CHAPTER 8
Building in FIBERGLASS

Fibreglass – Materials and Tools

TYPES OF FIBREGLASS

Boat designers with experience in steel and aluminium will immediately notice that most fibreglass materials have lower strength and stiffness values than the metal alloys. Because fibreglass materials are much lighter than metals, thicker laminates can be designed so that the stiffness can match that of metal hulls.

There are a number of types of fibre used in reinforced plastics but glass fibres are the most common because they are inexpensive to produce and have relatively good strength to weight characteristics.

With the exception of chopped strand mat (CSM), reinforcements used in a marine glass fibre application usually utilize bundles of fibres oriented in distinct directions such as glass cloth and woven roving. Some are aligned in a single direction others multidirectional and the strength of the laminate will vary accordingly.

There is a considerable variety of glass reinforcements but we are mainly interested in what is known as E-Glass or electrical grade glass that was originally developed for insulators, for electrical wiring, and is now used almost exclusively as the reinforcing material commonly known as fibreglass. E-glass is the most common reinforcement used in marine laminates because it is relatively inexpensive, has good strength properties and resistance to water degradation.

Another glass fibre known as S-Glass is a structural glass typically used in higher strength applications. It has a greater tensile strength and stiffness than E-Glass and in general, demonstrates better fatigue resistance but at a considerably higher cost which means that it is limited to selected applications.

There are other types of fibre such as carbon fibre and graphite fibre, used as reinforcement and known as Multi-axial Engineering Fabrics or just plain Engineered Fabrics which, when knitted stitched or woven into materials, include names such as Double Bias, Biaxial and Tri-axial Fabrics and Woven Fabrics and so on but these are specialised materials which probably won’t concern you. There is even an aluminised fibre used primarily for its cosmetic appearance which has a thin coating of aluminium to create a highly reflective surface but, so far, this is not used in boatbuilding.

When you decide to build a fibreglass boat you should, primarily, be guided by the boat’s designer and the technical knowledge of your material suppliers. Don’t be confused by the vast array of materials on the market, most will never concern you. The majority of readers of this book will be concerned with building a strong, practical boat, so unless you are considering a specialised race boat, lightweight flyer or multihull, you can concentrate on E-glass and use the more traditional fibreglass boat building materials and methods.

CHOPPED STRAND MAT – CSM

Unlike continuous fibres, Chopped Strand Mat is literally short chopped strands sometimes described as random discontinuous fibres (about 1½” – 37mm long) and held together with a soluble resinous binder. CSM is available in varying types and weights from ¾ ounce per square foot [225 grams per square metre] upwards however, 1½ oz. [450 g/m 2] and 2 oz. [600 g/m 2] are the weights you will most often see expressed by designers and manufacturers of boats. In our own material lists we simply say 1½ oz. Mat [450 g/m 2] and so forth.

CSM can be used as a “bulk builder” in a laminate where build-up is required but without great strength. In a laminate, layers of CSM should be used between layers of woven roving as a cushion to promote a good bond and where the strength (or lack of) in the CSM, is complimented by the strength of the roving.
The amount of resin required to impregnate CSM is approximately 2 \frac{1}{2} times the weight of the mat.

This is what chopped strand mat looks like.

CONTINUOUS ROVING
Supplied coiled in square boxes which are referred to as “cheeses”, this material resembles a coil of light rope and is used with a fibreglass depositor machine (chopper gun) thus the alternate name “gun roving”. Over the years, the lower price and availability of these guns has made it worth considering their use even if you are building a single boat. You will always get your money back when the boat is finished and, for a modest outlay, save a lot of time and expense in the process.

Using a depositor gun, the continuous roving is cut into short lengths (like CSM) and deposited by the gun, which also mixes the resin and catalyst. They all come together as they leave the gun head, and are sprayed simultaneously on to the job. The result is a quickly applied chopped strand mat lay-up. This same gun can also used as a resin depositor only, to wet out the alternate layers of roving or fabric. This is the procedure used for production moulding but is equally suitable for one-off male moulded boats. If you are considering using a female mould or laying up your hull using the “Panel Construction” methods, then the chopper gun and continuous roving may be a great investment.

Gun laying requires an experienced operator to get a perfectly even layer of mat and resin to the job. When building on a male mould, evenness of the application is most important, so some experience with the gun is an advantage although not difficult to learn.

Continuous roving is used for ‘spraying up’ hulls and other parts. The roving is lead to a gun which chops up the roving into very small parts and deposits the roving and measured amount of resin into the mould. The skill of the operator plays a large part in the success or otherwise of finished product when using this material to build a boat.
WOVEN ROVING - WR
Woven roving is much like woven cloth except that it is much heavier and woven differently. It looks much like basket weaving with heavy bundles of non-twisted strands of glass fibres woven loosely at right angles so that there is relatively, a lot of space between individual bundles of strands. These spaces allow resin to flow through and more easily wet out of the roving. The amount of resin required to impregnate woven roving is approximately equal to its own weight.

Woven roving is stronger than CSM in all respects and you should make sure your fibreglass hull contains a sizeable proportional amount of this material.

This material is the real meat of your fibreglass laminate and is sold in various weights per square yard or square metre. Woven roving is available from 8 oz. per square yard [270 g/m²] to 27 oz. per square yard [900 g/m²], with a variety of intermediate weights. It is supplied in a number of weave patterns such as, bi-directional, unidirectional, biaxial, triaxial, double bias and specially stitched fabrics

The designer of your boat will generally specify the type of woven material he wants you to use in the various parts of your boat. Woven roving should never be laminated one to the other, without a layer of chopped strand mat between.

COMBINATION FABRICS
Some glass fibre fabrics are available with a thin layer of mat already attached. This makes it one “easy to install fabric” especially for hand laying as is can be applied quicker and more evenly than separate layers of the mat and roving. You should check with your local fibreglass supplier to see which of these materials they recommend for your intended use.

FIBREGLASS CLOTH
Woven reinforcements generally fall into the category of cloth or woven roving. The cloths are lighter in weight and require more layers to achieve a set thickness. Their use in marine construction is usually limited to small parts and repairs or sheathing plywood, usually using epoxy resin. They are available in a variety of weights per square yard or in grams per metre.

Fibreglass cloth will mostly be used as a sheathing material. Combined with a suitable epoxy resin, this glass fabric can provide excellent protection to your plywood or timber boat where it can be used on all exterior surfaces including the hull, deck and superstructure.
CARBON FIBRE
Carbon fibre is an aramid which is an aromatic polyamide, better known by trade names such as Kevlar (DuPont) and is produced by spinning a solid fibre from solution. Applications include boat hulls, sails, bullet proof vests and aircraft parts to mention a few. The main difference between “Carbon” and “Graphite” fibres is that they have differing amounts of carbon in their make-up but, basically, they are not dissimilar so that they can be interchangeable. These fibres are not subject to stress rupture as with glass fibres and high temperature performance is exceptional. Carbon fiber offers the highest strength and stiffness of all commonly used reinforcement fibres but the major setback is their high cost. Notwithstanding the cost, carbon fibre and engineered fabrics using carbon and graphite fibre, play an important role in many marine applications where certain design standards are demanded however, the price of this material would need to come a long way down the scale before we could recommend it for general purpose use in boat building.

PVC FOAM CORE
PVC foams have almost exclusively replaced the urethane foams that we used to use to in boatbuilding as a structural core material. Foam cores were more commonly used in hull construction only however, recent developments have produced some excellent PVC foams that can be successfully used in deck structures. Better known brands include Airex Tm and Core-Cell Tm. Manufactured in different densities, foam core can be used for most boat building applications. A number of manufacturers market PVC foam cores to the marine industry in sheet form and as with the balsa products, solid sheets or scrim backed block configurations are available.

You should check to see which material is locally available. Make sure it is a PVC foam and it is the correct density for your particular project. If you are using foam core for decks, you should ensure that it is of a suitable type for that application.

LEFT: Close-up of balsa-core

BALSA CORE
Balsa core is a closed cell structure that is available in sheet form for flat panel construction or in a scrim-backed block arrangement that conforms to complex curves. This consists of small blocks of end grain balsa attached to a fine scrim netting. The flat panels can be used for bulkheads and furniture and the flexible scrim-backed core for shaped hull and deck construction. End grain balsa
has a high compressive strength, and is ideal as a core material for decks and power boat hulls. It exhibits good stiffness and bond strength however impact absorption is lower than for PVC foam and, in the case of damage, water absorption can be a problem. Best restricted to use in decks and superstructures where water penetration is not so likely to occur.

**Balsa**

DuraKore ™ is a product marketed by Baltek Corporation and provides the properties of an end grain balsa core material without the need of a mould. It will form a compound shape over a set of temporary frames in the same manner as the cedar strip plank building method. It comes in planks that are made from sandwiching rigid sheets of end grain balsa between two layers of thin veneer. The sheets are then cut into planks or narrow strips, which have finger joints at each end to allow them to be scarf joined to make up the required length. The core is then covered on both sides with fibreglass to form an effective sandwich structure. Due to water penetration, all forms of balsa when used as core materials have become discredited over the past few years so may best be avoided.

**Polyester resin**

Polyester resin is a thick viscous liquid like syrup to which a catalyst (and sometimes an accelerator) is added. However, polyesters, like most plastics, lack the inherent strength of metals and are very brittle. In order to improve their tensile strength and allow them some flexibility, they are often reinforced by the addition of fibres of carbon, glass, sisal, cotton or other suitable materials. Once reinforced with glass fibre, their strength can far exceed that of steel.

There are two basic polyester resins used in the marine industry, orthothalic and isothalic. The ortho resins were the original group of polyesters and are still in widespread use. The iso resins have better mechanical properties and show better chemical resistance. Their increased resistance to water permeation has prompted many builders to switch to this resin in marine laminates.

Curing of polyester is accomplished by adding catalyst and accelerator (usually fixed amounts of catalyst and variable amounts of accelerator) – although most resins are now pre-accelerated. Gel times can be controlled through resin formulation to suit the climatic conditions. The gel time of a resin is the time taken after the addition of catalyst and accelerator for it to set to a jelly like state. Most modern resins are pre-accelerated, and therefore, we only have to add catalyst except when using pigment or fillers which may require an additional quantity of accelerator.

The pot life of resin is the time taken for the mixed resin to gel in the mixing bowl. When polyester resins harden after going through the gel stage, they produce their own internal heat which is called “exotherm”. This exotherm is much greater when there is a large bulk of resin such as in the mixing bowl. In thin layer form such as when it is spread out onto a mould with glass reinforcement, the heat escapes easily from the large surface area before it can build up to a very high temperature. For this reason, the pot life of a resin is much shorter than the time taken for the resin to gel on the mould.

When resin cures in a mixing bowl, the exothermic heat can be so violent, that the resin will smoke and crack and burn if touched. Therefore, do not mix more resin than you can use in a reasonable time.

It is not advisable to reduce the amount of catalyst to slow gel time because of the risk of under cure. Sufficient gel time control can be had by varying accelerator content. The disadvantage of pre-accelerated resin is that this control is removed.

The shelf life of polyester resin is greatly improved if it is kept in a cool place away from light and it can vary from one week to three years depending upon storage conditions.

Un-waxed polyester resin; where it is anticipated that a period of time will elapse between starting and completion of a particular section being laminated, an un-waxed resin should be used. Un-waxed resins can take up to several days to achieve full cure thus facilitating the bonding of the subsequent layers. When cured, the surface, using un-waxed resin is difficult to sand so a coat or waxed resin or gelcoat will be required.
Waxed polyester Resin; as the name implies, this resin has had wax added to provide a smooth, non-tacky surface which will not pick up dirt or other debris. It is used for laminating in any area where the work is to be completed without further laminating or as the final finished layer where you may wish to later sand the surface. Resin can be pre-waxed or added as required.

**THINNING RESIN.**

Polyester resin may be thinned by adding a MAXIMUM of 15 parts of Styrene Monomer to 100 parts polyester. Check with your supplier. The first coat of resin applied to wood can be thinned for deeper penetration. It should not be necessary to thin laminating resin as this weakens the cured laminate. Thinning will lengthen the surface cure time and will require more catalyst.

For health reasons, there are now some “Low Styrene Emission Resins”. They have a substitute for Styrene Monomer or a reduced quantity in their make up. These resins are quite different from high viscosity resins which can be thinned with Styrene Monomer.

**VINYL ESTER**

Vinyl esters are the “epoxies” of the polyester range and well worth the extra cost. The handling and performance characteristics of vinyl esters are similar to polyesters and it has been shown that a thin layer with a vinyl ester resin can provide an excellent barrier to resist blistering in marine laminates. If you are building on a male mould use vinyl ester in the final layer below the water line using a fibreglass tissue to assist with the build up. In a female mould it has to be the first layer backing up the gelcoat.

**EPOXY RESINS.**

Other than when building a boat using the wood/epoxy technique, the high cost of epoxy resins and the handling difficulties have limited their use in fibreglass boatbuilding. Epoxy resins show the best performance characteristics of all the resins used in the marine industry but they can be difficult to use under anything but the very best and controlled conditions. Aerospace applications use epoxy almost exclusively.

**GELCOAT or GEL COAT**

Gel coats are designed as a protective coating for structural laminates. They are available in brush and spray versions and are best applied at a thickness of 0.5mm. Most exterior gel coats are based on isothalic resins with low styrene emission and are available in both brush and spray forms. Nowadays, they are blister resistant and usually approved by marine authorities.

*Here we see gelcoat being applied to a Spray 28 female mould.*
There are several types of gelcoat, each having its own particular function. The most commonly used, is the one for female moulding. This gelcoat comes in various colours and is unwaxed. It is usually pre-promoted and, as with resins, will need catalyst added before being applied to the mould surface. Clear gel coats have an increased resistance to water permeation because they contain no pigments and when backed up by a vinyl ester resin laminate virtually eliminate any possibility of surface blistering known as Osmosis.

The type of gelcoat you choose, and the way you apply it, will certainly affect your finished boat. If you are building a male moulded boat, you may well replace the exterior gelcoat with a urethane or epoxy based paint system. Interior gel coats gives a durable smooth finish to your work and are sometimes referred to as flow coat. They brush well without leaving brush marks as they contain thickening agents and are pre-waxed.

**FUEL AND WATER TANK RESIN**
Special isothalic based resins are available to coat the interior surfaces of fuel and water tanks and these resins ensure that a suitable barrier is set up between the liquid and your fibreglass laminate. After post-curing, they should be odourless and tasteless when used in water tanks.

**PAINTS**
Polyurethane and epoxy paints when applied correctly, perform well on male moulded boats and often enhance some of the older gelcoat systems. The development of new paint systems and coatings is ongoing so consult your paint supplier for the latest technology.

**ACCELERATOR**
Cobalt Naphthenate is the common accelerator (or promoter) in most polyester resins and should never be brought into direct contact with catalyst (MEKP), outside of the resin mix, as an explosion could result. For safety reasons, general laminating resins are usually supplied pre-promoted and extra accelerator can be added if you require a quicker setting time although, as they are pre-promoted, we
usually have to adjust the catalyst level. In this instance, we should be using un-promoted resin and adjusting the amount of accelerator to suit the conditions. Never add excessive amounts of the accelerator to any resin.

**CATALYST – MEKP**

MEKP (Methyl Ethyl Ketone Peroxide) is normally a clear liquid commonly known as catalyst which must be handled with extreme care. Polyester resin will not harden without catalyst. The amount of catalyst added to the resin is critical and it is normally used in a ratio of 1-2% by weight of the total polyester resin. As a rule of thumb, 20mls of catalyst is usually needed for 1kg of resin. Accurate measurement is important because a small increase or decrease of the amount of catalyst can have a large effect on the working time of the resin.

The catalysts used with polyester resins are almost invariably organic peroxides. These are unstable and should be treated with the greatest caution. They are all irritating to the skin and cause burns unless washed off immediately. Injury can be more serious if catalyst is splashed into the eyes. Immediate treatment in such cases is to wash out the eyes continuously with plain water or weak bicarbonate solution.

