FIBERGLASS BOATS

3RD EDITION

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Dedication

To my grandchildren, Nichola, Simon, Sam and Hayley. In the hope that helped by this book, builders can be inspired to make good fiberglass boats which will last long enough for them, one day, to buy cheaply and go adventuring; as I did with my beloved old *Crimson Rambler*, built long before I was born and to which I owe much. For no boat, however grand or fast, will ever bring as much fun and adventure as one's first, cheaply bought, old cruiser.

Author's note

Except where stated all photographs are my own but I am indebted to the companies who, over many years, have allowed me to take them, in particular and most recently the help given by Tony Brewer of Bondicell Ltd, Lymington. My thanks also to the many owners whose boats, with or without their permission, I have photographed – usually the nasty parts, as these most interest a surveyor. Some have been my own.

Introduction

'Knowledge discloses to wise men and disguises from fools how little they know'

This is a completely new and rewritten edition of *Fibreglass Boats*, and is confined to general principles and good practice. It does not go into detail like some other books which are a tale of how one amateur built one boat, but is applicable to all fibreglass boats. Or indeed to anything made of fibreglass, from kitchen sinks to church steeples. It also covers the little known basic theory of fibreglass, the way it fails, what it will do, and even more what it will not do, much of it never published before.

It is written in language the average boat owner or boatyard worker can understand. Frightening formulae and equations are reduced to the minimum and simplified, inserted for interest rather than essential reading. No knowledge of chemistry or mathematics is required.

Into the book have gone my forty years' experience of fibreglass boats, principally as a surveyor specialising almost exclusively in fibreglass. Consequently I have far wider experience of the good and bad points of fibreglass, what happens to it over the years, the silly mistakes and even gross blunders that are made, than a builder with his own limited range for a particular market niche.

As before, the book covers how to turn a bare moulding into a strong and seaworthy boat. Then we examine how to keep it that way for our children and grandchildren. Most wooden boats sailing today were built before fibreglass was thought of; it would be a sad reflection on our times if fibreglass boats did not last as long.

Like many other young men without much money my first small cruiser was built in my grandfather's day (and cost less than my present yacht's modest little dinghy! And half the price of the liferaft – despite needing it a lot more!). Will there be boats like that for my grandsons? I hope so, and I pray this book may help. Incidentally that old boat is still sailing and giving adventure to another generation who have not attained the affluence so widely assumed essential to own a boat.

The first edition of *Fibreglass Boats* was written when my daughter was a baby. Now I have grandchildren that age. Fibreglass boats too have grown up and are currently going through a period of development as radical as any in their history. Gone is the optimistic over-confidence of early years. As in life, time and experience bring wisdom. At last we are beginning to realise how little we know. Moreover what *is* known is not known widely enough or else is ignored. Fibreglass is not the slapdash, foolproof process it was thought to be in the early years of boundless enthusiasm, but a very complex material which undergoes subtle changes throughout its life. Until recently, this view would have been regarded as heresy.

Fibreglass has become widely accepted and is now not only the conventional building material for boats but is actually respectable – something which even the most optimistic would hardly have believed possible forty years ago. Unknown millions of fibreglass boats have been built, from dinghies and canoes through to yachts and fishing boats of every size, up to warships of almost a thousand tons.

Owners should never take a fibreglass boat for granted simply because it is made of fibreglass, especially a new boat that has not had enough use to reveal its faults. Moreover they should not assume the boat is automatically suitable for their purpose. Increased lightness of construction and sophistication under the competitive pressures of higher speed at lower cost may mean that it cannot take treatment that would never be questioned on an older, sturdier fibreglass boat.

Most attention nowadays is directed towards current production, new developments and wonder materials. That is of academic interest to the vast majority of owners whose boats are older. They are concerned with what they have now. It is largely for that majority that this book is written.

I am one of the few remaining who can remember the way boats were built ten, twenty, thirty years ago, even the exciting pioneering days forty years ago. Therefore I frequently describe how boats used to be built because that is what is relevant to many of today's owners, as well as boat repairers and surveyors. If you know how boats were made then, the limited state of the art, what was common practice, the often primitive and, by modern standards, unsatisfactory conditions, untrained workers and other problems builders faced, you can understand better what is happening to those boats now.

Some things will be regarded as heretical. But I have been so labelled before. I was one of the first to suggest, in the days of wild claims for 'no maintenance', that fibreglass boats *did* need maintenance and that they would one day have to be painted.

The previous editions of *Fibreglass Boats* were in print for over twenty years with separate editions in Britain, the USA and Russia (during the Cold War too). Wherever I go in my modest cruising style I find boatyard managers with a copy on their shelves, and boats with a copy on board. On desert islands I have met people who said they built their yachts with the aid of my book. May this edition be as useful to as many.

