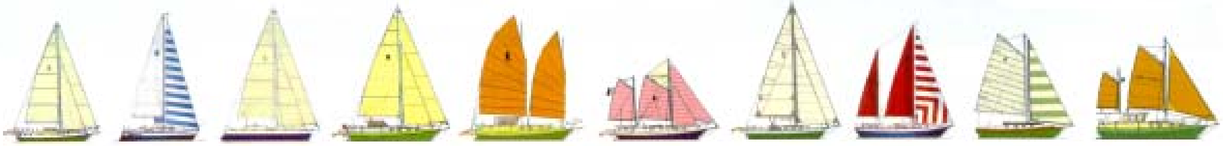
BUILD YOUR OWN SAILBOAT

STEEL . FIBERGLASS. TIMBER









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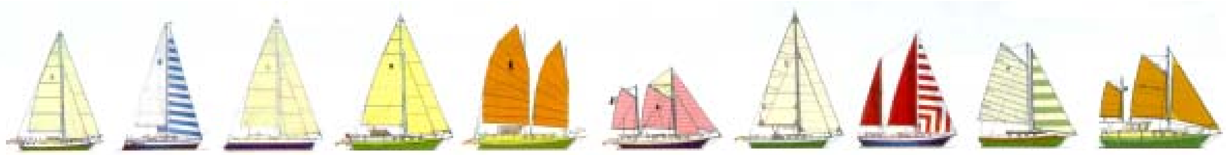

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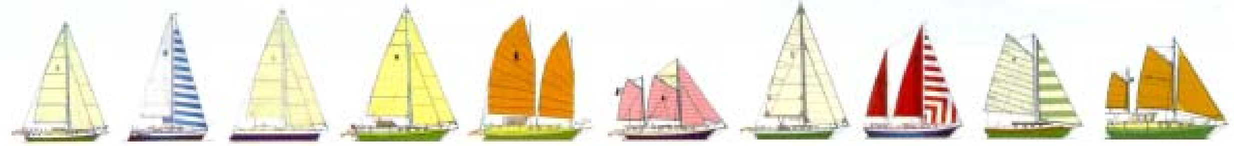

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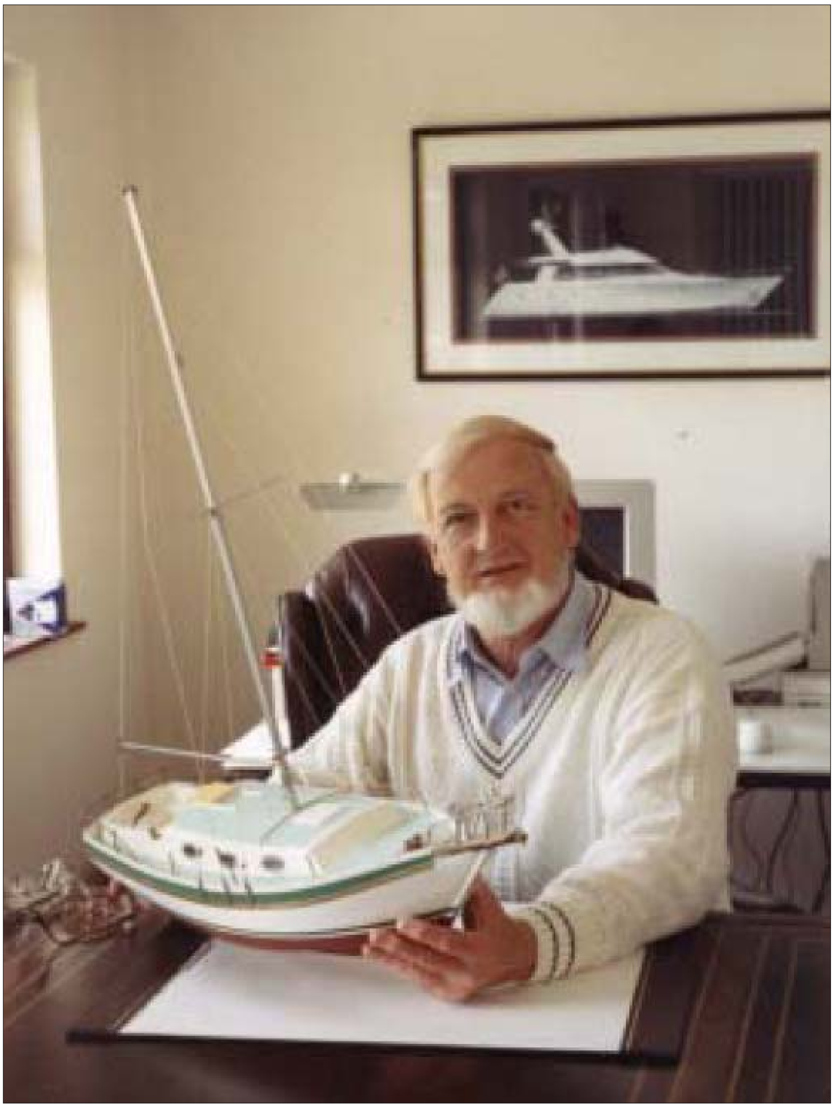
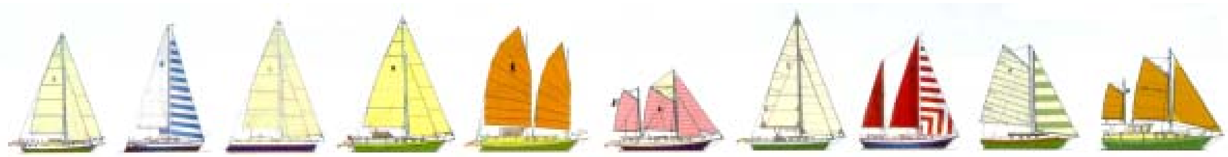
Introduction & Acknowledgements

Firstly let me apologise / apologize for the ‘Trans-Atlantic’ spelling in this book ! Having lived many years in the US, being of Australian origin and having finally settling in Europe; one may understand that when it comes to spelling I use a ‘mix’ which causes the editors of my printed books to give me a lot of stick ! Also as this e-book will be read on both sides of the Atlantic and across the Pacific, I could not quite decide which of the main spelling choices I should use. I hope you will enjoy reading BUILD YOUR OWN SAILBOAT as much as I have enjoyed collecting the material from my correspondents who as you will see are sailboat owners themselves and have made a massive contribution to this book. Where to start! So many people have contributed so much; if your name or perhaps a photo of your boat appears within these pages; you are one of thousands of sailboat owners & builders who have helped to make this book possible; my thanks to you all.



Special thanks are due to the following people: to my wife Gwenda, who has supported me in my work for forty years; to Andrew Slorach, my long-standing associate; Edgar van Smaalen my



partner in Holland, to George Love, my boatbuilding mentor; to the editors of all the boating magazines worldwide who published notices that helped me collect the details of so many of my boatbuilding projects; to David Sinnett-Jones, the circumnavigator who encouraged me when I was starting this manuscript; to Philip Sheaf who assisted in collecting the material.

This book is written for those who are still undecided as to which boatbuilding method and or material they would use to build their next boat. The word ‘build’ is meant to cover a boat you totally or partially build yourself or have totally or partially professionally built by others.

My own exposure to custom boatbuilding began in the early 1960s when, after purchasing a boatyard as an investment. I decided through choice and circumstances, to take a more ‘hands on’ approach to protect my investment.The latter involved serving a five year informal apprentership (after all I was the boss) under three great boatbuilders: George Love, a wonderful old time boatbuilder, Barry Long, who had served a long apprentership & had considerable experience in all aspects of his craft, and finally Len Freestone, a pioneering fibreglass boatbuilder who had immigrated from the UK to Australia and brought his considerable skills with him.

My next step was to enroll on the US-based Westlawn Yacht Design course. As with many things in life, my decision to study further was caused by a trick of fate when a so-called ‘expert’ we hired to design a boat for our yard made a mess of the job, so I decided some in-house expertise was needed.Thus began my yacht design career over all those years ago.

Experience in plywood and timber boat construction using the cold moulding technique was soon followed by the introduction of fibreglass boatbuilding methods. During the early 1970s when the oil crisis at the time made the supply of fibreglass resins doubtful at best,

I explored steel construction methods by visiting Holland and spending considerable time in the local boatyards. Fortunately the Dutch are very forthcoming when it comes to sharing their knowledge and I was able to quickly grasp the finer points of this boatbuilding technique. Now, over 30 odd years and 35,000 boats later, I am pleased to share my boatbuilding knowledge with you.

Bruce Roberts-Goodson. www.bruceroberts.com

CHAPTER 1.

HISTORY OF OF CRUISING SAILBOATS

First a little history. In my opinion cruising as we understand it today - that is long distance sailing in small boats for pleasure rather than for profit - began in the late 1890's. It all started when retired sea captain Joshua Slocum found that he could not make a living out of the rebuilt former oyster dragger, the 36 ft 9 in (11.20 m) *Spray*. The record of Slocum's rebuilding the *Spray* and his subsequent adventures has inspired tens of thousands of people to cruise in their own boats ever since he wrote his book *Sailing Alone Around the World*.

In 1962 a Brisbane yachtsman affectionately known locally as 'Shotgun' Spencer presented me with a battered copy of *Sailing alone around the world* . E H Spencer was a well-respected Brisbane businessman, who took his sailing very seriously; so seriously that during one important yacht race when another competitor did not obey the starboard rule, he showed his annoyance by diving below and appearing on deck with his shotgun and firing both barrels across the bows of the offending yacht. 'Shotgun' Spencer had certainly earned his name. Barred from taking part in future races, he was something of a local hero to the younger yachting fraternity. I would like to recount those early days when I was in my twenties and had just learned to sail in one of Australia's skiff classes. The Australian 18ft [5.5m] skiff, is an open boat with a veritable cloud of sail. The 18 footers have a smaller sister, the 12ft [3.6m] skiff. This design is still raced, and is an open boat with an oversized sail plan. The whole arrangement is only kept upright by the weight and tenacity of a crew of four; kept busy, especially the bailer person, whose job it is to remove the water that often flows over the gunwale.


DESIRE our 12 ft skiff with sliding gunter rig.

Our 12 foot skiff was named *Desire* and had been raced in Sydney and won a national championship, but, as happens with many fine boats, she was in sad shape by the time the hull came into my hands. The rig was unrestricted, so *Desire* was fitted with the complete rig, formerly used on Reg Lipke's race winning, 16ft

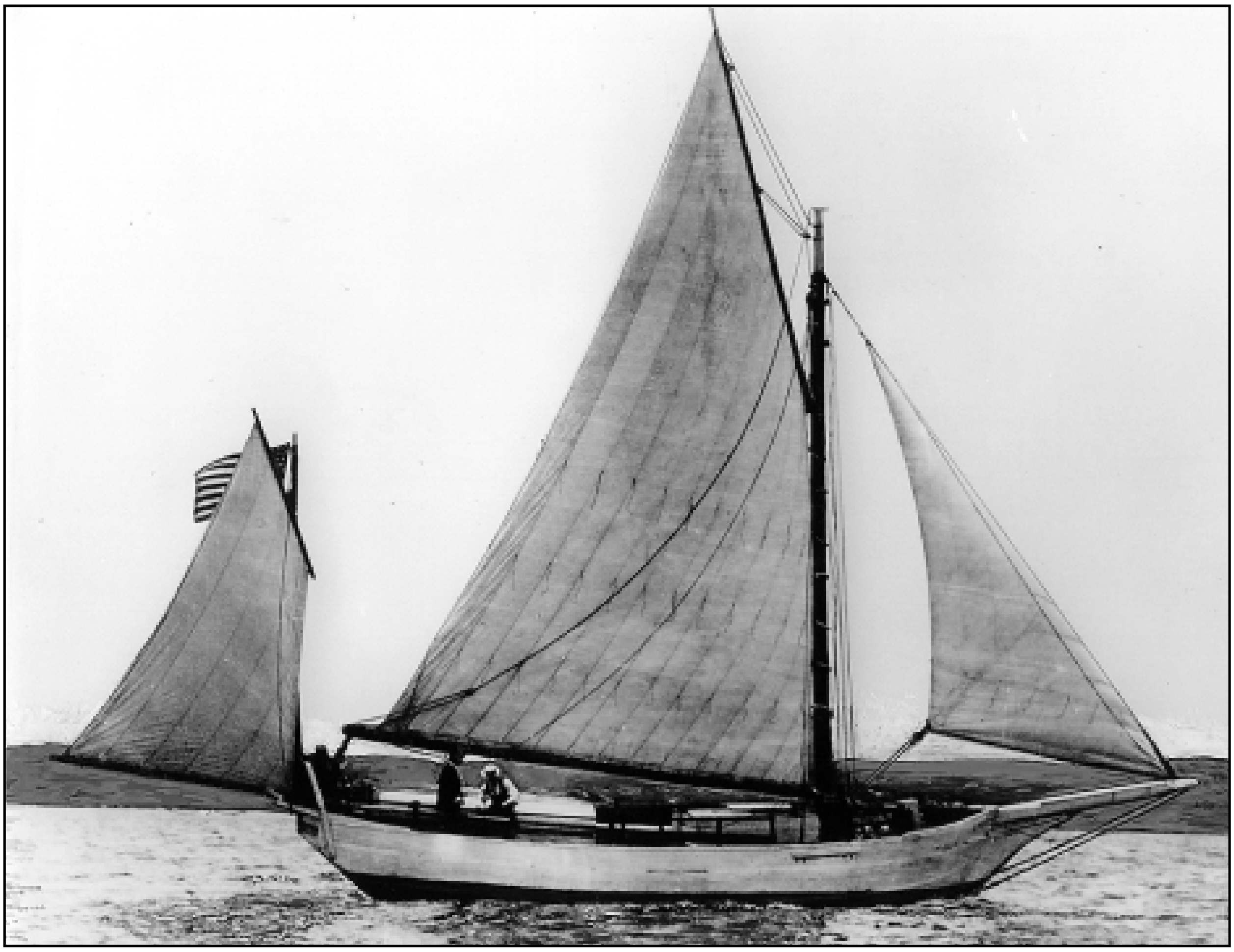
[4.9m] skiff. Remembering that the hull was 12ft [3.6m] long, the dimensions of the rig make interesting reading; mast 27ft [8.2m], boom 14ft [4.3m] bowsprit 8ft [2.4m] and the spinnaker required a three piece pole measuring 20ft [6.1m]. There was no ballast, other than that supplied by the live and very active crew. After a stint of building and racing multi-hulls, time was taken out of the boating industry to enable me to study Naval Architecture. Soon after re-purchasing my old boat yard in partnership with Andrew Slorach, I became reacquainted with the *Spray* when Charlie Jupp and John Haskins walked into our office and by coincidence both expressed an interest in having Spray replicas built in fiberglass.

Here we see DESIRE with her new rig - Crew Bruce, Ian, Noel and Gwenda Roberts-Goodson as bailer girl, see white water going over the side !

The stories of Joshua Slocum and his sloop *Spray* are standard reading for any cruising yachtsman, and his book, makes fine reading. Over the past eighty or so years, *Sailing- Alone-Around-The-World* has been the inspiration for many of those who go to sea in small boats.

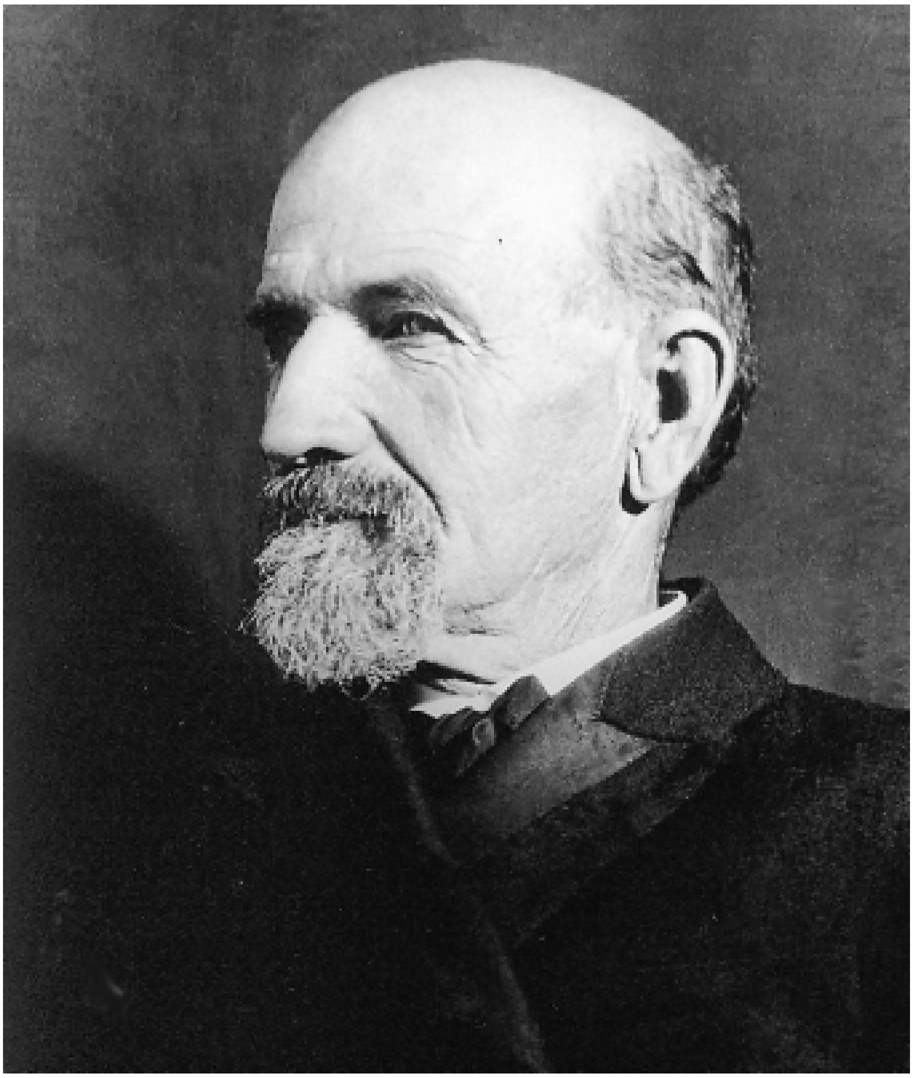
John Haskins, a *Spray* enthusiast approached our design office and as asked if we could prepare plans for building a replica *Spray* in fiberglass. John had already built a perfectly executed scale model of the boat and had incorporated some small modifications that he felt would update and improve the vessel without losing the concept of the original design. By some lucky coincidence while we were considering John Haskins's request, another yachtsman, Charlie Jupp approached us with similar requirements. Charlie had just sailed an 8ft draft [2.4m], narrow beam boat out from England to Australia. The experience had convinced him that a shoal draft sailboat was better suited to his needs. Charlie was already familiar with the *Spray*, and suggested that if our negotiations with John Haskins came to fruition he would also like to build a Spray for himself.

At about this time, we were fortunate in securing a copy of Ken Slack's book *In the Wake of the* Spray, which provided a wealth of information for our project. Ken, an Australian, had included details not only of the original Spray, but had researched the twenty or so replicas or copies that had been built since 1902. For those not already familiar with Joshua Slocum's *Spray*, perhaps this is a good time to recap some of the exploits of this fine boat, and to lay to rest some misconceptions and half truths that have persisted about her over the past 90 years.



This rare photograph shows SPRAY off Sydney with Joshua Slocum and Sydney business man Mark Foy. They are trying out the new set of sails that Foy had presented to Slocum. Photo courtesy Dr Kenneth E Slack.

In 1892 at the age of 51, Joshua Slocum was given a decrepit sloop called *Spray.* and spent the next two years rebuilding this vessel. He removed the centreboard and replaced nearly every piece of timber in the hull, deck and superstructure. He sought to improve the seaworthiness by adding some freeboard, so that the boat would be better suited to the deep water sailing he obviously had in mind. All the materials used in the reconstruction were collected around Fairhaven, in Massachusetts, where *Spray* had lain in a field for several years. The boat's lineage is clear when one examines photographs of early examples of the North Sea fishing boats that have worked off the coasts of several countries bordering that area; and rumour has it that the *Spray* was over one hundred years old when she was given to Joshua Slocum. There was a story that she had worked as an oyster dragger off the New England coast. Joshua Slocum, a seaman with vast experience, must have recognised something of the potential of his new acquisition, for otherwise he would not have invested two years of his life in the total rebuilding of her. As it turned out, he could not have made a better choice.