**RESIN PUTTY – FILLERS**

This do-it-yourself material can be made for a fraction of what you would pay if you bought it, made up, from your local supplier. You will use sizeable quantities of filler (commonly referred to as “BOG”) during construction of any fibreglass boat. There are several materials that can form the dry ingredients of the resin putty mixture. These include industrial talcum powder, Q-Cells and micro balloons. When mixed with waxed polyester resin and a small amount of additional accelerator they make and excellent and economic filler. This material, if stored in a covered container, will keep for up to two or three weeks. When you want to use the filler, you simply dig out a quantity and place it on a mixing board. You then add a dash of catalyst. This does not have to be measured, as you will soon gauge the mount required to make the bog set in the desired time. Check with your local fibreglass supplier as to the recommended materials.

**FIRE RETARDANT RESINS**

Designed for either general laminating or gel-coating, these resins are a benefit in areas where there is a higher than usual fire risk. As fire retardant resins are generally more expensive than regular laminating resins, most builders tend to only use them where necessary.

**ACETONE**

Acetone is a highly volatile material, used as a general purpose solvent and cleaner. Used for cleaning brushes and rollers after laminating. Acetone should be stored in a sealed metal container and measured out in small quantities; say 2” [50mm] in the bottom of a plastic container in which you should thoroughly wash the brushes and tools. You can store brushes and rollers in clean acetone overnight, make sure you use a sealed container, as acetone has a high evaporation rate.

**RELEASE AGENTS**

Release agents are liquid or pastes which are applied to mould surfaces to form a barrier skin and prevent sticking by the resin or gelcoat. Polyesters stick very well to most materials and surfaces and if no release agent is used, it is impossible to remove the lay-up or casting from the mould.

**BARRIER & CLEANSING CREAMS**

In some instances the skin can be irritated by polyester resin in which case it is wise to use a barrier cream in conjunction with gloves. Low cost disposable gloves are available and specialist barrier creams should be available from your fibreglass supplier. It is always recommended to use rubber gloves when working with epoxy resins.

**FIBREGLASS – SAFETY EQUIPMENT**

Before working with glass and resin you will need a range of safety equipment. This will including breathing masks, to prevent you form inhaling noxious fumes and dust particles. You will also overalls or other protective body clothing and goggles or industrial spectacles for eye protection. In some cases, prolonged exposure to resins and other glass fibre materials can cause skin rashes or unpleasant discomforts.
Hooded suits are becoming more popular as they totally isolate you from the environment. Some hoods have built in breathing apparatus with filters and most are designed so they do not restrict your vision or movement.

**RESPIRATORS AND BREATHING MASKS**
A respirator or mask is one of the most important pieces of safety equipment when working with fibreglass. You will need protection from simple dust through to potential cancer causing fibres and vapours, especially in some paint systems. These items of safety equipment range from the simple paper mask, through to simple air supply units, which totally isolate you from the surrounding environment. You should discuss the various options with your fibreglass supplier who will advise you on the availability for each particular use and workplace situation.

Some respirators will not work when used over a beard or for that matter (designer) stubble. If you are not clean shaven, then consider using a suited hood.

Amongst others the 3M Corporation have available some excellent breathing appliances.

A well-run building workplace can take the pressure off the safety equipment by providing a clean environment. Keep rubbish off the floor. Remove fibre trimmings immediately and make sure you have adequate ventilation. Keeping a clean workplace will go a long way to keeping you healthier. You will reduce fire risks and keep your insurance man happy.

**HAND PROTECTION**
You are working with chemicals so your hands should be well protected. Although most fibreglass boatbuilders work without protection, using gloves or barrier cream will protect sensitive skin and even non-sensitive skin.

**EYE PROTECTION**
Some hoods and respirators also incorporate eye protection. For certain jobs, separate goggles are important. You will need to choose between goggles and safety glasses, both of which should provide side protection. When grinding fibreglass and other associated materials, it is amazing the various trajectories the ground particles can take so always wear eye protection when grinding.

**EAR AND HEARING PROTECTION**
If you are working in conditions where the noise level is in the 80 plus decibel range, you should consider using ear plugs or earmuffs. One professional boatbuilder even insisted that the foam earplugs have florescent cords so the foreman could see, from a distance, that the plugs were being worn!

**BODY PROTECTION**
Good body protection is achieved by wearing a disposable body suits that have improved in the past few years so that most feel comfortable to wear while still providing the necessary protection. How you feel about wearing a suit may depend on the climate. Some hot climates call for creative arrangement such as the tissue paper suits worn by some boat builders. Overalls are still a good option.

**FOOTWEAR**
Your feet are the easiest things to protect. A lot of fibreglass workers wear sneakers/sand shoes and although these aren’t the ultimate protection they do a good job in this environment. When gun laying sneakers are very useful as they can be slipped on and off without hands which is useful when you came off the job and want to change footwear.

**FIBREGLASS – THE TOOLS**
Other than electrical tools, you will be able to purchase most of the tools you require for fibre glassing at the same outlet as your other fibreglass supplies. You will need an assortment of brushes, metal rollers, paint scrapers, plastic containers and measuring devices. A few of the items you can make yourself or scrounge like used plastic ice cream containers for mixing resin and some hand sanding tools.

**PAINT SCRAPERS**
You will need an assortment of paint scrapers. Usually the cheaper ones have more flexible blades and these can be used for handling the resin putty “Bog” and fairing up various areas of filler. Purchase a selection of widths from 1" [25mm] to 6" [150mm] of which one or two can have the corners rounded so that they can be used for creating fillets. Paint scrapers can be cleaned in acetone after removing any residue of hardened bog.
DISK SANDERS
It is a good idea to buy a disc sander of reasonable quality as it will do a lot of work. The right size is about 7" [175mm]. Choose a low or duel speed disc sander that will be happy running at 4000 RPM. As well as a rigid backing, the sander should be capable of being fitted with an 8" [200mm] circular foam pad (Ferro) to which you can attach the adhesive type sanding discs for finishing work. You will need a selection of varying grits.

OTHER SANDING DEVICES
You will need a selection of sanding blocks and boards. One particularly board is a piece of plywood 4' 6" [1.37m] x 6" [150mm] x ½" [12mm] thick which when fitted with handles and sandpaper attached makes an excellent device for obtaining a good finish on a hull or deck. The board is handled with long sweeping strokes that follow the contour of the hull and will tend to even out any unfair areas. There is a variety of power sanders with all types of actions so check them out and find the best for your job. Always use any new sanding tool on a test area before committing its use to large areas of your boat.

BRUSHES
All the brushes you purchase should have unpainted handles and you will need a variety of sizes

MOHAIR ROLLERS
Mohair rollers are used for applying and spreading resin as part of the hand laminating process. Again you will use different sizes but mainly 5" [125mm] and look for plastic or unpainted handles and it is a good idea to have a few replacement sleeves. After use, always remove the sleeve from the roller and
thoroughly wash in acetone. Make sure you always use mohair rollers as other types, sold for painting, will soon fall apart when used with fibreglass resins.

**PLASTIC BUCKETS AND CONTAINERS**

For mixing resin save all suitably sized plastic containers and have your friends save theirs too. You should also be able to buy ice cream container “seconds” from your fibreglass suppliers. You may also purchase some small plastic buckets. Half gallons [2 lit.] and one gallon [4 lit.] will be the best size for the job. The hardened resins will crack out of these after use. It is a good idea to use one specially calibrated and marked bucket for measuring out the specified quantities of the resin as this will save the bother of actually weighing every batch.

**JIGSAW**

When building any boat, there is a considerable amount of trimming required and an electric jigsaw is one of the best tools for these jobs – able to be used on a work bench or in confined spaces. On glass fibre, you should only use high grade cutting blades including tungsten and diamond blades and the unit will handle the fibreglass laminate with ease. Equipped with the correct wood cutting blades a jigsaw will make short work of cutting out plywood bulkheads and furniture.

**SURFORM**

A great little tool for surfacing wood or fibreglass, it comes with flat and rounded blades and is available from most hardware stores.

**ELECTRIC DRILL**

A good cordless drill is not only for drilling holes but with the addition of a set of hole saws and other attachments will see plenty of action during, and after, any boatbuilding project.

**STEEL ROLLERS**

Steel rollers used for rolling the mat and roving remove any air bubbles trapped in the laminate. With a bit of practice, these steel rollers also roll the material to a smooth finish. A range of sizes is required including some very small diameter ones for getting in the corners and wide ones for bulk work. Check with your supplier regarding the various sizes and types.

**SCALES**

A set of kitchen scales that weigh up to 10 pounds (4.5 kg) will be ideal for weighing out the resins and you may be able to pick these up second hand.
SCREEDS
You will need a variety of screeds, most of which are made from flexible plastic or thin metal. You can make your own or buy ready made from your supplier. A handy screed can be made from an old saw blade with, or without, the teeth ground off.

VACUUM BAGGING EQUIPMENT
You may want to use vacuum bagging when installing any core materials used during the construction of your hull and deck. Details of the equipment required will be covered in a special section dealing with vacuum bagging techniques.

MISCELLANEOUS ITEMS
Other important tools include some heavy duty scissors to cut the fibreglass roving. CSM should be torn unless you want a sharp edge and with woven roving, pull out a strand as you cutting line. Also needed is a paddle mixer which can be attached to a variable speed electric drill running at slow speeds. A table on which to lay out the mat and roving with a device to hold the roll at one end is a necessity. Also required is a measuring glass or bottle for the catalyst and a selection of woodworking tools, clamps, and ladders etc.

FIBREGLASS - BUILDING THE HULL
As there several similarities in the way that you would build a batten mould for building a fibreglass boat and the way that you would tackle the same job when building a wood epoxy vessel, please also read the initial part of chapter 6 where you may pick up some useful hints that will assist you in building your fibreglass batten mould.

There are alternate methods which you use to build the hull of your fibreglass boat. You need some form of structure to use as a mould to create the shape of your hull, decks and superstructure. These moulds can be grouped into two main categories consisting of male or female structures. The construction methods used to create the moulds is covered in this chapter.

FIBREGLASS – BUILDING A MALE MOULD
With the advent of Computer Assisted Design CAD and Computer lofting, it has become possible for the designer to supply the builder with very accurate full size patterns. Usually included with the full size patterns, are the frames, stem, expanded transom, deck beams, cabin top beams and miscellaneous other items, which can be made directly from these patterns. Before CAD and computer lofting, drawing the lines plans and lofting the boat full size was a long, skilled and expensive process taking around 250 man hours to complete. Now it is possible to reduce this time to less than one tenth, so we invest more time elsewhere in the designing process.

Having the personal knowledge of several thousand 18’ to 70’ [5.48 M to 21 M] boats being successfully built using full size patterns, I can say with absolute confidence that you should try to obtain a plan with full size patterns. You will save many frustrating man hours and the boat will be shaped as the designer intended it to be.

FULL SIZE PATTERNS
For masochists and those who either want to build a boat from archive materials where patterns are not available, or for those who are unfortunate enough to deal with a designer who is unable or unwilling to provide full size patterns, you may be forced to undertake the job of completely lofting your chosen design full size. There are several books available which cover the subject fully. I will leave it to you to research lofting if you are forced into this action.

If you do have to loft full size, make sure you do the complete lofting job. Do not take shortcuts by lofting frames only, without drawing out all the water lines, buttock lines etc., all full size. If you take short cuts with lofting, you will regret it when you start to assemble and fair your hull.

If you are fortunate enough to receive full size patterns with your plans, please use the patterns. On no account should you try to “improve” the patterns by re-lofting the lines. There may be a slight movement in paper patterns due to atmospheric changes but this movement is usually evenly distributed throughout the patterns. Provided you are working under reasonable conditions, these variations will not be large enough to affect the finished product. When ready to use the patterns, you should pick a
day when you believe the temperature and humidity will remain constant. Prepare to transfer the paper patterns to a plywood floor or “take off” the frame shapes and other various items as shown on your patterns. If you want the ultimate accuracy and are prepared to pay extra, then you can ask your designer to supply the patterns plotted on Mylar film but this is expensive and unnecessary.

LAYING OUT THE PATTERNS
Most full size patterns are plotted or traced on 24” [610mm] or 30” [760mm] or perhaps even 36” [1 metre] wide paper or Mylar film. These sections are laid side by side wallpaper fashion to reveal the complete set of frames, stem pattern and other elements of your boat that are supplied full size.

You will find the patterns generally show one side, or half the shape of the frame. As most boats are symmetrical, your patterns need only show one side of the boat. Usually frames 0, 1, 2, 3, 4 and 5 are shown on the right side and frames 6, 7, 8, 9 and 10 are on the left side of your assembled patterns. Some designs may also have half frames, for example 1.5, 2.5 and so forth. You will need the radius of the expanded transom so you can later form the transom to its correct rounded shape. Study your patterns with the lines plan. The lines plan will contain frame spacing and other important measurements that you will need when setting up your hull framework.

When laying out the patterns, you will need a space that is wider than the beam of your boat. The best way to lay out the patterns is to make up a plywood floor that is equal in size to the patterns plus a percentage. The various sheets should be taped down in position, making sure the centre-line, headstock or base line and waterline all match up. Your patterns may also have small cross reference points; these must be correctly lined up to give an accurate shape. Once you have the patterns laid down in position, there are several ways to transfer the lines or the frames and the stem. You will need to mark the lines on to the timber, so you can cut out the shapes as shown in your plans. Illustrations show some methods; your plans may suggest others.

MAKING THE FRAMES
When you are making up the frames or moulds as they are sometimes called, it is best to make up the two halves of the frame at once. This is achieved by nailing the two pieces of timber together, usually 1" by 8" [25mm x 200mm] or similar sized material and of suitable length to cover the section of the frame you are making. The two pieces are tacked together and the pattern marked out on one side.
Clearly mark the waterline, sheer line and headstock line where they occur, on any one frame section. After you have joined up, faired and clearly marked the line of the outer edge of the frame you are making; then carefully cut the frame section out on a band saw or other suitable saw. Make sure you cut the frame piece square off the marked surface otherwise the two sides of the frame will not match.

Once you have assembled the pieces of the frame to make up one half, which consists of two layers; these should be joined on one side with gussets. Next remove the nails holding the frame halves together and lay out the frame as you would open an oyster and bingo you have the entire frame.

Before you attempt to assemble the complete frame, measure directly from the patterns, the width of each frame at the headstock line; shear line and waterline and make a check mark on the opposite side of the frame patterns and include the frame number. Now you have three reference points to make sure the other half of the frame is laid out symmetrically. Problems can arise if you try to use the offsets when taking the measurements off the patterns as these may not have been corrected at time of lofting.

Now you can lay out the complete frame by installing the headstock or baseline board, and gusset the keel together; add bracing and strengthening members to the frame as shown in your plans. Your frame must pass the test of both sides matching the master pattern. You now have one completed frame ready for installation on the strong back, bedlogs or setting up rails. After you have marked out all the frames, stem and the backbone and they have been cut out and assembled, your next job is to prepare your strong back or bedlogs.

**SETTING UP THE FRAMES**

Usually, the bed-logs or strong back are made from 6" x 2" [150mm x 50mm] or similar sized timber, depending on the size of the vessel. Your plans should give guidance on the scantlings and assembly method for the setting up base. The size of the strong back, which is the width and length, will be decided by the shape and size of your hull. The forward end will be narrower to accommodate the shape of the frames whereas the aft end will be wider for the same reason. As the widest part of the hull is normally around or just aft of the centre, it will be easy to arrange adequate support in this area. Sometimes it is best to build the strong back coffin shaped, to offer the best support to the hull, at all its various widths.

The setting up height is quite important. The hull will be upside down and there must be room for you to have easy access under the sheer and into the interior of the hull. Your hull must not be so low as to allow the bow, which is usually the lowest point, to touch the floor. Once the strong back is completed, it should be checked for level in all directions. The use of chocks and wedges can correct any misalignment. Make sure any blocking or wedging is done so it will remain permanently in position until the hull is completed. If you are working on an earth floor...
you may wish to install concrete pads. The strong back and the whole mould structure must be capable of supporting the weight of the completed hull, until the laminating and fairing is completed and the hull turned over.