Hugo du Plessis
Yacht Samharcín
Royal Cruising Club

Terminology

Fibreglass is the registered trade name of Fibreglass Ltd in Britain, and Fiberglas, the trade name of Owens-Corning Fiberglas Corporation in the USA (both now under the same ownership) for glass fibres supplied by those particular companies.

In Britain 'fibreglass' has been adopted as the popular generic term for glass reinforced plastics also called GRP. With the increasing use of other reinforcements such as carbon fibre and Kevlar, the term FRP, fibre reinforced plastics, is more correct. But 'fibreglass' (with a small f) is the term which has stuck, whether technically correct or not.

So bowing to general use, I refer to the moulded material as fibreglass and thank Fibreglass Ltd for permission to use the term. Where the context refers to the actual glass fibre reinforcement I use the term glass fibre because those companies are not the only makers.

In a lifetime of sailing, and in particular the world of liveaboard cruising folk in which I now spend most of my time, I have met many lady sailors and lady skippers, including singlehanders. Most have been competent seamen and when it came to boat work good handymen too. Or to use an old term, good ship's husbands.

The use of 'he' or '-man' is in no way meant to be discriminatory. It is common usage in the English language. Therefore unless obvious from the context, 'he' may be taken as referring to both sexes. We are all members of the hu*man* race.

Acknowledgements

I am indebted to many people over the last forty years, whose names are lost in the mists of time. Also those hundreds of trusting owners who asked me to examine their boats. I have learnt something from every boat.

For this edition I thank the many companies who have given help and information despite being of little commercial benefit. In particular Mr A J Horton of Scott Bader Ltd, Michael Taylor of Tyler Boat Company, Patrick Mouligné of R P Associates, Damien Jacquinet of Nidacore, Tony Brewer of Bondicell. Sovereign Chemicals kindly lent me their latest moisture meter for evaluation.

Finally the late Adlard Coles who persuaded me to set one finger to typewriter for the first edition of *Fibreglass Boats* in 1959 when fibreglass was fresh, young and exciting. Also my faithful helpers in those days, Leonard Pilgrim, Kathleen Rixon and Ada Chapman working in the stables of my old family home at Newtown Park.

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A

General principles

Fibreglass is not like traditional materials. Anyone working on a fibreglass boat must have a general idea of how the boat was moulded and the particular characteristics of the material, especially its limitations. This applies whether fitting out a bare shell, making alterations in later years, fitting equipment to a new boat, or effecting a repair.

It is also something the owner should know if he is to maintain and use the boat properly and keep within its limitations – a most important point frequently overlooked. Unlike a sturdy old wooden boat, it cannot be taken for granted that a fibreglass boat can sail anywhere, especially the popular cruiser/racer built to sail faster at lower cost in a competitive market.

A basic familiarity with the techniques of moulding is assumed, just as books on building wooden boats do not go into simple carpentry.

CHAPTER

1

Principles of fibreglass boatbuilding

People talk about the 'fibreglass revolution' as if the material caused the revolution. Not so. The revolution has been in factory production. The demise of the local, waterfront boatbuilder, building one-off boats to order, went hand in hand with the change to boatbuilding factories in industrial areas with a range of standard boats, often subsidiaries of large companies in unrelated industries. Boatbuilding has become big business and the market international.

This development was inevitable to satisfy the booming demand of an affluent society. It had already started with wooden boats. There were redundant wartime factories with the expertise to make aluminium or steel boats, but they missed the opportunity. Fibreglass just came along at the right moment and proved the most suitable material for the new scale of production, while itself requiring that scale to be economic. Now it has ousted wood, the traditional material since the dugout canoe, and has become conventional itself. Technically it is not greatly superior to wood, steel or aluminium and in some respects is worse.

The individually designed, one-off yacht has gone, except for top flight racing machines. Production boatbuilders must sell one design to as many buyers as possible. Builders need to think in hundreds, even thousands, because large capital investment is involved.

Designs must have wide appeal, be fashionable and 'safe'. Consequently they tend to follow similar lines and look alike, strongly influenced by racing and rating rules even for cruising yachts. The market is very competitive and is dominated by the need for performance and comfort. Other types of boats are still built, but outside this fashionable mainstream the choice is limited.

The industry is governed by what can be sold at greatest profit in greatest number, and yet is critically dependent on selling in those numbers. Factory builders cannot fall back on repairs and fitting out as a waterfront boatyard can. Like an aircraft which loses flying speed they will crash. Boats are a luxury market, the first to be hit by any recession. The survivors have generally been those with the best business management and not necessarily the best boatbuilders.

Construction is dominated more by production convenience than best boat practice. In particular, little consideration is given to what can be maintained, modified or repaired conveniently and cheaply in later years. Yachts are no longer built to last, as they were in our grandfathers' day. Now they are consumer durables.

Speed sells. In seeking ever more competitive performance even ordinary boats become lighter and flimsier, as computerised design refines the parameters.