The man himself - Studio photograph of Joshua Slocum.

Slocum spent a year commercial fishing in the boat on the Atlantic coast; then, after proving the worth of the vessel to his satisfaction, he decided to make a voyage that, even today, is not undertaken lightly.

Slocum's trip proved a resounding success. Not only did he achieve what he set out to do - that is circumnavigate the world single-handed - but he proved for all time the many fine features of *Spray;* features that we have seen proven over and over again in the several hundred replicas that are now in service around the world.

Building replicas of *Spray* is certainly not new. Although we believe that in 1969 ours were the first ones built of fiberglass, many copies had already been built in timber, following similar construction methods to those used to build and rebuild the original model.

Now is probably a good time to consider just what constitutes a Spray replica. As we know Slocum altered his original boat during the rebuilding; and many replicas, copies and/or Spray types that were built between 1902 and 1968 did vary in one way or another from Slocum's boat as she was when he sailed her around the world.

It is our experience, and the evidence of all the hundreds of owners we have made contact with, that-without exception-Spray replicas and near copies have retained all the fine features.

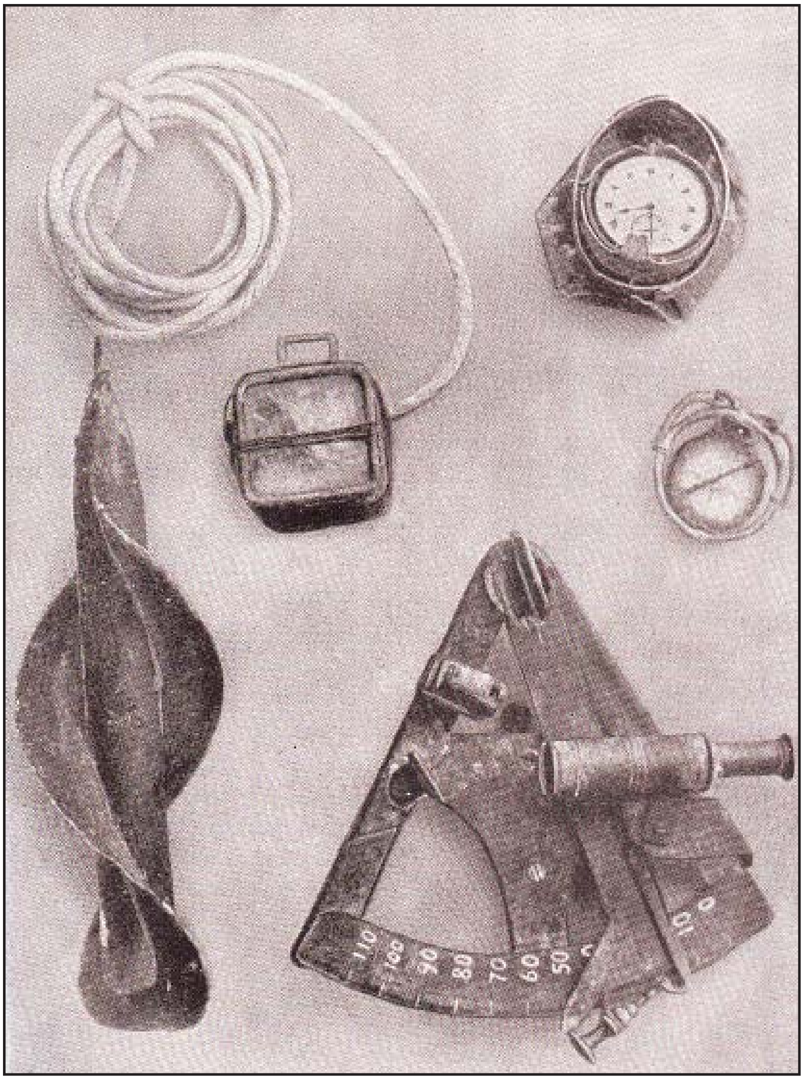
In Slocum's wake have come many thousands of cruising sailors, some of whom have become well- known personalities as a result of their exploits. One not so well known early cruising sailor was Fred Rebel. Fred not only made history when he sailed from Australia to USA in an 18 ft (5.49 m) skiff, he also made his own charts! Indeed, not only his own charts but every item of navigational equipment and put them to the test over 9,000 miles (14,483 km) of ocean.

Fred Rebel was a carpenter down on his luck and had fled his native Latvia in the wake of revolution to arrive in Australia just in time for the Great Depression to start. After a series of successes and failures in his new country and the sight of thousands of his host countrymen clearing out to the bush, Fred decided to move on towards California. So with no job and little over £100 capital, Fred began the second migration of his life, this time by small boat.

He bought one of the well-known Sydney Harbour 18-footers, a very fast boat with an inordinate spread of canvas. So large a sail plan in fact that in anything much more than a zephyr it needed a crew of sixteen burly crew to keep it upright. It has been accurately described as the most spectacular racing boat in the world, and the very worst to sail across an ocean. However, this was the boat Fred chose and he immediately set-about strengthening her and fitting a canvas spray cover as a crude cabin.

Work on the boat was straightforward, he was a carpenter and he knew about wood. Navigational preparations on the other hand were an immense challenge, particularly to a man whose sea experience had been limited to a steamer's stoke-hold. He spent his days pouring over books in the public library until finally he acquired a 70 year old navigation manual. The library's atlas from which he compiled his charts must have been of an even earlier vintage, about the time of Cook's last voyage by the sound of it, for when Fred later came to use his charts he found quite important groups of islands missed out entirely. But his most interesting achievement was in the construction of his navigational instruments which he describes as follows:

'The materials I used for my sextant were several pieces of hoop-iron; a Boy Scout telescope, price one shilling; an old hacksaw blade; and a stainless steel table knife. I broke pieces off the table knife to make the mirrors. They had to be ground optically flat, which I accomplished by melting a lump of bitumen on to them for finger-grips and by rubbing them over emery-cloth laid on a piece of plate glass. I used three grades of emery cloth—coarse, medium and fine and finally I gave the steel a mirror finish by rubbing it on a damp cloth with red oxide (or jeweller's rouge). 'The hacksaw blade was for the degree scale. I chose it because of its regularlycut teeth and because I could bend it into an arc. I also chose the radius of arc so that two teeth made one degree. I took the temper out of the blade so that I should be able to reshape the teeth, and for a



tangent screw I took an ordinary wood screw: that would engage nicely with the hacksaw. This way I could read half-degrees of arc straight off the teeth of the hacksaw. But half a degree of latitude represents 30 nautical miles and you need far greater accuracy than that. So I enlarged the head of the screw, and subdivided its circumference by sixty. Thus I was able to read to minutes of the arc off the screw head itself , that was the hardest job to make.'

A chronometer was essential. Fred could not make one so he did the next best thing and bought two cheap watches (each as a check on the other) for a few shillings. He wrote *'I slung them in gimbals, so that the motion of the boat could not affect them.'* Another essential instrument handmade was the taffrail-log. He wrote, 'I *made my spinner from a bit of broomstick, to which I set aluminium blades at such an angle that the spinner would turn once for every 12 in (305 mm) of passage through the water. For the indicator I adapted a little clock, gearing it down so that every minute on its face should mean I mile of distance sailed. When I tried this log out, I found there was a slip of 20 per*

ABOVE LEFT: *The instruments made by Fred Rebel.*
ABOVE: *Fred using his home made sextant.*

cent; but an error in a nautical instrument does not matter, provided it is constant, you can allow for it. And until the time when the works of the little clock corroded with the sea air and water, this taffrail-log served me well.'

Fred left Sydney in his boat *Elaine* on 31 December 1931 and arrived in America one year and three days later. This narrative is not intended as an invitation for you to rush out and start looking for the perfect 18 ft (5.5 m) cruising boat. The experiences of Fred Rebel are included to illustrate just how small some boats are that people have acquired when *choosing for cruising*.

You do not have to intend to set off around the world when you make the decision to adopt the cruising lifestyle. Weekend sailors can enjoy their cruising just as much as long distance sailors. As with all endeavours there seems to be a perceived (in my experience often erroneous) pecking order among cruising folk. Do not try to emulate the singlehanded, three times around the world person, if that is not your thing. Cruising can be enjoyed close to home equally well. You can adopt the sensible attitude that you will gradually extend your cruising grounds as your experience and other circumstances permit. What has this to do with *choosing for cruising*? In my opinion it is a big factor. So many people's cruising plans have come to grief because they felt obliged to overstate and then overreach *their own* sensible cruising goals.

Cruising will mean different things to different people; your cruising may be coastal in nature and all undertaken within 100 miles (or less) of your home port. You may prefer gunkholing either locally or in some nearby cruising ground. If on the other hand you are going to make that world girdling voyage, then you will need to give even more serious consideration to selecting the right boat.

Of course many successful voyages have been accomplished in unsuitable boats, but here we are trying to avoid depending on large slices of luck. Choosing just where you intend to cruise may be one of the hardest decisions you will have to make. Being honest with one self will play an important part in this decision. It is always more romantic to dream of far off locations than it is to admit to yourself (and friends) that what you would really like to enjoy is some local cruising involving minimum hassle and maximum relaxation.

Where you intend to cruise will definitely influence your choice of boat. As you read each chapter you will be able to relate various types of hull configuration, keel types, accommodation layouts etc., to a particular type of usage. Some boats are suitable for sailing in many and varied locations, while others are more specialised. This book will try to guide you through these areas of choice.

You will find that cruising people are often very opinionated; in some ways this is what gives them the confidence which in time combined with experience, makes their cruising successful. As soon as you mention to any one remotely connected with the sea that you are planning a cruise in your own boat you will receive a myriad of advice. In the following pages I have tried to sort out not only the type of advice you should consider but also to alert you to the questions, to which you will need answers. Without previous experience, intending cruising folk can sometimes be led to at best, choosing an unsatisfactory boat, or at worst creating the conditions that lead to a disaster that will put paid to their cruising ambitions forever. Some of you may have met individuals who have tried cruising and failed; all that follows is my attempt to guide you and your family to a successful cruising experience that will last as long as you all find it rewarding and enjoyable. You will notice the frequent mention the word *family* throughout the text; family can mean wife, partner, children and perhaps even one or more pets. If you do not consider the family from the very beginning then your cruising experience will be short lived. The most common story related by those who have tried cruising and failed, is one where it was assumed that the entire family would share and enjoy the type of cruising you have in mind. This attitude leads to frequent arguments, or worse; sometimes desertions and separations at the first port of call. As mentioned earlier, cruising people are often opinionated and as such will often recommend or decry a specific product, being more than happy to make sure you note the brand name. I too have often recommended products or services by name, but be warned; in this changing world where takeovers of companies are common place, the quality of products often change for better or worse. Make your own enquiries and compare products etc.

This happy couple Herbert and Petra Fritz built their Roberts 53 steel sailboat themselves. Herbert made everything with the assistance of talented friends. Recently I met Helmut Haas and his wife Angelika who have retained me to design a custom a 78 ft motor yacht - Helmut informed me that he was one of those friends mentioned above - it is really a small world !
Herbert and Petra sailed around the world starting from their home country Germany - they called at our Marine Park boatyard in Australia.

CHAPTER 2.

BUDGETS AND PLANNING

Initial planning and calculations of how much will it all cost. How to save money and keep within your budget. Budgets for acquiring your boat and for maintaining the cruising lifestyle. VAT certificates. Earn as you cruise. Your boat may play a part in your income. Chartering your boat. Setting up a workshop. Boat size for cruising and crew requirements. Where to look: new or secondhand or build? The KISS factor. Hull types, including keels and other appendages. Selecting a hull type. Formulas and technical considerations and what they mean. Displacement length ratios and meanings. Seaworthiness, hull ends, overhangs, hull balance, self steering capabilities with and without mechanical devices Slipping your hull and the ability to go aground. Raised decks, poop sterns and anchor wells. Self steering capabilities see also rig and self steering. Underwater considerations; draft limitations, types of ballast, centre-boards, drop keels, twin keels. Rudder types; transom hung rudder. Hull construction materials; selecting the hull material and the choice between glass fibre, steel, aluminium or wood, advantages and disadvantages of each. Motor sailer hulls.

What a depressing subject budgeting is when you may be just starting to explore the possibilities of your (first or next) cruising boat. Unfortunately the subject of finance will be one of the foremost things you will need to consider. Everything to do with cruising has a price and some form of budget is required at every step from your first planning session through to enjoying your cruise. If you do not have a well planned budget, you are unlikely to have a successful cruise.

DEFINE YOUR CRUISING GOALS

What type of cruising do you have in mind? Occasional weekends and annual holidays; long term or full time cruising? The answer to this question will have a great bearing on your budget requirements. If you are planning the former your biggest expense will be the boat itself, whereas if you are considering long term voyaging your budget considerations will become more complex.

Once you have clearly defined your cruising objectives then preparing your budget can take shape. The last thing you will want is to end up with a mountain of debt when you come back ashore. All cruising experiences have a beginning (planning) middle (the cruise which may last for a number of years) and an end (the day you sell your boat and take on a shorebound existence).

AFTER CRUISING ?

You should budget for all aspects of your future lifestyle. Most people tend to ignore the last part of the exercise; they either think they will never return to a shoreside life, or they just ignore the subject altogether. You can plan and budget for all main stages of your cruising adventure including the end, and still not detract from the overall excitement. Choosing the right boat will go a long way towards the planning for the end of the cruise; a well chosen boat capable of holding or enhancing it’s value, will help to provide you with a re-establishment fund when you move ashore. This is not to suggest that you necessarily put a limit on the length of your cruising experience; many cruising individuals, partners and couples like Eric and Susan

Hiscock, the Pardy's and many other lesser known people, have managed to continue and enjoy a cruising lifestyle for many years. You should be aware that some time in the distant future, you may need to re-establish yourself ashore. Each individual or couple will have limits of one form or another. Lifetime partnerships often start when couples meet in foreign ports, children are born, and other factors may require a change to your plans during a cruise.

APPORTIONING AVAILABLE FUNDS

Now to get down to specifics. Let us assume you have a certain amount of money available and you have caught the cruising bug. As yet you do not have a vessel or perhaps the boat you currently own is unsuitable for the type of cruising you have in mind. For those planning a long distance cruise (as opposed to local weekend cruising) you will need to divide your available funds into at least two main plus several smaller components. The first sizeable chunk of your budget will be for the acquisition of the boat. You will have several options including having a boat designed and built to your requirements, building your own from a suitable design, buying new, or finding a suitable secondhand craft. It would be difficult to set an accurate budget until you have investigated each of these options.

The second main budgetary consideration for those who plan either to cruise full time or continuously for several months each year, will be the expenses associated with day to day living. Items such as food and clothing, boat maintenance, mooring and haul out fees will have to be allowed for. Add to this, visas and other associated paperwork, which can often be more expensive than expected. There will be the cost of additional gear and equipment such as replacement of lost or worn out items, plus new charts, pilot books and the like.

CRUISING FROM UK AND EUROPE

Cruising full time could involve leaving the UK in September and utilising the trade wind route to make the West Indies for Christmas, cruising in that area until Spring and then returning to the UK, taking about 12 months to accomplish the round trip. Thousands of cruising boats make this type of voyage each year including those who make detours to encompass the Atlantic islands and the Mediterranean. The step of heading into the Pacific takes a bigger commitment, one that you may wish to consider after you have explored areas nearer to home.

CRUISING FROM USA

US east coast based sail boats often restrict their cruising to the beautiful coastline, heading to Maine or down to Florida and the east coast of Mexico or out to the various islands of the Caribbean. For these sailors crossing the Atlantic is the big commitment. US west coast sailors usually cruise up to the San Juan Islands off Washington State and the Canadian Gulf islands and then possibly on to Alaska. Other west coast based boats' head for Mexico and always the big decision is to head out into the Pacific. West coast sailors have the option of an exploratory cruise to Hawaii; if they find long sea passages are not for them then they can simply return to the west coast and the thousands of miles of beautiful cruising.

CRUISING FROM AUSTRALIA

Australian yachtsmen also have many choices; with their huge coastline and the proximity of the Pacific islands, they have plenty of places to explore before taking off on a long cruise. East coast based sailors often head for Lord Howe Island and use this round trip as their shake-down cruise.

CRUISING FROM A FOREIGN PORT

For those committed to long distance and full time cruising and considering the above options, you may prefer to travel by conventional means to your chosen cruising location. You can acquire your boat in the area where you want to commence cruising. At many of these locations you will find boats for sale by people who have not planned their cruise as well as you have! For example if you live in the UK and you have in mind some Pacific cruising, you will find the market for used boats in Australia very much to your liking. The prices in Australian dollars, when converted into sterling, make the boats seem very inexpensive.

The same applies to UK residents with their eyes on the Caribbean; there is a good selection of used boats to be had in the USA especially in Florida. Other good places to look for a suitable boat are those areas which are the first major port of call for cruising boats. These early ports of call include Hawaii, Noumena, Fiji and the Azores, as well as places in and around the Mediterranean such as Gibraltar, Portugal, Spain, Greece and Turkey, where you can often find a bargain. Exchange rates fluctuate and the current value of your currency verses the currency in which you will be required to pay for the boat, may well be a deciding influence in deciding whether to purchase locally or abroad.

BUYING ABROAD

If you are shopping for a boat away from your home territory you will need to be very careful about the ownership rights of the person selling the boat. You would be wise to deal through a local broker with a good reputation; better still would be a broker who has affiliations in your home country. To buy a boat dockside from some unknown owner would be the height of folly as many have discovered to their cost.

EUROPEAN RESIDENTS

You will also need to explore the VAT minefield. From January 1 1993 when the EU single fiscal area came into being, boats can be transferred and sold freely between residents of EU countries without duty being levied provided that evidence is produced that VAT has been paid on the particular vessel. The best proof of VAT paid status is the 'green flimsy' the EU standard document that is issued when VAT is paid on a new boat. For older boats where VAT was paid before the VAT rules were properly documented the next best thing is an original letter form the Customs office stating that in their opinion they are satisfied that VAT has been paid on the vessel. In the UK you should contact your local HM Customs office, where you can obtain up to date information on what is required for you to formalise the VAT paid status on your present vessel or on a boat you are interested in purchasing.

A special exemption exists on boats built before January 1985 provided they were in European waters on 31 December 1992 and the owners can prove it, then they are VAT exempt. If the boat was built *after* this then VAT will sooner or later have to be or will already have been paid. Where the boat was located on 31 December 1992 is the deciding factor as to where VAT had to be paid. In my own case the UK built S28 *K*I*S*S* was in Holland on the fateful date; that is where the VAT was paid before I consented to purchase the boat. My current boat was built in Holland in 1991 but was in the UK on the 31 December 1992 so the VAT was paid in the UK. As the green flimsy did not exist for this boat it was necessary for the seller to obtain a letter from the UK Customs that they accepted the proffered evidence that the VAT was paid. This original letter along with previous owners' bills of sale, builders' invoices and SSR certificate now forms part of the 'ship's papers.'

There is a quirk in the VAT laws the rule being that if you purchase a VAT paid boat outside the EU and then bring it back into EU waters then you will have to pay the VAT. If you are considering buying a VAT paid boat that is currently located outside EU waters, make sure it is returned to an EU country again and check the VAT status before you make the purchase.

NON EUROPEAN VISITORS

For those USA, Australian, New Zealand and other non European residents who want to cruise the Mediterranean, and perhaps cruise through the French, Dutch and Belgian Canals (highly recommended), the idea of obtaining a boat in Europe has its attractions. For one thing the long ocean crossing can be avoided There is also the possibility of having the boat built in the low cost labour countries of the former Eastern block. The very reasonable building and labour costs of the UK (compared with Germany and certain other EU countries) make acquiring a suitable boat in this area worth serious consideration.