Once you are satisfied that the strong back or support rails are level in all planes and securely in position, install a string line down the centre line and mark out the station spacing on the rails on both sides of the strong back. All station marks should be marked square off the centre. Nailing 2" x 1" [50mm x 25mm] cleats across the strong back or bed-logs, at each station point, may be the best way to accurately position the frames. Make sure you consider which side of the station mark your frame
is to be positioned. Make sure the frames are installed square off the centre line and level across the headstock line. It will be necessary to attach each frame to the strong back. You may attach the headstock to the upper rail or the bed-log, by through bolting, coach screws or skew nailing. Access to the strong back or bed-logs may decide your method of attachment. Remember you will not want the strong back to come loose and be waving about during the turning over process.

Use adequate braces and temporary supports to hold the frames in the correct position until they are all installed. Make sure they are all square relative one to the other and that the individual spacing remains constant throughout. Normally the frames are erected so the forward edge of the forward frames, those ahead of station 5, are in line with the station mark. The aft edge, of the aft frames should be in line with the station mark. Frame 5 can be positioned so the centre of the frame is on the mark. The reason for this positioning of the frames in relation to the station marks, is so that when the battens are installed, they will touch only the forward edge of the forward frames and the aft edge of the aft frames. This eliminates the need to bevel the frames. As this is the mould you are building and not part of the hull, it is not necessary to consider the frames and battens as a permanent structure, but as a mould former. Consequently, a considerable amount of time can be saved by not having to bevel these frames. Provided the frames are installed as outlined above, you will find that the battens will lay around the frames in a smooth and fair manner, without needing to be bevelled.

INSTALLING THE STEM
The next step is to install the stem and backbone. Fit these parts in the slots that have been pre-cut to receive them. The stem will need temporary support until the battens are installed. Take check measurements to make sure the stem is in the correct position, relative to the sheer line and the centre line of the hull. At this stage, the biggest mistake you can make is to have the stem off the centre line of the hull. Check everything against the centre string line and use plumb-bobs, a large square and tape or ruler to make absolutely sure everything is correctly located.

KEEL AND SKEG
A word about the keels and skegs on sailboat hull moulds. You should attach the keel frames to the hull frames by screwing - do this in a way that allows you to unscrew the keel section before removing the mould. Sometimes the keel will be reluctant to part from the mould so by making provision to allow the hull mould to be removed without the keel section, you will overcome this potential problem. Skegs can also be built separately and attached to the mould with a screwed gusset as the same problem may arise.

BATTENS
You should now have your mould battens prepared and these may be scarfed into full length to match the station marks. Some battens should be fitted to the station marks, others may be fitted to the frames. It is a good idea to fit some battens to the frames and some to the station marks. This helps to keep the mould in position during the turning over process.

NOTE: BATTENS MAY BE CLOSER TOGETHER FORE AND AFT.

BATTEN HEIGHT ¾ THIS SHOULD NOT VARY ON MOULD WILL BE FLAT.
BATTEN BOTH SIDES SIMULTANEOUSLY.

USE STRIPS OF ¾ PLYWOOD TO HOLD BATTENS FAIR BETWEEN FRAMES AND TO JOIN SHORT BATTEN LENGTHS.

PARTIALLY BATTENED MOLD
STRONGBACK AND SEVERAL FRAMES OMITTED FOR CLARITY.
the length of our hull or you may join them on the job using plywood fairing strips as described later in this chapter. It is wise to obtain battens of the correct width and thickness otherwise they will not bend to a fair shape on your hull. For sailboats between twenty-five feet [7.5m] and sixty-five feet [20m] the best size battens are 1 ¾” x 5/8” [44mm x 15mm]. For power boats, with flat bottom sections, you may use larger battens in this area, say 4” x ¾” [100mm x 20mm] which will usually lay in place without giving you any problems.

Once the frames, stem and backbone are in place, you may install a few battens to check the fairness of the structure to this point. If you have followed the full size patterns and cut and assembled the frames with due care, you should find the framework very fair and accurate. The main thing is to have a fair hull so you may shim and trim frames as necessary to make sure the battens lay in a fair curve. From now on, your eye will be your guide. You will soon develop a skill that will allow you to spot an unfair lump or hollow in your mould.

**INSTALLING THE BATTENS**

You can start the battening process at any part of the hull mould, but make sure that the battens are progressively installed on either side. If you batten up say twelve inches [310mm] on one side of the hull, then make sure you next install the battens in the same area, on the opposite side of the mould. This will prevent any pulling or deforming of the structure due to having battens in one area and not having battens to balance the opposite side. At this time you should be particularly careful, to make sure, that the stem remains straight and true, right on the centre line. After installing a few battens over the entire area of the hull, you will find the mould will take on a more rigid form and it will be easier to maintain the correct shape.
During the early stages of installing the battens, you should be giving consideration to building and installing the transom. There are several ways to build a transom and one is to form it as we have shown in the photos and sketches. Most of the latest plans include the developed shape for the transom, this with the known radius, will offer another way to easily form the correct shape as the designer intended. We have noticed that some designers who specialize in plans for amateur builders have taken to designing boats with flat transoms. A flat transom is an exceedingly ugly thing and not at all necessary. It is so simple to have at least a small amount of camber or curvature in the transom of your boat. Flat transoms always look concave or hollow, so we suggest you don’t do it.

As the battening of the mould former proceeds, keep a careful check to make sure there are no low or high points in the structure. If you find several battens wanting to go past a frame without touching it or can only be made to touch the frame by pushing inwards and deforming the batten, then let the battens lay as they may, and pack out the frame to suit. If you find one frame is particularly high and needs some trimming to make the battens lay fair, then dress a little off that frame.

If you have been careful in following the full size patterns, and setting up your mould former, then the battens should go on without any problems. If some errors have crept into the structure, now it is the time to make sure you eliminate them. If the battens have run past a frame without touching it, then fasten the battens to the other

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*A section of the deck camber pattern will make a suitable curve to form the transom. Make up the formers as shown here and the add the battens as shown below.*

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*Battening up the transom is a simple job once you have installed say four horizontal camber boards to support the vertical battens. We used to recommend plywood cored transoms but as rot can be a problem best stick to single skin or approved cores as with the hull.*
frames first, then go back to the frame that is low and pack it with a piece of plywood or timber, to build up the frame and provide support for the battens. The battens can then be nailed into position.

**Adding Fairing Strips**

After installing the battens on the hull and the transom, the next step is to add internal strips, as shown, which are installed to fair up the battens between the frames. The battens that need to be joined can be joined on these fairing strips. Installing these fairing strips is a job for two people. One person to nail through the batten into and through the fairing strip, and another person inside the hull structure with a “dolly”, or heavy metal weight against which the nail can be driven. This procedure will cause the nail to bend over and clinch up tight. Clinching is a common boat building practice and one that you would use frequently if you were building a wooden boat. The “dolly” should be a solid piece of steel, of a size that will fit comfortably in the hand. The ideal shape is a piece of solid round steel say 2 ½” diameter by 6” long [60mm x 150mm]. The dolly is used end on. When the battens are joined between frames on the plywood fairing strip, they will be held firm and fair. If there are any small irregularities they can be lightly sanded at a later time.

Use adequate plywood strips, at least one or two between each frame and no more than 1’-6” [500mm] apart, so if frames are more than 3’-0” [1 metre] apart, use two strips between each frame. Clinch nail to every batten. Best cut the strips into 4” [100mm] widths and use ¼” [10mm] to ½” [12mm] thickness of plywood.
In areas where the battens are low, they can be very carefully tapped out from inside the hull until they are fair. Again, packing is used to make sure the re-positioned battens stay where they are put.

**After you have checked over your mould and are satisfied with the fairness of the entire structure, the next step is to cover the entire mould structure with builders’ plastic.**

**CHECKING THE MOULD**
A ½” x ¾” x 6’-0” [12mm x 20mm x 2m] long timber fairing batten laid diagonally across the mould battens will show up the high and low spots on your mould. If there are any localized bumps or lumps, a heavy grit disc. Something in the region of 16 grit should be ideal for the job. Now is the time for you to go carefully over the entire hull and fair off any irregularities with the sander. As in all your work from now on, let your eye be the judge. View the mould from every angle and when you are satisfied that it is as fair as you can possibly make it, it is time to take the next step in your building programme.

**FINISHING THE MOULD**
By this stage you should have decided whether you are going to use a cored method such as PVC foam or balsa to provide the sandwich structure or the cheaper urethane foam, which will later be removed, and add stringers to the interior of your hull. The next step is to cover the entire mould structure with builders’ plastic. This plastic is quite thin but strong. Check at your local hardware store where you should get a good choice of materials. The plastic comes in rolls and is best installed by taping it into position with plastic tape and stapling where necessary – cover staple holes with plastic tape. Once you have the mould covered in plastic the next job will be to install the core material.

**OPEN FORM VERSUS SOLID FORM MOULDS**
Before we move on to installing the core material, we should consider one alternative I have mentioned up to this point. The type of mould I have usually preferred and used is the open form or batten type mould. A few builders of one off fibreglass boats opt to take the mould process one step further and cover the mould with a skin and then go on to install the inner laminate first, then the core is vacuum bagged into position, and the outer laminate installed and faired to complete the hull. You will make your own decision after costing of the mould sheathing materials and the extra labour involved and time. You should also consult with your fibreglass material supplier who can advise you regarding the latest materials and techniques.

**FIBREGLASS - INSTALLING THE CORE**
At one time we used both end grain balsa and foam core for building fibreglass hulls. In recent times balsa core has become dis-credited due to the number of hulls that have become damaged due to water penetration of the fibreglass and into the balsa core. In our own defence we generally recommended balsa be installed above the waterline. In the light of current experience, we do NOT recommend balsa cores except for decks construction.

One method we have used for attaching the PVC foam core to the mould is to sew it on. For best results use a medium size bag needle with light string or nylon yarn. Make the stitches about 3” [75mm] long. Outside the hull the stitches are let into grooves, which you cut as you proceed so they will lie flat with the surface and do not interfere with the installation of the laminate. The rows of
stitching should be 9" to 12" [230mm to 310mm] apart. We have found it best to stitch vertically up the sheet, first along one edge and then progressively working across the sheet in vertical rows. Additional stitching may be necessary where the sheets join, using a cross stitch patterns up the edges of the sheets which should ensure that both sheets lay uniformly on the mould former.

Another possible method, depending on the suitability of the foam, is to drill holes in the battens and screw the foam from the inside, removing the screws before the hull is turned for removal. One or two missed screws will stop the mould releasing so you have to get them all out.

Install the foam sheeting carefully to insure there are no hips or hollows in the hull surface. It will take a considerable amount of work to fair out any large irregularities created at this stage, so utmost care will ensure a fair hull and one that will need the least amount of finishing to provide a professional looking surface when the hull is completed.

You may use wire toggles, if necessary to help pull the sheets into a fair shape. This is only necessary if the stitching will not do the job in a difficult area. A toggle can be a length of copper or other wire with a nail or strong toothpick twitched on to the outside. The toggle wire is pushed through the foam and twitched on the inside on to a nail inserted into a batten.

This cored hull is the same one shown earlier to illustrate a well battened mould. The first layer of fibreglass has already been added in the area of the keel where the core material was substituted by installing Masonite or thin plywood as the base for the fibreglass laminate.

NON-CORED AREAS OF THE HULL

There are certain areas of the hull where it is not recommended to use core material and these include the skeg, keel and areas below the cabin sole line, effectively, anywhere below the waterline so, in cored boats, these areas of the mould should be sheeted with a cheap polyurethane foam which is later removed. The keel sides and bottom can be covered with ¼" [6mm] Hardboard/Masonite which is waxed and a release agent applied to eases the removal of the mould former from the hull. Some keel moulds have to be made detachable from the hull mould to facilitate removal of the hull. It would be wasteful to install expensive core materials in areas where it will later be removed. In our own designs we always recommend that the area under the cabin sole be single skin so this means that the hull area below the waterline should always be covered with cheaper foam which is shovelled out after the hull has been turned upright. As with all forms of construction, there are many ways to achieve the same results. You should follow your plans. If you have a good idea not covered in your plans, then consult your designer before making any major changes to the recommended building methods.
PLYWOOD CORED TRANSOMS
Previously plywood, as a core material in the transom, was popular. The problems of water penetration and rotting the plywood has been discovered over the past few years so if possible try and avoid any plywood except in the interior fitting out of your fibreglass boat.

If you are building a powerboat and planning an outboard or stern drive installation, then the plywood cored transom is a possibility but make sure the plywood is of the best quality marine grade. As your transom will have some camber or curve, you can pre-laminate several layers of thin plywood to this camber and after cutting to the approximate shape install in position, on the mould. Now you can trim the transom to the exact shape to allow it to tie in with the side of the hull. Make sure you fasten the transom from inside the mould so you can release it after turnover and before you remove the mould from the hull.

You may prefer to laminate the plywood transom in place. In this case, install the first layer by screwing from inside the mould and then laminating the other layers of plywood on to the first, by gluing and stapling from the outside. You should fit the transom so that the plywood overlaps the core on the hull and then radius the outer edges. All edges on the hull must have a radius before the first layer of fibreglass.

PRIME COATING THE CORE
After installing the core, the next job is to apply a prime coat of the resin and then you should go over the whole hull checking the fairness and applying resin putty or fairing out any imperfections, where necessary. It is important when building a fibreglass boat on a male mould to see that it is as perfect as possible before going on to the next stage. Different core materials will absorb different amounts of resin prime coat. With balsa core, after filling any gaps with resin putty, you may want to apply one or two thinned coats to seal the surface and then another coat of regular laminating the resin – check your suppliers recommendation. PVC core will needs at least one coat of resin primer.
SINGLE SKIN OVER A MALE MOULD

For a single GRP skin hull over a male mould, the building of the mould follows the same procedure as for a cored hull. Instead of using a PVC foam core you will now use cheaper urethane foam which is removed once the hull is turned. This is a rigid foam and is purchased in sheet form similar to PVC. It is usually removed with a shovel and the interior of the hull has to be sanded in preparation for further laminating, stringers, bulkheads etc. Single skin may be a bit cheaper to build than sandwich but there are a lot of advantages in using sandwich so consider all aspects and design features before deciding which you will use.

The illustration shows on the left a hull with a core and on the right is a similar hull with C-Flex planking in place of the core. Study the drawings to see the progress from the mould frames set up on the strongback, battens, core material and laminate.

This illustration shows the sequence and areas of the various layers of mat and woven roving that are applied to the outside of the core materials.
FIBREGLASS OUTER LAMINATE
The first layer of your laminate should be a light chopped strand mat, either 1 or ½ oz per square foot [300 or 450 g/sq.m]. These are easy weights to work with and will provide a good key between the core material and the bulk of the laminate that follows. This first layer is very important as the bond between it and the core material must be as perfect as possible. If in doubt, make up some sample pieces using scrap core material as a base. For the bulk of your hull laminate, you should use only unwaxed general purpose laminating resin. The final layer of the outer laminate should also be a chopped strand mat and the resin should be waxed to facilitate the sanding that will come next.

WHICH DIRECTION?
There are at least five directions you may use to apply the various layers of the glass laminate. The first layer of mat should be laid in the most convenient direction. You need only butt the joins in the mat. Most fibreglass mats have a slightly braided edge that will blend and make a clean join, if carefully rolled, and this join will not be visible after the resin has cured.

You should apply a layer of the resin to the core before laying the mat. The first layer of CSM must be carefully wet out and rolled to remove any bubbles. Do not over saturate the mat, but roll out the excess resin, with a steel roller. If you work from the top then the resin will flow down through the laminate.

INSTALLING TWO LAYERS AT ONCE
It is good practice when laminating a hull to apply a layer of the mat and a layer of roving simultaneously – mat always first. The method is to lay up the mat and use the roving to help soak up the excess resin, which the mat often holds. The roving and mat are rolled out at the same time. If you become proficient, you will find this method of installing your laminate offers the smoothest finish and the best resin/glass ratio. The object of the exercise, when laminating, is to have the correct resin to glass ratio. The strength is in the glass so you do not want a resin rich laminate nor do you want your laminate to become resin starved - you will soon recognise a good laminate.

