 6 sheets marine ply**
(b) **1/2400 X 75 X 9 Oregon pine***
(c) **1/1000 X 75 X 19 Oregon pine***
(d) **4/1600 X 42 X 19 Oregon pine***
(e) **4/3300 X 150 X 12 Oregon pine***
(f) **1/2700 X 19 X 19 H.W.**
(g) **2m/ 6oz fibreglass cloth and 2m/ 6 oz chopped strand matt**
(h) **4 L. Polyester resin**
(i) **900g pack epoxy resin (Araldite)**
(j) **3L Acetone (cleaning hands and brushes)**
(k) **100 gms. 35mm silicone bronze nails**
(l) **100 gms. 20mm silicone bronze nails**

*** Hoop pine may be used here if boat is not to be left in water for long periods.**

Chapter 4

Building boats by other methods



Procedure

1. Make a model and prepare your plans or alternatively buy your plans.

2. Make two pieces of 75mm X 50mm pine at least as long as the finished boat and plane one edge to each to be perfectly straight.

3. Make up the temporary frames from any timber available that is strong enough - steer clear of knots. Rough hoop or radiata pine should do the job. The corners should have a ply gusset in each side.

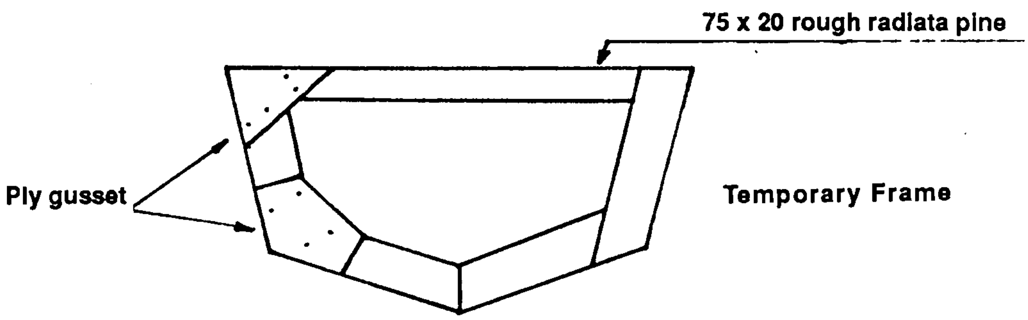


Fig 4.1: Make up the temporary frames from any available materials

4. Lay the two pieces of 75mm X 50mm on the floor with the planed face down and screw or nail two pieces of 150mm X 19mm onto them so that a long frame 600 wide is made. Turn the frame over with the prepared face up as shown in Figure 4.2 over.

5. Refer to your plan to find the positions of your frames. (Your station points). Our transom is one of the frames. Don't try to build a boat with less than three frames. Mark out the positions of the station points and firmly fasten the frames in position ensuring that they are centrally positioned.

6. Refer to your plan for the shape of the stem. When made from plywood it should be at least 20mm thick. Laminate the pieces of ply but make sure that it is over size with the shape of the stem clearly marked on it. Fasten the stem (uncut) into position on the ground frame.