The recently enacted European Recreational Craft Directive (RCD) and the requirement to pay VAT on boats remaining in EU waters for over 6 months, make it a sensible alternative for non EU residents to buy their boat within the EU. Non EU residents who bring their boats into EU waters will need to pay the VAT or limit their stay to less than 6 months. The current rate varies between 15% and 20% depending in which EU country you are located when the tax is due and payable.

Cost saving is not the only reason (although it can be a very good one) for buying your boat abroad. In some cases time restrictions, unwillingness of your partner to undertake long ocean crossings, and numerous other circumstances may make the idea of starting from a foreign port an attractive option.

BUDGETING FOR ADDITIONAL EQUIPMENT

Even the best equipped boat will require many additional items to meet your particular needs. My own Spray 28 *K*I*S*S* was 'well found' when I acquired her. She had been built by an American couple Hal and Dorothy Stufft and equipped for similar cruising to what I had in mind, at least for the following two or three seasons. On reviewing my last two years' expenses for her I note that the equipment added totalled some thousands of pounds. She did come *well* equipped but obviously not *totally* equipped, as my records revealed. The above examples illustrate the need for extra funds to be put aside for unexpected expenses including taxes and additional items of equipment that you may have overlooked but will require for one reason or another.

This brings us to the KISS factor, the initials being an acronym for 'keep it simple sailor' or less politely 'keep it simple stupid'. This saying which I am told originated in the engineering industry, it is well worth remembering when considering all things boating.

BUDGET FOR THE BEST

When budgeting for additional items to complete the fitting out of your cruising boat, always consider buying the best. Perhaps that will be the best you can afford, but nevertheless this should be the best. Most experienced cruising people can relate stories of their own regrets at cutting corners, when purchasing a particular item of boating gear. Naturally you will be looking for the best price; you had better be, or your cruising experience will be shortened due to over extending your budget. If you allow a known price for a particular item and then are able to obtain it at a better price, then you will be able to offset the cost overruns that will certainly occur.

BOAT JUMBLES

In my opinion one of the greatest British marine institutions is the 'Boat Jumble.' This wonderful source of inexpensive, often top quality equipment and boating gear, is unparalleled in most other countries. After attending the *Beaulieu Jumble,* the grand daddy of all boating jumbles, I am sold. Unless you have considerable boating experience, you should attend these Jumbles accompanied by a knowledgeable boating friend. Know what you are looking for and only part with your money if you are absolutely sure of the suitability of the item for your boat. Make sure you are confident of the quality and you should have checked the best prices available from more conventional sources. Assure yourself that the item was legally obtained by the vendor! When it comes to price, haggle like your life depended on it. Under no circumstances buy something 'that you think may come in handy', but for which you have no specific need; most boat owners homes and boats have a collection of such items; the smart ones sell them at the next available Jumble.

REPLENISHING THE COFFERS

So far we have only discussed the budgetary outgoings; many of you will have plans for replenishing your coffers during your cruising. If you are planning weekend and annual holiday cruises only then you will most likely have a regular shore-side income and the next few paragraphs may not apply to you.

For those of you who are planning to retire or take an extended break from your normal employment; you should consider how you can replenish your coffers as you cruise. Consider your skills and those of your partner. Do either or both of you have skills that can be utilised for earning extra income during your cruise?

One of the more obvious earners is chartering; although this is so obvious as to be over worked when it comes to expectations, it is surprising just how many cruising people make a success of *part time* charter. If you have the right boat and perhaps just as importantly, the right disposition to deal with charter parties or individuals, this possible money earner is worth consideration. Referring to *part time* charter; this can mean a couple of weeks per year for some expense sharing friends or several short charters by strangers who come recommended to you in one way or another. Unless you are running a full time professional charter operation, you should choose carefully when deciding who will spend time as a paying guest aboard your boat.

EARN WHILE YOU CRUISE

Consider you and your partners personal skills. Again the obvious ones include boatbuilding experience in any material. You may have obtained your boatbuilding experience by building and or fitting out your own boat. This is a factor worth considering when you are deciding how you will acquire your boat. The actual building and fitting out of a reasonable sized cruising boat will certainly add to your marketable skills.

Most tradesman have marketable skills, welders, metal workers, carpenters, plumbers and electricians will find part time employment not only ashore but among their less handy cruising contemporaries. If you have some experience with the maintenance and repair of electronic equipment you will be *very* much in demand.

Dentists, Doctors Chiropractors and other professionals can often earn worthwhile fees both ashore and among the cruising population. Some licensing requirements may interfere with your activities ashore but it is worth investigating in advance where you can legally practice. You may be able to obtain a licence in those areas you plan to visit. Language skills can be turned into cash as can secretarial experience. Computer literacy is a definite skill and one that will always find a ready market. Writing articles and perhaps a book on your experiences is another possibility; be aware that these latter activities are in a crowded market and are not that well paid.

USING YOUR BOAT TO GENERATE INCOME

In the planning stage is when you should decide if the boat itself will play a part in earning income as you cruise. The prospect of chartering may cause you to select a certain type of layout to allow some separation between the hosts and guests. If you are planning to earn income from a trade or profession then you may wish to include a workshop or work space in the accommodation layout. You will have your own ideas of how important the work space is to your future cruising needs. Do not become carried away with this element; you will be better advised to make the work area fit the boat rather than choose the boat to fit the work area!

What is all this talk of working when you are cruising? You may be fortunate enough to have a reliable income to cover your costs. Perhaps you can lease out your house while you are away, you may even acquire a property with that eventual purpose in mind.

It is a wise cruising person who covers many sheets of paper with figures before starting to look for a suitable vessel. After you have what looks like a workable budget you can start to consider acquiring a suitable boat to be your cruising home for the future weeks, months or perhaps years ahead.

‘HOW BIG’, USUALLY REFERRED TO AS ‘HOW LONG’ ?

Over the years my office has dealt with literally hundreds of thousands of enquiries from those who intend taking up the cruising lifestyle. One of the most asked questions is how big a boat should I choose. Our reply is always the same, *‘choose the smallest boat that will satisfy your current requirements.’* Will your children want to accompany you when they are past the early teenage years? Do not expect to have a continual stream of friends and relatives who are clamouring to join you for various sections of your voyage. Unless you are very wealthy do not choose a size of boat that will require a crew to assist you in handling the vessel. As for the upper size range; well set up cruising Sail boats up to 55 ft (16.75 m) can be handled by a two person crew; this includes a husband and wife combination. How small is too small; one Canadian couple built and sailed a Roberts designed 18 ft (5.48 m) trailer sailer from Montreal to Australia; they even took their cat along. Please do not take this later example as a recommendation.

GUNKHOLING

This term will mean different things to different people. When I think of gunkholing it brings to mind lazy sailing and exploring in protected bays and estuaries and rivers. For this type of sailing your cruising boat can be as small as you wish; a considerable amount of this type of activity is undertaken in open boats. When it is time to anchor at night, a boom cover often serves as a shelter. Portable gas or primus stove and a bucket may be all of the ‘appliances’ carried on this cruising boat.

The right boat and an inquisitive mind are two important qualifications when considering gunkholing. Shallow draft is a major benefit when looking at this type of cruising. Once the water gets really thin you will no longer be able to rely on your depth sounder so you will literally have to feel you way in many of these areas. Detailed charts of the area you are exploring are essential, if none are available then it may be fun to make your own thus enhancing the enjoyment of the current trip plus adding to the enjoyment of future visitors to the area.

Nature watching is one of the many attractions of gunkholes. You may also find unusual man made oddities; follies, abandoned fishing and other commercial operations, historical relics and occasionally a human eccentric. On reflection I can claim to have encountered all of the above and they all bring back pleasant memories.

TRAILER SAILING

The size of your trailer sailer will be restricted by the width limits placed on road vehicles by the authorities in various countries or individual states. In general the width limit is 8 ft (2.43 m) however in some places it is a little more generous but usually never exceeding 9 ft (2.74 m) without special permits. As far as the length is concerned, a boat with 8 ft (2.43 m) beam should not exceed 28 ft (8.53 m) in overall length. Before you restrict yourself to the local legal trailer width, you may want to consider just how often you really intend to move the boat by road. Many people find it is easier to leave their ‘trailer sailer’ in the water all season and just bring it home for winter storage; if this is your situation then it may be more useful to exceed the trailerable width limit by owning what is a ‘Pocket cruiser’ and obtain a permit to move the boat to and from the water twice a year.

If you intend to use your boat as a true cruising trailer sailer then you will need to check width limits and other requirements for the areas where you operate the boat. In the EU (European

Union) these regulations are being harmonised so that you can trail your boat across borders using one set of rules. This agreement will make trailer sailing much more attractive; you can take your boat from the UK by ferry and trail it anywhere in Europe (using it as a camper or caravan along the way) and commence your cruising from some desirable location. You could even leave your boat and trailer safely tucked up in a boat yard ready for the following season. If you can not afford a large boat at this time or if you prefer some of the benefits of owning a smaller vessel including lower initial investment and less maintenance**,** then a trailer sailer or pocket cruiser may suit you best.

ACQUISITION CHOICES

In this area your choices lie between buying new, having a boat custom built, purchasing second hand or building from a hull and deck package or from plans and patterns.
These choices are all effected by your particular requirements. You and your partners present age, financial situation, family considerations and perhaps the desire to get on with it, can influence your choice in this matter. Many people who will be retiring in a few years plan well ahead and have all the above options available. Those with foresight can have the boat ready for their retirement and enjoy uninterrupted cruising.

BUYING NEW

Buying new is an obvious option. If you buy a new stock boat, you will find that it will most likely need some modifications and a considerable amount of extra equipment before you are ready to start any serious cruising. New boats bought *off the shelf* are usually the least equipped of all; you will need a hefty budget allowance to outfit your new acquisition. You will have the gratification of instant ownership (very important to *Now* people) and of course, if you choose well, your new boat and its existing equipment should serve you for several years. You should be able to avoid the large expenses of the replacement of major items such as mast(s), rigging, sails, engine and the other equipment that either comes with, or is added to the boat soon after the initial purchase.

CUSTOM BUILDING

Custom building is an exciting way to acquire your cruising boat. This term usually refers to having the boat built and/or mostly completed by a professional builder. For those with some boating experience and a patient disposition, this can be the best way of obtaining the cruising boat of your dreams. You will have the opportunity of being involved from conception to completion of you boat. Many of you may not have the time or the inclination to become so intensely involved, however it is a worthwhile exercise if you can arrange it.

If you can manage the project yourself, then there are considerable savings to be made. With some intelligent planning you can end up with a beautiful custom cruising boat for less than the cost of an *off the shelf* equivalent. You can choose an existing design or have a designer prepare custom plans and patterns. If you are able to source your own engine, mast, rigging, sails, deck hardware, engine and interior fittings, you can save many thousands off the cost of the finished boat. Any large chandler or marine hardware store will offer worthwhile discounts in return for the size of order that you will have at your disposal. It may even be worthwhile setting yourself up as a ‘boatbuilding enterprise’, this will give you access to trade discounts.

BUYING A PRE-OWNED BOAT

Buying used is another option but the purchase of a second hand boat can be fraught with traps for the unwary. The term *buyer beware* is never more apt than with buying a used boat. If you are able to deal direct with the owner you may avoid some of the pit falls associated with this type of purchase. There are many honest and trustworthy yacht brokers and boat salesmen handling used boats, however there are also many who have received their sales training selling used cars and the like. You must make sure you are absolutely satisfied BEFORE you hand over your money. ALWAYS hire a qualified surveyor to check out your boat purchase before you part with *any substantial* amounts of cash.

In the USA boats are often documented which is a similar arrangement to the UK Part 1 Register. In the UK Part 1 certificate will be a good way start to proving ownership; make sure you call the Registrar Generals office in Cardiff to check that the document is current. The certificate issued by the Small Ships Register is not a proof of ownership but it will be a start. Another way to check ownership is to contact the yachts insurers and, the harbour master where the boat is kept.

BE SURE OF YOUR TITLE

It is well to remember that at least in the UK, if you buy a boat from a person who does not have legal title to the vessel and it is later reclaimed by its lawful owner, you will most likely be out of pocket and lose your boat and your money. The boat you are considering buying may be subject to a hire purchase agreement, it may form part of a legal dispute or there may be some other impediment in the title. Make sure you carefully check builders certificates, bills or sale and any other documentation that is offered to prove the current ownership.

SURVEYS ARE A MUST

You will often have to pay for the boat to be hauled out before it is in a position to allow for a full survey. To cut your potential costs, why not conduct a very detailed inspection of the interior, galley equipment, pumps, heating, batteries as well as mast(s), rigging, sails, dinghy and electronic equipment before you commit yourself to a full survey. Do not be rushed, do not be afraid of being a nuisance, take your time. If you have trusted and knowledgeable friends who have a *proven* knowledge of things boating, ask their help and advice at this early stage. Do not ignore advice because you have fallen in love with the boat. Assemble your facts and on no account part with your cash before you are in possession of all the information as to the boats condition.

BUILDING FROM A HULL OR FROM PLANS

Building from a hull and deck kit can be an economical way of acquiring a custom built boat. Many of the cruising boats you will see in far off and exotic locations were completed from a 'hull and deck kit.' If following the footsteps of others is any indication then this is one of the most popular ways to obtain a genuine offshore cruising sail boat. Hull and deck packages are available built from *glass fibre*; good selection available, *steel* unlimited selection, *aluminium,* treat with caution, and *timber*, becoming rarer.

Building from plans is the most time consuming option and one which will require some special skills. If you do not already possess the type of experience that would allow you to build your own boat then you may be able to acquire the skills you need as the work progresses. If you are already an experienced welder, woodworker or have some knowledge of glass fibre, then you are well on the way to assuring that you can build a seaworthy boat.

As steel becomes increasingly popular as a boatbuilding material, we are seeing many more cruising boats built by owners and workers who gained their experience in small metal shops. There are many designers around the world who specialise in preparing boat plans and patterns for those who want to create their own boat. The builders of these cruising boats have the advantage of knowing every part of their cruising home. Repairs are easier, quicker and certainly less expensive if you have built the boat yourself. Most people who have self built their boat have gained additional marketable skills that can extend their cruising lifestyle infinitum.

CHAPTER 3.

CHOOSING THE HULL

Hull types, including keels and other appendages. Selecting a hull type. Formulas and technical considerations and what they mean. Displacement length ratios and meanings. Seaworthiness, hull ends, overhangs, hull balance, self steering capabilities with and without mechanical devices Slipping your hull and the ability to go aground. Raised decks, poop sterns and anchor wells. Self steering capabilities see also rig and self steering. Underwater considerations; draft limitations, types of ballast, centre-boards, drop keels, twin keels. Rudder types; transom hung rudder. Hull construction materials; selecting the hull material and the choice between glass fibre, steel, aluminium or wood, advantages and disadvantages of each. Motor sailer hulls.

In days past one could be excused for thinking that there were as many hull types as there were boats afloat. A visit to any marina will reveal that times have changed; the advent of series fibreglass production has produced rows of almost identical boats. Many of these boats are suitable for local and coastal cruising but very few should be considered for long distance voyaging. It is a fact that most successful *long distance* cruising boats will not be found at a boat show; the most successful *long distance* cruising boats are purpose designed and built.

To qualify the following paragraphs I must say that in the mid 1960s I designed and built many one off, fibreglass hulled, cruising boats and we still do. In the early 1970s when petroleum products became difficult (and in the case of polyester resins), almost impossible to obtain, I started to design steel boats. In this period (except in Holland) there were very few steel hulled pleasure boats of any type. Today I would estimate that 50% of the offshore cruising boats that are actually 'out there doing it' have steel hulls and most of these have steel decks and superstructures as well.

If you are building, having built or purchasing a purpose built cruising boat then you will be able to choose the construction material you prefer. If you are buying a production boat then the chances are that it will have a glassfibre hull and you will live with that choice. A well built glassfibre hull can provide the basis for a fine cruising boat. In many cases 'well built' should read custom built. It is a fact that many (most) sailboats spend much of their life securely tied to a well protected dock and provided they can withstand the occasional coastal sail, then they are deemed to have fulfilled their role. Unfortunately when considering a boat for serious coastal or offshore cruising one has to assume that sooner or later the boat will have to withstand all that nature can offer.

There are only a few 'production' fibreglass sailboats that can meet the criteria required to warrant the title of 'serious cruising boat'. Fibreglass has the potential to be formed into a hull that can withstand the type of punishment that you can expect your boat to experience any time you venture offshore. I have sailed in many fine examples of successful fibreglass cruising boats; most of these were custom and purpose built for serious cruising.

If you are planning to purchase a 'production' fibreglass boat then you may be able to intervene in the building of your boat to the extent of selecting a heavier laminate and additional strengthening than would be the norm for the particular design. While I have designed and been involved in the building of many sandwich fibreglass hulls; my personal preference when considering fibreglass would be for a single skin hull. Why ? Easier to repair, problems if any, would be more obvious before they require a major repair. The sandwich material does provide some insulation from heat, cold, condensation and sound. You can add suitable insulation inside a single skin hull in the areas where it is required (usually above the waterline).

The main advantages of choosing a cruising boat built from fibreglass are, low maintenance (if buying used, have the hull checked for osmosis), the wide selection of sizes and types available in both new and used models. You can expect good resale value (fibreglass is widely accepted by the average weekend sailor), and finally you may not have to defend yourself for owning a steel boat. Most readers will feel that I have already covered the disadvantages above!

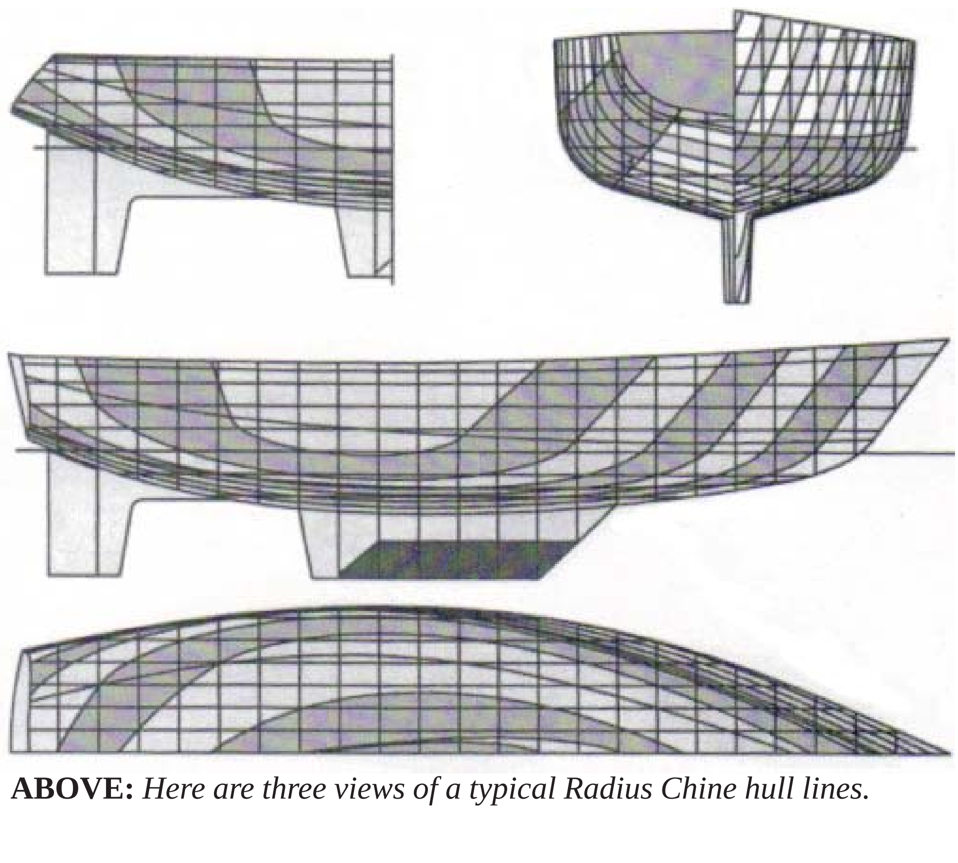
When choosing the hull material for a cruising boat my preference is for steel. In my opinion the advantages of using steel include, super strength (steel will withstand a grounding or striking a foreign body better than any other hull material), versatility and cost (it is much less expensive to have a steel hull custom built than is the case with any other material), ease and cost of repairs (should you have occasion to need repairs to your boat, you will find competent steel workers in all parts of the world). finally, quite often you will want to modify or 'Improve' your existing cruising boat, with steel this is a relatively simple matter. If you are buying a second hand boat, make sure you have the hull thoroughly checked by a competent marine qualified surveyor who has experience with and understands the steel construction.