When installing the laminate wet out the surface to receive the laminate as well as the underside and top of the laminate. No need to use excessive amounts of resin, more importantly make sure the fibreglass material is evenly saturates and well rolled out to remove excessive resin.
LAMINATING WITH A TEAM
Another method of applying your laminate is to have a team of helpers, so the laminating can be completed without any interruptions, over a few days. You should have enough help to apply at least one full layer (mat and roving) over the hull per day. Do not apply more than two layers per day as the curing process will generate too much exothermic heat and may distort and damage your laminate. Using this method, you will apply one layer all over the hull before starting the second layer. Some of your team may be installing the second layer a few hours behind you, while the others are still completing the first layer. Four people are the maximum who can be gainfully employed on one hull, one mixing the resin and pre-cutting the lengths of fibreglass fabric and three applying the laminate. Within reason, the faster you build up the laminate, the better the bond will be between each succeeding layer. Technical data can be obtained from your materials supplier and, in most cases, they will be happy to visit during lamination to see that everything is being done in a proper manner.

NOTES ON LAMINATING – ALL METHODS
For ease of handling, try to obtain mat and other fibreglass materials that are about 30" [760mm] wide. When laminating, always overlap the joints of the preceding layer and if you are using a unidirectional roving, change the direction for each layer. Never allow the edges of one layer to lay over the edges of the previous layer. Not only will this weaken the laminate, it will also cause a high spot. Wherever possible, always tear edges of the mat to blend in to the surrounding laminate and always start and finish with a mat layer - never laminate roving to roving without a mat between. It is a good idea to trim the sheer as each layer of laminate cures. It is easy to trim around the sheer and anywhere else where trimming is required, when the laminate has just cured and before it reaches its final hardened state. A sharp trimming knife will do the job nicely. If you let the laminate set really hard before trimming the sheer, you will need to use a jigsaw or diamond saw to cut off the excess laminate.

When you have completed the design laminate for hull or deck, do not be tempted to add extra layers to “make it stronger”. If you have any queries about the laminate, please consult your designer. Do not, under any circumstances, just add a little more because you believe you will improve the strength of your hull, you are adding unnecessary weight and wasting money.

The extra laminations needed for the keel and other areas below the waterline can be added once the full hull laminate is complete. If you have used an isothalic resin, for increased resistance to water permeation, it is advisable to coat all areas below the waterline with several layers of vinyl ester resin and fibreglass tissue. Before you start on the serious finishing work, check over your hull and, using a fibreglass putty, fair out the obvious humps and hollows.

FINISHING TECHNIQUES
The easiest way to check if your hull has any unfair areas, it to have sunlight or strong artificial light shining from one end as you look along the hull either with or against the light. If you really want to check the fairness, then the best time is at night. Shine your torch along the hull and you will soon see all the imperfections in the surface. Use this technique frequently during the final fairing process.

At this stage, you can expect your hull to show some imperfections and these can be removed during the final fairing operation. You have to decide the standard of finish you are prepared to accept. Set your standards as high as possible. Work towards this goal and you will end with a hull you can be proud of. The resale value of your boat is important and the better the finish the higher the value.

FINISHING THE HULL
If your hull has been carefully laminated and will not require too much finishing, you will be a lot closer to achieving a good looking boat than a sloppy builder and you will avoid a lot of back breaking hand sanding.

The first process in finishing a hull, is to sand the surface with a disc sander running at not more than 4000 RPM. Use a soft pad (Ferro type) equipped with 30 to 40 grit open coat floor sanding type discs. The soft pad will prevent you from digging holes or causing other imperfections as you sand the hull. After you have sanded the outer layer of the mat, you must decide whether you need a professional plasterer to apply your screeding material. If your hull is unfair and has many humps and hollows, you would be best advised to have a local tradesman screed your hull with resin putty “bog”.

RESIN PUTTY

The type of resin putty to be used here is made from waxed resin with enough industrial talcum powder or micro balloons or other suitable filler mixed to a suitable thickness similar to soft butter, not too thick and not too thin. You will need a steel screed that is about 2'0" [610mm] long. The best screeding tools are made out of the type of steel that is used for making handsaws so an old saw with the teeth ground off would serve the purpose.

The resin putty “bog” will have extra added accelerator, about a half to one percent – talk to your supplier for the correct amounts. Make sure you experiment with your resin putty mix, before you start hull. Colours can be added to different bog layers to show what progress you are making. If you hull is reasonably fair or even if it is not, you may elect to do your own screeding using the materials as outlined in this chapter. You will soon get the hang of it.

The method is to start at the keel line and work down towards the sheerline, screeding down the hull, until you have covered the entire surface. Now sand off to a smooth finish and repeat the process working along the hull or diagonally so that the hips and hollows are covered from at least two directions. If your “bog” starts to cure prematurely or if it contains lumps and foreign matter; throw it away because it will only cause tracks and grooves in the area you are trying to screed. You will have very little success if you use “bog” that is not smooth and of the correct consistency. You will need some practice to decide the right amount of the catalyst to use with each mix. It is not wise to use a mix with a setting time of longer than fifteen minutes, as your “bog” will probably suffer from under cure and clog up your sanding discs when you get to that stage. If your mix is too fast, because too much catalyst is used, it will set before you have a chance to screed it out. It is best not to leave your “bog” unsanded overnight as you will have a difficult job to sand it the next day. At least sand the worst before leaving it overnight. You may want to start your “bog” finishing on the transom so if you do have any problems, you find out on a small area rather than the hull itself. It is important to get your

Chas Hornick checks out the fairness of his Spray fibreglass hull. Use two of your senses to check out the fairness of your hull, sight & feel play a large part in achieving a fair hull surface that will still look good when you apply the all revealing finish coats to the surface.
Make sure to trim at the sheerline as you go; it is much easier to trim after each layer is set rather than wait until all layers are in place.

Screeding your hull is a very important operation. Make sure that you do a thorough job of fairing your hull BEFORE painting!

Building a cradle around your hull will make the turning operation go more smoothly and the cradle will support your hull for the remainder of the construction program.
“bog” mix right because you will use the same formula throughout the boat. It is important to keep the sun off any part that is being bogged. Even a weak sun will increase the cure time and cause distortion.

**FINAL LAMINATIONS AND FINISHING**

The final hull laminations are so important that they are repeated here. The final layer in your lay-up should be a chopped-strand mat … The extra laminations needed for the keel and other areas below the waterline can be added once the full hull laminate is complete. If you have used an isothalic resin, for increased resistance to water permeation, it is advisable to coat all areas below the waterline with several layers of vinyl ester resin and fibreglass tissue.

Experienced laminators and this includes builders who have laid up their own hull, can apply a layer of the mat and a layer of woven roving in one operation. The advantages are that the laminate can be rolled out and any previously formed irregularities can be eliminated by using firmer pressure on the high spots and a lighter pressure on the low areas, thus ironing out the laminate and resulting in an even surface. Keep this in mind when installing your main laminate. Once your hull has been screeded and spot filled, sanded off and any surface tissue or finishing cloth that is required has been applied, you are ready for final hand sanding and painting.

About now, is the time when many people say enough is enough. It is not enough. If you paint your hull without carefully taking the final finishing steps, you will forever be disappointed in its appearance. You will also greatly undermine the resale value of the completed boat.

**PAINTING YOUR HULL**

Now a final sanding of the refilled areas, one last check over your hull and you are ready for the final finishing. Usually you will be applying one of the polyurethane or epoxy finishes. One last word on finishing - no matter how smooth and fair you think your hull is you may find it is not as perfect as you thought. When you apply the final gloss, the truth will become apparent. If you consider your finish absolutely perfect, then you will most likely be satisfied with the result. If you accept less than a perfect finish now, you may be disappointed later.

There is a wide selection of paints that are suitable for protecting the outside of a fibreglass hull - some for above the waterline, some for below. The method of application of your finish coating, will depend upon which material you select. If you believe your hull surface is sufficiently good to accept a high gloss finish, then you may be spraying your final coats. If you are of the opinion that your hull surface will not look it’s best with a shiny smooth surface, then you may prefer to roll and brush on the finish coating.

When you roll on your finishes using a short nap mohair roller, you will achieve a slightly orange peel effect. This can be used to advantage by rolling the second last coat, lightly sanding the finish and then spraying the final coat. This will take away the high gloss finish that may not be appropriate for your hull. No matter what material you select as a finish coat, make sure you try samples before committing yourself to applying the material to the complete hull surface. In some cases rolling followed immediately by brushing can give a passable finish to an imperfect hull. One last job before you turn you hull is to trim the sheerline after carefully marking it from the sheer batten. You should have been doing this right through the laminating process, but if not, you will need to do it now. You will need a tungsten tipped saw or a jigsaw fitted with a tungsten or diamond blade, to cut the fibreglass. It is much easier to trim the sheer while the hull is upside down and close to the ground.

**PREPARING FOR TURNING HULL UPRIGHT**

After you trim the sheerline, install a 3” x ¾” [75mm x 20mm] timber batten around the sheer. Scarf the batten to a length that will go right around one side of your hull. The batten is first clamped in place and then secured to the hull using self tapping screws that are located every twelve inches [305mm] around the batten. The screw should be long enough to go through the batten, the outer laminate and some way into the core, not so long as to go into the mould. After the mould is removed, install a similar batten inside the sheerline. The reason for fitting the outer batten before the hull is turned over is to protect the edges of laminate and add some stiffness to the hull shell after the mould is removed. Once the hull is turned and the mould is removed, you will find the hull is quite flexible, so the outer batten is part of the system that will keep your hull in shape until you can install the inner laminate, bulkheads and other hull stiffening.
Adam and Barbara Szczurowski photo of their Spray 36 fibreglass hull. If you are building a Bruce Roberts designed boat then your plans will show this type of turning over cradle. This arrangement has worked for all types of sailboat, powerboat and even catamaran hulls.

There are several ways of turning the hull - The one shown above uses one crane and an arrangement with two shings as shown. As shown elsewhere you may prefer to build a cradle around your hull.
TURNING THE HULL
Please make sure to read the chapters on building in steel and wood epoxy as you may find some useful tips that could be applied with it comes to turning your hull into the upright position.

There are several methods that have been used to successfully turn the hull and remove the mould former from the hull shell. In some respects, the method you will choose will depend on the size of your boat. Boats up to, say 25 feet [8 metres], can be handled without mechanical assistance. A few bottles of cheer and a number of your friends will take care of the turning over operation. For larger hulls a more serious approach is required.

If you are building in a shed, it is a simple matter to turn you hull and mould over in one operation. Use two chain blocks and endless slings that are placed around the hull about 25% in from the bow and stern. The chain blocks are then used to raise the hull and mould off the floor and rotate the entire structure in the endless slings. The hull can then lowered into a prepared cradle. Next attach the chain blocks to the mould structure and lift the mould out of the hull. The hull is now moved out of the way and mould lowered and inverted ready for re-use, sale or demolishing. Another method of turning hulls of any size is to use a crane fitted with a spreader bar and two endless slings. Assuming the hull is in shed, it then has to be removed either by using pipe rollers placed under the strongback or dragged out on skids.

MOVING HULLS
You can move large, bulky and heavy hulls and decks by the use of the simplest of devices. A few 2" diameter [50mm] pipe rollers 9' [230mm] long can be used to roll your hull, if you set down planks for the rollers to run on and keep taking the rollers from the back and placing them at the front as the hull moves along the desired path – angle the rollers if you want to move the hull in that direction. You should use 4" x 2" [100mm x 50mm] timber levers say 5'0" [1.5 M] long when you want to lift the hull and mould structure to slip pipe rollers under the strongback or bedlogs.
Another method we have used to turn large hulls is to build a framework around the hull. A strong cradle built over the hull while it is upside down and braced through and under the sheer will make a good turning over cradle. Use three sets of frames, one forward of the keel, one in the middle of the keel and one aft of the keel. Diagonally bracing will be required. See illustrations shown here for extra guidance. Use coach bolts throughout the assembly of your turning over cradle. When upright, the cradle should be capable of supporting the hull until you complete the project. Once your hull is in the upright position, the crane can lift the mould from the hull and turn it upright ready for disposal. If you reuse a mould you may be liable to pay the designer of your boat a royalty payment. It is wise to check the legality of such a move.

**BUILDING THE EZI-BUILD FEMALE MOULD - IDEAL FOR CHINE TYPE HULLS.**

If you are considering building a chine hull such as a power boat, single or double chine sail boat or similar craft, you should consider using the “Ezi-Build” fibreglass technique. There are two main Ezi-Build methods - one where you build an inexpensive female mould and lay up the hull in that mould and another where you pre-make the hull panels and assemble them inside a simple frame mould.

First we will look at the female mould method. Back in the early 1960’s, we were designing fishing trawlers that could be built of fibreglass using inexpensive one-off or limited production moulds. With the current rise in the number of people interested in power boats and the acceptance of chine hulls in general, we decided to simplify and streamline our original methods to make them suitable for one-off production by amateur and professional builders.

When looking at these techniques, we were developing a new range of power boat designs using the latest CAD software so that these designs did not involve difficult curves but instead were easily assembled in simple one-off moulds. These new designs all reflected the ability of the computer to produce absolutely fair, developable hull surfaces suitable for turning flat sheets of fibreglass into attractive hulls. Most of the original designs were directed towards steel or aluminium but the demand for similar fibreglass methods led us to develop computer lofted hulls with full developable surfaces and the result is the Ezi-Build technique.

Moving this Spray 33 hull will not present much of a problem but shifting larger hulls may present a more difficult problem and require considerable fore-thought and planning.
You are making frames for a female mould so the curvy shapes will be on the inside. Make sure the framing timber is wide enough to leave enough material on the outside to support its share of the weight of the finished hull.

Here we see the frames set up for building the Power Sailer Cat 35. These hulls are built using a combination of our 'panel' and 'ezi-build' fiberglass construction techniques.
ALWAYS STUDY YOUR PLANS
Once you have selected a design to build, and armed with a suitable set of plans and full size patterns, your first step should be to carefully study these plans. This advice applies no matter which building method you are using. Every hour of study can save many hours of construction time. Make sure you have allowed adequate study time before you start to build your boat.

LAYING OUT THE PATTERNS
If you are working with printed full size frame patterns, you should not open them until you are ready to use them and you will need an area at least as wide and tall as the boat you are building. This area should be as wide as the beam of the boat plus a minimum of one foot [305mm]. The depth should be the depth of the hull, plus a minimum of 3 feet [1 metre]. This space will be the minimum required to construct the frames over the patterns. This procedure will be explained in your plans and should be easy to follow.

“EZI-BUILD” MAKING THE FRAMES
When marking the frame shapes on to the timber, you should use a dressmakers wheel or nails, as shown in your plans, for transferring the shape of the patterns to the timber framing material.

Please excuse the quality of this photograph; it was taken in 1969 when we were building the first fibreglass trawlers in the Southern Hemisphere. Here we see how a split mould facilitates the easy removal of the hull from the mould.
Remember, that you are making frames for a female mould. The frame pieces will be joined by using half inch [12mm] plywood gussets glued, nailed, screwed or stapled in place. Screws are strongest but staples are quickest and most convenient. Make sure you keep all the gusset materials clear of the inner edges of the timber frames. Later, you may need to trim these inner edges with a plane and nails or gussets will interfere with this process.

Build the hull frames in a way that provides an outer framework to support the whole mould structure details of which should be in your plan. In designs under 32 feet 10 metres, the bottom of the support structure can be canted 45 degrees which will enable the whole structure to be tilted, side to side, for easy lamination. On larger hulls, it is advisable to hang scaffolding inside the hull structure to support planks for working from.

**SPLIT MOULDS**

You may want to consider a split mould. Here you build the mould in one piece, but with the intention of separating the mould down the centre line so that laminating can take place from a corridor up the centre of the hull. This is a bit more complicated and should only be used on larger hulls, if at all.

To achieve a split mould, the centre line board and the stem and the transom centre line boards are all doubled up and bolted together so they can be separated when the mould is completed and you are ready to commence the laying up process. The transom can be a one piece affair that is designed to be installed after the hull is assembled.