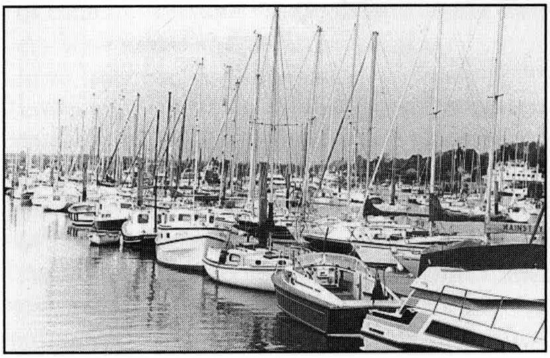
Comfort is the other selling point. Many 'luxury' yachts stuffed with creature comforts have hulls of poor quality. Price is no guide to the integrity of the hull, yet no part of the boat is more important. Since marketing and economics dominate factory boatbuilding we must view fibreglass boats in this light.

What is 'fibreglass'?

What is this stuff, fibreglass, which fills marinas? It consists of two principal components. A thermoset plastics resin, generally polyester but sometimes epoxy, and glass fibre reinforcement. Despite the popular name it is typically about 80% resin and only 20% glass fibre.

The resin is always the major part. Fibreglass boats are really plastics boats. They look, feel and behave like plastics, which gave rise to much contempt in the early days, and scathing remarks about soap dishes, which was not helped by some novel designs. In theory it is possible to make a boat out of polyester resin alone and it would look exactly like a fibreglass boat – as long as it held together. But it is not possible to make a boat out of glass fibre alone. It would be as watertight as a woolly jumper and as shapeless as a wet blanket. Neither material by itself can make a

a



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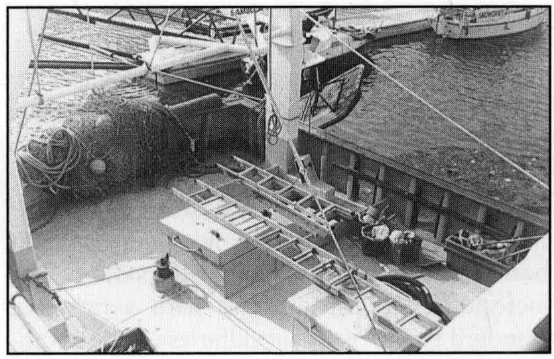

Photos 1.1 (a) A typical modern scene. Row after row of production cruisers, fast, fun to sail but mostly lightly built, designed for performance and comfort below. **(b)** At the other extreme are sturdy, hard working fishing boats handling heavy gear in all weathers. Note the close spaced, massive frames (Photo: Aqua-star Ltd, Guernsey).

boat, but together they form a very versatile and strong material.

The role of the polyester is underestimated. It makes the boat watertight, binds the fibres together without which their strength cannot be captured, and gives the shiny colourful finish we recognise as 'fibreglass'. A more accurate term would be a polyester boat as the French and Germans refer to them. Yet despite being the minor component the glass fibres are still vital. Buried within the moulding they provide strength and toughness, reinforcing the brittle polyester. They are not dissolved, as is sometimes thought when the fibres become almost invisible; as everyone knows glass is transparent.

Composite materials are common. Reinforced concrete and motor tyres are two everyday examples. Most materials in nature are composites too. Wood is a far more complicated composite than anything made by man, who is himself a bone-reinforced chunk of flesh.

Why glass?

Glass is a very inert material. It does not absorb water and thereby swell or rot, it has high heat resistance, and does not burn. Only the strongest chemicals attack glass. It virtually lasts for ever. On the face of it, an ideal material for marine use. Yet, as is well known, glass is very easily broken. So how could glass make anything strong? A very good question.

Glass breaks because it does not bend, as we learn when we are young and try to 'bend' a window with a ball. Yet if it can be prevented from bending, or rather from bending sharply, it is a remarkably strong material in both tension and compression. When embedded in resin, glass fibres cannot bend, so their strength can be captured without their fragility.

You are probably reading this by electric light, brought to you along wires suspended on strong glass insulators dangling from great pylons. But it is as very fine fibres that glass shows its most remarkable strength, 500,000 lb/in^2 or 35,000 kg/cm^2 -- many times more than the strongest steel. However, it has never been possible to capture such high strength in practice, principally because the fibres are very sensitive to notch effect, just as a glazier uses a diamond cutter on window glass. Even touching a fibre is enough to damage it, so the effective strength is only a tenth of the highest theoretically attainable.

There are a few fibres stronger than glass, such as sapphire whiskers (but not Kevlar or carbon) in the realm of aerospace, where the sky is the limit in cost. Yet there is one fibre not only stronger but so common that it is in every household: a spider's web. Scientists are attempting to train spiders to produce webs in commercial quantities and one day the boast for a super racing machine may not be Kevlar and carbon fibre but some exotic cobweb. My house should be worth a fortune!