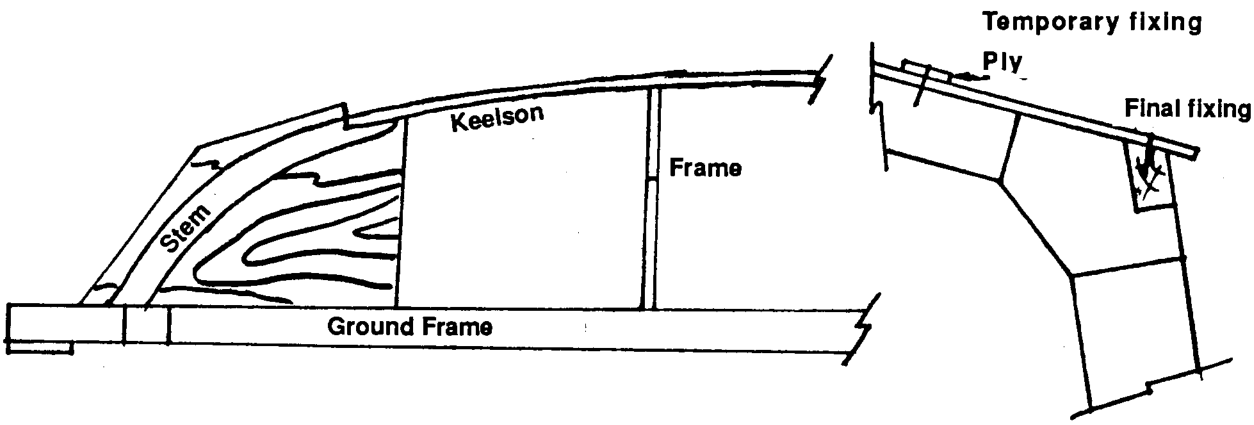


Fig 4.2: Note that the stem is marked out on the larger sheet of ply

7. Fit the gunwale and chine to the frames, working both sides at once. Remember, if the frames are to be removed, the fastening will have to be done from inside.

8. Fit the keelson. Glue and screw it securely to the transom and the frames but screw only to the stem and frames.

9. Pull the gunwales into the stem. This may take two or three attempts before you have the joint satisfactory. Screw in place, no glue.

10. Plane the 'V' shape on the edge. Pull the chines into the stem allowing as natural a curve as possible. Cut and fit. Screw in place with no glue. Check all joints with the stem. You will notice that the stem will finish with a 'V' shaped edge. Remove all screws from the stem and cut it out remembering to allow that little extra for the 'V' on the edge. Glue all joints and replace screws.