The only disadvantages with steel as a construction material are perceived rather than actual; for instance you will often be told that steel requires excessive maintenance, not true, a well prepared and painted steel boat will not require attention for several years. Another misconception is that steel is heavy; it is a fact that in the 40ft (12.19 m) and above size range a steel boat will weigh the same as a *well built* fibreglass boat of the similar length.

A lesser known but potentially fine hull material is Copper nickel; this metal does not rust, is impervious to marine growth and except for cosmetic reasons never needs painting. Several fishing trawlers and a few power and sailboats have been built from Copper nickel and they have been very successful as far as long life and freedom from maintenance is concerned. Although more expensive than steel copper nickel is worth your consideration if you are building a new boat that you plan to own for a considerable number of years.

Although it *may* be preferable to have the hull, decks and superstructure all built from the same material, there are occasionally good reasons not to adhere to this often quoted rule. One example is building a steel hull combined with an aluminium deck and superstructure. This arrangement puts the super strength where you need it and allows weight saving where it will offer the most advantages.

Now let us consider the various hull types. A sailing boat operates simultaneously in two fluids. Considering the peculiarities of each you will find that



ABOVE: *Here are three views of a typical Radius Chine hull lines.*

there are several ways that a boat can move at the same time. A well designed hull will move in a considered and expected manner. It will behave in a way where it can provide you with secure and comfortable living quarters. It will do all of these things while transporting you and your crew to your chosen destination.

HULL

For the purposes of explaining the various terms related to the hull, assume the hull includes the keel, skeg and other appendages. Often when one speaks of the hull, we also mean the decks and superstructure. In this chapter we are concentrating on the hull only and other areas will be covered later.

In the 1970s it seemed that most people considering cruising boats desired a hull fitted with a long keel. There are many types of long keels and some are ideally suited for cruising while others are totally unsuited; some long keels have very bad habits. The traditional long keel had the rudder hung directly off the aft end of the keel that was set at an angle. In order to accommodate the propeller, it was necessary to cut an aperture either in the aft end of the keel or in the forward edge of the rudder or partially in both areas. For various reasons this arrangement *invariably added an undesirable amount of weather helm*. The modern 'long keel' embodies a long fin or a full keel as embodied in the Spray range; with a distinct heel extending aft from the bottom of the keel, the rudder is then vertical and supported at the lower end by the heel (see sketch). This latter 'long keel' arrangement where the rudder is further aft and separated from the keel in most cases results in a well balanced hull. (see Keels).

Canoe sterns and other *double enders* were also highly thought of at one time and are still highly regarded in some quarters. Some of these boats could trace their heritage back to Scandinavian origin, again enhancing their appeal to the embryo cruising yachtsman. Today,

ABOVE: *Roberts 432 radius chine hull. Note all TACKED together before full welds are run.*

potential cruising people are better informed and most ask searching questions before making a final choice of design or hull configuration.

Although not strictly accurate in nautical terminology, the terms stern and transom are often used to describe the aft end of the hull. Not all sterns have transoms. Most sailboats today have either a traditional transom or reverse transom stern. One relatively recent development is the advent of the 'Sugar scoop' stern which incorporates a vertical transom within a reverse angle ending to the hull. This arrangement usually features steps for re-boarding from the water or when the boat is moored stern-to in European fashion.. The reverse transom is also often fitted with boarding steps that are built into the transom itself. The above comments have been included as it would be easy to overlook one of the most important benefits of the reverse transom.

Listed in this chapter are some of the terms you will encounter when discussing various hull forms. If you are already knowledgeable in these names and their meanings then feel free to surf through this section. Understanding the water lines is always important and more so if you are building a new boat or buying new and have access to a set of hull lines. This set of drawings is commonly referred to as *the lines plan*. To fully understand the content takes considerable experience, however there is much vital information that can be understood by all. A lines plan generally consists of three views of the hull; body plan, profile and plan view. The hull is bisected by the stations, water lines and buttocks; see accompanying drawings.

By studying the lines and relating these to the hydrostatic information that normally accompanies the drawings, you will be able to learn a considerable amount about how the boat will perform in a variety of conditions under both sail and power. If you do not have the experience to make some sense out of this information then seek the help of a knowledgable friend. If you have engaged the services of a naval architect or qualified yacht designer then you should act on his advice; it would not be polite to seek advice from another designer. If you don't trust the judgement of your chosen professional, change to another with new lines etc.

CANOE BODY

The main part of the hull ***excluding*** the keel and skeg is sometimes used by designers for separate calculations with or without the keel attached. The canoe body can be *flat floored* (relatively flat on the bottom) or moderately *veed* through out its length.

CANOE STERN

This a term used to describe a certain type of stern. The true canoe stern would be more pointed than a stern so described today, and even a stern best described as having a golf ball shape, is sometimes described as a canoe stern. Sometimes also referred to as a *double ender,* this type of hull is not as popular as it was a 10 to 15 years ago.

LENGTH

This should be a simple indication of the size of a hull in at least one dimension, however even this simple term can be confusing. The terms *length over all,*(LOA) and *length over deck* (LOD), are often confused. Length overall in its true meaning is the actual length of the hull including bowsprit or boomkin and any other items that extend beyond the hull. Often the term LOA is used to express the length of the hull only; this is incorrect and our own design office has been guilty of this mislabelling. Sometimes a design has several sail plans and these involve bowsprits of different lengths so it more accurate to ignore these items when stating the length.

Make sure you understand the true length of the hull; in its true expression it should read LOD or *length over deck.* There is another associated term, LPD, *length between perpendiculars,* which is often used to describe the length of the hull when boats are *'built to class'* such as Lloyds rules, the American Bureau of Shipping or the more recently introduced

European Boating Directive. This measurement indicated in a brochure or advertisement, is usually the same as LOD. One sure way to ascertain just what you are getting for your money is to measure the boat yourself.

WATERLINE LENGTH

This measurement is usually expressed as LWL or DWL *load or designed waterline length.* The waterline runs from where the bow enters the water to where the stern or aft canoe body and the water meet. The designer usually shows it from station 0 to station 10. This is the designers educated guess of where the waterline will come to on the hull. Many boats are advertised with a stated displacement and waterline length that may not be relevant to the actual boat cruising in trim. (See Displacement.)

BEAM and WATERLINE BEAM

These are BOA and WB respectively. Beam overall or beam (max), are used to express the widest part of the hull; usually at the sheer or deck line and near the longitudinal centre of the hull. In boats with tumblehome (that is where the widest part of the hull is below the sheer) the widest beam will be below the sheer or deck. WB or BW expresses the widest beam at the waterline, usually located a little aft of the location of the widest BOA.

DRAFT

More correctly spelt draught this measurement represents how much the hull draws, or in simpler terms the amount of hull and appendages that will be under the water. In the case of a centreboard or drop keel hull there will be usually two alternative measurements shown, one to represent the draft with the keel raised and the other for the maximum draft with the keel or centreboard in the down position. In the case of a fixed keel sail boat the draft will include the keel. The draft may vary depending of the loading of the hull; number of crew, state of the fuel and water tanks and the amount stores on board, can all affect the draft.

DISPLACEMENT

To those of you who have heard the joke about the three most often told lies, I add a fourth, displacement. The true displacement of the hull is the actual weight of the entire boat including the ballast keel, stores, water, fuel, equipment and crew. Usually the true displacement (when known) will be shown in long tons (2240 lbs = 1 long ton) or tonnes, kilograms or even in cubic feet (35 cu ft of sea water = 1 long ton). As fresh water weighs only 62.4 lbs per cu ft, your boat will draw more in fresh water. The reason that the true displacement figure rarely appears in reviews and published information about most sail boats is that *light displacement* has been held as a virtue in some quarters. I do not agree but consider moderately heavy displacement to be a desirable feature for a cruising vessel.

Within certain limitations, the heavier the designed displacement, the more stores, water and fuel the boat can carry without adversely affecting the performance. The worst combination is an overloaded light displacement cruising sail boat. (See also Displacement length ratio.)

CENTRE OF BUOYANCY and CENTRE OF GRAVITY

Usually shown respectively as CB and CG, these terms refer to the centre of the displacement of the hull. If the hull is to float level as designed, then the CB must be directly over the centre of gravity (CG). The boat will change trim until the *actual* CB is over the CG. For example if you add in items such as a new water tank, heavy anchor chain or davits, then you will change the centre of gravity of the boat and the trim will change until the CB is directly over the CG.

CENTRE OF FLOTATION

Usually expressed as CF, this is the centre of the *area* of the waterline. If you take a slice through the hull exactly on the waterline and then find the centre of the area of that section then that is the CF of the hull. On most hulls the location is a little aft of the CB and like the CB the CF is usually shown as a distance aft of the bow or as a percentage of the waterline aft of station 0.

POUNDS PER INCH IMMERSION or KILOS PER CENTIMETRE IMMERSION

These are shown respectively as PP/I or K/CM. These terms indicate the weight in either pounds or kilograms required to sink the hull evenly in the water either one inch or one centimetre. In almost all hulls as the hull widens above the DWL so the number increases proportionally as the hull sinks past its designed waterline.

WETTED SURFACE

Shown as WS, this indicates the wetted surface area of the hull below the waterline. Some designers place a great importance to this figure stating that the greater the surface area of hull that has to be pushed through the water the less performance can be expected from the particular hull. As there are many other factors that contribute to the overall performance of a cruising boat, you should not put too much importance on this number.

PRISMATIC COEFFICIENT

Usually indicated as PC or CP this is a figure that represents the underwater portion of the hull as follows; if you take a block of wood that has the maximum length, width and depth of a the hull with the shape of the midsection carved throughout its length and then carve the underwater shape of the hull from this block; the CP is the relationship of the volume of the finished block as opposed to the block originally carved to the midsection shape throughout. The number represents the fullness of the ends of the hull. The more you carve away the ends the smaller the PC number. PCs can range from just below 0.50 for a fine racing hull through to 0.70 or more for a motorboat. Most cruising Sail boats will have PCs that fall between 0.53 and 0.59

CENTRE OF LATERAL PLANE or CENTRE OF LATERAL RESISTANCE

Known as CLP or CLR these terms refer to the *geometric* centre of the underwater profile of the hull. If you were to attach a line to this exact point and tow the hull sideways then the hull should move through the water without turning one way or the other. This calculation is used when laying out a sail plan.

CENTRE OF EFFORT

Known as CE, this the other equation needed by the designer when matching the sail plan to the hull. The CE is the *geometric* centre of the sail plan usually calculated by adding the area of the fore triangle and the main (and mizzen if present) and calculating the centre of all sails. It is usual to place the CE of the sail plan ahead of CLR. The amount of *lead* depends on many factors, and these calculations are best left to an experienced designer.

DISPLACEMENT LENGTH RATIO

Commonly called the D/L ratio it is calculated by taking the displacement in tons and dividing by 0.01 DWL cubed or Dt / (0.01 DWL)3 or as follows:

$$\text{D/L ratio} = \frac{\text{Displacement in long tons (2240 lbs =1 long ton)}}{(0.01\ \text{DWL})\ 3}$$

The resulting figure can compare the fullness of hulls. Each designer has his own pet theory as to the ideal D/L ratio for boats intended for different purposes. The ratio may vary depending on the waterline length so one has to consider this figure only in conjunction with other factors. For most cruising boats the D/L figure usually lies between 280 and 420,.cruising boats need adequate *designed* displacement. Overloaded cruising boats will have heavy displacement whether you like it or not, so make sure your cruising boat was designed to carry the large loads that form part of any cruising experience.

Size is not everything, however you may decide to start with the largest hull that your budget allows. The main thing, is to not over extend your budget; we have all at one time or another, allowed ourselves to become 'house poor'; do not extend this thinking to your boat. You can not assume your children or friends will want to cruise with you on a long term basis. Unless you plan to charter, do not allow the 'guest cabin or spare berths' to dictate your choice of size of hull or interior arrangement.

RESISTANCE

While you will be relying on the wind to drive your boat in the desired direction, there are many other related factors working against your intentions. One speed limiter is wind resistance caused by the wind drag on areas such as hull topsides, superstructures, mast(s) and boom(s), rigging etc. While racing yachtsmen are always searching for slimmer spars and rigging and lower profile hulls and similar areas of drag reduction, these options are often not compatable with cruising boats. There are many other areas of your boat which cause resistance, for example skegs, feathered or free-wheeling propellers etc. In all cases you will need to weigh up the benefits of reduced resistance as opposed to loss of living space, ultimate strength and other desirable features of a successful cruising boat.

Now that we have a range of terms to refer to, let us consider the different types of hull that may be suitable to contain your ideal accommodation layout while providing a safe and comfortable vehicle to transport you and your family to your desired cruising locations. By this stage you should have decided on your cruising goals and have a preliminary budget so you can eliminate unsuitable hulls from your calculations.

KEELS

This term covers the part of the hull below the canoe body. The keel may be part of the hull in that the hull sections flow smoothly from keel to hull (some times described as a hollow heel). In other cases the keel and hull meet at a definite angle. Keels may be subdivided into long keel, long fin keel, fin keel, drop keel, centreboard keel, wing keel, bulb keel, twin keel and bilge keel. For the purposes of discussion let us consider twin keels as keels that carry ballast and where a centreline keel is eliminated and replaced by the twin keels. Bilge keels are usually simple plates placed outboard at about 25% waterline beam, and are accompanied by a centre line ballasted main keel.

Keel glossary: Root chord= Horizontal line at the top of the keel span or length along the top of the keel where it joins canoe body). Tip chord = Horizontal line at bottom of the keel span or length of bottom of keel). Span = Distance between root chord and tip chord or simply the depth. Mid span foil = Shape of foil at half way span or shape of foil halfway down the keel. Vertical CG of ballast = Vertical location of the centre of gravity of the ballast. Leading edge sweep angle = The leading edge angle measured from the vertical. Trailing edge angle = Angle of the trailing edge measured from vertical, may be positive (top aft) or negative (top closer to bow). aspect ratio = Ratio of keel depth to averaged or mid span length or D x MS = Aspect Ratio

When you start considering what type of boat will best serve your particular requirements, you will need to decide, whether you prefer a long or short keel hull. There are a variety of sub-types within the two broad definitions. Maximum draft will be an important consideration and this is one of the first subjects raised by most clients when they are considering a stock or custom design. Unless you are planning to undertake most of your cruising in particularly shoal waters, you should consider the 'one fathom line' when deciding on a suitable draft for your boat. As one fathom equals 6 ft (1.83m), we can assume that any draft under 6 ft or say

2 metres is a reasonable compromise. Considering draft verses length of hull, you can assume that most hulls with a LOA of under 50 ft (15.24m) can be arranged to accommodate a draft of 6 ft (1.83 m) or less.

It is our experience that drop keels or centreboards do not make ideal cruising partners. On the KISS principle, it is easy to see that any keel that requires constant attention, as in the case of drop keels and centreboards, is particularly vulnerable to damage.

SHORT FIN KEELS

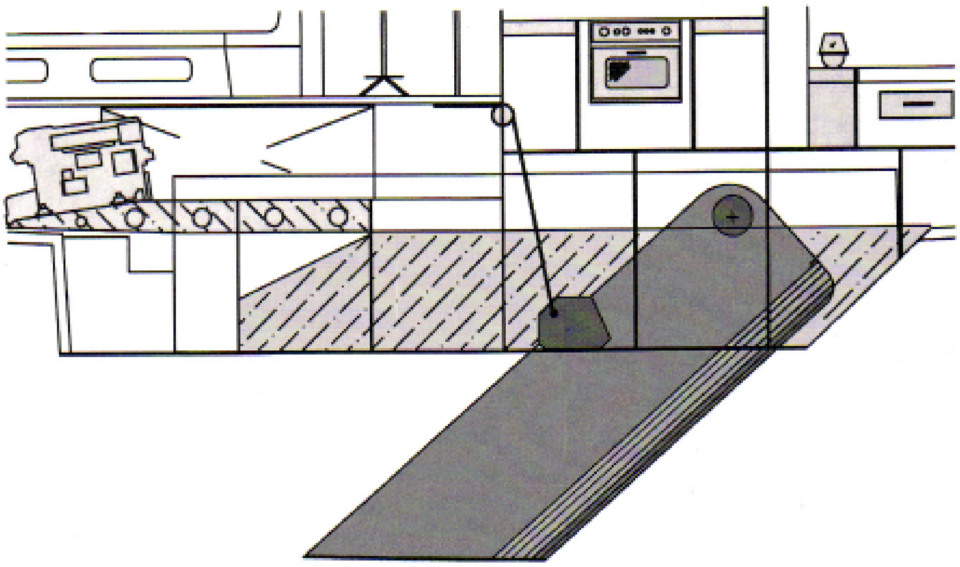
Current thinking amongst the racing fraternity is that a fin keel with a narrow span (fore and aft dimension) and deep draft and with most of the ballast in a bulb, offers the best performance. This type of keel is difficult to engineer and would be easily damaged when going aground. It is virtually impossible to slip in remote areas. Needless to say that a boat fitted with this keel would also be impossible to beach, and it also results in a draft that is too deep for many of the worlds most popular cruising grounds. This keel arrangement is totally unsuitable for a cruising boat.

Do not choose a keel that is too thin in section (plan form). Short fins (span or profile view) and thin foil sections (plan view) are normally accompanied by deep draft; all undesirable features in a cruising boat. There are many acceptable foil sections that can be used to design a cruising boat keel. Each boat designer has his own pet group of foils and it is not necessary for you to make an in depth study on the subject. If you follow the advice above you will be off to a good start.

LONG FIN KEELS

When considering a hull with a short keel (suitable ones are generally referred to as a long fin) you should look for one where the keel length at the point where it joins the hull, is between 30 and 40% of the waterline length. For example on a hull with a 30 ft (9.14m) waterline the root of the keel would measure between 10 ft (3.05m) and 12 ft (3.66m). This is only intended as a rule of thumb, as mentioned above any keel substantially shorter than 30% of the waterline length will have many disadvantages when cruising.

On a cruising sail boat fitted with a fin keel this should be accompanied with a skeg and preferably one that includes a fence. Make sure the skeg has a generous fore and aft length where it joins the canoe body. The skeg to hull join can be improved strength-wise (at the



The ballasted drop keel is one way to obtain minimum draft but the complexities of these keels are obvious even in the simplest form of raising arrangements as shown here.

ABOVE: *This ballasted drop keel can be used in the New York 65 and in the Roberts 434. This type of arrangement should be avoided unless it is necessary because of extremen draft restrictions etc.*

expense of a small loss of performance) by the addition of a fillet running fore and aft and at 45 degrees to the canoe body and the skeg.

TWIN OR BILGE KEELS

Twin keels, this term generally refers to twin ballasted keels with no centre keel. Bilge keels can be similar but with the addition of a centre keel; the ballast can either be in the centre keel or divided between the three appendages. Bilge plates are often erroneously referred to as bilge keels, however usually this type of arrangements consists of a centre keel containing all of the ballast and twin bilge plates that may be simply bolted on to the hull.

In the early days of twin keels, there were some interesting cases where the twin keels sank into the muddy bottom, a not unusual occurrence with any keel, however in these occasions when the tide rose the keels detached themselves from the hull and remained firmly stuck! Fortunately better construction techniques have eliminated such happenings.

Twin and bilge keels have enjoyed a long popularity in the UK. Due to many of the anchorages and harbours drying out at low tide and in some cases mud berths being the only type of mooring available, this type of keel seemed the only answer. Several head to head tests have been conducted where similar hulls were fitted with twin keels, centre keels and centerboards and sailed together. In these tests the single keels usually came off best followed by the centre-boarders and with the twin keeler turning in the least impressive performance.