When you are laying up in a split mould, you install the basic laminate in the normal manner except that each layer is stepped back at the centre line where it will later be joined. After the laminating is completed, the mould is reassembled by moving the two halves together bolting along the centre line. Now you install the remainder of the laminate plus the extras usually installed in the areas of the keel etc.

For one-off boats, the relatively cheap Ezi-build mould, which is easy to disassemble, has eliminated much of the need for the more complicated split mould and, for those of you who think that these methods present more work than is justified, compared to building a one-off hull over a male mould, let me assure you after having sanded many fibreglass hulls, I feel these methods are by far the best and fastest way to build a one off fibreglass power boat or multi chine sailboat hull.

*After assembling all the frames, they are set up on a system of bedlogs.*
SETTING UP THE FRAMES
The frames, are set up on a system of bedlogs so that the whole structure is true and level in all directions. If the bedlogs are level the hull structure will also be level. It will be necessary to run a centre line wire or string line up the centre of the bedlogs. The frames will all have a centre line marked on the top headstock and the bottom cross bar. It is a simple matter to set up the frames spaced as shown on our plans. A plumb-bob hung from the headstock centre line of each frame assures that the frame is vertical and on the centre line. Use a large builders square to make sure the frame is square off the centre line.

SETTING UP THE STEM
Install the stem and centre line board, which is an extension of the stem and runs the full length of the bottom of the hull, simultaneously with the frames and using adequate props and bracing. A tip on setting up the frames – if the frames forward of frame 5 are set up with their forward face on the station line and the frames aft of frame 5 are set up with their aft face on the station line, then most of the bevelling and fairing will be avoided. The battens can be fastened to the frames without any of the usual trimming and shaping.

The best sequence for installing the frames is to set up the centre frame first, usually station 5. Make sure this frame is truly vertical, using a plumb-bob hung from the centre line marked on the headstock. Use a large carpenter’s square to ensure the frame is at right angles to the centre line. Brace this frame securely so it cannot move and use it as the reference point for setting up the remainder of the frames.

When all the frames, stem, centre line board and transom centre line board are in position and securely braced, then you can start to install the battens. Battens are best if made from 5/8" [15mm] thickness timber. Scarf the battens into full length pieces, the length of the hull plus a few inches for trimming. The batten width may vary. For the bottom you may use wider battens up to 4" [100mm] and for the sides a width of 2" [50mm] best. You should have a stock of wider boards of the correct thickness and then rip the battens to selected width depending on the requirements of your particular hull shape.

INSTALLING THE BATTENS
First install the chine battens, one close to each side of the chine. Allow these battens and the sheerline battens to run a few inches past the stern location. Now you may install the transom section of the mould. Camber boards are half checked at right angles to and on to the transom centre line board. Once the camber boards are in place, batten up the transom vertically. It is usually not necessary or advisable to nail the side and transom battens together, use plywood strips outside the battens placed near the intersection of the side and transom battens to hold the battens fair.

You should have a fully developed and expanded transom pattern in your plans. Using this pattern you may prefer to make up the transom as a separate unit and serve it up to the

Looking from outside the mould structure; note fairing strips on outside to keep the battens fair and also note the frames could be a little wider.
mould in one piece. If you make the transom as a separate unit, it can be at least partially laid up away from the main mould. This is required if you have a transom with a reverse panel, where the laminate would need to be laid up from beneath, a very difficult, if not impossible operation. If you build the transom in place, then the transom pattern can be used to cut the lining material.

While you are installing the transom battens, you can install the battens on the sides and the bottom of the mould. Always install battens on alternate sides of the centre line, working progressively on both sides. After all battens are in place, install fairing gussets or strips of one half inch [12mm] thick by four inches [100mm] wide plywood, clench nailed on the outside of the battens, one or two strips between each frame. The strips run from sheer to the chine and from the chine to the centre line. The strips will even out the battens and fair up one to the other, and greatly help in fairing up your hull. You will need two people to install these plywood strips. As you will be attaching the mould lining with contact cement rather than nails, you should make sure the battens are fair before you start to install the lining material.

CHOOSING THE MOULD LINING
When all the battens are installed and you are satisfied with the fairness of the mould, the next job is to install the lining. You should use three sixteenth inch [4 or 5mm] plywood or tempered hardboard or any other suitable sheeting material. If you use plywood it will need to be coated but be sure that the coating is compatible with the fibreglass – do a test. From this stage onward work closely with your fibreglass materials supplier and take his advice on the correct wax and release agent to use on the mould.

INSTALLING THE MOULD LINING
No matter which mould lining material you choose, it will need to be attached to the battens with contact cement. Nail only where absolutely necessary as the nail heads will show up in the finished laminate and can be difficult to fill. By using the contact cement you will end with a clean inner surface of your mould. Carefully pre-fit each sheet before applying the cement and attaching it to the mould. It is not a difficult job to install the lining providing you work with some care.

FINISHING THE MOULD
Once you have installed the mould lining, you should fill any small gaps with mould wax. Radius any areas where you need to have rounded corners. For this job, you can use body filler or any other polyester based material that is compatible with the fibreglass laminate you will be installing.

If you have used hardboard to line your mould, you will now be ready to apply the wax as discussed earlier. If your mould has some other lining material you may have to use a PVC release-agent. You should talk to your material suppliers about the most suitable system.

INSTALLING THE LAMINATE IN THE EZI-BUILD MOULD
Even if you later intend to paint the hull the most important part of the laminate is the gelcoat and first layer. We would recommend you use some form of gelcoat, either pigmented or clear.

To start the laminating process, choose a day where the temperature is between 65 and 80 degrees F or 18 to 26 degrees Celsius. Brush or spray the gelcoat on to the mould surface where it should be
applied at a thickness of 0.5mm. You can measure the thickness of the gelcoat by using a special
gauge obtainable from your fibreglass supplier.

Ideally, you should use a clear isothalic NPG gelcoat and back it up with a layer of surface tissue and
vinyl ester resin. This is important so see your resin supplier about getting the right materials if you
want to be sure of increased resistance to water permeation and avoid any possibility of osmosis, at a
later date.

You will need two or three helpers as you start to lay up the hull and it is advisable, for temperature
control, to be at the same stage of lamination each day with each successive layer. If the laminate
overheats from applying too much material at one time, it may cause distortion and pre-release from
the mould.

**FIRST LAMINATES**
The day after you have applied the gelcoat, you should apply the first layer of light chopped-strand
mat, usually ½ ounce per square foot [150 g/m²]. This layer is very important and should be carefully
rolled out to avoid any chance of air bubbles. Air bubbles in any layer are a nuisance but in the first
layer, they could lead to problems. Vacuum bagging is one solution to avoiding these voids – see
chapter.

Once the gelcoat and first layer of mat are in place you will have passed the most critical stage of
your laminating process. Providing you follow some form of temperature control, you should go on to
complete the laminate without any problems. As mentioned earlier, always finish your laminating at
the same part of your hull each day. Three willing workers can lay up a fifty foot [15 metres] hull in
a few days. Two layers of fibreglass per day, one mat and one roving, is a reasonable amount to install
at one go without causing the laminate to overheat. New resins are being formulated all the time so you
must have the latest technical data and support from your materials supplier.

The number of layers of mat and roving required will be shown in your plans. After the layers that
cover the whole hull surfaces are completed, you will most likely be required to install extra layers in
the areas of the keel and below the hull waterline. Most laminate schedules call for overlapping and
or interleaving the various layers in the areas such as the chine and keel, thus building up extra strength
where it is required.

Again, we remind you to trim the sheerline of your hull each day. This will usually be done as work
progresses and about an hour after the final layer for the day has been installed. Once you have
installed the basic laminate and any extra layers called for in your plan laminate schedule, you should
add any stringers, sole shelf, deck shelf etc and any other reinforcing members called for in your plans.

You should then install all the ribs, stringers, bulkheads and web floors before you remove the hull
from the mould. After you have completed the installing of the stringers and ribs etc and if you do not
plan to use the mould again, you may prefer to remove only the mould above the chine or water line,
leaving the bottom section to act as a cradle.

**EZI-BUILD SANDWICH HULLS**
If you are building an Ezi-build sandwich hull, then you will lay up the outer laminate plus any extra
layers in the critical areas, before you install the core material which may be PVC foam or end grain
balsa. In either case, the best method to install the core is to use Vacuum bagging techniques that are
described elsewhere in this book although the core can be installed manually. If you intend building
a sandwich hull, please read the chapters on one off building, where you may pick up a few ideas on the
handling of core materials.

**PANEL CONSTRUCTION**
The panel method of building a one off fibreglass boat is a variation on the Ezi-build technique. The
method is ideally suited to building chine hulls including catamarans and any power boat or single or
multi-chine sailboat hull. The main advantage of using this technique is that a full mould is not
required. You will retain the advantage that a minimum of finishing is required for the outer surface
of your hull. Very little filling and sanding will be needed to achieve an excellent professional standard
of finish.

For panel construction, the system of building the female frames and setting them up on a set of bedlogs,
is similar to the methods used when building an Ezi-build mould. Only a few battens are required to
hold the frames square and vertical. The technique of setting up the basic framework to hold the fibreglass panels is similar to the first stages of building the Ezi-build mould. The fewer battens required and the absence of a mould lining material, are the main differences between the Ezi-build and the Panel methods.

Additional bracing is used on the outside of the frame assembly and once the frames and the few battens are installed, the mould is ready for the fibreglass panels. The success of the Panel method depends upon the builder obtaining accurate information such as computer generated full size patterns for the frames and either patterns or computer lofted offsets for the panels. We have successfully used this method when designing power catamarans and out builders report excellent results using the technique.

LAMINATING PANELS
Once you have the basic framework in place, you can think about laminating the panels. Before you proceed, check over your framework to make sure it is true and level. It is very important that the framework is sufficiently braced to insure that the shape will be maintained during the installation of the panels.

LAMINATING TABLE
First you will have to build a laminating table. The surface of the table is very important as any blemishes in the surface of the table will be faithfully reproduced in the outer surface of your laminate, so it should as smooth as you can make it. The top surface of the laminating table can be made from any one of several materials, however ¼” [6mm] tempered hardboard backed up with adequate framing would be my choice. There are many others to choose from as long as they have a smooth shiny surface and are compatible with polyester resins, should serve nicely. As the sandwich panels can be large, the table top material is best if available in one piece. Check this out as the fewer joins the better. In most cases, you will need to prepare the surface with a wax and release agent. See preparing the Ezi-build mould. Once the panels are laminated they are laid inside the framework and joined together.
The method of making each panel is quite simple, providing you have accurate patterns or offsets for each panel. Using masking tape, mark out the shape of each panel on the laminating table and lay up the required laminate to form one panel. If you are using a core material, it should be installed while the laminate is on the table. Consider which way the panel will need to bend, if any, when it is laid in the mould, before installing the core on your laminate. Depending which brand you are using, cores often take a bend better in one direction than another. Usually only outer laminate and the core are installed while the panel is on the table.

STEPPING BACK THE LAMINATE

The edges of the panels do not receive the full laminate or core. These are stepped back from the edges so that after installation, the full laminate can be completed where two panels join. When a panel has been laminated, it is removed from the table as soon as possible. The panel is installed in the framework while it is still “green” as it is easier to fit into place while it still has some flexibility. When you have all the panels in place and they have been joined, the remainder of the inner laminate is then installed.

Some deck parts, cabin sides, cabin tops and other areas of your boat can have both sides the sandwich laminated while the panel is still on the table. This is only recommended in areas where there is a minimum bend required to place the panel in its final location. Installing the interior laminate, stiffeners, if required, and bulkheads etc., follow similar methods to those used in other fibreglass hulls.
FIBREGLASS – LAMINATING THE INTERIOR
This section covers the interior reinforcement required in most single skin hulls, whether they male or female moulded.

SECONDARY BONDING
Before we consider any internal reinforcement, we must consider how we are going to bond this to the hull. The term secondary bonding refers to any laminating where you are adding to the cured laminate. For instance, where you are installing a bulkhead, a web floor, a stringer or a rib, you would be making a secondary bond. If you find it necessary to stop work on your basic laminate for over 48 hours, you will have to make a secondary bond when you recommence the laminating process, although I doubt if most builders would class it as such. Usually, a secondary bond can be as good as a primary bond as long as proper preparation has been made.

In practical terms, it is impossible to build a fibreglass boat without incurring many situations where secondary bonding is required. Providing you understand the process and take due care, there is no reason to expect any problems during construction, or when the boat is finished.

There are several things you can do to prepare a fibreglass hull for secondary bonding. In all cases you should sand the primary part so that no shiny surface, dirt or any other foreign material remains where the new part is to be bonded in place. In addition, the hull interior surface can be wiped with styrene or acetone to remove any impurities and help key the surface for further laminating but, you should talk to your materials supplier about this to obtain the best recommended methods for any particular brand of resin or climatic condition. Always prime coat plywood before you bond it into place.

STRINGERS AND RIBS
Single skin fibreglass hulls will almost certainly require stringers, ribs and web floors. Sandwich hulls may require some stringers and ribs and will require web floors. Your plans will show you what types of stiffening your hull requires and where it is to be located. Stringers and ribs have similar construction. It is normal to install the stringers first and then use an intercostals type of rib. An intercostals is simply a short length of rib between each stringer, running from the sheer or deck shelf down to the sole stringer or sole shelf. The transverse webs take over from there in supplying the athwart ships stiffening.
There is no reason why you should not lay out the system of ribs and stringers with foam and then apply the laminate simultaneously. A problem that may occur is that the foam cores of the stringers and ribs are easily damaged and you would need to be very careful until you have installed some fibreglass covering. A foot in the wrong place and you can do damage. Electrical wiring and plumbing can be placed in these stringers but if there is ever a problem you will never know where it is coming from, as we once found out to our cost, so it may be best to keep the wiring and plumbing external. Wiring can be set into cored deckheads but you have to know where the lights are going to be and some certification authorities are not keen on this.

Stringers and ribs are usually foam cored. Rigid urethane foam of about 2 ½ pounds density can be purchased in sheets of a thickness equal to the depth of your stringers and ribs. Cut this material into strips on a band saw or other fine bladed saw and, if you are careful, you can even use a handsaw. Angle the saw to make stringer cores that are wider at the base than the top. Alternating the cutting angle will ensure there is no wastage. Stringers and ribs can be various shapes to play special roles in the hull. For instance, a stringer that will form a deck shelf will be flat on the top to accept the deck panel, but angled underneath. A sole stringer will be flat on the top and shaped to fit the contours of the hull. The engine bed stringers may be vertical on the inside and flared outwards on the outer sides.

All the shapes can be arranged when you cut the foam into strips, so make sure you have the right materials on hand. The various lengths of foam stringer material are butt joined and placed in the hull where they are quickly fastened into position with a hot mix of resin putty. A few spoon size lumps of putty set about 6 inches [150mm] apart will hold any foam stringer in place until you are ready to apply the stringer laminate.

Stringers and ribs are generally covered with a mix of mat and roving. Some stringers have extra layers of roving on the tip to create an I beam effect. Your plans should give you the laminate requirement for all the stringers and ribs in the hull. When installing the stringer and rib laminate, you will extend it out in varying amount on to the hull surface. This bonding extends out from 4” [100mm] to about 6” [150mm] each side of the stringer or rib. Webs in a power boat are usually arranged in an “egg crate” configuration so they not only stiffen the bottom of the hull, but also support the cabin sole and you can also fit the tanks into this areas.
INTERNAL TANKS
Internal tanks in fibreglass boats are easy to build and make most use of the available space giving maximum capacity for fuel and water in the area selected. Purpose resins have been developed for coating the inside of these tanks and, properly built, they should provide an economic, maintained free alternative to fabricated tanks. Post-curing of the tank resin is necessary in water tanks to rid them of chemical taste and this can be done with the heat from a light bulb. Once they are fully cured they can be filled with water and lemon juice and left until the boat is ready for launching – pump them out before launching to save weight. All tanks should have inspection access.