11. Stand back and check the shape for similitude. Allow glue to dry.

12. Plane excess material off chine and stem . Cut the inside shape of stem.

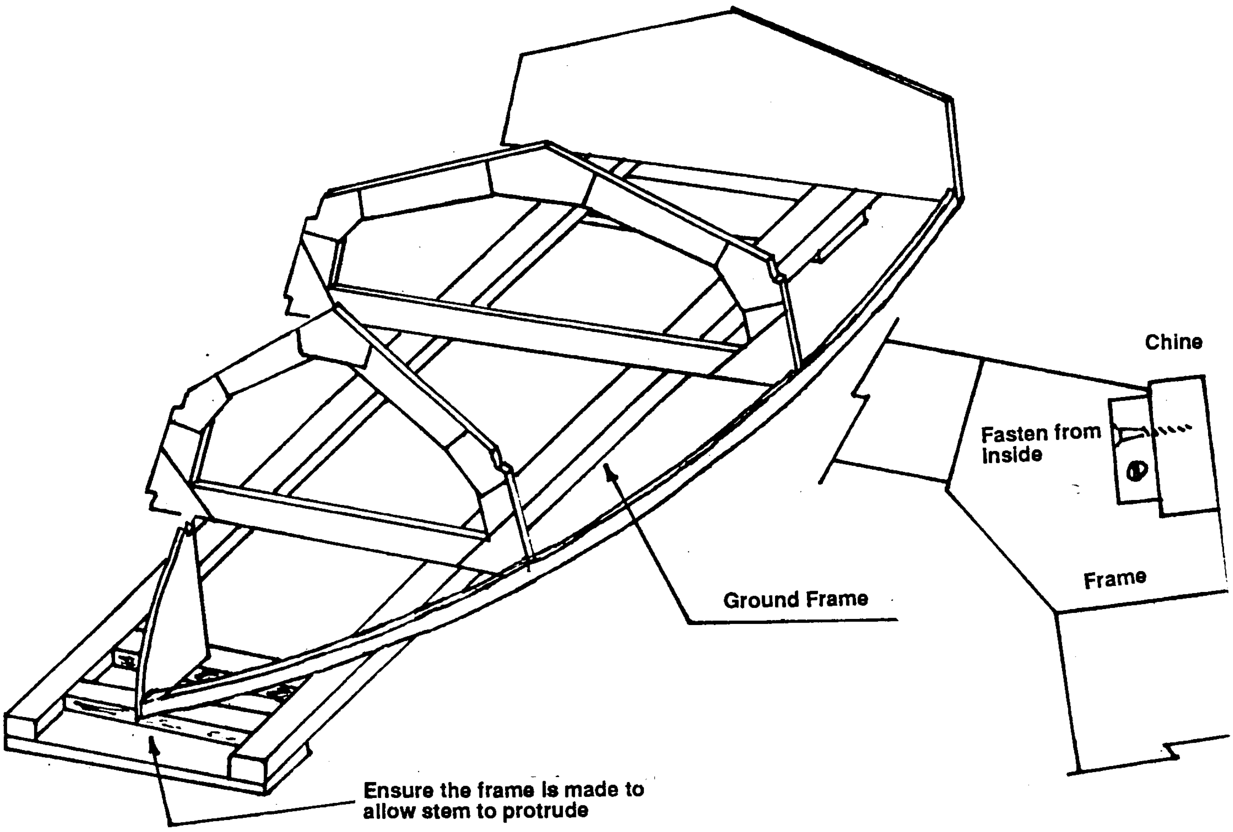


Fig 4.3: Lay the frame out on station points

13. The sheets of ply will have to be spliced together. See Figures 3.1 and 3.2.

14. Lay plywood sheet over half the bottom and mark out the shape. Allow just a little extra for cleaning off.

15. Apply glue to the keelson, chine and that part of the stem the bottom covers. Drape some paper over the frames to ensure that there is no chance the sheet will be glued to the frame and fasten the sheet in place with either monel or silicon bronze boat nails. You may find it necessary to temporarily nail the sheet to the frame. If you nail through a small piece of waste ply first it will be easier to remove. Allow glue to set.

16. Clean off overhanging material at chine and keelson. Continue fitting sheeting until all is in place. Clean off excess material and sand hull thoroughly.

17. Carefully turn boat and ground frame over. Measure for, and fit permanent spreader to allow easy fixing later. Dismantle frame and allow hull to come away.

18. Sand the inside surface. Plane off the top edge of gunwales. Take particular care where deck is to fit.

19 . Fit permanent spreader at fore deck and fasten deck. Clean off deck edges and fit two seats.

20. Make up knees to reinforce the transom / gunwales joint and glue and nail them in place, flush with the top. Make up and fix knees to strengthen the seat / side joints. Sand thoroughly.

21. A sacrificial spotted gum keel should now be fitted. Do not run the keel to the absolute back of boat as it may interfere with steerage when using an outboard engine.

22. Paint your dream in your own colours.

Building a fibre reinforced plastic boat

Fibre reinforced plastic boats are built with a moulding operation. The plastic is cast as a shell inside a mould and the plastic is reinforced with fibres of glass.

1. The original boat is built from almost any material and finished to a fine finish.

2. The 'original' is inverted and a release agent (floor wax) is applied and buffed to a high shine.

3. A very hard setting resin called tooling gel is applied and allowed to cure (10/12 hours).

4. A heavy coat of glass and resin is built up over the hull and strengthened with an external framework to inhibit warping. The process thus far is known as working a 'male mould'.

5. The outer glass and resin, together with the frame, is peeled away from the 'original'. This is known as the female mould. The 'original' is disposed of. Boat manufacturers usually destroy the original to lessen the chance of copy theft.