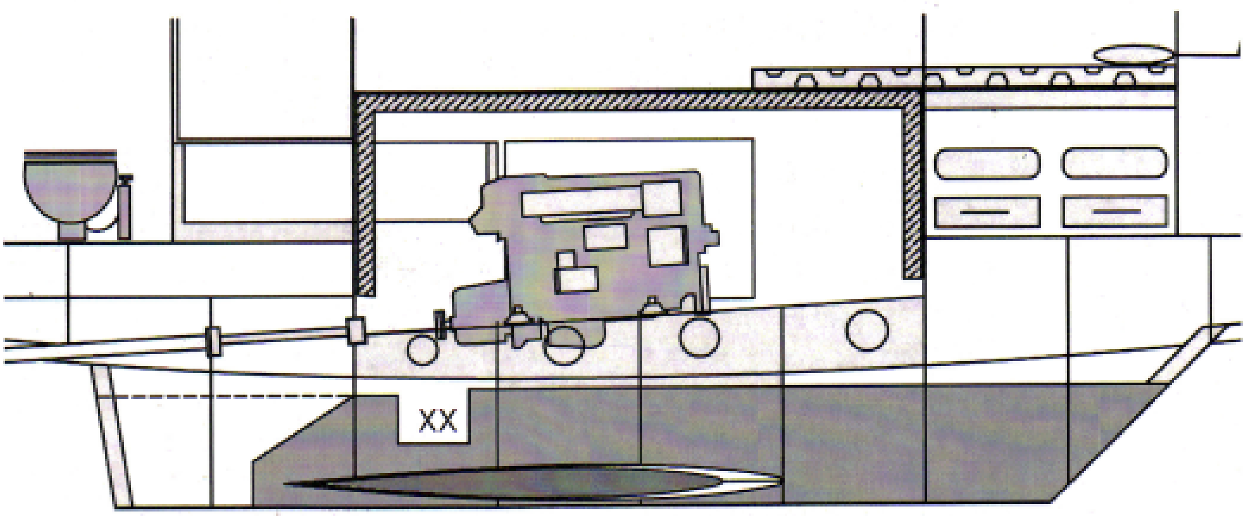
If your cruising demands you have use 'drying out' mooring and you are worried about the complexity and some of the other disadvantages of centreboard or drop keel boats, the twin keel configuration may be your best choice

BULB KEELS AND FLARED KEELS

The bulb keel that I would consider suitable for a cruising boat is not one of those affairs hung on a long (deep) thin (plan form) keel but rather a thickening of the keel at the bottom of a regular short or long fin as described above. The idea of a bulb is to get the ballast down where it will have best affect in adding to the stability of your boat. A bulb need not be a *bulb* but the lower part of the keel can be *flared* to accept more of the ballast down at the bottom of the keel. I have been experimenting with this type of keel and the initial results are promising. The patented *Scheel* keel is another example of this type.

WING KEELS

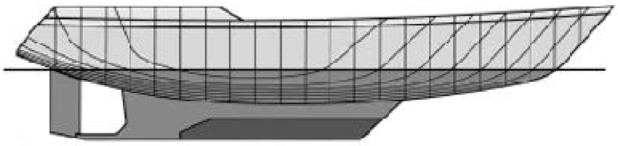
Wing or winglet keels can provide a good way of decreasing the draft, however *unless they are carefully designed* they can be prone to becoming entangled with any stray ropes, kelp and similar items that may be lurking just below the water. Another problem for those whose



boats dry out, is that unless the keel is designed to prevent this, the suction that can be set up between a wing keel and a soft muddy bottom can result in the keel wanting to stay put. Providing you are aboard at the time, then rocking the boat side to side can usually overcome this problem. Wing keels should be relatively thick and should be designed so they are adequately jointed or part of the main keel structure. The long thin versions that are seen on some racing sailboats have no place on any cruiser. Do not rule out a wing keel, just consider the options carefully, before making the decision to incorporate this feature on your boat. A wing keel may be designed so that it is more of a bulb as described above than an actual wing in shape.

LONG KEELS

There are three distinct types of long keel and many sub types however in my opinion, only two of these main types are suitable for cruising boats. Firstly, eliminate the undesirable type of long keel; that is one where the aft end of the keel has a considerable rake, sometimes as much as 45 degrees from where the aft end of the keel joints the canoe body. The bottom of the aft end is nearer the bow. Often the rudder is hung directly on the aft end of this keel. The nett affect of this arrangement is that the action of the rudder tends to have a twisting rather than a turning motion and expends some of its effort to turn the bow down and stern upwards rather than simply steering the hull. There are two types of long keel that make excellent cruising partners. The first is typified in the *Spray* hull. This keel is easily identified by the fact that it runs full length of hull from the forward end to where it blends into the stem and then drops gradually so that the aft lower end is a greater distance from the waterline than at the forward end. This is a very traditional keel arrangement favoured for the past 200 years in fishing boats and other work boats of the past . *'The sea does not change'* and any proven and successful hull type is



ABOVE: *Roberts Sprays have a typical 19th Century long keel - this works well despite the shallow draft offered by this type of hull and most importantly, it is well proven in practice.*

worth consideration, especially when it has evolved over the past 200 years.

The second long keel type that I favour is best illustrated in the, Maurice Griffiths new Golden Hind 34, Tom Thumb 26, Roberts 432 and similar long keel designs. These keels feature a well cut away forefoot to balance the fact that the bottom of the keel is level with the waterline; this all has to do with the area in profile of the keel and the relationship with its fore and aft location relative to the waterline of the hull. If the centre of the area of the keel is too far forward then an undesirable amount of weather helm is almost a certainty.

Another feature of this type of long keel / canoe body combination is the sizable open area between the aft end of the keel and the forward end of the vertical rudder. The resulting large aperture has many advantages including allowing a generous space between the propeller blade tips and the canoe body and the heel. The large aperture provides excellent protection for the shaft and the propeller.

WATER BALLAST

This type of ballast as the name suggests consists of water that is held in tanks usually located towards the sides of the hull. The tanks are connected by one or more large diameter pipes and a pumping arrangement so that the water can be transferred from one side of the boat to the other. The windward side tank is kept full thus adding to the stability of the boat when sailing to windward; on or during tacking the water is transferred to the other side. These arrangements can have some benefit in a trailer sailer or similar small sailboat. The inability to tack quickly, the chances of the boat being unprepared in the event of a sudden wind shift are just two of several the reasons water ballast is unsuitable for any offshore cruiser.

SKEG

This appendage is located near the aft end of the waterline and ahead of the rudder; its purpose is to enhance the effectiveness of the rudder. Skegs are of varying widths (in profile) but only 10% of the area ahead of the rudder is considered as effective in helping the rudder to steer the vessel; the remainder of the skeg makes an important contribution to the boats directional stability. Skegs can be vulnerable to damage so they have to be built in such a way as to withstand grounding and being caught in underwater obstructions such as fishing nets etc. From the mid seventies to recent times I was a strong supporter of the longish fin keel and skeg combination. There are no doubts about their effectiveness in helping to steer the sail boat. More recently I have decided that a modified long keel fitted with a substantial heel or shoe combined with a separately hung rudder may be a better option.

ABOVE: *Roberts Safety Skeg is recommended if you build a boat incorporating a skeg and a long fin keel. Available on Roberts designs.*

FENCE

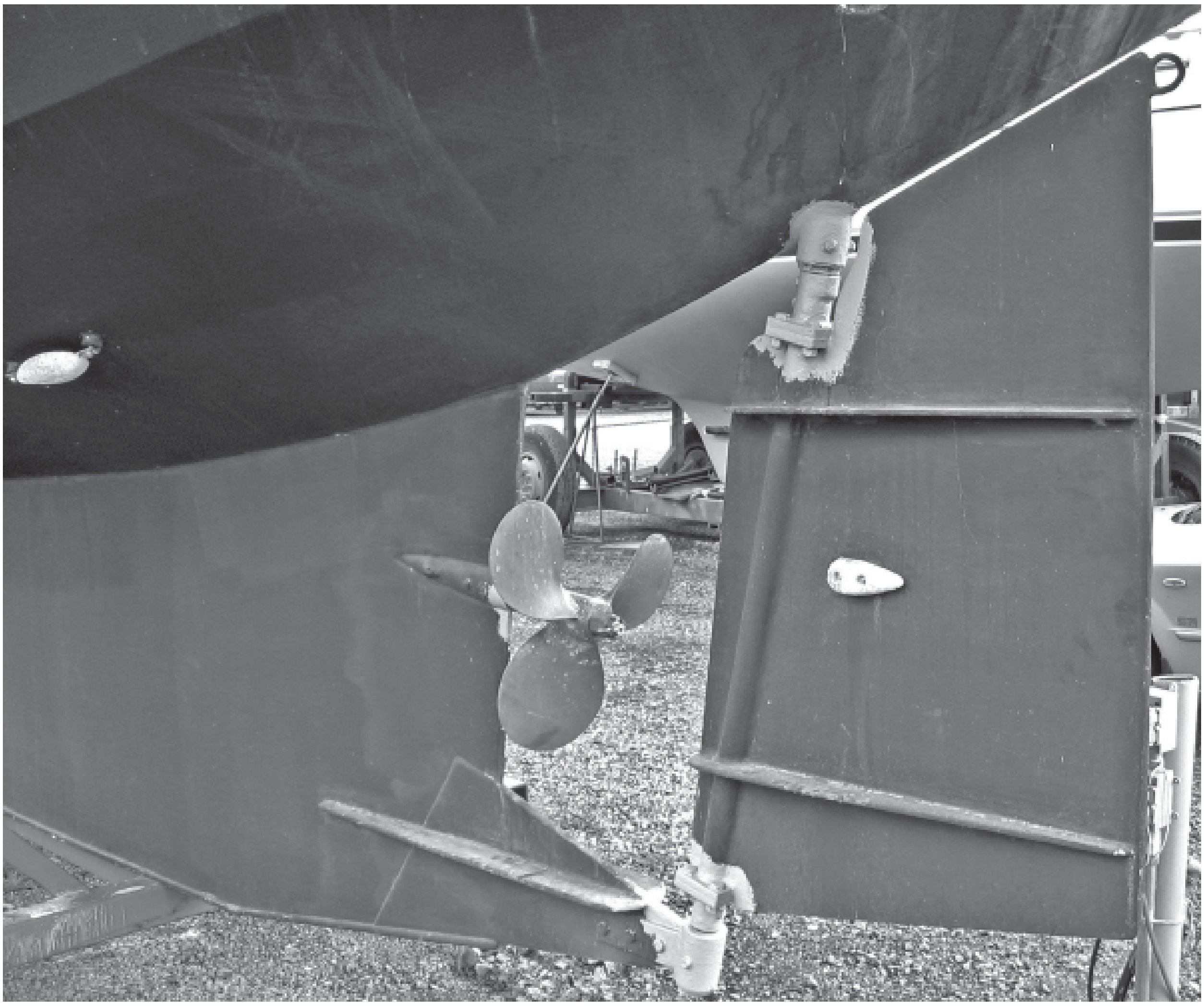
A fence is a worthwhile addition to any skeg it is a centreline fin that runs between the upper leading edge of the skeg and sometimes as far forward as the aft end of the keel. The object of the fence is to add strength where the skeg joins the canoe body and also to add additional directional stability to the hull. This appendage is sometimes retro fitted to assist in the correction of weather helm.

HEEL OR SHOE

These terms when used in conjunction with the keel refer to the aft extension of the keel which is used to support the lower rudder bearing and forms the aperture between the aft lower part of the keel and the rudder. As mentioned elsewhere, this arrangement is finding favour with more cruising yachtsmen who are familiar with the shortcomings of other keel-aperture-rudder arrangements. (See also Aperture.)

APERTURE

Sometimes referred to as the propeller aperture. The aperture is where the propeller shaft and the propeller are often located when the boat is fitted with a skeg or a long keel/heel combination. Apertures can take many forms and in times past they were just large enough to accommodate the propeller with a small clearance all round. If the clearance between the tips of the propeller blades was too small then severe cavitation could result. In designing skegs at one time we used to try and arrange the aperture in the skeg; sometimes this made the skeg weak and vulnerable to damage. Neither is it a good idea to cut away the rudder to form part of an aperture. The answer was to have the propeller shaft exit the hull ahead of the skeg however this removes the protection for the propeller that was a desirable feature for a cruising vessel.



ABOVE: *This type of rudder is a BAD idea on a sailboat. You should build your rudder so it is airfoil shaped in section; this rudder could be greatly improved by plating each side of the webs.*

RUDDER TYPES

The rudder type will often be governed by the keel and transom choices. If your hull has a transom that is located close to the aft end of the waterline then you may consider a transom hung rudder. While this does make a satisfactory cruising arrangement, it is seldom practical because most modern cruising hulls have either a reverse transom or an overhanging stern.

Rudders come in many shapes and sizes and it is worth understanding the terminology before considering which type of rudder is best suited to pointing your cruising boat in the right direction. If your rudder fails, then you may have to consider other methods of steering your boat. Although rudders have been located at just about every possible part of the hull, we will consider only those that are near, or at, the aft end of the waterline.

TRANSOM HUNG RUDDER

This is a rudder that is usually attached to or hung on a transom or canoe stern and is attached to the hull by way of pintles and gudgeons. This arrangement has the advantage that it is easy to ship and unship for repair or for allowing the propeller shaft to be removed. To use this rudder you will need a hull where the transom and aft end of the waterline terminate at or near the same point. One disadvantage is that this precludes aft overhangs which can provide additional waterline length when the boat is heeled. Usually transom hung rudders have a fixed blade but may be combined with one of the shoal draft varieties. (See shoal draft rudder.)

ABOVE: *This type of rudder is a good idea on a long keeled sailboat. Sturdy heel, flanged fittings for easy removal; rudder is a good shape and plated both sides and propellor tube is nicely faired.*

SHOAL DRAFT RUDDERS

These are sometimes seen on centreboard or drop keel boats. The bottom half of the rudder is arranged like a kick-up centreboard; the blade will raise itself with or without assistance in the event that the boat is about to go aground. This type of rudder is found on coastal cruisers that frequently sail in shoal waters. Another version will have a dagger board blade, similar to a dagger centreboard; the disadvantage of this type is that it can easily be damaged or broken if it is not raised in time.

BALANCED RUDDER
This is a rudder where a portion, usually between 5 and 10% of the blade area, is ahead of the rudder shaft. The idea is to correct weather helm and/or make the steering lighter. My opinion is that balanced rudders only hide a problem rather than correct it so be cautious when you see a hull with this type of rudder. Another problem with balanced rudders is that when the rudder is turned more than a few degrees, it can act as a brake.

SKEG HUNG RUDDER
This is a rudder that is aft of a skeg. The effect of this arrangement is that the skeg enhances the effect of the rudder while providing directional stability and enhanced windward performance. Stay away from arrangements where the skeg is only half the depth of the rudder and the bottom half of the rudder carries some balance; this arrangement is notorious for catching stray ropes and lines and playing havoc with your steering.

HEEL OR SHOE SUPPORTED RUDDER
This rudder is usually arranged with the bottom end of the rudder shaft supported in a cup bearing located on the heel. The upper end of the rudder shaft enters the canoe body at around station 10 (aft end of the waterline). This rudder is usually not balanced. The whole arrangement forms a closed box (in profile) where the shaft and propeller are protected from damage from the many objects floating on or near the surface of our oceans. For cruising boats, this is one of my recommended rudder arrangements.

TWIN RUDDERS
Sometimes used on twin keel or on drop keel types and often combined with twin steering wheels. The idea is the leeward rudder is always in the optimum location to give maximum steering control. In practice twin rudders on sailboats are more trouble than they are worth.

ABOVE: *Here we see SPADE rudders which in my opinion are best suited to powerboats !*

SPADE RUDDERS

As the name suggests, shaped like a spade and are hung on rudder post or shaft. These rudders usually have 5% to 10% of balance and are often seen on racing sail boats. As these rudders are unprotected by any skeg or heel and are unsupported on the bottom, they are more suspectable to damage than most other types. Not my idea of the ideal cruising rudder. In the rarefied air of sail boat racing these rudders rule supreme; the variety of shapes is only outnumbered by the claims made for some designers latest creation. Recently spade rudders shaped to mimic a sharks fin (up-side down) was the hottest item; later the designer decided that for optimum performance the aft end of the keel should match the inverted sharks appendage. This latest thinking seemed to disappear after one season.

HULL ENDS AND OVERHANGS

Over the years there have been many theories as to the best shapes for the ends to the hull and the correct amount of overhang at the bow and the stern. For those not totally sure what the above terms mean here are some definitions. The hull ends refer to the forward end, forward overhang and area about the bow, and the aft hull end generally refers to the area including over hangs and area around the stern.

The period from well before the Second World War through to the 1960's spawned hulls with longish overhangs; extreme examples had an length on deck twice that of the waterline. Many of these boats were designed to a racing or rating rule; the theory was that as the boat heeled it picked up considerable (free) waterline length and so 'beat the rule.' Cruising boats built during this period often mimicked the inshore and offshore racing boats of the time. The Cruiser/Racer or Racer/Cruiser was a product of this type of thinking and as with many other things built to please all, these boats often pleased no one; too slow to make a good race boat and too wet or otherwise unsuitable for serious cruising.

Fortunately at the present there is a more distinct division between sail boats designed and built for racing and those designed and built for cruising. Moderate ends are the rule and it has been conclusively proven by thousands of long cruising crews that a boat with moderate ends makes the best sea boat.

ABOVE: *This Roberts 342 has a fin keel combined with a skeg and rudder - great for local cruising and round the bouys racing but not for round the world cruising. The Roberts 342 does have alternate keel arrangements that ARE suitable for serious offshore voyaging.*

MOTOR SAILER HULLS

The term motor sailer used to mean a boat best described as a 50/50 that is 50% motor and 50% sail. Occasionally one would hear boats referred to as 60/40 or by some similar definition. Today this distinction has been blurred to such an extent that I am not sure the term has any true meaning at all. As it is a term you will encounter when you go out searching for your cruising boat we had best decide what most people mean when they refer to a boat as a *motor sailer.* To add more confusion to the definition of a motor sailer, we now have a similar expression being developed as part of the new (European) EU Boating Directive.

My interpretation of the term motor sailer is best expressed by the Pacific Coast Fisherman 40. The PCF 40 is a motorboat (pure displacement hull, with a fishing boat heritage) that has been fitted with a modest but effective sail plan (one recently sailed from Australia to Ireland). Having mentioned the exploits of one PCF 40, I hasten to add that I would not recommend this type of boat as a serious long distance passage making vessel, but rather as one ideal for coastal cruising. Needless to say planing hull power boats are not suitable for conversion to motor sailers; this has been tried by some UK and US boat building companies that should have known better; the results were less than satisfactory.

More recently you are likely to hear the term motor sailer applied to a variety of sail boats equipped with a varying sizes of auxiliary power. Considering the term motor sailer in its more recent usage I would say that a boat fitted with an engine with a capacity of more than 2.5 horse power per 1,000 lbs displacement, (1.82 Kw per 454 kg) might be termed a motor sailer.

You will need to consider the hull form rather than the general terminology, when you are making your decision as to which hull is most suitable for your particular type of cruising. If you are considering cruising the canals of Europe with the odd foray into the Mediterranean, then a motor sailer in its true context could be the right choice for you.

ABOVE: *Not all motor sailers are this obvious, the 'Pacific Coast Fisherman 40' as its name suggests is based on a displacement fishing boat hull. One recently 'sailed' from Australia to Ireland.*

CHAPTER 4.

DECKS AND SUPERSTRUCTURES

General configuration and layout above the deckline. Decks and Superstructure arrangements; centre verses aft cockpit, raised decks, raised foredeck, raised poop or raised midship layouts. Pilot houses. Window and port sizes. Hatches; types and sizes. Deck covering. Llifelines, Pulpits and Pushpits.