WEBS
Webs can be made from solid fibreglass which has been laid up flat on a laminating table. An alternate method is to fit plywood or hardboard webs and then install the laminate on either side including the bonding on to the hull. The webs are generally set on ribs or stringers so as not to create a “hard spot” where they meet the hull. The tops of the webs should be fitted with a 1" x 2" [25mm x 50mm] timber or foam rib. Cover this rib with the web laminate, excluding the very top, and it will add strength to the arrangement and provide a landing for the plywood sole. Before proceeding, study the section of your plans covering the installation of the ribs, stringers, web floors and bulkheads. Often the bulkhead positions will govern all the spacing of the transverse webs, so marking out the bulkhead locations is an important step in your building programme. We generally recommend spacing the webs and ribs, if required, equally between the bulkheads, but there may be exceptions to this rule so the best idea is to follow the designer’s recommendations.

ENGINE BEDS
As the bottom stringers are generally installed first it is a good idea to include the engine stringers and beds at this time. The location of the engine stringers, if called for, especially if there is a twin engine installation, will govern the spacing of the other bottom stringers. Engine bed stringers can be all foam and glass construction or they can have timber or steel inserts. You plans should specify the recommended method(s) for building the engine beds for your particular boat. Size of the engines, both physical and by horsepower ratings will be important factors in deciding just how you build the beds. There are special high density cores available for this purpose - check with your supplier for details. Overkill in this area is recommended.
Usually engine beds have a laminate that consists of alternate layers of mat and roving with extra layers on the top of the beds. A required system of athwartships webs is installed to support the engine beds. These webs will be cut away below the engine to allow room for the sump. If you are using a foam and glass, or a foam glass with timber or steel inserts, it is best to build the basic core structure and then laminate the complete structure as one unit. This avoids as much secondary bonding as possible. The area under and around the engine will need to be particularly well covered with interior gelcoat. On smaller boats, engine beds can be made from plywood on edge, heavily glassed and with angle iron bolted to the tops to support the engine. This is a well proven system.

**BULWARKS**

On sandwich hulls where there is a bulwark or toe rail, we recommend that this be solid glass which means that any core material be removed. You will later add stiffness to the bulwark by carrying the deck laminate and bonding up to the top of the sheer. You may also add bulwark posts or webs to complete the strength of the bulwark.

Solid glass hulls naturally have solid bulwarks.

**BULKHEADS**

Once any stringers and ribs are in place, the next big job is to install the bulkheads. In some cases, the bulkheads may be fitted before the webs, where the bulkhead itself serves as a web. Bulkheads are generally made of one or more sheet of plywood. As most boats are wider than the available plywood sheets, you can order pre-scarfed plywood or rebate and glue the sheets although this is not as strong but, with furniture attached, there is little difference by the time the boat is finished. Another method is to make the bulkheads out of more than one layer of plywood. In the case of ½” [12mm] bulkheads you can laminate two layers of ¼” [6mm] and for ¾” [20mm] you can laminate two layers of 3/8” [10mm] and so forth. Stagger the joins of the sheets and glue and temporarily staple together. Before you bond the bulkhead to the hull, be sure to give it a prime coat of resin, where it is to be bonded. This prime coat should extend all around the edge of the bulkhead and about 6” [150mm] on to the bulkhead surface. As you will probably want to paint the bulkhead, at a later time, limit the resin to areas where you will be bonding only. Generally speaking, epoxy resins and glues can be used over polyester but not the other way and it is best to have bare plywood for any bonding and gluing. In many cases, bulkheads will be installed on a rib where an angle joint of fibreglass should be extended for 4” to 6” [100mm to 150mm] on to the hull and the bulkhead reducing a small amount each layer to avoid a hump. A number of holes of about 2” [50mm] diameter may be cut around the perimeter of the bulkhead then chamfered
from both sides to accept the fibreglass. The bulkhead bonding will then be joined from each side, through these holes, greatly increasing the strength of the bulkhead to hull join. Only the main structural bulkheads need to be installed at this stage. These will be arranged so that the tops are allowed to rise far enough above the sheerline of the hull to allow for the shape of the deck and cabin including the cabin top cambers. On larger pleasure boats and on most commercial vessels, it may be necessary to have some form of bulkhead stiffening which will be shown in the plans. In small to medium size boats, the bulkhead stiffening may take the form of the framing for the furniture and joinery, which will be fastened to the bulkhead. It is possible to make the bulkheads from fibreglass using core materials such as Balsa or PVC foam, but our experience shows it is better to make the bulkheads from plywood unless there is some compelling reason to use fibreglass sandwich - such as incorporating furniture into the bulkhead.

INFUSION & PRE-PREG BUILDING METHODS.

Infusion and Pre-Preg methods of building a fibreglass boat are similar in that the both lay-up the mat and woven roving reinforcement materials in a mould. The infusion method then inserts the resin once all the layers of reinforcement are in place. The pre-Preg method is to lay up the reinforcement materials and the resin at the same time but use an oven to accelerate the curing of the laminated part such as a complete hull, deck or other part. Because, certainly in the case of infusion moulding and to a lesser extent Pre-Preg the methods are still in the development stage and capable of being executed properly by a handful of experts. If you want to learn more about these advanced methods then I suggest you obtain a copy of PROFESSIONAL BOATBUILDER see www.proboat.com. The October/November 2006 issue has some coverage of infusion fibreglass techniques together with many other interesting articles on boatbuilding.

LAYING OUT THE SIDE DECKS ETC.

Once the bulkheads have been installed, you can mark out the deck camber, the angle of the cabin sides and the cabin top camber on your bulkheads. Your full size patterns may include camber patterns for the decks, cabin tops and the pilot house but, if not, it is a relatively simple job to accomplish. It is usual for the decks to have the least camber, the cabin tops a little more and the pilot house the most.

When marking out the cambers, start with the deck camber and mark this right across the hull. Next, measure the side deck width and mark it. Now draw in the cabin sides at the correct inboard angle and lastly measure up the correct height for the cabin top and mark in the cabin top camber. The bulkhead should now show an end-on view of that section of the cabin's structure. Mark out all of the bulkheads in a similar manner. Double check everything before you cut the bulkheads to shape and make sure you check you have the correct headroom. It is not advisable to increase the headroom without consulting the designer of your boat.

It is wise to install all of the bulky items into your hull before the deck and cabin top are fitted, so your next steps should be to rough out the interior furniture, fit the tanks, install the engine, ballast and bring aboard any large items that may be difficult to bring through the hatch at a later date. It is also a good time to give some thought to electrics and plumbing. It is relatively easy to run wiring and pipes at this stage – think where your lights and switches are going to be and where you will require plumbing outlets.

TANKS

Once a tank is installed, it may be built-in or removable, you don’t want to have to do anything to it again other than general maintenance so it is very important to do the job right the first time. Diesel fuel tanks can be built from stainless or mild steel, aluminium or fibreglass. Water tanks should be stainless steel, aluminium or fibreglass. Never use aluminium for holding tanks as there are chemicals in human waste that may corrode the aluminium. Both fuel and water tanks can be purchased, pre-made in rigid or flexible synthetic material. I prefer to avoid the use of petrol or gasoline as a fuel for boat engines, or for any other use in a boat but in some situations this may be unavoidable so, be sure you seek professional advice on any such installation and what safety precautions to take. Over the years there have been some bad accidents with petrol/gasoline installations so you cannot be too careful with this fuel.
In fibreglass boats, fuel and water tanks can be made of fibreglass, usually built in to the hull under the floor or furniture – special resins are available for this purpose and, in the case of water, are tasteless. Fibreglass tanks are not difficult to make and can save a lot of money – consult your fibreglass suppliers or boat designer for details. Don’t forget to correctly vent all tanks. The pipe for drawing off the liquid should enter through the top of the tank and not quite reach the bottom. In the case of fuel tanks, there should be a little reservoir around this pipe to stop the fuel sloshing around when the tank is low. If a drain cock is fitted, it should be easily accessible and at the lowest point of the tank. There should be access holes, large enough to allow cleaning of the tank interior, in every compartment. The tops of these access holes should bolt in place and be fitted with a sealing grommet or compound. Thoroughly test all tanks with up to 3 pounds of air pressure and post cure fibreglass tanks for at least 24 hours with a light bulb.

Do not over tank your boat. I have seen some builders turn their boat into a virtual tanker. Today it is unnecessary to carry great quantities of water as the water makers are now more efficient and affordable. If you do plan to carry a sizeable amount of fresh water; for sake of safety, make sure to have more than one tank.

This sketch shows all the elements that go into a marine diesel fuel tank. Water tanks will be similar in many ways. Mild steel is fine for diesel tanks but stainless steel, special plastics or fibreglass should be used in the construction of water tanks. No matter which material you use to construct your tanks, you must test the tanks for leaks before you install in the hull

Estimate your fuel and other requirements sensibly. Flexible tanks made of various forms of synthetic are available and can be useful especially in trailerable boats and for one off long distance trips where the normal tank capacity would be insufficient. Other than trailerable boats, I would not recommend installing flexible tanks as a permanent arrangement. Some builders/owners use them where the irregular shape of an area calls for special consideration and where the flexible tanks is the simplest solution. My advice is to consider all other options before using a flexible tank in other than a temporary situation.
PROPELLER APERTURES, HEELS AND SKEGS

On older long keel boats it was usual to cut an aperture in the aft end of the keel to accommodate the stern bearing and propeller. Today most long keel boats are designed with a metal or timber heel or shoe attached to the aft end of the keel so apertures are seldom cut into the keel itself. In cases where there is not enough room for the propeller aft of the keel and ahead of the rudder, it will still be necessary to cut an aperture.

As it may be desirable to place the engine in your hull before the installation of the deck and superstructure, it is probably a good time to consider forming the aperture or arranging the heel on your hull. If the engine is to be installed at a later date it is still possible to prepare for the installation using a cardboard or plywood mock-up of the engine and using measurements from the manufacturer’s brochure.

The size and location of the propeller will go some way towards governing the angle of the engine (maximum angle 10 deg) and the size and location of the aperture. Next you need to figure out the shaft line. This can be obtained using the simple plywood mock-up of the engine. This mock-up should show the shaft line in relation to the engine and gear box and position of the engine feet. It is possible to buy an angled gearbox but, even though the engine remains level or near the level in the hull, the gearbox will still have to be lined up with the shaft.

The pre-prepared profile mock-up can be arranged so that it is in the proper position relative to the engine beds. Once the beds are installed, the profile can be used, in conjunction with a string line from the centre of the drive shaft to a hole in the aperture to obtain the correct shaft line. In fibreglass boats, once this shaft line is established, you can make a fibreglass shaft tube over a mandrel, with the cutlass bearing in place, and glass the tube in to the boat making any final adjustments through the engine mounts.

There are three types of aperture. One is where the aperture is cut out of the aft end of the keel. The second is where there is a skeg and the aperture is cut out of the skeg or, better still, the propeller is just in front of it and the third, and more desirable arrangement, is where the bottom of the keel is extended in the form of a shoe (heel) which is used to take the lower rudder bearing. The first two types are usually found on sailboats. The third is found on both sailboats and displacement hulled power boats.

Where the aperture is cut out of the back of the keel, it should be cut out so that it will provide room to remove the propeller without having to remove the rudder and the shaft could be slightly offset so that it can also be removed without removing the rudder. The aperture should be of sufficient depth to allow at least 2" [50mm] propeller tip clearance both top and bottom. Once the aperture is cut then it must be reconstructed from foam or timber and shaped to allow the fitting of the shaft tube with fluting above and below the tube to facilitate a clean flow of water around the rudder and propeller.

This photo illustrates a typical rudder and supporting heel. The heel can be steel or steel or timber encased in a heavy fibreglass laminate, about the same weight of glass is used on the bottom of the keel. Note the nice touch by way of the fancy fish on the top of the rudder.
This method of attaching the rudder stock to the stub that carries the steering quadrant inside the hull is one we borrowed from a trawler builder. The method uses keyed and welded flanges joined with 4 to 6 stainless steel bolts which are wired together to ensure that they do not loosen in time. This system makes for simple removal and re-installation of the rudder should that be necessary.

ROBERTS SAFETY SKEG
Back in the late 1960’s when we started to design boats with skegs they seems to be the answer to all steering and handling problems sometimes associated with the long keel / rudder hung off the back of the keel configuration. Alas time has proven that the skeg is one of the most vulnerable items of the underwater area of your sailboat. One solution was the Roberts ‘Contemporary Long Keel’ which has proved to have most of the benefits of the skeg and none of the vulnerability of the normal skeg.
A more recent development in combines the benefits of a skeg and long fin keel arrangement; this is achieved by tying the aft end of the keel to bottom of the skeg by way of a bar or heel.

This is the new Voyager DS 440 hull featuring our answer to problems with skegs. Not only is the skeg considerably strengthened but the propeller is protected from odd lines and kelp that can cause problems at the most inopportunity moments. This safety skeg arrangement will feature on all new sailboat designs where the long fin / skeg and rudder combination is part of the design.

APERTURE IN SKEGS
Apertures in skegs have not been seen for many years and are best avoided. Much of the benefit of the separate skeg is lost when a large area needs to be removed to fit the propeller and bearing. Either the shaft should exit the hull ahead of the skeg or some alternate arrangement should be considered.
In recent years, I have favoured the heel arrangement where the bottom of the keel is extended aft in the form of a shoe to the location of the bottom of the rudder shaft, thus allowing for the propeller and bearing. The shaft should then exit the keel at a location to give the propeller tips adequate clearance.

**Stern Tubes**

You may wish to fabricate your own fibreglass stern tube – if you know a bit about fibreglass, it is not difficult and a fibreglass stern tube in a fibreglass boat is the obvious way to go. Study the illustrations shown here and this will give you a good idea of how this can be accomplished or follow details given in your plans.

**Sailboat Rudders**

The first step in making the rudder is to make a template of the shape using the measurements and other information shown in your plans, plus some check measurements taken directly off your boat. The pattern should allow for the top and bottom bearings and is best made from ¼” [6mm] hardboard or plywood. The rudder stock should be made from 316 grade stainless steel and may be solid round or heavy walled tube. Your plans should give you recommended sizes or you should consult a qualified marine engineer. When welding the tangs to the stock, be very careful not to distort the stock by applying too much heat in any one area so make sure the welding is undertaken in a progressive manner to minimize the chance of distortion. The rudder core may be made of plywood, timber or...
foam or a combination. Foam has the advantage that it is easy to shape and any water that may seep between the fibreglass and steel shaft will no effect. When the core is in place, dress off the rudder to its desired airfoil shape.

Lastly, you will install a heavy laminate of fibreglass to the entire rudder. It is important to achieve a good seal where the fibreglass meets the steel shaft. Epoxy resin would give the best bond between the fibreglass and the stainless steel although most Rudders are still made using polyester and foam as any water inside would have little effect.

**MARKING OUT THE BULKHEADS**

By now you should have your deck and cabin top camber pattern prepared. If you have not already done this look at your plan and transfer the measurements for the deck widths, cabin lay-in, cabin heights etc., on to the bulkheads. Mark out each bulkhead ready to receive the decks and cabin structure.

It is a good idea to cut several temporary camber boards to be used as intermediate supports for the cabin and deck during construction. As it is unlikely there will be enough bulkheads to support the deck structure while you are moulding it in place or, bonding on a pre-laminated section, these camber boards should be installed until the deck and cabin are complete. Temporarily fasten the camber boards to the deck shelf and they will then either support the hardboard form work that makes up the in-place mould, or the parts of the pre-laminated deck as mentioned above.

**BUILDING THE DECK**

There are a number of methods that you can look at to build your decks. You can use an in-place hardboard mould, a purpose built female deck mould on which the deck is laid up in one piece or sections, fibreglass sandwich panel moulded decks or straight plywood sheathed in fibreglass.

**HARDBOARD IN-PLACE DECK MOULD**

This method involves building a timber and hardboard mould on the hull and after the decks and cabin are completed, the hardboard mould is removed in pieces from underneath. This method is well proven and thousands of decks have been built this way. Using the hardboard, you will finish with a smooth interior but the outside will have to be finished. You must sand the exterior of the decks, cabin and cabin top to achieve an acceptable finish. If you choose, it would be a simple matter to attach any suitable fabric lining material to the smooth interior. Think of this option as a male moulded deck and superstructure.