Making fibreglass

Fibreglass is a man-made material. But so are all others. Even wood, a product of nature, has to be carefully selected, sawn and shaped. The difference is the way these materials are made

Table 1.1 Comparative fibre strength – tensile

	E glass	*S glass*	*Kevlar 49*	*Carbon*	*Dyneema Polythene*
Tensile strength					
lb/in^2 x 10^3	450	600	525	490–700	390
MPa	3100	4140	3620	3400–4900	2700
Tensile modulus E					
lb/in^2 x 10^6	10.5	12.4	18	33–75	12.5
GPa	72	85	124	230–540	87
Elongation to break %	4.3	4.8	2.5	1.5	
SG	2.55	2.49	1.44	1.80	0.97

Note: *Quoted figures can vary considerably according to grade and source, particularly carbon fibre. (Ref: Du Pont,* Kevlar User Guide*); Anchor Reinforcements data.*

into a boat. Wood is bought in planks or sheets of factory-made plywood. Steel is supplied in plates or sections of precisely known strength and quality. Screws and nuts and bolts are bought in boxes. But fibreglass is 'made' on the spot by the user, from polyester resin and glass fibre. It can be compared with making a cake. Moreover, just as there are good and bad cooks, so there are good and bad moulders.

Regardless of how carefully the suppliers of the resin and glass control these basic materials (and nowadays that is pretty reliable) the strength and quality of the end product are entirely in the hands of the moulder who uses them. This cannot be emphasised too strongly.

Polyester resin is supplied in drums in liquid form. The glass fibre comes in rolls. In simple terms the technique is to saturate the glass fibre with resin in a mould so that when the resin solidifies, which it does quite quickly by the addition of peroxide catalyst without heat or pressure, a hard, strong material is formed. Moreover this does not have to be formed to shape afterwards like wood or steel; it is at once in the shape of the mould, and substantially in one piece, not built up from many separate pieces held together with innumerable fastenings. But an absolutely essential requirement is some form of mould or support until it has set.

Although basically easy, the process is so unlike any other that if you have not used these materials before do some trials before tackling anything important. That includes the repair kit you picked up in the chandlery in case it was ever needed. When up the creek is not the time to find out how to use it.

Lamination

A fibreglass moulding is built up layer by layer in a series of laminations, similar to plywood. Each layer of fibreglass is strong but is bonded to other layers by lines of unreinforced polyester resin. There is little intermeshing of the fibres. Considered as a whole, the strength is adequate. But unlike the resorcinol of plywood, polyester is not a strong glue. Therefore the boat's design, especially detail design and

Table 1.2 Comparative strength of materials

	Fibreglass				*Steel*	*Aluminium*	*Plywood*
	Mat	*Woven rovings*	*Design Mat/WR*	*Uni-directional*			
SG	1.5	1.7	1.6	1.8	7.1	2.7	0.8
Weight lb/ft³	94	106	100	112	443	168	50
Glass content % Gc	30	50	40	60	–	–	–
Strength x 10³							
Tensile lb/in²	12	27	18	40	35	20	8.5
N/mm²	85	187	123	277	240	140	59
Compressive lb/in²	17	21	19	24	35	20	4
N/mm²	117	147	132	162	240	140	28
Modulus x 10⁶ E							
Tensile E lb/in²	0.9	2.0	1.4	2.5	30	10	1.2
N/mm²	6.4	13.7	10.0	17.5	206	69	8.3

Note: Figures quoted for the various forms of fibreglass vary greatly, as do the moulding tolerances. These are typical only for comparison. Nowadays the practice is to calculate for the particular lay up and combination of mat and rovings. These values are based on formulae specified in the EEC draft proposals for GRP boats as follows:

Ultimate tensile strength $1278\,Gc^2 - 510Gc + 123$ N/mm²
Tensile Modulus E $(370\,Gc - 4.25) \times 10^3$ N/mm²
Compressive strength $150\,Gc + 72$ N/mm²

Other authorities use different formulae. There is no general agreement.

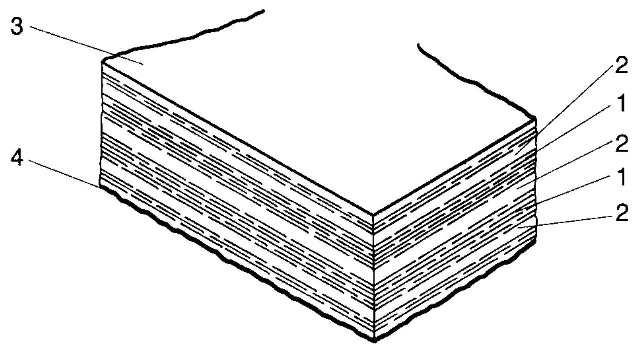

Figure 1.1 Laminates
A fibreglass moulding is made up of layers of glass reinforcement, 1, bonded together with layers of weaker unreinforced polyester resin, 2.