This chapter is an OVERVIEW of the subject of Decks and Superstructures; the actual building process will be dealt with in the individual chapters covering building in the various materials. You may already have a favourite deck arrangement; by arrangement I mean you will choose between centre or aft cockpit, trunk cabin or flush deck, open cockpit or pilot house. Perhaps you prefer a raised deck either forward, amidships or aft by way of a poop stern. The boat you are considering may have a combination of two or more of the features outlined above.

This Roberts 36 features a raised foredeck.

If you are having a boat built or are otherwise in a position to choose the construction material for your deck then you will want to consider the following: In most boats the construction material used for the decks and superstructure is the same as that used for the hull. Occasionally you may want to vary this convention but do proceed with caution. One excellent combination is to utilise a special fusion strip to match an aluminum deck and superstructure to a steel hull. For slogging through unknown waters there is nothing like a steel hull; for saving weight, ease of construction and general suitability, aluminium is tops for decks and superstructures. If you can not afford aluminium then an all steel boat would be my next choice.

PLYWOOD DECKS AND SUPERSTRUCTURES
Using timber and/or plywood to build decks and superstructures is not a good idea; no matter how careful you are at the construction stage you will most certainly have problems in later years. Rot is the problem; I was once very forcibly taken to task by a person who read the words ’dry rot’ in one of my Boatbuilding books; I am still talking about ‘dry rot’, even though it is usually damp in appearance.

FLUSH DECKS
In the past flush decks were considered by many to be a desirable feature of any cruising boat that was intended to be used for serious offshore passage making. Most arguments advanced in favour of flush decks were based on the idea that the integrity of the whole hull and deck was better preserved by the elimination of raised cabin sides, short deck beams, trunk cabins and similar structures. This argument could be sustained when boats were built mainly of timber. Today most boats are built of either fibreglass or metal (steel, aluminum or copper nickel) and it is much easier to build a single homogeneous structure. The development of

The flush deck version of the Roberts 35can be be built in fiberglass or steel and has proved to be a popular choice for those who favor this arrangement.

modern adhesives has improved the structural strength on modern timber boats so even if you choose this material you are not restricted to flush deck or any other particular arrangement.

Although flush decks are no longer considered an absolute necessity for the ultimate cruising boat; this type of structure can be used to advantage either in part (see raised decks, poop decks and the like) or in total for certain types of boats.

The disadvantage of a totally flush decked boat is that in the unlikely event of a 180 degree total capsize, this type of hull will take longer to right itself than a boat with a cabin structure. Another drawback is that there are less opportunities to install hand holds as installed on most cabin tops. Personally I feel more exposed on a flush decked hull than on a boat with some superstructure providing shelter and handholds as one moves about the deck.

At time of writing the EU Boating Directive is still under final development. However I am of the opinion that it will not look kindly on flush deck designs due to the additional stability when in the *inverted* position. Until the final draft of the directive is available we can only speculate as to the direction of future design trends that will be generated by this legislation. So far we have been considering total flush deck boats, now let us consider the areas where partial flush decks may be appropriate.

PARTIAL FLUSH DECKS

A sensibly designed raised foredeck can add additional room both actual and perceived, to the fore cabin of any cruising boat. The fore deck should not be so high at the bow so as to interfere with the forward vision of the helmsman. A step down in the deck height near the bow incorporating a well, can offer protection in an area where you will be handling the anchor and gathering in headsails.

The raised poop stern has gained considerable favour in recent years and thousands of cruising sail boats feature this arrangement. This structure is usually combined with a centre cockpit and often accompanied by a pilot house. The poop deck is achieved (at the design stage) by simply moving the aft cabin sides to the outside of the hull or by raising the hull sides in this area. One has only to go below on a boat featuring a raised poop stern to appreciate the spacious feeling offered with this arrangement. The raised poop usually makes it easier to incorporate an 'en suite' shower and head, a very desirable feature especially if the crew number more than two persons. Another feature often accompanying the poop stern are larger than usual aft cabin windows (one could hardly describe most of them as ports) which are often incorporated into the overall design. (See ports and window openings.)

A few boats are built with raised deck amidships. In a small to medium sized cruisers this arrangement can add considerable room in the main living area of the hull. Other advantages

Incorporating a Poop deck into the design is another way to provide a spacious aft cabin and is often laid out as the master suite in when this arrangement is featured.

of this feature could include the extra working area on deck especially around the mast. It may be possible to incorporate a clear stowage space for an upturned dinghy.

DECK COVERINGS

Your deck will need some form of treatment to provide a non slip footing as you move about the boat. If you boat is fibreglass then it may have a 'non-skid' pattern moulded into the fibreglass; however I have yet to see a satisfactorily moulded fibre glass non-skid arrangement on any boat.

The least expensive treatment to make a deck safe to walk on, is to apply a special paint which contains a grit to provide the non-skid surface. Many steel boats use this paint/grit combination and provided it is installed in a proper manner it can work well and still look attractive. When installing a painted non-skid surface you should leave small borders around various fittings and alongside the cabin, inside the bulwark etc., which do not have the grit

Here we see a good example in the use of composite deck tread material that has been thoughtfully laid out on this steel Roberts 434 that was built in Sweden.

added. Be careful how you lay out these un-gritted areas as you do not want to leave skid inducing shiny spaces in high traffic areas. If the un-gritted areas are no more than 1 1/4" (320 mm) wide around any feature then you should not have a problem; you can always fill in any problem spaces with gritted paint.

The next step up in cost and appearance is to use a deck covering like 'Treadmaster' or a similar product. These coverings are composite materials formed in patterned sheets suitable for gluing to your deck. When laying out this covering you should use a similar pattern as suggested for painting decks with gritted material. Available in a range of attractive colours, these products are bonded to your deck with a special glue that is complimentary to the particular product you are installing.

The diamond pattern on some of these sheet products can be hard on your bottom or other areas that may come into contact with the deck; do not use it on cockpit seats or similar locations. There are alternative less harsh patterns that can be used where a user friendly non-slip surface is required.

At the top of the desirable decking material league is a laid teak deck. Teak is used on the best laid decks however there are other suitable species of timber that can be used for this purpose. In Australia the local Beech is often used and I have seen Douglas fir laid decks in vessels built in the USA. The advantages of a laid deck are that it provides a sure footing when wet or dry, it offers additional insulation, gives your boat a 'finished look' adding to the resale value by at least as much as the original cost of the decking. If you can afford it, teak is the best.

As the laid deck is almost always installed over a substrate deck; the teak can vary in thickness from one quarter inch [6 mm] or less to one inch [25 mm]. The method of fixing the teak deck will vary depending on the material used to build the regular deck. If you are building a new

This teak deck is installed on a Roberts 432 built in the UK and is a good example of what can be achieved by carefull planning and layout combined with fine workmanship as shown here.

ABOVE:
We have seen this coaming grow from the laminated structure through fiberglassing and now with the top covered with the teak decking; See chapter 7.

LEFT:
Here is an overview of the main hatchway, sliding hatch and hatch 'garage'

RIGHT:
Here is a closer view at the shiding hatch and garage.

ABOVE:
Here is a small sample of the sole area complete with teak planking. Note the mast support which will be trimmed with timber or similar.

TOP and LEFT:
The decking on the cabin top and decks is now completed, sanded and ready for use !

The pilot house on this Voyager 542 'Western Grace' adds to the appearance of this beautiful boat.

boat then you can sometimes allow for the strength and thickness of the teak when specifying the scantlings for the substrate deck.

On a light to medium displacement timber or fibreglass boat to avoid adding excessive weight, you may wish to use full size scantlings for the regular deck and then install thinner teak decking set in epoxy. On a boat with steel decks and in most other cases, I prefer to see a minimum of five eighths inch [15 mm] of teak used; my own boat had a wealthy previous owner and it came with a one inch [25 mm] thick beautifully installed teak deck. Laid decks can give one an unequalled pride of ownership.

PILOT HOUSES

The pilot house or wheel house is known under various names and has been a feature used on all types of boats since time immemorial. Earlier this structure was often referred to as a 'dog house'. The term wheel house is easier to understand. In 1972 a client of mine installed a house of his own design to one of my boats. When I made an adverse comment he replied that he would remove the structure when I took my drawing board outside; fair comment.

The last 30 years has seen a great rise in popularity of the pilot house and I can not imagine designing any boat without including at least one version that incorporated one of these structures. Many boats have pilot houses retro fitted and this is something you may want to consider when considering purchasing a boat that does not already incorporate this facility. In the past clients have often been somewhat diffident in asking for a pilot house explaining that the boat was to be used where it was 'too hot', 'too cold' or 'too wet' to do without the security and comfort of this feature. Pilot houses are here to stay and I would not personally consider owning a boat that did not incorporate this feature.

Pilot houses can be very short, sometimes no more than an steering shelter; or medium length, closed at the aft end with a lockable door and with steering, navigation and seating for other crew members; or long, with considerable accommodation inside usually including steering, dinette, galley etc; in fact a full saloon. I have often seen some so called *pilot houses* without steering facilities; in my opinion these 'raised saloons' defeat the whole idea of this desirable feature.

If you are laying out your superstructure arrangement and intend to include a pilot house then I recommend you start by planning for a medium length version. The steering station will include a comfortable chair for the helmsman and a generous size opening hatch above the steering station; this is useful for viewing the sails. Provide for a navigation station which may be the main one or an auxiliary one for the helmsman's use. Include seating for two or more additional crew members.

The forward facing windows can be either regular or reverse sloping and occasionally vertical as seen on some traditional craft. If you look at most fishing boats, you will notice that the forward wheelhouse windows are almost all reverse sloping, the reason for this is that these windows are much less prone to reflections which impair your vision. They are also less likely to need the services of a windscreen wiper as the forward top 'eyebrow' usually keeps most of the rain off the glass. After having lived with both types I would trade the glamour of regular sloping windows for the practical aspects of the reverse sloping variety. Electric wipers are a nice feature and recommended if your budget will support the expense.

If you are building a new boat make sure that the cabin and wheelhouse sides slope in at least 10% otherwise they can look as though they lean out, which does not look good.. There is one notable UK design where the sides do actually slope outwards, enough said!

On the subject of superstructure styling, do not allow any new boat you are building to be too extreme in this area. In a few years when you want to move up, down or out of boating you may find you have difficulty or are unable to dispose of your vessel.

PORTS AND WINDOWS

These need special treatment when installed in structures such as a pilot house. The larger areas of glass usually associated with poop sterns will also need careful consideration. In practice larger windows have proved satisfactory provided they are of reasonable proportions and glazed with heavy safety glass, perspex, lexan or similar material. Needless to say larger windows must have adequate framing; in fact windows that often appear large are not always large at all; these can be small areas of window backed up with a (sometimes disguised) system of framing. If you feel that the openings in your boat are of such a size as to present a safety hazard then you should carry plywood shutters. Make sure you have arranged a well organised method of fixing the shutters, because when and if they are required the speed and ease of fitting may be very important to the safety of your boat. In all cases you should have the ability to close off the openings in case of breakages. Most boats have at least six regular portlights and these can vary in size and shape and may be fixed (non-opening) or have the ability to open. Opening ports are

For a professional finish ... No matter what meterial you are building in, recessed windows and ports look the best !

notorious for leaking so if you can live with fixed ports you will have a dryer boat. Ventilation is best arranged by opening cabin top or deck hatches which are easier to keep water proof due in part, to their accessibility and geographical location on the boat.

HATCHES

Hatch is correctly hinged on forward side on the fore-cabin of this Voyager 542

Hatches are now usually built with aluminum frames and are glazed with tinted plastic or safety glass. The modern hatch will provide more light than any number of portlights could ever do. You will need hatch covers to be used in hot weather. Do not stint on the quality of these hatches, as in the event of extreme weather conditions the integrity of your boat may depend on these items. If you are fitting out a steel boat then steel framed hatches may be appropriate. Regular hatches come with all forms of opening arrangements including forward opening, aft opening, forward and aft opening. It is wise to have one hatch in each compartment than is large enough to allow any member of the crew to exit in an emergency. Hatches should be capable of being opened firstly from inside, preferably from outside as well and should be fitted with a suitably strong locking device to keep intruders out. Some marine hatch manufactures have a line of hatches made especially for commercial use and while these do not have glazing or other light admitting features they are ideal in areas such as the fore deck where they will be subjected to maximum loading. If you are fitting new hatches make sure you check with other owners before you settle on any one type; a leaky hatch is one of the most annoying items on any boat. I have seen one special ventilation hatch that opens in all four directions plus straight upwards; this hatch did not open to allow crew to exit, but may be useful set in a pilot house top or similar location.

Most cruising folk want comfort in the cockpit - hence the cushions.

Sliding companionway hatches need special attention. There are a few propriety ready made examples available however it is likely that you will have to fit a custom made one on any boat intended to be used for serious offshore cruising. The main hatch will usually be part of the main entrance and exit to and from your boat and as such should be capable of being secured against unauthorised entry. Unfortunately secured does not mean a simple locking arrangement but more likely a hatch and companionway arrangement that will deter all but the most determined intruder.

COCKPITS

Cruising boats were not always fitted with this feature, in fact a few still manage without them. Most of us prefer the security real and perceived offered by a well designed self draining cockpit. These work particularly well when combined with protective coamings and comfortable seating. The dimensions of this arrangement are most important and can influence the safety and comfort of the boat in many ways. It is desirable but not always possible to have the cockpit seats measure 6ft 6 ins (2.00 m) long; this allows a person to lay full length. The width of the well may be best arranged so a person can rest one or both feet on the seat opposite; this generally means a 2ft (610 mm)or 2ft 3in (686 mm) wide well; the depth is best at 1ft 6in (457 mm). Seats should be between 1ft 3in (381 mm) and 1ft 6 in wide and for comfort behind your knees, rounded on the inboard edge.

The height of the seat back that usually forms part of the coaming will vary depending on the design however about 2ft 0ins (610 mm) seems to work out well for most people. All cockpits should be self draining with two separate outlets of generous size, minimum 2" (100mm) diameter. The cockpit drains should be fitted with sea cocks that can be closed when required. Finally you should have a reasonable view forward when seated in the cockpit; this easier said than achieved especially if there is a pilot house structure ahead of your cockpit.

The choice between centre and aft cockpit is usually governed by your choice of interior layout. This choice has become blurred with the advent of staterooms fitted beneath and around an aft cockpit.

Modern stern complete with fold up boarding ladder.

TRANSOMS

If your boat is fitted with a 'regular' transom, and if you fit an aft boarding ladder make sure it hangs vertically when in use; many ladders can swing under the boat when you attempt to use them and this makes it difficult for a person to climb back on board. The best transom ladders have treads rather than just pipe rungs. In bare feet it is difficult to climb a pipe step even if it is sheathed in plastic tube.

Transom steps or 'Sugar scoop' sterns are considered here because they form an extension to the deck and superstructure and cockpit layout. For many years the reverse transom stern did little for the cruising boat except mimic the earlier racing designs and give the boat a 'racier ' appearance. Several designers have laid claim to designing the first transom steps but whoever came up with the idea deserves our heartfelt thanks. Transom steps can be coupled with a boarding ladder if you find that the first step in the transom is too high to reach from the water.

It takes very careful design to arrange the transom so it is just clear of the water to make boarding easier and yet still retain enough clearance on all angles of sail and not cause a ‘rooster tail’ with the attendant drag.

BULWARKS

Bulwarks or at least a decent toerail are usually found on any cruising boat. Bulwarks of varying heights are easily arranged on boats built of most materials so if you are planning a new boat then give this item your earnest consideration. Bulwarks can range in height from say 6in (150 mm) to 3 ft 3in (1000 mm); usually the larger the boat the higher the bulwark can be without detrimentally effecting the boats performance. For any given length, traditionally styled boats accept higher bulwarks without spoiling their appearance. Boats as small as 25 ft (7.6 m) LOA can have a 4 to 6 in (100 to 150 mm) bulwark and 40 ft (12.19 m) boats look fine with one that is 1 ft 3 in (308 mm) above the deck.

When deciding on a bulwark it is usual that in order to keep the hull topsides to a reasonable height, a resonable height is in proportion to the boats length and this is one item that you must check with the designer of your boat before making changes. You will have to balance the height of the bulwark against the location of the side decks as they affect the interior accommodation. For example can a seat be sited under the deck and still provide sitting headroom. You must also consider the overall height of the topsides with the bulwark in place.

LIFELINES, PULPITS AND PUSHPITS

This safety feature is rightly considered a necessity on any cruising boat. The height is very important, 3 ft (914 mm) above the deck is about right however this would look too high on

This Spray 52 built by Gil Davenport clearly illustrates both adequate bulwarks and life rails that are designed to keep you safely on board under all conditions.

many smaller boats. If you have a bulwark then some of the height will be absorbed in this feature and the lifeline stanchions are only needed to make up the remaining height. The 2 ft (609 mm) stanchions that are fitted to many boats are too low to be of any practical use and can cause adult crew members to over balance.
If your boat is over 35 ft (10.66 m), and especially if it has a traditional appearance, then you may want to consider stainless steel or galvanised/painted pipe lifelines in place of the usual wire. One arrangement I can recommend is to have pipe stanchions and upper rail of the same material and the centre line can be of coated wire. On most modern production sail boats lifelines consist of regularly spaced stanchions with two plastic covered wires running fore and aft from pulpit to pushpit. Small rigging screws or turnbuckles are used to tension the lines which are led through eyes in or on the stanchions. This arrangement may be adequate for local sailing but would be totally inadequate if you intend the have children on board; in the latter case a netting arrangement right around the perimeter of the deck will be necessary.
To avoid people using the stanchions as hand holds when boarding and leaving your boat, you should arrange a boarding opening with special reinforced stanchions. In any case make sure the stanchions are not only of sufficient dimensions and strength to withstand the weight of a fully grown person being thrown against them but also that they are strongly secured to the deck and or bulwark. A stanchion that is secured to the deck as well as to the top of the bulwark will be the strongest and most secure arrangement.
The height of the pulpit and pushpit should match the lifelines but in any case it should be a minimum of 3ft 3in (1.00m) above the deck; in the case where the lifelines are lower than I have recommended, you should make the pulpit and pushpit a little higher without spoiling the appearance of your boat. If you have steps in the transom then you will most likely want a gate in the pushput.

Above is a view of the fine Spray 52 built by Gil Davenport. This design features a steel hull and deck and an aluminum pilot house and makes a fine family sailboat in the style of a sailing trawler.

CHAPTER 5.

RIGS and SAIL PLANS

Choosing a sail plan for cruising; cutter, ketch, yawl or schooner. Modern or traditional. Unstayed rigs, contemporary Bermudian or gaff. Types of standing and running rigging. Winches, reefing systems, bowsprits. Equipment for self steering. Other self steering devices. Extra sails and their uses; storm sails and spinnakers.

WHICH SAILPLAN ?

The past few years has seen a quiet revolution in the number and style of rigs available for cruising sail boats. You may already have a favourite arrangement in mind; you should at least study the options, several of which you may not have previously considered.

One of your first decisions will be choosing the number of masts required to carry your selected sail plan. Although this decision is somewhat tied to the particular type of rig you prefer, there are overlaps in size where you could choose one, two or more masts and still have an efficient rig.