The camber boards or temporary deck beams are cut and installed at say 24" [610mm] centres by nailing to the deck shelf. Next install sufficient longitudinal battens or deck stringers to support the hardboard lining. Generally stringers should be about 9" [230mm] apart and these are checked into the temporary camber boards. You can expect to use ¼” [6mm] hardboard or a similar material. While we refer to hardboard in this text, you may be using a similar material such as melamine coated plywood however, to avoid confusion, we will refer to the lining as hardboard. The whole structure of camber boards and stringers should be set ¼" [6mm] or at a thickness equal to your lining material below the upper surface of the deck shelf. This is so that the fibreglass laminate will run smoothly from the hardboard lining material across the top of the deck shelf and go on either up the bulwark or on to the exterior of the hull to form a “Coffee can” hull to deck join.

Nails should be kept to a minimum when fastening the hardboard to the framing for the in-place deck mould. Any nail heads will show (unless covered with a lining material) on the finished laminate from inside. Fasten the hardboard to the framing using contact glue.

The upper smooth face of the hardboard will provide the surface on to which you will laminate the deck. Study the sketches shown here and your plans which should give you sufficient guidance for the deck join and other features of fabricating your particular deck and cabin. You will note that there are certain areas that the hardboard will not cover for a particular reason. It will only extend out to the inboard edge of the deck shelf because as you laminate will go from the hardboard and bond on to the top of the deck shelf.

After all of the hardboard sheeting is completely installed, remove any unevenness by placing bracing under the formwork. Radius all edges and corners a minimum of 3/8" [10mm] – these radii will need
to be fine sanded and coated, with two or three layers of polyurethane to make them non-stick for the fibreglass laminate. This radius can usually be achieved through the careful application of resin putty (bog) using a putty knife with a rounded end. Cabin top edges will have to be formed from an easy-to-sand timber.

Once you are satisfied with the finish of the formwork for your deck and superstructure, you should then cover all the hardboard surfaces with four coats of non-silicone wax polish—consult your fibreglass supplier for the correct material. Allow at least one hour drying time between each coat of wax. Pay particular attention to the corners and joins. The areas to be waxed are those where you will later want to remove the formwork such as the hardboard and any special shaping you have arranged for the corners. When the final coat of wax has been applied and polished, you should then coat the entire area to be laminated with a PVA release agent. Talk to your resin supplier about the supply and use of this material.

Do not wax or cover with release agent those areas where you want the fibreglass resin to stick to the surface. Areas such as the top of the deck shelf, tops of bulkheads, the toe rail, the hull sides where the laminate will be bonded to the hull, either outside or inside the bulwark, or any other area where you want the fibreglass of the deck to be bonded to an area of the hull or elsewhere as noted.

These sketches illustrate several areas of the temporary deck and superstructure mould and later mouldings including several areas where the inner laminate come together and the use of core material is not appropriate.
PLYWOOD PADS
Now is the time to consider where you are going to place any plywood inserts to allow for later through bolting of the various fittings. The ply inserts should be the same thickness as the core material and the fittings will include such items as chain plates, stanchion bases, windlass, bow fittings, cleats, sail track, winches and mast step or where the mast will go through the deck in the case of a keel stepped mast. The plywood pads may be only slightly larger in area than the base of the fitting concerned. The idea is that the plywood will not crush, as might happen with foam or balsa, when the fitting is through bolted and the bolts tightened. Although balsa core has excellent compressive strength, it is not equal to the type of strains imposed by through bolting the fittings. At this stage, you can make up all of the plywood inserts, mark their location, and identify each piece before they are put aside ready for installation at the same time as the core material.

APPLYING THE DECK LAMINATE
The first job in fabricating the deck will be to install the inner laminate. The inner laminate will consist of a varying number of layers of mat and roving. The number of layers will depend on the type and size of your boat however the laminate should be clearly shown in your plans.

This drawing illustrates the various layers of the mould and deck and cabin structure, Note, framing, battens, Masonite or plywood, inner fibreglass laminate, core material and finally the outer fibreglass laminate. Some filler and considerable fairing and sanding will be required to complete the job.

INSTALLING THE DECK CORE
Before installing the last of the mat, check over the laminate and carefully sand off any humps or bumps. When you are satisfied with the evenness of the laminate installed so far, simultaneously install the last one or two layers of the mat and the core material. The core material will usually be ½” or ¾” [12mm or 20mm]. The core material, usually end grain balsa or PVC foam comes in sheets that are usually made up of small squares of material attached to a scrim cloth and in most areas you can install complete sheets however, in some areas such as the cabin sides and cockpit you will need to cut the sheets to fit. It is a good idea to prepare one area at a time, say one third of the deck and cabin area can be pre-fitted with the core sheets. These sheets should be numbered and laid out in an area
Where they will be placed and in a manner similar to which they will be applied to the deck and cabin. It is necessary to work quickly when installing the core so everything should be well prepared.

When installing the last layers of the Mat before the core is to be fitted make it a resin rich layer as some resin will be absorbed by the core material. Next, lay the core sheet on the wet mat and apply enough pressure to feel that the balsa is well bedded. The resin should squeeze up between the joint in the blocks and where the sheets join. It may be necessary to use a system of weights to hold the core in position. This should only really be necessary in difficult areas, such as where there is excessive camber or where you are installing the core where it will not lay smoothly in position. It is a good idea to use plastic sheeting under any weights, so that the weights do not get glued to the core surface. You may want to look at using “Vacuum Bagging” to install the deck core – see later chapter.

Once the core is installed and the resin has cured so that the core stays in place, then fill any gaps with resin putty and seal the top of the core with two coats of resin. You can then lightly sand the surface to remove any rough edges and other irregularities before proceeding. If necessary, you may also use a resin putty screed to smooth out the surface however do not overdo this as you may impede the bond between the core and the outer layers of the laminate – your materials supplier should be able to advise you at this stage. The more attention you pay to achieving a smooth surface to the core the easier it will be to end with a smooth outer and final surface finish to your deck and cabin. Some designs may suggest solid glass cabin sides, cockpit sides and coamings but stick with the core material, if possible. On some occasions you may be required to apply the core to near vertical surfaces. Depending upon what material you are using the answer to this problem and any others should be in the manufacturer’s brochure or available from your supplier.

Once the core is in place and dressed off to your satisfaction, it is time to install the final outer deck and cabin laminate. Use the same techniques here as suggested for laminating a male moulded hull. There is no point in installing more laminate than your plans specify. You will do more harm than good if you put in extra layers causing excessive weight in the wrong place. This will be your last opportunity to even out your laminate and make life easy when you come to the final finishing of your decks and superstructure. Once you have installed the outer laminates then it is time to consider finishing the surface using similar techniques to those explained in the chapter on building male moulded hulls.

**DECK TO HULL JOINS**

When considering the deck to hull join there are three possibilities that we have available - chemical, secondary and mechanical bonding. It is common to use at least two, chemical and mechanical or secondary and mechanical however secondary bonding on its own is the most common and is usually sufficient.

The chemical bond is where the deck is bonded to the fibreglass of the hull structure whilst they are both in a “green” state but this is difficult to achieve as one would have cured before a chemical bond is possible. If too much time has elapsed between the lamination of the hull and the installation of the deck, you will not achieve a true chemical bond. Secondary bonding is more common where the two surfaces have been sanded and cleaned in preparation for the join – if necessary, read again the earlier text on “Secondary Bonding” before you go further. We have made test panels to simulate a secondary bonding and in destruction tests, the laminate has usually failed elsewhere before it failed at the join.

Add to this a mechanical join, which is achieved when the toe rail is bolted through the hull and deck laminates where they meet at the sheer or where the rubbing strip is bolted through the deck laminate which has been brought over the edge of the hull. Another join can be made when bolting the rubbing strip through the deck shelf and any inner bonding that joins the underside of the deck to hull. So now we have the possibility of bolting both vertically and horizontally!

**LAID TEAK DECKS**

It is possible to install a teak deck on top of the fibreglass deck but this means screwing into the fibreglass laminate and possible leaks, at a later date. Keep the thickness of the teak down to say 3/8"
[10mm] and install the teak planks using a marine polysulphide or epoxy. The grooves or spaces between the planks should be filled with polysulphide. There are specialists who do this type of work and so it may be worth while employing the expert for his experience and specialised knowledge.

Here we see how laid deck planks are nibbed into the centreline king plank. See text for more details. Photo by permission of Rob McGill and Nina Morissette.

SEE MORE IN CHAPTER 7 ON TREAK DECKS.

A teak deck does provide a great finish to any boat. Fortunately there are now composite non-timber ‘look alike’ teak decking materials available which allow to have a simulated teak deck without all the associated problems of the real thing.

NON-SKID DECK FINISHES
All horizontal surfaces and anywhere where a person might place a foot should be finished with non-skid. This can be achieved using either a prepared deck paint which incorporates pumice or other non-skid material, or by applying fine clean sand in the last two coats of the outer surface paint. Washed, coarse beach sand is probably the most effective and can be sprinkled on to the deck through a stocking or a tin with holes punched in the top. The sand is applied to the penultimate coat and areas around the cabin, hatches, winches and coamings should be masked so that you have a clear area when applying the final coat. Another method is to apply one of the synthetic or cork based non-skid materials which are sold in sheet form and are cut, fitted and glued to your decks.
No matter what method you use to create a non-skid surface, make sure you arrange the non-skid material in such a way as to provide small sections, strips or panels of smoothly finished deck around the edges of the sheer, around the inner surface of the decks where they meet the bottom edges of the cabin sides. There should be a small smooth strip around all hatch coamings and areas where fittings are to be installed. Check out other boats, you can obtain many ideas from the boats you see in the local marinas.

Before you finish your decks, you should consider your hatches. If you are going to fit commercially made hatches, do not cut the hatchways in your deck until you have the items on hand and can make accurate templates or take proper measurements off the hatches themselves and leave a clear strip around the hatch.

There are several different composite materials available in a variety of materials that have been specially formulated for use as non-skid deck covering. The diamond tread material shown is a popular choice.

**REMOVING THE MOULDING MATERIALS**

Once the decks and superstructure are complete, it is time to remove the inner timber and hardboard formwork. First, carefully remove all the timber camber boards and supports and the longitudinal stringers – a lot of this material may be useful in framing the furniture so save what you can. You will find some longitudinal stringers and pieces of hardboard locked into the structure by the bulkheads, so very carefully saw or cut through on either side leaving the small piece intact above the bulkhead. You could use a very sharp knife or a saw set to a very fine depth to cut along the edge where the hardboard will be later covered with a trim strip or bonding. Some glue can be added, if necessary, to fix this remaining piece in position or, leave it to be covered with resin putty before finally bonding the bulkheads.

**BONDING THE BULKHEADS**

After you have removed all the form work it is time to consider the bonding of the bulkheads to the under side of the deck, cabin sides and top. If you are not going to cover the bulkhead, you may want to mask them off parallel to the areas where the bonding is to take place, and trim the glass as it cures, otherwise the bonding will have an untidy edge. Normally the bonding will extend three or four inches
[75mm to 100mm] on to the bulkhead and to the deck or cabin side or top. Make sure you thoroughly sand and clean the areas where a residue of wax or release agent would inhibit the bonding.

Once the inner bonding has been completed, you have basically finished the building of your decks and superstructure. You should now look at forming the furniture and consider what type of lining material, if any, you will use to finish the interior. There are many attractive and serviceable types of lining for fibreglass boats. Some builders like to use a short pile carpet that is glued to the interior, or you may choose one of the foam backed vinyl materials or, go the traditional route and install timber lining – tongue and groove timber looks good and is relatively easy to fit and, last but not least, a simple gelcoat and paint finish looks good. Too much timber trim in a boat can make it excessively dark below. In the areas where the bonding between the hull and the bulkheads and between the underside of the deck head has been done, you may want to install a timber trim strip to cover the join. While you have been planning and building your boat, you should spend some time looking at other boats for ideas. Pay particular attention to the various fitting out and finishing techniques.

**SANDWICH DECKS AND CABIN**

For sandwich decks, the choice of core material is either PVC foam or end grain balsa. Check with your suppliers for the best material to use. There are now some PVC foams that are suitable for decking. The thickness of the core and the laminate requirements should be specified in your plans. Your plans should also clearly show if any supporting beams and girders are required. A well-engineered sandwich cored deck should not require extra beams – the strength is in the sandwich and the supporting bulkheads. Boats over 40 feet [15 metres] may require some reinforcing in the deck especially if built to survey.

**MASTER DECK MOULD**

Your first job should be to cut the master camber board; sometimes your full size patterns will include this otherwise, you will need to draw out the camber from measurements. You should make up a full width plywood or timber camber pattern. By using a wide plank, which can be edge laminated to a suitable width, you can make both male and female patterns with the one saw cut.

Next job is to build the master deck mould. This mould will serve to mould for all the deck and cabin top panels and even curved cabin fronts can be laminated on this mould. Make the mould wide enough to fit the widest section of the deck or cabin on your boat. This may be the aft deck, poop deck or perhaps the cabin top. On sailboats and on some power boats, the camber is often greater for the cabin tops than the deck, however for a power boat with a flying bridge, it is best if the standard deck camber is used for all purposes. The reason for this is you do not want a heavily cambered deck in the flybridge area.

The length of the master deck mould should be a few inches longer than the longest panel required but, as panels can be joined, 16 feet [4.9 metres] long is sufficient for most boats up to about 65 feet or [20 metres]. Build the deck mould without sheer (fore and aft camber) as when first moulded, the deck panels will be flexible enough to bend to the shape of the hull.

Build the master deck mould using similar techniques to those used to build the hull mould. Set up the structure on bedlogs and build the mould with the camber in reverse. Use the female camber boards as the frames and install battens to receive the mould lining. Waxed hardboard will serve well as the mould lining. Attach the mould lining with contact cement and nail only where necessary. Any nails will show up in your finished moulding so try to avoid excessive nailing although most areas will have to have non-skid applied so this is not a major problem. Prepare the mould by waxing with non-silicon wax and, if necessary, apply release agent. Tests can be made to see how well the mould releases.

Place temporary beams across the hull in the areas where the deck moulding may need to be supported – these mouldings should almost be self-supporting straight out of the mould. Supporting beams should be inside the deck shelf so the pre-laminated deck part can sit flush on the shelf. Make a pattern of the section of the deck you are going to laminate and transfer it to the mould. To make the pattern, you can use strips of plywood stapled together to get the approximate shape and then use a spiling block to obtain the exact shape marked on to the pattern or, trim the moulding once it is in place. Use masking tape, to outline the shape on the deck mould.
It is probably better not to use gelcoat as you will have to paint and apply the non-skid after moulding and joining the parts. It is possible to apply a non-skid pattern to the mould surface however this can be tricky and should not be attempted without experience also, you will later be bonding the deck in place and would probably spoil the effect of the mould-in pattern. Use a similar laminating technique to that used for the hull, no more than two layers per day or whatever the manufacturer recommends for the particular resin that you are using, otherwise the deck piece may distort and pre-release from the mould. It is important to remove the deck part from the mould as soon as it can be handled. This means that it will be “green” and can take up the sheer, if any, of the hull. Therefore, make sure the centre of the panel is well supported, camber boards set right across the hull at every 3 feet [1 metre] apart should be sufficient. Check after you install the first piece.

Any deck beams, girders or special stiffening called for in your plans should be laminated on to the panel while it is still in the mould. Allow for the deck shelf when installing beams as they should be shortened by the width of the shelf. If you want to use interior gelcoat, then should be applied to the deck panel while it is still on the mould. Keep the gelcoat away from the edges where it will later be bonded to the deck shelf. Keep any cored material stepped back from the edge to allow the inner and

This illustration of the master female deck mould shows the fore-deck outline marked on the mould ready for applying the fibreglass laminate.
outer layers of laminate to join by way of a tapered edge of the core as shown in the drawings. Side decks can usually be laid up flat on a piece of hardboard on the ground or on a bench. You will be surprised how quickly you can make the deck and cabin with this method.