The side that was laid up against the mould with the gel coat, 3, is smooth. The opposite side, 4, uncontrolled by the mould face is uneven.

attachments, must not induce delamination.

When applied 'wet-on-wet' there is good chemical bond and with glass mat some intermeshing. With a largish moulding, however, all layers cannot be made like this because of the time involved. Workers like to eat and sleep. So much of the moulding must inevitably be wet-on-dry, ie new layers on top of fibreglass that is already hard. When newly set, fibreglass is still chemically receptive to fresh resin, but later the bond becomes purely adhesive.

Resin/glass ratio

It is commonly quoted and assumed that the glass provides the strength and the resin just keeps the water out. Therefore the more glass the stronger the moulding. While true in theory, it neglects elementary engineering principles. Stiffness, ie resistance to bending, is proportional to the cube of thickness (Chapter 18). The principal requirement in boatbuilding is rigidity, not high strength, the figures most often quoted. Generally when a boat is stiff enough a boat is strong enough.

Within reasonable limits, for a given weight of glass fibre and therefore strength, a high resin content moulding will be stiffer than a low one. It will also be more damage resistant – a valuable practical characteristic which gets little consideration. The boat will of course be more expensive, heavier and, crime of crimes, slower.

Moulding

A fibreglass boat cannot be moulded in thin air in the way that a wooden boat can be made where only lines on paper existed before. The first stage is to create the shape – a pattern. In effect you have to make two boats in order to get one, although in terms of practical economics it is one boat to get hundreds. The initial shape can be made of anything. It does not need to float. It can be just a shape, a master pattern. Yet as every moulding depends on the accuracy of that pattern, it must be absolutely right. Unlike building wooden boats there is no second chance with fibreglass. Mistakes will be locked in. If wrong, all will be wrong.

The surface finish will be reproduced in exact detail too. Any blemish will be copied by every boat. So a great deal of time, trouble and expense will go into giving the pattern a superb finish.

Traditionalists bemoan the passing of the skills which go into building a wooden boat compared with what they decry as the crude 'bucket and brush' way fibreglass boats are moulded. They overlook the skill required to make the pattern and mould, which is far higher than for building a wooden boat. Paint and putty can cover bad work on wood. But when making the pattern for a production run of hundreds of fibreglass boats there is only one standard: perfection.

From this master pattern is made the female mould, nowadays always fibreglass too. This is a negative mould – the shape of the moulding in reverse; the boat inside out. Obviously the moulding has to come out of the mould and the easier the original shape allows this, the better.

If the finish of the mould is good, every moulding will come out of the mould needing virtually no further surface treatment. This is a great saving in labour compared with the careful preparation, painting and making good required with other materials.

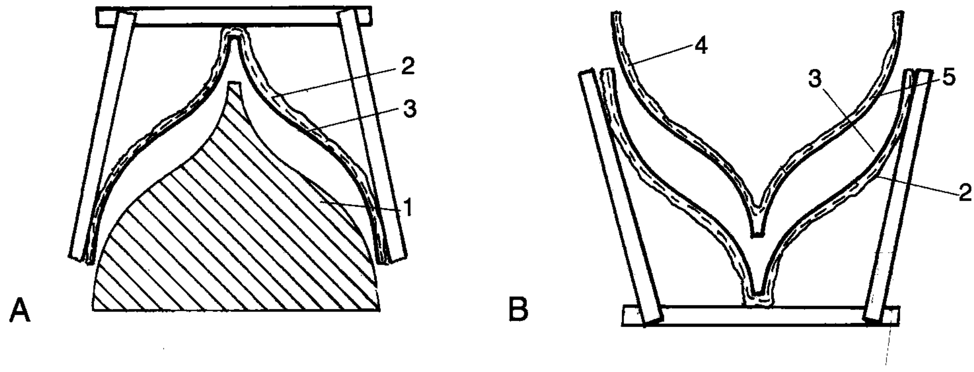

Figure 1.2 Moulding: pattern – mould – moulding
A First is made the shape, the pattern, 1, accurate in size and detail and as nearly perfectly finished as possible.
Over this is moulded the fibreglass mould, 2, the exact negative of the pattern. The gel coat, 3, picks up the perfect finish of the pattern.
B The mould is inverted and in this negative shape is made the moulding, 4, with the exact shape and surface finish of the pattern. Note that the gel coat, 5, is now the outside.