LEFT: *The gaff cutter on this Spray 28 looks and works well on this boat.*

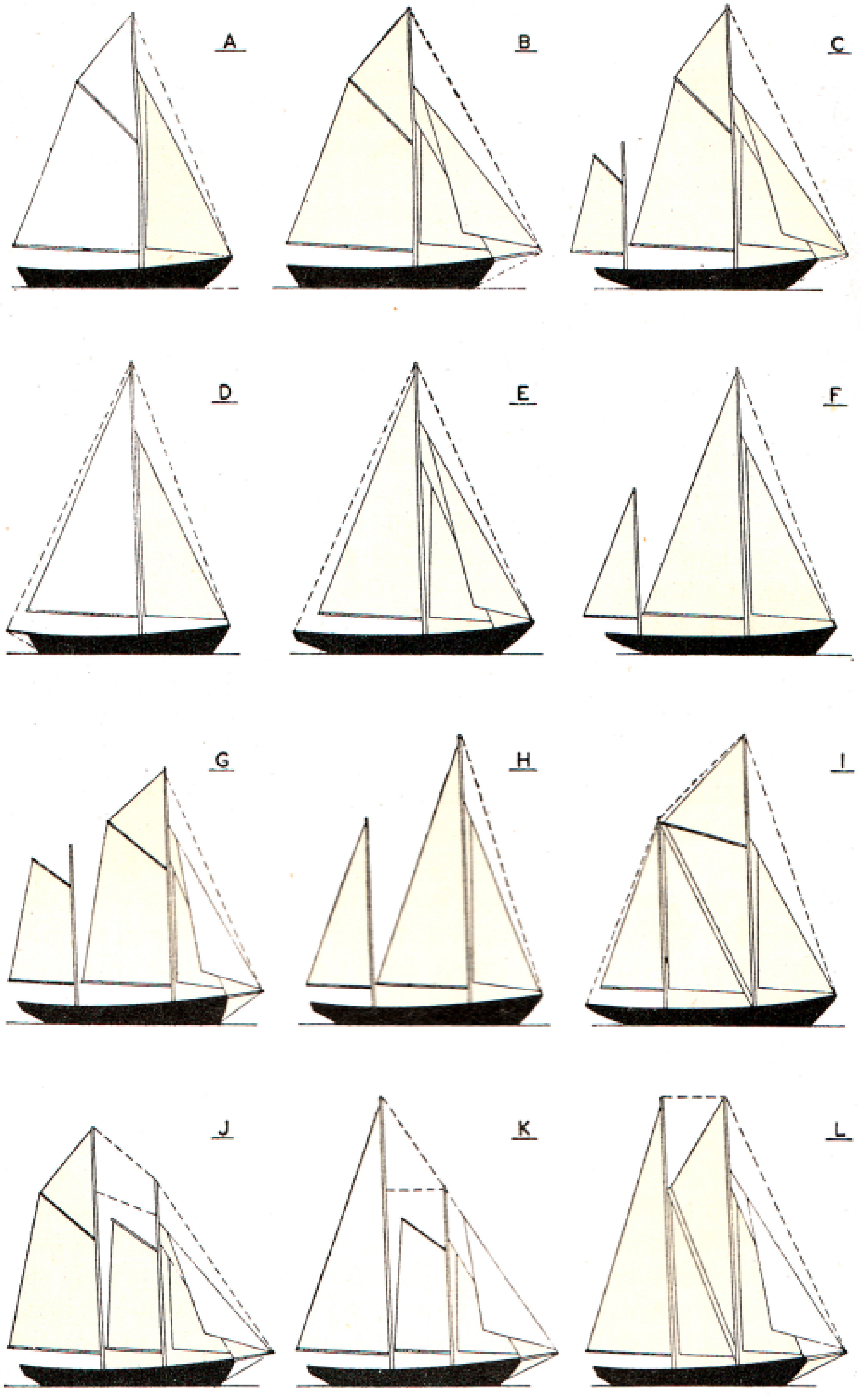
BOOMS

When considering purchasing or building a cruising sailboat check the height of the boom(s). The height should be arranged so that when any crew member is standing in the cockpit and if practical also on the side decks, then all booms will clear a persons head. Although it is not always possible to have the boom(s) arranged to achieve absolute safety in this area, it is well to remember that many crew have been knocked over the side by a wildly swinging boom.

Jib booms are another potential source of problems and the benefits such as automatic tacking of the staysail or a non-overlapping single headsail are somewhat offset by the potential danger to life and limb especially when working on the foredeck after dark; conversely if you have a jib boom you may have less occasion to go forward in dark or daylight hours.

HOW MANY MASTS?

In the past I have tended to recommended a single mast (usually a mast head Bermudian cutter) for boats up to 40 ft (12.19m) LOA. The single masted cutter rig used on this size of boat usually results in a mainsail of under 500 sq ft (46.45 sq m) and the headsails will also be of such a size that the weakest member of the crew with the assistance of winches, can raise lower and sheet the sails. On boats over 45 ft (13.71 m) I tend to recommend two masted configurations, this will keep all of the individual sail sizes to manageable proportions. In between 40 ft and 45 ft is a grey area where either arrangement would be a matter of personal preference. Many builders and owners choose to install rigs well outside these parameters; for instance there are many Roberts 36 ketches and an equal number of Roberts 53's rigged as cutters. Since the early 1960's I have preferred cutter headed arrangements for both single masted cutters and ketches.



YACHT RIGS

(*A*) gaff sloop; (*B*) gaff cutter; (*C*) gaff yawl; (*D*) Bermudian sloop; (*E*) Bermudian cutter; (*F*) Bermudian yawl; (*G*) gaff ketch; (*H*) Bermudian ketch; (*I*) wishbone ketch; (*J*) gaff schooner; (*K*) schooner with Bermudian mainsail and gaff foresail; (*L*) staysail schooner.

TRADITIONAL RIGS

This is good time to consider whether you prefer gaff or any other rig to power your cruising hull.. Do not become so enamoured with a style of rig that you insist on using it no matter how unsuitable it is for your type of boat. Apart from ending up with a totally unsuitable rig you could find your boat is unsaleable when you decide to move up or down in size or finally move ashore.

If you choose a traditional style of boat similar to an English style Pilot cutter, a Spray type, a Bawley or barge yacht, then the gaff rig when matched to one of these hulls, can make a very satisfactory cruising companion . To install a free standing carbon fibre rig on one of these traditional boats would be a very unsatisfactory arrangement from the practical, common sense and aesthetic points of view. For example, a successful carbon fibre masted rig usually depends on the hull being easily driven, not overly stiff and capable of good acceleration and this type of boat heels easily before taking up its sailing angle.

Lovers of the gaff rig often wish to combine this with the schooner layout. Again traditional boats can be matched up with this arrangement often creating a profile unmatched in beauty by any other rig. Part of the pleasure of owning a cruising or any other type of boat is 'pride of ownership', all of the owners of schooners I ever met are very proud of their boats.

If you choose a gaff rig it is a good idea to try and minimise the weight aloft; for instance if you install solid naturally grown timber masts then you may use laminated hollow timber for the gaff spar and perhaps for the boom as well.

ABOVE: *Here we see a traditional Spray 33 sporing a modern masthead cutter rig. Note the clean set of the sails with perfect slot between jib and staysail.*

Another arrangement that can prove satisfactory is the Bermudian schooner. This rig can come in a variety of arrangements. It is not uncommon to see schooners with gaff foresails and Bermudian mains or conversely, gaff mains and Bermudian foresail. Another well tried rig is the Bermudian staysail schooner, that is Bermudian main and one staysail between the masts backed up by a fisherman sail set above the staysail.

Almost all the rigs discussed here and elsewhere are best arranged with two headsails, providing the cutter headed arrangement previously discussed. Many owners enjoy a long association with gaff rigged boats while others are attracted to the rig by its beauty and charm are unable to handle the extra work and maintenance that is a part of living with these rigs. One advantage of the gaff rig is that it can be much less expensive to install than a modern rig and many traditional boats accept the less expensive gear and 'look right.' The galvanised fittings and natural fibre cordage are in keeping with the overall appearance of the boat; expensive stainless steel fittings could look out of place. A well designed gaff rig will accept a natural grown timber mast and boom; fortunately there are still places where you can select your own spars from the forest. In the case of Spray replicas and Spray types, these have been successfully rigged as Bermudan cutters and ketches as well as just about every other rig in existence.

MODERN MASTHEAD RIGS

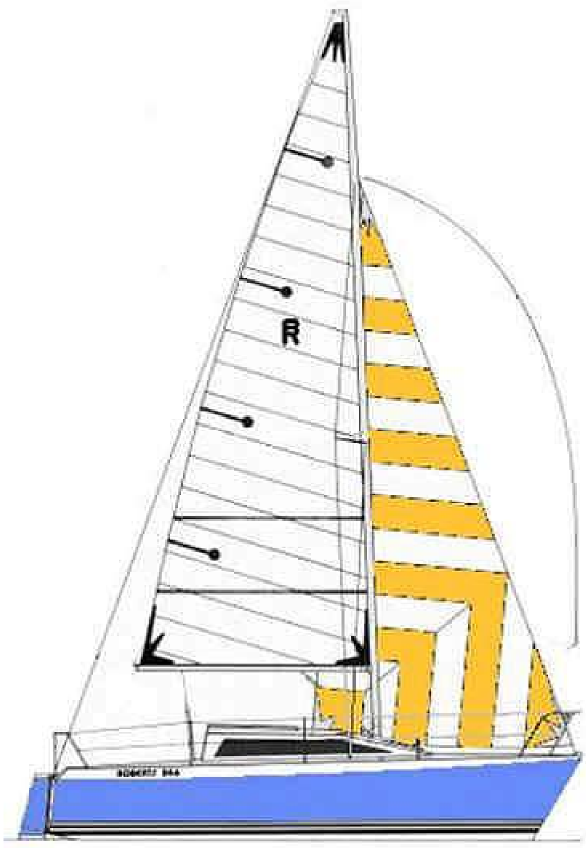
To most people this rig represents the most convenient and reliable arrangement for a cruising boat sailed by a family crew. You could think of this as a square form of rigging; the forestay, backstay and the cap shrouds all go to the masthead thus squarely supporting the mast in four directions. Depending the height of the mast, it is divided into either two or three panels where spreaders are located. From near the roots of the spreaders, shrouds are led to the chainplates. The lower shrouds are usually set in pairs led forward and aft of the mast. (See diagram).

A cruising boat fitted with a Bermudan cutter mast head rig, single mast cutter or cutter headed ketch, is best arranged with two or more sets of spreaders on the main mast. A requirement for most cutters is running back stays that are best arranged so that the upper end joins the mast just below the upper set of spreaders and the inner foresail (staysail) tang. The angle of the runner and the location where it meets the deck will need careful consideration; the standard practice was to make the angle at the top end match the angle of the inner or staysail forestay. If the angle is adjusted (reduced) so that both runners may be left set up when short tacking, then this has a definite practical advantage for short handed sailing. You should consult the designer of your boat, before making any changes in this area.

FRACTIONAL RIGS

Lovers of lighter displacement cruising boats sometimes prefer the fractional rig. This is usually arranged as a Bermudian sloop (there is not room for two headsails) and the headsail can be smaller and usually reaches up the mast to a location 7/8 or 3/4 of the distance from the deck. One supposed advantage is that with a larger mainsail the size of the headsail is reduced. Fractional rigs are generally more fragile than their mast head equivalents and in my opinion are not recommended for an offshore cruising boat.

Back in the mid 1960s when modern mast heads rigs were becoming established for both racing and cruising sailboats, the 7/8 and 3/4 versions were tried and found to be less desirable than a full masthead arrangement. The modern fractional rig is race bred and mainly intended to allow the mast to be bent from the top, the result being to give more control over the sails especially the main. With his arrangement the forestay and the cap shrouds all terminate at the 3/4 or 7/8 location and the backstay is the only stay that extends to the top of the mast. The fractional rig results in the spreaders angled



ABOVE: *The Roberts 246 has a fractional rig.*

backward sometimes as much as 30 degrees with the cap shrouds led over the tips of the spreaders and down to the chain plates. The fractional rig is based in part on the 'minimalist' theory that in the case of windage less is best; this may be fine on a raceboat where a large crew is available to maintain and operate the rig, however on a cruising boat with minimum crew it is often necessary to expect the rig to look after itself.

It is well to remember that the stiffer cruising boat requires a stronger rig. This fact was very forcibly brought home to early designers of large cruising multihulls. Some of these boats were more heavily built and carried greater amounts of stores etc., than their racing counterparts. When too lightly rigged, many of these multihulls were dismasted despite the wide staying base provided for their rigs. Single hulled moderate to heavy displacement cruising boats which may heel as little as 10 degrees in anything under a full gale, are typical of boats where an over strength mast and rigging is recommended.

The science of matching the rig to the hull is best left to an experienced designer; there are so many interrelated factors where an owner could easily make the mistake of mismatching hull and rig thus creating a potentially expensive and dangerous situation. Here we are outlining some of the options but before you make changes to an existing boat or design I recommend you contact the original designer or if that is not possible then seek advise from a suitable qualified person.

FREE STANDING RIGS

These modern rigs sometimes called 'Cat' rigs or in the case of a boat with two masts referred to as a 'Cat ketch' or 'Cat schooner', are worth your consideration when one counts the number of possible failure points on a stayed mast; on the average 40 footer [12.19 M] the number is over 50. Add up the turnbuckles, swages, toggles and other items where a breakage could cause your rig to collapse and you will see why some owners are becoming interested in this option.

LEFT: *Roberts 420 whith a Cat Ketch free standing rig.*

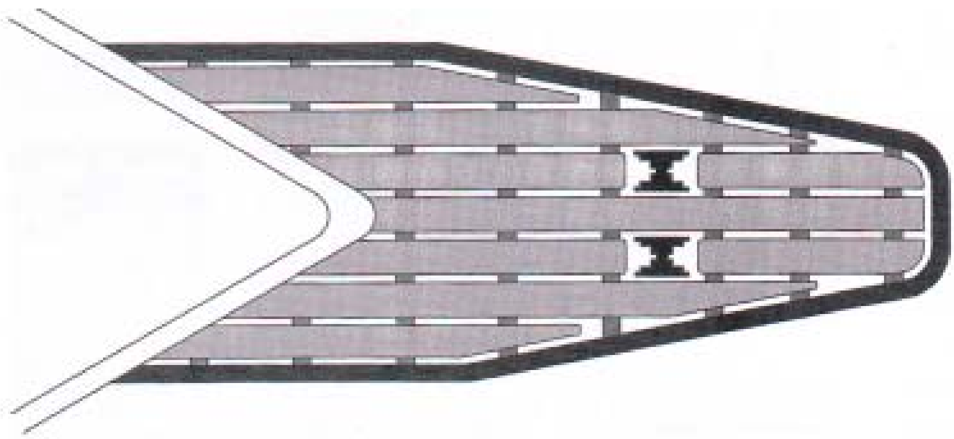
JUNK OR LUG RIGS

The Chinese have used these rigs on the rivers and for coastal cruising for thousands of years. What is not so well known it that the not so distant past these junks were much larger and used for long distance passage making voyages. Some 35 years ago Englishman Colonel H. G 'Blondie' Hasler developed a simplified and modernised version of the traditional Junk rig and used in on '*Jester*' a boat that was to prove the worth of Hasler's Junk rig designs. During the past few years hundreds of cruising sail boats have been equipped with this rig and it has proven to be a viable alternative to the more popular traditional and modern rigs. Modern junk rigs are capable of creditable windward performance and can often out-reach and out-run boats fitted with more conventional sail plans. Some of the advantages of the junk rig are, easy to reef, low initial and maintenance costs, lack of standing rigging (less to go wrong), and a certain beauty.

LEFT: *The owner of this Roberts 25 tried the junk rig before building a larger junk rigged cruising boat.*

ABOVE:
This bowsprit is combined with the spare reel of anchor line, jib boom and pulpit.

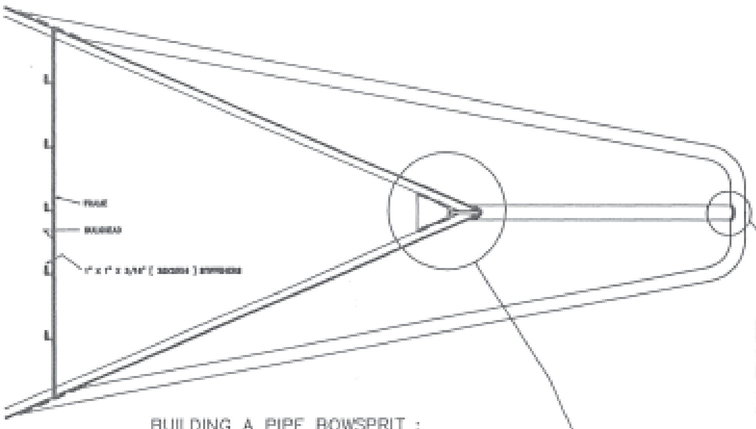
BOWSPRIT
One item that is not out of place with any rig is a bowsprit and many modern Bermudian cruising rigs as well as traditional boats sport this appendage. Some are short affairs used simply to keep the anchor out of the way and to provide a platform ahead of the forestay thus making it easier to handle the larger headsails. If, due to change in trim through loading, bad design or for some other reason your boat develops excessive weather helm, then the presence of a bowsprit will most

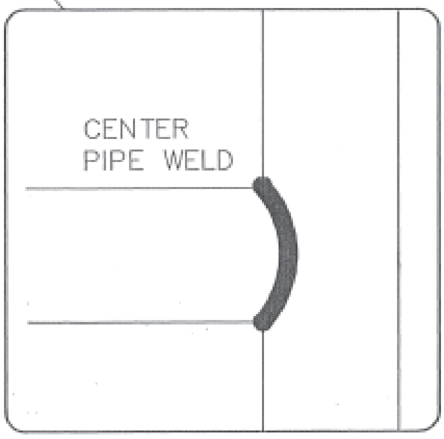


ABOVE:
This bowsprit can be added to any sailboat and is built as described below. Overall size and scantlings will depend on the size of your boat and if is expected to carry a forestay or is only used as an anchor handling platform.

BOWSPRIT DETAIL

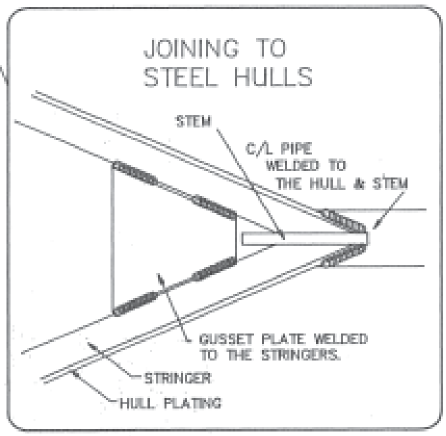
THIS BOWSPRIT MAY BE USED AS AN ANCHOR HANDLING PLATFORM OR AS AN EXTENSION TO YOUR "J" MEASUREMENT DEPENDING ON THE SAIL PLAN OF YOUR DESIGN. DO NOT MOVE THE FORESTAY FORWARD UNLESS SHOWN IN YOU PLANS. FORESTAYS THAT ARE TERMINATED ON THE BOWSPRIT WILL NEED A BOBSTAY TO ACCEPT THE LOAD.

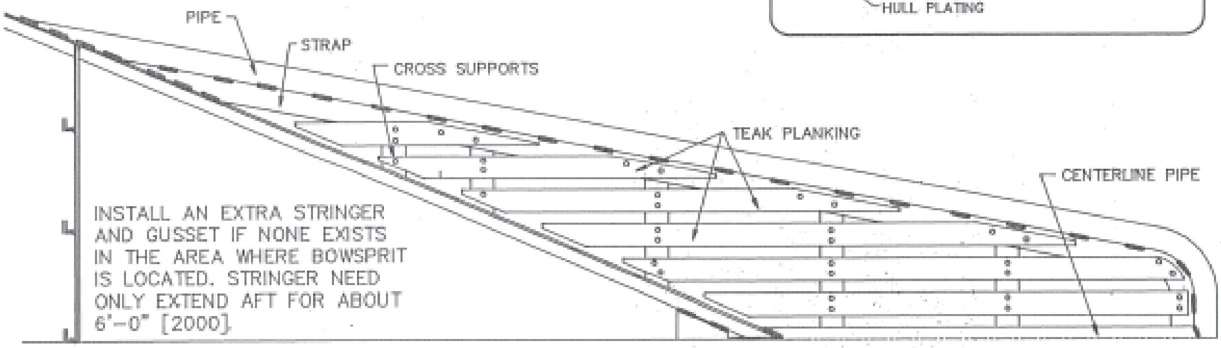




BUILDING A PIPE BOWSPRIT :

THERE ARE SEVERAL WAYS TO BUILD AND FIT A BOWSPRIT ON YOUR SAILBOAT. YOUR PLAN WILL GIVE YOU A GENERAL IDEA OF THE SHAPE THE OVERALL LENGTH OF THE SPRIT. NOW YOU HAVE TO DECIDE THE EXACT TYPE OF ARRANGEMENT THAT YOU PREPER AND HERE IS ONE SUGGESTION.
THE BOWSPRIT MAY BE CONSTRUCTED FROM EITHER 2" [50] 2 1/2" [60] OR 3" [75] S.S OR GALVINISED PIPE. THE BASIC STRUCTURE IS FORMED UP AS SHOWN AND MAY BE WELDED TO THE HULL OR FLANGED AND BOLTED TO SUIT YOUR HULL MATERIAL.
TO THE INSIDE OF THE PIPE IS WELDED 2" X 5/16" [50 X 8] STRAP AND CROSS SUPPORTS 3" X 5/16" [75 X 8] ARE INSTALLED AT 1'-3" [380] CENTERS.
THE PLANKING CAN BE 2"X3/4" [50X20] TEAK OR SIMILAR. SCREW OR BOLT PLANKING TO THE EDGE STRAP AND TO THE CROSS SUPPORTS. SNAPE OFF SHARP ENDS WHERE NECESSARY AND BEVEL EDGES OF PLANKING AT 3/16" [4] TO AVOID SPLINTERING ON THE EDGES AND ENDS OF THE PLANKING.
WELD FORESTAY TANGS, BOBSTAY TANGS ETC., TO THE CENTER PIPE. BOBSTAY WILL BE REQUIRED IF FORESTAY IS FITTED TO THE BOWSPRIT. ARRANGE ANCHOR LINE / CHAIN GUIDES TO SIDES OF CENTER PIPE AS REQUIRED.
IF THE FORESTAY IS FITTED TO THE BOWSPRIT, THEN THE STRUCTURE MUST BE ABLE TO ACCEPT THE STRAINS OF THE RIG. BUILD CAREFULLY AND STRONG.