6. A number of boats can be made in the female mould. A mould can produce up to 100 boats.

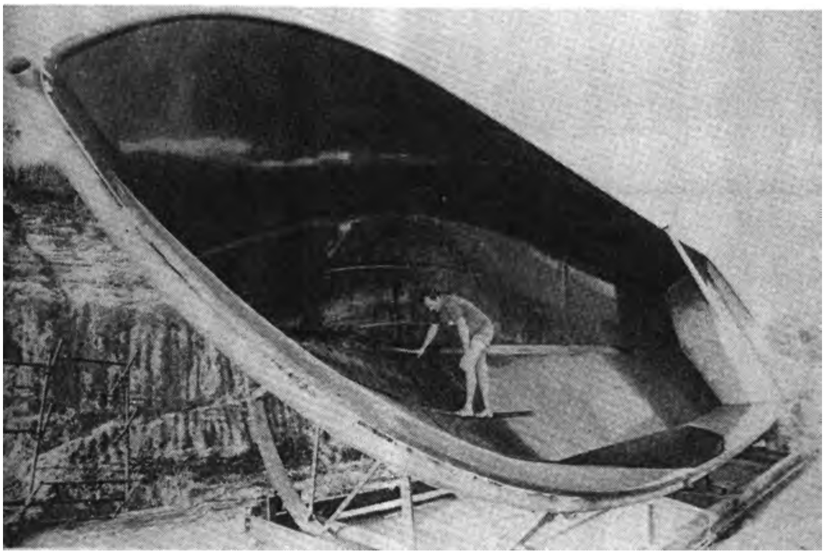


Fig 4.4 The female mould after the original has been removed

7. Apply release agent . (Wax or Polyvinyl Alcohol)

8. Apply gelcoat (colour) and allow to cure (10 to 12 hours)

9. Apply laminating resin and chopped strand matt. The weight of the glass is governed by the size of the vessel being built and ultimately the use to which it will be applied.

   The resin is cured by a chemical reaction which produces heat. (Exothermic reaction).

   Excessive build up of the material will cause excessive heat. The heat will shorten the life of the plastic in the boat and the mould. A heavy section is best built in a number of lighter lay-ups.

   Some manufacturers build cooling tubes into the mould to control the heat with a continuous flow of water.

10. The boat and mould are separated after final cure by using wooden wedges and/or floating out with water (Polyvinyl alcohol is water soluble).

11. Fittings such as seats etc. can be glued in place with the resin.

12. Trim the edges and give the boat a general clean up.

Items you will need to build in fibre reinforced plastics

1. Good quality pair of scissors.

2. 2/25mm paint brushes. (El chepo)

3. Accurate measuring cups for measuring volumes of resin and catalyst.

4. Ice cream cartons.

5. Wetting out roller.

6. A 100mm brush. (For wetting out large areas of glass, this is a must)

7. One clean 4l paint can for acetone. (Brushes, rollers etc) This must have a re-sealable lid.

8. Talc powder.

TIP:-

Store your acetone in a hydrocarbon resistant plastic jar. Have two lids, one with a ' 2mm' diameter hole. Lay jar on side to wash hands in fine stream.

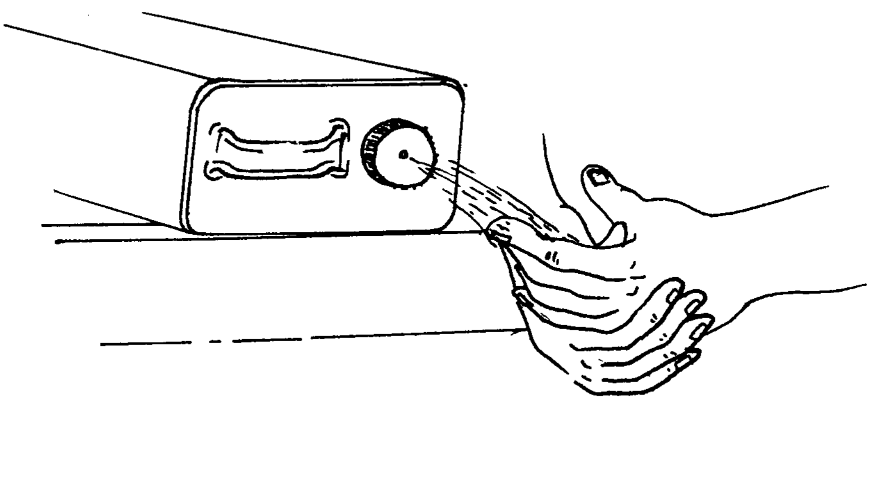


Fig 4.5: An easy way to wash off that sticky feeling after using fibre glass.