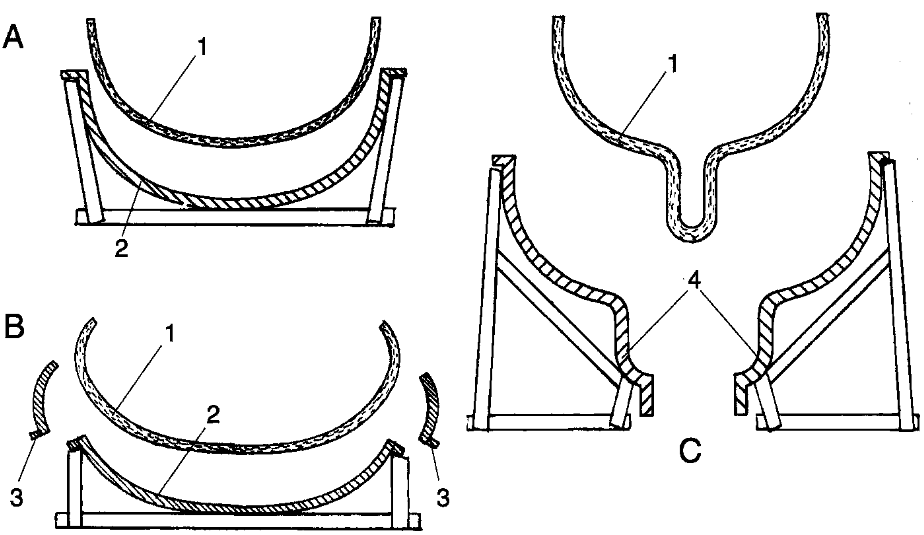

Figure 1.3 Mould shape
A A simple shape, 1, will release from the mould, 2, easily as it is a straight draw.
B If there are undercuts a straight draw is impossible. So the portion causing the undercut, 3, must be detachable.
C Deep shapes are also difficult to release and often made in a mould split along the centreline, 4. This makes moulding easier too.

Seldom realised, by enthusiasts starting off, is the capital cost to make a set of moulds. The shapes are often complicated and parts must fit accurately. A substantial production run is essential to amortise the cost. The price of the boat must be based on a guess of future sales. Then it is sink or swim, which is why a recession sinks so many boatbuilders who guessed wrongly at the state of the economic climate several years ahead. Fibreglass boatbuilding is a risky business.

Mouldless construction, used for one-off boats or backyard building, is a misnomer. A former of some kind is still essential but in this

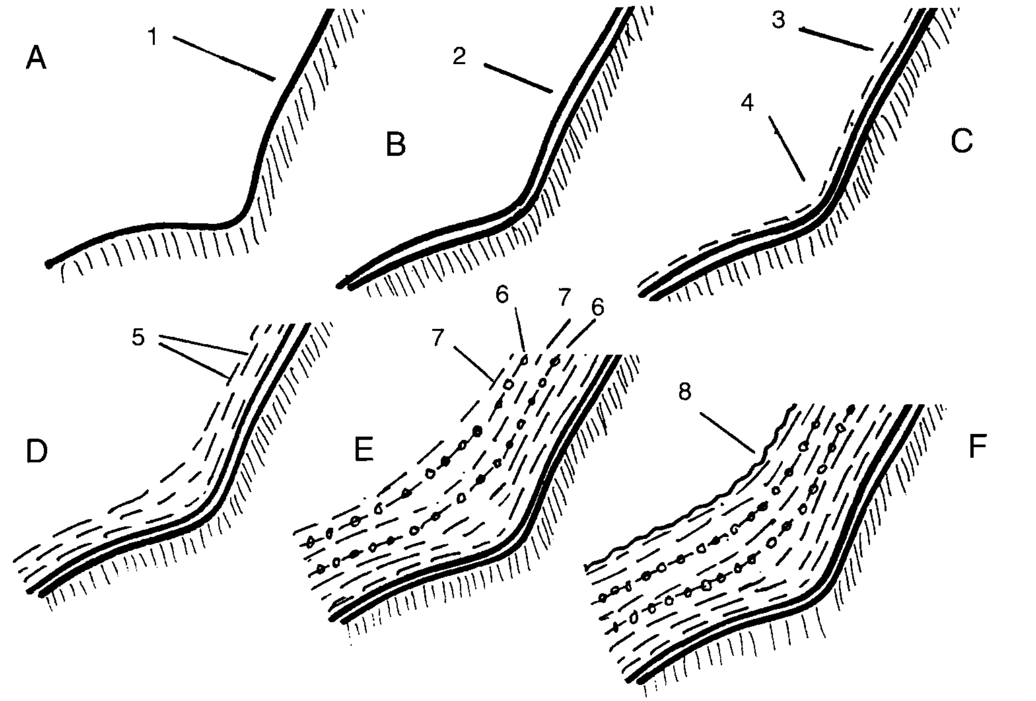

Figure 1.4 Sequence of moulding
A The mould is carefully polished so its own gel coat, 1, will impart a good finish to the moulding. Release agent is applied if necessary.
B The first step is applying the gel coat, 2.
C As soon as possible the first layer, 3, is moulded very carefully. This is the most critical of all. It should be thin mat and must be worked perfectly into features, 4.
D When the first layer has set sufficiently that it cannot be disturbed one or two further layers of mat, 5, are moulded. These may be thicker. Note how the feature is rounding off and becoming easier to mould.
E Now the main structural layers can be built up using alternate layers of woven rovings, 6, and mat; as many as required. The last layer should be mat, 7.
F The final stage is a thick coat of finishing resin, 8. Note how this inner surface is uneven because it is not controlled by the smooth mould face.

case it is a cheap, simple, expendable male mould (Chapter 31).