**FEMALE MOULDED AND PANEL DECKS AND SUPERSTRUCTURES**

If you can build a female mould for the cabin and cockpit you can save a lot of finishing work. This avoids much of the sanding, which is required to obtain a satisfactory finish on male moulded decks and cabin structures. If you are building a boat under 33 feet [10 metres], you may want to consider making a female deck mould that incorporates the deck and superstructure in one piece. This mould would be female in form and would give you a smooth outer surface. The inner mould surface should be covered with a lining material similar to that used for the male moulded methods. Another choice is to build female moulds for the cabin, cockpit and other shaped parts and make the decks as flat panels. These simple moulds are reasonably basic and easy to build using cheap pine and lining with a waxed hardboard.

Single skin decks are not usual on pleasure boats but common on workboats of over 45 feet [13 metres] where a heavyweight system of beams and girders is required to take the extreme loads of fishing gear and deck equipment.

**BONDING THE DECK**

All deck sections and panels should be bonded from the inside and outside. Your plans will should show how many layers this should be and how you should taper the laminate towards the edges to allow for this, when laying up the panels. This will help in avoiding ugly bulges where the deck has been joined. Remember to sand off any residue of wax before attempting to bond the sections. When joining the panels and bonding the deck to the hull it is useful to have a piece of plywood on which the fibreglass can be saturated in a down-hand horizontal position then it can be, carefully, picked up and put in place ready for rolling. This avoids trying to apply resin in a vertical or, worse, an upside down position.

**CABIN SIDES**

Lay up the cabin sides on a single flat hardboard table or similar mould surface. A flat mould can produce many and varied panels for use in the superstructure and elsewhere. The cabin sides can be solid glass or cored sandwich and the procedure is the same as for the decks and cabin tops.

**BULWARK STIFFENERS**

If you have bulwarks on your boat and they are single skin, then you should think about some stiffeners. These stiffeners can be very attractive and give your boat a “Little Ship” appearance. They should be solid fibreglass and the top of the stiffeners should be at least as wide as the cap rail. They should be made so that the water can drain and disperse through the scuppers.

**HULL DECK JOINS**

If you are using the “coffee can” join where the deck laminate is continued over the hull sheer down a few inches on to the hull, then you will need to mask off the hull below the line where the overlap bonding will end. Sand the area of the hull above this line so you will have a good key for the overlapping bonding. As the bonding proceeds make sure you trim each layer cleanly along the top of the tape on the hull side. This will create a fair line with a clean edge that can be covered by your rubbing strip or moulding.

When you are moulding the various sections of deck, it is a good idea to join these on the top of a bulkhead as the top of these bulkheads can be thickened with suitable timber flanges.

Once you get used to the “Ezi-build” methods, you will find many ways to use the methods we have briefly outlined here. Using panel construction combined with inexpensive moulds, will allow you to build just about anything, easily and quickly. There is nothing new in the methods we have described, just the re-introduction and rearrangement of a few techniques we have been using for many years.

These methods described in this book are best used for one off boats or where a limited number only are to be produced. If you are intending to build more than 5 fibreglass boats of the same design, then you should consider building timber plugs and “taking off” fibreglass moulds which would be capable.
of producing any number of hulls and decks. Nowadays, these plugs can be produced through computer modelling which is known by such names as CNC Pattern Making or CNC Milling and which is quick, accurate and painless except to the pocket!

PRODUCTION MOULDS
As mentioned, if you are planning to build a number of hulls, you may want to consider a full production mould. The usual method is to build a plug and, from this, make a mould capable of withstanding long and frequent use. The plug can be made of timber in a similar manner to building a one off timber and batten mould. Cover the exterior with three or more layers of plywood and then sand and paint. The plug must be perfect on the outside, but underneath the construction can be rough and ready as the plug only has to last until the mould is completed.

The mould is laid up over the plug. First, a parting agent such as wax or PVC release agent or a combination is applied to the plug. Next, a coat of tooling gelcoat and then the laminate is gradually built up to a thickness that will make the mould strong enough to last as long as required. The outside is fitted with foam and glass ribs to stiffen the structure. Finally, plywood and timber, or sometimes, steel is bonded to the mould to allow it to be tilted or set on a cradle when in use. Remove the mould from the plug and, if everything goes according to plan, the mould with some final interior finishing is eady for use.

Deck moulds are built in a similar manner. First, a plug is constructed from plywood, chip board or whatever will do the job, then a mould is taken off in a similar manner to the laminating of the hull mould. Give some thought to the hull to deck join which is usually in the form of a flange or overlap. Sometimes, the join is designed to be made under the top of the toe rail. A coffee can join is where the deck overlaps the hull in the manner of the older types of coffee can lids.
If your budget allows, these plugs can be produced through CNC computer modelling which, as already stated, is first class but expensive and can only be justified if you are going to make a certain number of boats.

Fibreglass is only one of several materials you can use to build a boat however it is one of the most versatile and easiest for a person without previous experience to use. I have seen many, indeed hundreds, of beautifully built one off fibreglass boats. Unfortunately, I have seen a few, fortunately, a very few, terrible examples but this applies to any material. Please work towards making every stage one that you can be proud of. This way, you can be assured that the result will have a top resale value and will bring you, the builder, considerable enjoyment and profit.

**VACUUM BAGGING**

It is quite possible to vacuum bag polyester/glass laminates, but there are a few things that you must look at to determine if it’s practical for your application. The vacuum bag process brings atmospheric pressure to bear evenly on the curing laminate but applies no load to the mould so that excess resin is squeezed out and, usually, soaked up in a disposable outer wrap. This technique requires a vacuum bag and a vacuum pump capable of pulling a significant vacuum (at least 25 inches of mercury), and various accessories and supplies. You should allow for the cost of the vacuum bagging equipment, materials (pre-release film, peel ply, breather, vacuum bags, mastic tape, vacuum pump etc.), and extra labour as you will have to finish a complete layer, or two, before the bagging can be applied. This means that you will have to be using a slow cure, low exotherm resin. To offset this added cost, with the correct vacuum, you will gain the advantages of a near perfect resin/glass ratio and have any fumes extracted from the laminate and ejected via the vacuum pump. Until now vacuum bagging has been mostly restricted to commercial use and a few enterprising owner builders.

Vacuum bagging epoxy laminates is more common as the cure is slower and the strength/weight ratio, usually, more critical. With polyester/glass laminates, it is more usual to use vacuum bagging on the core (dry bagging) rather than on a solid fibreglass laminate. Vacuum bagging allows cores to be bonded in place with minimal amounts of adhesive. When you compress fibreglass under vacuum, you can lose up to 30% of the thickness, which will greatly decrease the stiffness so coring the laminate may be the only way to go. Your materials suppliers should be able to supply most of the equipment and advice that you will need for vacuum bagging or tell you where to get it and, possibly, advise where you can see the technique in operation.

**BULKHEADS**

At this stage your bulkheads should be installed and standing square above the sheer. The first thing is to mark out the width of the side decks and, to accomplish this, it helps to mark the camber right across the boat from sheer to sheer - this way you will get an even camber. Later you will mark the amount of the cabin side lay-in and the height and camber of the cabin.

Now is a good time to check the headroom. Do not be tempted to increase the headroom without checking with the designer. An inch or two [25 to 50 mm] of extra headroom may spoil the line of the boat whereas it may be possible to lower the sole before raising the cabin.

If you find you need more headroom it should be done in increments, partly by lowering the sole, partly by raising the freeboard of the hull and partly by increasing the height of the cabin sides so talk to the designer as it is his job to consider all aspects of changing any design especially where the changes may affect the stability of the boat.

Next mark out the cabin top camber and the lay-in of the cabin sides and you now have a sectional view of the side decks and cabin structure. Note: the cabin top camber is usually greater than the camber used for the decks as too much deck camber may lead to more problems than having too little. You could find that you may not be able to work on the decks or cabin top in any sort of a seaway without the possibility of sliding overboard.

**CAMBER PATTERNS**

Any camber is part of a large circle. For decks, a camber of 3% of the boat’s beam is normal. For cabin tops, 5% of the width of the cabin top is the maximum recommended. Cambers have reduced in recent years as modern methods, materials and higher freeboard makes it unnecessary to have the larger
cambers that were fashionable in the past. For power boats fitted with a flybridge, the cabin top camber should have a maximum of 2%.

**INTERIOR JOINERY**

Once you have installed the bulkheads and the sole, the techniques used to fit out the interior of a steel, fibreglass or timber boat are all very similar. A considerable amount of the joinery is attached to the bulkheads and the sole but where the joinery is attached to the hull, you must make special provision for this attachment depending on the hull material. Fibreglass is probably the easiest as it can be bonded almost anywhere, steel and timber need purpose grounds put in place to take the furniture.

Making a cardboard ‘mock-up’ of parts of the interior joinery is an excellent way to see how various items will work out in practice. The chart table shown here that is located ahead of the bunk-head, is a typical example of how to test out your accommodation arrangements.

**SUGGESTED JOINERY DIMENSIONS**

The dimensions of the human frame have changed considerably over the past years so we have to adjust accordingly. When I first started to build and later design boats, a berth with an overall length of 6'2" [1.88m] was considered adequate. Today, the same berth would be expected to measure around 6'6" [1.98m]. Here are a few measurements that I would consider relevant today.

Single berths should be 6'6" [1.98m] or minimum of 6'4" [1.93m] long and 2'6" [7620mm] wide. The width may be narrower at the extreme head and foot. The main width requirement is at the shoulders. Double berths should be 4'6" [1.37m] wide although two friends can manage with 4'3" [1.29m]. Most people will be familiar with the various measurements of Queen and King size beds and today I am often called upon to include these large size berths, especially when preparing plans for power cruisers. Queen size berths are usually 5'0" [1.52m] wide and 6'6" [1.98m] long. The space between upper and lower berths should be 21" [533mm], seats should be 18" [457mm] wide and between 12" and 18" [305 and 457mm] from the sole. The higher the seat, the less foot room is required. Seats require 3'6" [1.07m] headroom and 24" [610mm] frontage for comfort. If seats face each other, then 30" [762mm] foot room, although this is sometimes difficult to obtain in small boats. More time is spent sitting than standing so seating comfort requires a fair amount of consideration.

Clothes lockers should be at least 16" [406mm] in width or depth with a height of 40" [1.016m]. Ice boxes should be as large as the space available permits and have a minimum lining of 3" [75mm] of insulation. A well-built ice box is a creditable alternative to a freezer. The minimum size for a sink is 10" x 10" x 6" but larger is preferable. The sink should have at least 15" clear space above. Deep
sinks are to be preferred especially in a sailboat as the heeling can considerably reduce the working depth. If you are going to be sailing with your female mate, please ask her advice about laying out the galley. The standard height for tables is 28" [711mm] above the sole or 12" [305mm] above the top of the seats. 24" x 18" [610 x 457 mm] of table space is required for each person.

Galley work benches and sinks should be at least 15" to 18" [380 to 457 mm] wide and 36" [914mm] above the sole. Drawers should be no more than 9" [228mm] deep and the maximum dimensions should not be more than 30" x 20" x 9" [762 x 508 x 228 mm]. If the drawers are narrow, say 8" [203mm], then the depth may be increased to 15" [380mm]. Try not to make drawers too big as they can be unmanageable at sea. Make sure you include safety catches or special slide arrangements so the drawers stay closed in rough weather. The maximum pitch for ladders should not exceed 60 degrees and long ladders should rise 7" to 9" [178 to 228 mm] per step and each step or tread should be at least 7" to 10" [178 to 225 mm] deep. Hatches should be a minimum of 18" x 18" for ventilation and emergency use. All the heights given assume you have standing headroom in your cabin.

SAVING CASH
Try and think of ways you can save money on your fitting out programme. For instance, the mould from your fibreglass hull should supply some timber that can be reused for framing up interior joinery. If you plan ahead, you can use certain size timbers for the mould and setting up that can be either re-sawn or used as they are for another purpose at a later stage.

Tongue and groove flooring can be a very inexpensive and rewarding fitting out timber. Second hand timber can also be very useful. In my own early days of boatbuilding, we used to build all the fibreglass male moulds out of reclaimed house timber. Some recycled timber is better quality than you could possibly find as new stock in your local timber yard today.

For the construction of the saloon table, we would recommend the use of two sets of stainless steel or aluminium tubes sized so one fits inside the other. The larger tube has a thumb screw fitted to position the height of the table as required. Alternatively the table can be hung from a bulkhead leaving the sole space clear. With a reasonable amount of planning, a table of this type can yield as much useful space as a fixed table and, possibly, double as a cockpit table.

UPHOLSTERY
The bunk and settee cushions can easily be made at home with the use of a modern sewing machine or, they can be purchased from your local tent or bedding supplier. There are big savings to be made with a bit of shopping around for mattresses and cushion material and coverings and curtains.

LINING MATERIALS
If you intend to display all the interior hull surfaces, whatever building material, there will be a lot of extra work making them presentable so, interior lining is worth some thought. There are a wide variety of lining materials used to cover a basic fibreglass or steel hull. Quite often a wooden hull is deliberately left on display with dramatic effect. Lining materials can include vinyl, foam backed carpet, heavy cloth or timbers such as tongue and groove or pre-surfaced plywood veneer. I have seen ceramic tiles used to good effect in galley and stove areas, especially in traditional boats. Depending on what finish you use, you can often run your wiring and plumbing behind the lining.

Around the edge of the lining, trim strips or quad or other cover strips, including plastic, can be used to hide any joints and, in fact, the cover strips can be a feature in themselves. A vinyl, Laminex or Formica backed deck head with teak cover strips can be most attractive and relatively easy to fit. There are materials especially designed for these jobs and these can usually be found at your marine store or marine upholsterer.

Some vinyl materials give a really professional finish and are relatively easy to apply. These materials are made from expanded PVC and are available with an inlaid or printed pattern. This type of material is fully flexible and has a closed cell structure, particularly suitable for lining the interiors of boats. These specialised lining materials fit easily around corners and projections and can be bonded to almost any surface. It is usual to leave the lining installation until the boat is almost completed. This allows you to install any last minute, plumbing and electrical wiring without disturbing your finishing materials.
This attractive deck head lining arrangement of vinyl covered panels set between timber beams makes an attractive cabin or pilot house top finish in this area. The individual panels can be removed for inspection of wiring etc.

This attractive layout graces part of the interior of a beautifully built Roberts 532. The joinery and upholstery in this boat is to the highest standard possible and a credit to the builder.
READY MADE JOINERY
Ready made interior joinery such as pin rails, shelves, locker doors, drawer fronts, handrails, special timber mouldings, etc., usually in teak, can be purchased ready-made from specialist timber outlets or importers and are a great time saver and make economic sense. These items are not cheap, but will give your boat a professional finish, which may pay handsome dividends when you sell at some future dates.

Some builders go to the trouble of making wooden patterns for casting cleats, ports and other hardware at a foundry but, unless this is for a particular reason/hobby, it is usually cheaper and quicker to buy from the vast ready made selection of castings available these days from your local chandlers.

Unfortunately, space restrictions do not allow me to cover the fitting out with the amount of detail that the subject requires. At a later stage, I hope to devote an entire book to the subject. Until then, you can find several alternate publications that will be of great assistance in this area.

Finally, avoid using your boat before the fitting out is complete. It is almost impossible to use a boat and complete the interior simultaneously. If, for some reason, you can’t avoid launching the boat before it is finished, then make sure you fit out one area completely before starting another. Take your time with the fitting out process. You will never regret it.

OTHER CONSIDERATIONS
During the fitting out, there will be many things to consider in an orderly fashion, such as fire fighting equipment, drainage of bilge water to collection points, bilge pumping systems, ventilation, electrical installation, plumbing etc. many of these items may be covered in your plans or are subjects of complete books in their own right and are generally too complex to be covered here. Read everything on the subject that you can get your hands on.
ABOVE:
Sea Goat out on a day where there is not much wind, as Adam Szczurowski wrote “Here are some photos of us on a typical family outing”.

LEFT AND BELOW:
Adam Szczurowski designed and made the folding swim platform and davits for his fiberglass Spray 36 SEA GOAT. You will see other photos of Adam and Barbara Szczurowski’s boat elsewhere, especially in Chapter 19.