Then use talc powder to alleviate the sticky feeling.

Index

'Wetting out the final product'

About the Author

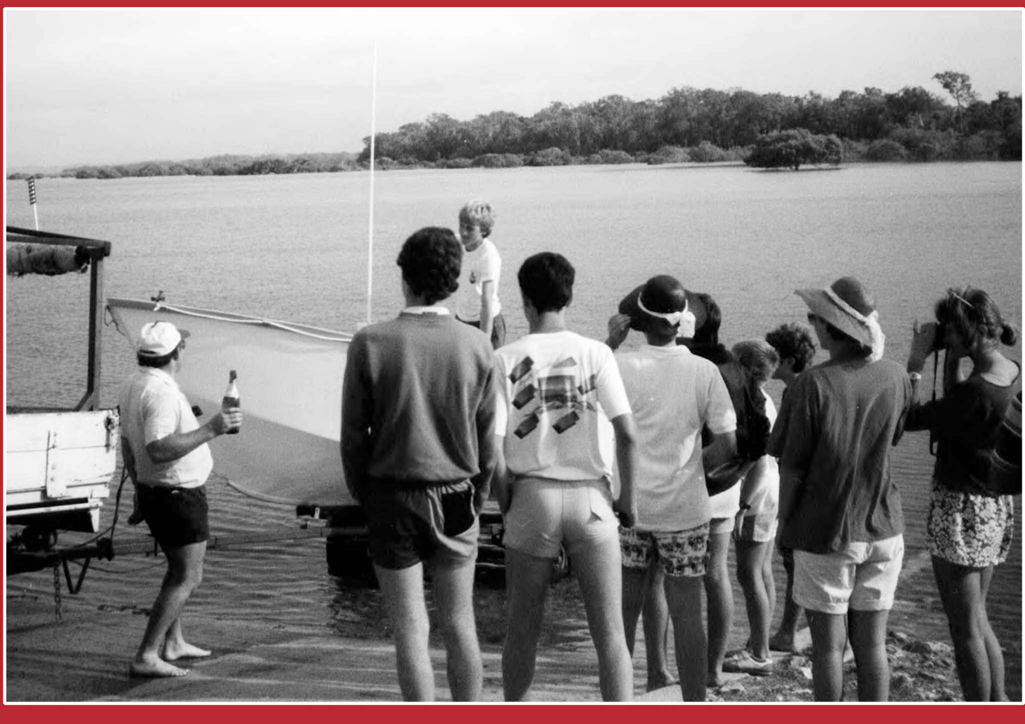
Bruce Heyer, a carpenter, joiner and teacher of thirty years built his first boat as a lad of fourteen, there have been many since then - both power and sail.

He began teaching Manual Arts in 1970, and Marine Studies in 1984 from a program he developed in 1977. This program naturally included boat building. His boat building skills has helped Gympie State High School procure its first four boats which have given very good service. In 1989 he spent time working in the Kawana factory of Kevlacat where he helped prepare for sale, a 17 ft. vessel which was later voted “Boat of the Year”.

Bruce, a graduate of Brisbane College of Advanced Education has been on a number of panels and committees for the Board of Secondary School Studies, for many years in both Manual Arts and Marine Studies Areas and is currently a member of the “Evaluation Committee” which is examining for the Board of Secondary School Studies, a syllabus that has been prepared by the Marine Studies Teachers of Queensland.

Bruce was a foundation member of the “Marine Educators Society of Australasia” and in 1990 was President of the Wide Bay M.E.S.A.

Bruce has taken an interest in “things nautical” including safe boating. To this end, he is a member of the Gympie-Tin Can Bay Coast Guard Flotilla where he has served as Staff Officer for two years and is currently serving as Public Relations Officer and Rescue Crew with the rank of Coxswain.



Wet Paper