Fabrication cost

No comparison with other materials is valid unless it considers the cost and trouble of fabrication. Wood and steel may be cheaper but they have to be bought in sheets, sections or planks, made in sizes and thicknesses to suit the supplier not the user. Before they are boat shaped and carefully fitted a lot has to be cut away by various means, all laborious, intensive and energy consuming. Then the many separate pieces have to be joined with innumerable expensive fastenings. Wastage is very high simply because the material is the wrong shape in the first place. Fibreglass, on the other hand, is moulded to size, shape and thickness by the user and needs little more material than is required for the job. There is very little waste, a virtue in a world where conservation is a rising hymn.

As fibreglass is the right shape first time and is in one piece, it means an enormous reduction in the labour cost. In principle it is no more trouble to mould a complicated shape than a simple one.

Gel coat

When moulding a fibreglass boat the finish is put on first. That may sound nonsense, yet it is quite simple. Consider a boat being made in a female mould. What is to be outside must obviously go into the mould first. This is the gel coat (Chapter 24), a thick layer of specially formulated unreinforced resin, which takes up the smooth, highly polished surface of the mould. After this the strength-giving fibreglass layers are built up.

Unlike paint, a different material applied last of all in conventional construction of almost everything else, the gel coat is an integral part of the moulding. It is polyester resin and so melds into the rest of the moulding as it sets and cures.

The gel coat is the only part of the boat which is seen, the familiar appearance of fibreglass – the sales appeal. So it has to be good. Less appreciated is its important role of protecting the structural fibres from minor damage. It is also supposed to keep water out, but of that more later (Chapter 26).

Inside finish

The inside or natural finish of fibreglass is quite different because there is no mould to form a smooth polished surface. Consequently it is uneven and often shows fibres or weave. The inside follows the general shape of the mould but not the detail and thus tends to round off features. Nowadays it is considered ugly and has to be hidden from view. Yet the inside of a wooden boat, with its untidy frames and seams, was considered 'boaty' and rather nice.

Although uneven the surface should be solid and glossy with resin, like 'a summer sea ruffled by a catspaw of a breeze', and reflects the skill and care of the moulder. Bad mouldings are resin starved, the mat has a prominent fibre pattern, even whiskers, and the weave of woven rovings is conspicuous, often with multiple pinholes. Perhaps this is why some builders are so anxious to hide it.

Photo 1.2 Not being controlled by the smooth mould surface, the inside is rough with a fibre pattern. Nevertheless it must be solid with plenty of resin, never fibrous, whiskery or full of pinholes. A glossy resin rich surface is even better. Note the nuts, not glassed over and accessible.

'No maintenance'

In the exciting pioneering days it was claimed that fibreglass boats required no maintenance whatever. That shiny finish would last for ever. (Fortunately this was before the Trades Descriptions Act.) It was probably the main factor making fibreglass popular, or indeed surviving at all in the face of widespread prejudice.

The aura still lingers, although it is more correct to say low maintenance. Certainly the colourful finish is durable compared with most in a marine atmosphere. After ten years or so the owner may consider painting the surface but for appearance only. The gel coat itself lasts the life of the boat.

That at least is the theory and for the topsides and deck is generally true. Unfortunately it has been discovered that gel coats have a tendency to blister underwater; the dreaded osmosis or 'boat pox' (Chapter 26). The fashionable and frequently unnecessary cure is to strip off the gel coat and replace it with something not much better. Yet in most cases the fault lies not in the gel coat, which may be the soundest part of the boat, but in the moulding beneath.

A wooden boat, painted every year, appears each spring in pristine freshness. But a fibreglass boat, denied this annual beauty treatment, must display the accumulated scars of previous years with nothing to hide its shame. That is what the magic slogan 'no maintenance' really means.

Other materials

Because it is easy to mould to shape there is a tendency to regard fibreglass as suitable for every part of the boat. This is bad practice. For many purposes metal and wood are better.

For good design one must think fibreglass, and not slavishly copy other materials. It may be cheaper or more convenient for production to make a part in fibreglass. But will it do the job as well? Will it stand up to wear? First and foremost a fibreglass boat must be a strong, seaworthy, practical, trouble free boat, not just a pretty, easily made, boat shaped fibreglass moulding.

Skill

Despite having become a factory industry, fibreglass boatbuilding has always been labour intensive. Only recently has it been more widely accepted that good moulding can be done only by good workers. Early on it was considered a crude bucket and brush job, on a par with pouring concrete. Being all done in a mould nothing could go wrong. Or so it was thought. Not like the skilled craft of building a wooden or steel boat. It was seldom appreciated that skilled or not, the moulders working in the mould were actually building the boat. Their workmanship was just as crucial as when building a wooden boat.

Tin cans v plastic bottles

It is often claimed that for serious cruising one must have a steel boat. Fibreglass is not strong enough. This is not true of fibreglass in general. What it does reflect is that most current fibreglass yacht design and building is not strong enough. It is unrealistic to compare a steel yacht purpose built for sailing round the world with a popular fibreglass fun-to-sail cruiser/racer made for weekend sailing.

A fibreglass cruiser can be made as strong and tough as you like. Moreover it would be lighter and faster than an equivalent steel boat, but inevitably uncompetitive with popular cruisers. As few moulders would interrupt their production cycle to make a specially strengthened boat, and would charge outrageously if they did, it is generally cheaper to order a one-off steel or wooden boat.

Strong fibreglass boats do exist – yachts as well as work and fishing boats – but inevitably in the upper price range. To add to the confusion, most expensive fibreglass yachts are no stronger than cheap ones.

Because one boat of a particular class has made a spectacular voyage, it does not follow that any other boat of that class can do the same. It may have been specially strengthened for publicity or by an owner later.

I have long been impressed by the way nearly all wooden boats, especially older ones, are considerably stronger and tougher than most fibreglass boats. This is not to imply that fibreglass as such is weaker. Far from it. But its nature allows a very different, lighter, cheaper construction, and its high material cost encourages the minimum in a competitive market. Fashion also demands ever faster boats. The scene is entirely different from when those wooden boats were built.

Existing boats

There is a huge and growing fleet of earlier boats, ten, twenty, even thirty years old. Unlike steel and wood, which have been

a

b

Photo 1.3 (a) The biggest fibreglass ships, the 470 ton minehunter, *H.M.S. Sandown*, built by Vosper Thorneycroft, Southampton, England (Photo: Vosper Thorneycroft Ltd). **(b)** The first large motor yacht, *Bebe Grand*, 55 ft (17 m), built by Halmatic Ltd in 1955 and still in service. Even after 30 years there were no blisters. To make a yacht of this size in those days needed much courage and faith at a time when most builders were making only dinghies – and people said even *they* had more faith than sense (Photo: Scott Bader Ltd).

around for generations. Millions of boats have been made without anyone knowing what is going to happen to them, or even how to get rid of them. To add to the difficulty there has been continual development. New boats will still give trouble but in different ways.

Many good boats have been made, conscientiously moulded to the state of the art at the time. One cannot do better, even though it is found later to have been not good enough. But there were also an awful lot of builders in the early boom years moulding hulls with unskilled, untrained labourers working on a speed related bonus. Quality control meant expense. These builders included many of the largest and best known.

Energy

Fibreglass is a low energy material. It takes comparatively little to make polyester resin, which is a by-product of the oil industry, described by those living near a refinery as the stink, and would otherwise be burnt as waste. Glass fibre needs a furnace to melt the raw glass but the energy required is not as great as for metal. After that, all the fibreglass moulding and subsequent work is done without heat or pressure. The only energy used is to heat the workshop.

Steel takes a vast amount of energy to dig it from the ground, ship the ore, melt and roll it into usable form. All fabrication, cutting, shaping and welding requires high energy. Throughout its life it needs more energy to shift the greater weight. Smelting aluminium needs even higher energy. Wood requires energy to fell and transform the tree into usable form and then power tools or human energy to shape it. It takes more oil to make a ton of steel, which is not made from oil, than a ton of plastics which is. And being lighter, a ton of plastics is a lot more material.

Simple chemistry

Like all organic chemistry the reactions are far more complex than simple school chemistry. However, one need not be a chemist to use the materials. A simple analogy can explain what happens.

Polyester resin in the liquid state consists of long chains of molecules, hundreds of groups long, like a centipede with hundreds of hands. When the whistle blows, in the form of adding catalyst, the centipedes join hands and form a solid lump. This is polymerising or hardening.

Centipedes are mere flesh and can be pulled apart quite easily. But imagine them crawling through a roll of wire netting. Now when they hold hands the wires stop them being pulled apart and the linked centipedes turn the flexible netting into a rigid, strong mass. If you see some similarity with reinforced concrete or a ferro-cement boat you are right. Similarity to a wooden boat is coincidental, the fact that both are boats.

Fitting out

The fibreglass moulding comes out of the mould more or less in the shape of a boat. How can that shape be turned into a sound, safe and seaworthy boat? The following chapters describe the basic principles.

These apply also to all work done later when making additions, alterations or repairs. As the boat ages and moves down the social scale owners become more impecunious and tend to do more of their own work. They often spoil their boats through ignorance. Obsolescence requires the addition of things unheard of when the boat was built.

Earlier boats were simpler and more easily altered. Modern boats with their sophisticated internal mouldings and fancy glued woodwork are often impossible to change. This, however, is a social problem. Yet a boat with a short life because it cannot be updated is a crime against nature.