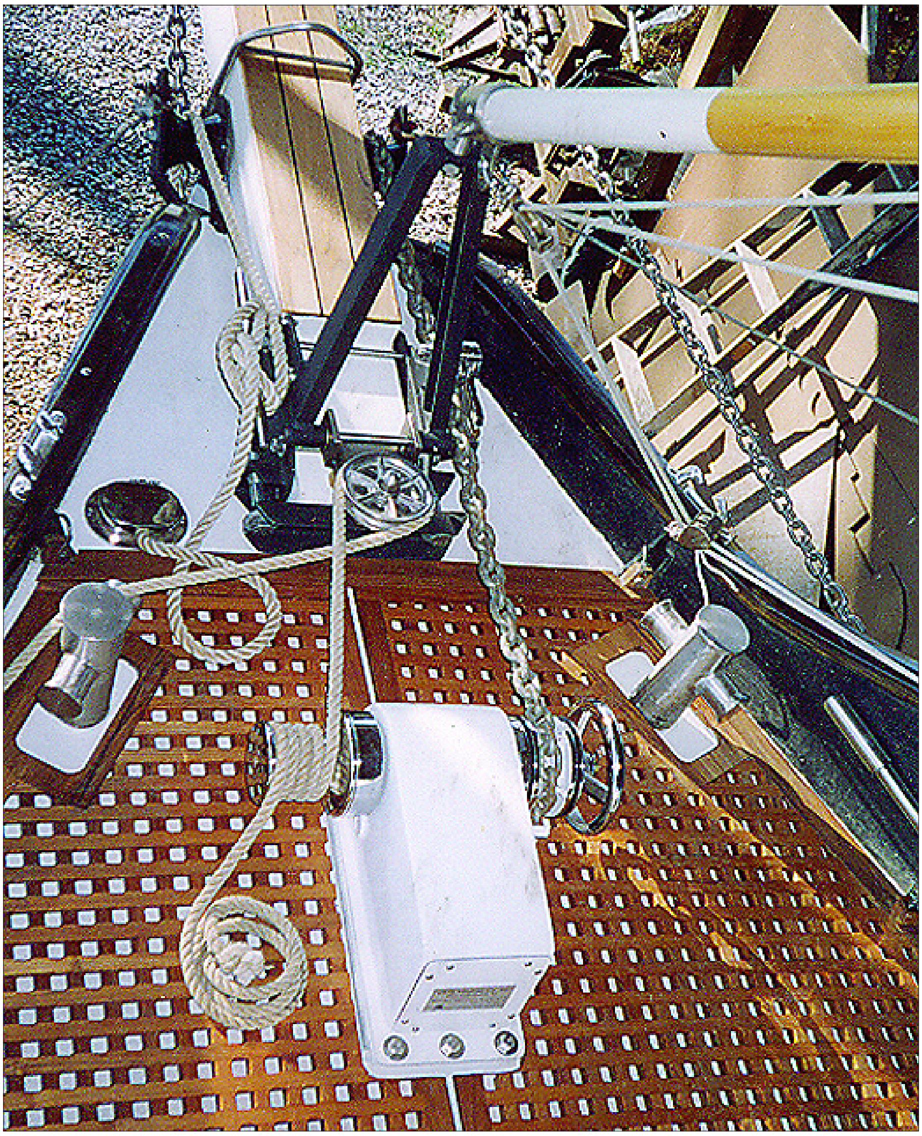




LEFT & ABOVE: *This bowsprit was built using the plans above plus other information that is included in all Bruce Roberts plans and patterns.*

ABOVE: *This traditional winch works well but take care they can bite !*

LEFT: *This arrangement in my opinion is looks busy'*



LEFT: *Here we see a traditional Spray with a very busy fore-deck and bowsprit area; see if you can identify all the items shown here.*

BELOW: *Most if now all of what you see on this Centennial Spray 33 built in New Zealand represents goo practice.*

likely help solve the problem. For instance if your problem is excessive weather helm, then moving the forestay forward may be all that is required to improve the situation. Weather helm can be caused by many factors and is sometimes a combination of several design faults. Shifting the centre of effort of the sailplan forward can often solve the problem. Adding a bowsprit is usually easier that moving the mast and rigging or other drastic alterations such as reshaping underwater sections of the hull..

The type of bowsprit I prefer is one built of say 1 1/2" to 3" (35 mm to 75 mm) galvanised or stainless steel pipe bent round in a open U shape and then decked in teak. This arrangement is strong and provides a generous working area forward of the bow. If you are not used to this type of appendage you will soon learn to allow for its length when docking or making other manoeuvres at close quarters. The bowsprit is more of a help than a hinderance and is most useful when picking up moorings, handling the anchor and dealing with unruly headsails. Depending on the length of your bowsprit, you may require a bob stay.

Many ‘performance cruisers’ incorporate carbon fibre pole bowsprits. These are usually of variable length and used to set the cruising spinnaker. This pole arrangement is not new, we used similar timber poles in the early 1960’s and called the sails ‘ballooners’ or ‘cruising chutes’ plus a few other names if they got out of control! Personally I do not believe the *symmetrical* regular spinnaker has any place on a cruising boat but the asymmetrical cruising spinnaker is well worth consideration and especially so if you have a reasonably active crew.

In the case of conventionally stayed Bermudian rigs it has always been my practice to design these with all of the upper and lower shrouds brought right to the outer edge of the side decks as opposed to narrowing the rig by bringing the lowers inboard to the cabin sides. The advantages of the narrower rigging at the lower ends is that it allows the crew to move about the side decks without ducking under the shrouds. The foregoing advantage is sometimes offset by the absence of a suitable anchoring point at the cabin side to take the high loads that are generated by the lowers. In broad beam boats it is possible to get a wide enough base for the lower shrouds to terminate on the cabin sides however if you rig any boat in this manner then you must have a chainplate that is attached to a bulkhead or other strong point that in itself has the necessary strength to accept the high loads.

MASTS AND SPARS

With the development of modern mast building techniques in both aluminium and carbon fibre spars, the whole matter as to what type of rig and number of masts needs more careful consideration. The return in popularity of the gaff rig for traditional and some not so traditional boats, the acceptance of free standing rigs used in conjunction with both modern and traditional arrangements such as the lug or Chinese junk sail plans, all contribute to a situation where it takes considerable thought before you make a final selection as to the best rig for your boat.

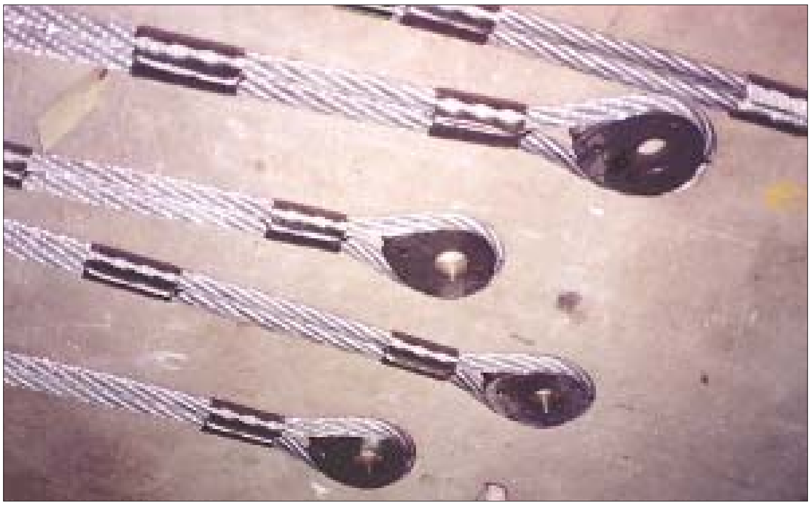
You may think that this is all academic if you intend to purchase a used or a new vessel. Many older boats will need so much gear renewed that it may be worth considering replacing the entire rig. You may be able to improve and update the rig by having the new one designed around the existing mast and chainplate location. In any case if you are planning to renew, replace or redesign the rig you will need the assistance of a person qualified to advise you in this area. If you are able to make contact with the original designer of the boat then this is your best option, otherwise engage a competent naval architect or yacht designer to help you with your new sail plan and rig replacement.

The loads on masts have not changed, they must still withstand compression (downward thrust) torsion (twisting from the spreaders) and local loads from boom, spinnaker pole and boom vang. Current thinking is that weight is more important than windage so it is important to choose a mast of adequate stiffness and strength while keeping the weights within reasonable limits. This is where the more recent developments in mast technology comes into play. For instance in a typical 50 ft [15.24 M] boat, a retro fit from an overweight older aluminium spar to a modern one made of the same material, can save several hundred pounds. It is well to remember that because of the difference in distance from the centre of gravity, each unit of weight saved aloft is worth several units of ballast.

TOP: *Pre-prepared rigging items made by the builder, parrel balls, blocks and belaying pins.*

CENTER LEFT: *Traditional splicing would look better in this company but the swages will be strong enough to do the job.*

BOTTOM RIGHT: *Ratlines work with traditional rigs and practical.*



In the 1960s the teardrop shape with a constant wall thickness was thought to give the best strength for weight ratio in most aluminium extruded spars. The 1970's saw the development of the elliptical section which has now evolved to the almost squarish section that represents the latest thinking in this area. It has been proven that the farther the side walls of the mast are located from the neutral axis (read centre of the mast in sectional view) the stiffer the spar. In stayed rigs, round sections are the least efficient and squarish sections are the most efficient because they locate more wall material farther from the neutral axis.

Rolled plate masts (as opposed to extruded sections) are becoming more popular for larger boats. The advantages of this construction includes the fact that plate aluminium is stronger that extruded sections therefore the wall thickness can be thinner for any given strength; the higher up the mast, the less need for strength. The wall thickness may be reduced towards the top of the mast, the result being weight saving where it is most beneficial. Plate masts can more easily be tapered from the mast heel to masthead, enabling more weight saving and adding aesthetic appeal to the mast. The benefits of this mast construction result in a lower centre of gravity.

Carbon fibre is now widely used in the marine industry and it is worth considering this material for your new or renewed cruising rig. This type of mast was originally used exclusively in conjunction with unstayed rigs and early examples were the subject of breakages. The failures of some of the early carbon fibre spars could be partly due to the fact that a new material (carbon fibre) was partnered with new rig technology (unstayed masts) so the experience gained in both areas makes carbon worth another look.

Another problem with carbon has been its high cost, usually about double that of an aluminium spar of equal strength. This higher cost is somewhat offset by the fact that most of the rigging is not required when the material is used in an unstayed rig. Carbon fibre fatigue properties are superior to aluminium meaning that in a mast it can flex more, and more often without failure. A carbon fibre mast weighs only 50% to 60% of an aluminium spar of equal strength and stiffness; this is another benefit, especially when considering ballast requirements. The boats' ballast, the carrying capacity of stores and water, are all factors that are interrelated, when choosing a new rig. The choice of carbon fibre is not limited to free standing rigs; already a few owners of conventionally rigged performance oriented cruising boats have chosen this material for their spars. One draw back to using a carbon fibre mast is that you will need to make special provision against a lightening striking your mast, see details in chapter 11.

DECK LIGHTS

No matter what type of mast you select make sure you have adequate deck lighting; these lights are usually located on the spreaders so they will need to be considered at the same time as the mast. The masts on larger cruising boats are required to carry a selection of equipment including radar, radio ariels, communication domes, as well as a variety of lights; keep this in mind when selecting the mast(s) for your cruising boat.

MAST STEPS

No matter whether you mast is deck stepped or keel stepped it will need some form of step to secure the lower end of the spar. Many commercially manufactured masts come complete with a cast aluminium step that is fastened to the deck and the mast simply sits in this arrangement. Check that your deck mounted mast step has the ability to drain water that lodges around the bottom of the mast. A tabernacle mast step may also be considered if you mast is not too long or too large; check with the designer of your particular boat regarding this option. Examine the mast support post that may be 3" (75mm) or larger, diameter metal pipe to ensure that it is up to the job. You mast under deck support may be in the form of a beefed up bulkhead; look for stress cracks and other telltale signs should the bulkhead not be strong enough without additional strengthening. If you mast is stepped on the keel, check if you have an arrangement that will allow you to alter the rake of the mast (this will change the fore and aft location of the foot of the mast).

STEPS ON THE MAST

Wherever possible you should fit the main mast with a set of steps for going aloft. Steps combined with a safety line are much safer than using a bosun's chair. The steps should have flat treads about 2" [50 mm] wide as all pipe treads are murder on bare feet. Steps should be carefully laid out and you can incorporate the spreaders into the system. Make sure that the step after the spreader follows your natural climbing pattern and that you do not have to change feet as you proceed aloft.

For gaff rigged boats where mast hoops or a similar arrangement precludes the use of mast steps, then ratlines are a good alternative. Although they usually do not continue up as high as mast steps, they have a superior appearance on any traditionally rigged cruising boat.

STANDING RIGGING

Many of the used production boats you may consider purchasing will have rigs that are worn out or totally unsuitable for deep water cruising. Stainless steel standing rigging has a definite life span and if it is more than five years old it will need careful checking and possible replacement. All sailboats with the exception of free standing rigs will require standing rigging. Some experienced cruising people still prefer to sail with a well set up traditional rig consisting of galvanised plough steel stays and shrouds all hand spliced and prepared in the traditional manner.

Dyform 316 stainless steel 1 x 19 standing rigging wire is a relatively new product being developed in 1986 to offer an alternative to rod rigging. At the request of Wallie Ivison of Norseman Marine (USA) the UK company British Ropes was approached regarding a product they had been making for some years. This wire was manufactured from a non-stainless steel material and was used for mining ropes and in nuclear power plants and similar applications.

ABOVE:

This steel deck, chainplates and rigging set-up show several good points. The area where the chain plates meet the deck is reinforced, the rigging screws and toggles allow the shrouds set up at the correct angle and also note the deck covering, substantial bollard and the way that the staunchions are located in reinforced socket bases. All in all a very neat set up and a credit to the builder.

When made in 316 stainless steel Dyform is over 25 per cent stronger and has 30 percent less stretch than similar sized regular stainless rigging. Early versions of this wire had some minor problems, mainly some sharp edges and minor rusting due to too low a polish however these deficiencies have long since been remedied and this rigging wire is now widely accepted by those cruising people who have made a study of the various types of rigging wire. Dyform can be swaged or it makes a perfect companion to Norseman end fittings.

No matter what type of rig you select or what type of materials you choose, remember that if you can fix it yourself you will be much happier than if you require outside assistance every time something goes wrong. It is obvious that help is not available in the middle of the ocean, it is equally undesirable if you have to pay some 'expert' to bring your boat up to operating condition, every time you make port.

Unless you have a paid crew, you had better know how to fix almost everything on your cruising boat. You can not fix machine made splices, but you can change Norseman, Sta-Lock or similar end fittings; if you have a traditional rig, you should be able to splice up new rigging as required.

When I came into yachting in the early sixties it was about the time that boat owners were making the transition from running rigging made from natural to man made. Having experienced both I along with most other cruising yachtsmen prefer the man made variety which is generally less bulky, more reliable, lasts longer and is easier to handle. No matter if your cordage is natural fibre or man made, make sure you know how to splice and care for all the lines on your boat and always carry adequate spare line.

WINCHES

The first cruising boat I ever sailed on had no winches. Dougie Drouin loved to do things the traditional way and his 35 ft [10.7 M] timber boat reflected his belief that sailing was a sport and as such, one was meant to extend oneself in all areas of the endeavour. Generous use was made of tackles and purchases to raise and handle the sails, break out the anchor and every other activity where additional strength was required. Today I do not think any crew would stay around for long on a boat as basically equipped as this.

When it comes to selecting winches it is much better to select a few well made and powerful examples than to cover your boat with several that will barely do the job. Today self tailing winches are considered the norm. Thoughtful layout of the running rigging can allow one winch to serve more than one line or even one purpose. Winches need to be well fastened and the mounting area reinforced as necessary to provide a strong point capable of spreading the load and accepting the enormous forces generated when a winch is used to its full potential.

CLEATS AND FAIRLEADS

Make sure your cleats are adequately sized to handle the lines that they are intended to accept: they may be made of aluminum, stainless steel or hardwood. Try to position them in such a way as to minimise the chances of your stubbing your toe. In many cases cleats have to be where they have to be, but you can usually manage to avoid locating them in the most dangerous places. Fastening the cleats to decks, coamings and cabin tops takes the same care as is used to install the winches.

For anchoring mooring lines to the hull I prefer 'bitts' to cleats; the bitt usually consists of two vertical posts with a cross bar to tie off the line. In the case of steel decks, it is possible to weld cleats and bitts directly to the deck. When securing to fibreglass or timber decks make sure that the bolts used to anchor these items to the deck are backed up with pads and large washers.

You will often need to install fairleads to avoid sheets and other lines fouling part of the rigging, coamings or other items of the superstructure. These and similar items need to be well attached and preferably installed in such a location and manner so as to not provide a hazard for the crew when moving about the decks.

When you are choosing blocks there is no need to purchase the latest 'high Tech' gear. Good solid quality blocks will serve you well. Make sure you carefully match the line to the correct sheave size and that all sheet leads are arranged so that your blocks are allowed to do their work without undue strain caused by poorly laid out sheeting. You may need turning blocks and other similar arrangements to avoid chafing your lines.

SAILS

The standard way to describe the dimensions of sails is as follows; P = The length of the luff (the edge that is attached to the mast) of the mainsail or mizzen. E = The length of the foot (the edge that is normally attached to the boom)of the mainsail or mizzen. J = The distance from the front of the mast to the forestay. I = The height of the jib halyard form the deck, in the case of masthead rig this will generally be the height of the mast from the deck.

For cruising sails you should still choose Dacron which offers the best all round performance and serviceability. The variety of materials used in building sails for the racing fraternity is best left alone and even if you can afford these materials, you will find that repairs and general servicing of the sails is far more difficult than with a normal Dacron sail. All cruising sails should be triple stitched and particular attention should be paid to the leather and other hand work required to finish off a good cruising sail. You should consider the ultraviolet resistance of the various types of sail 'cloth' before ordering any new cruising sails. On all but the smallest boats you should carry a sewing machine capable of making repairs to your sails and other 'canvas work' on your boat. Needless to say you should also carry a full set of sail making tools including a palm needles and thread. I have known many cruising people who have made their own sails, some from kits, others have cut and sewn their complete sail wardrobe from scratch. Making even one sail will give you a better understanding of the techniques required to make repairs when these become necessary.

REEFING ARRANGEMENTS

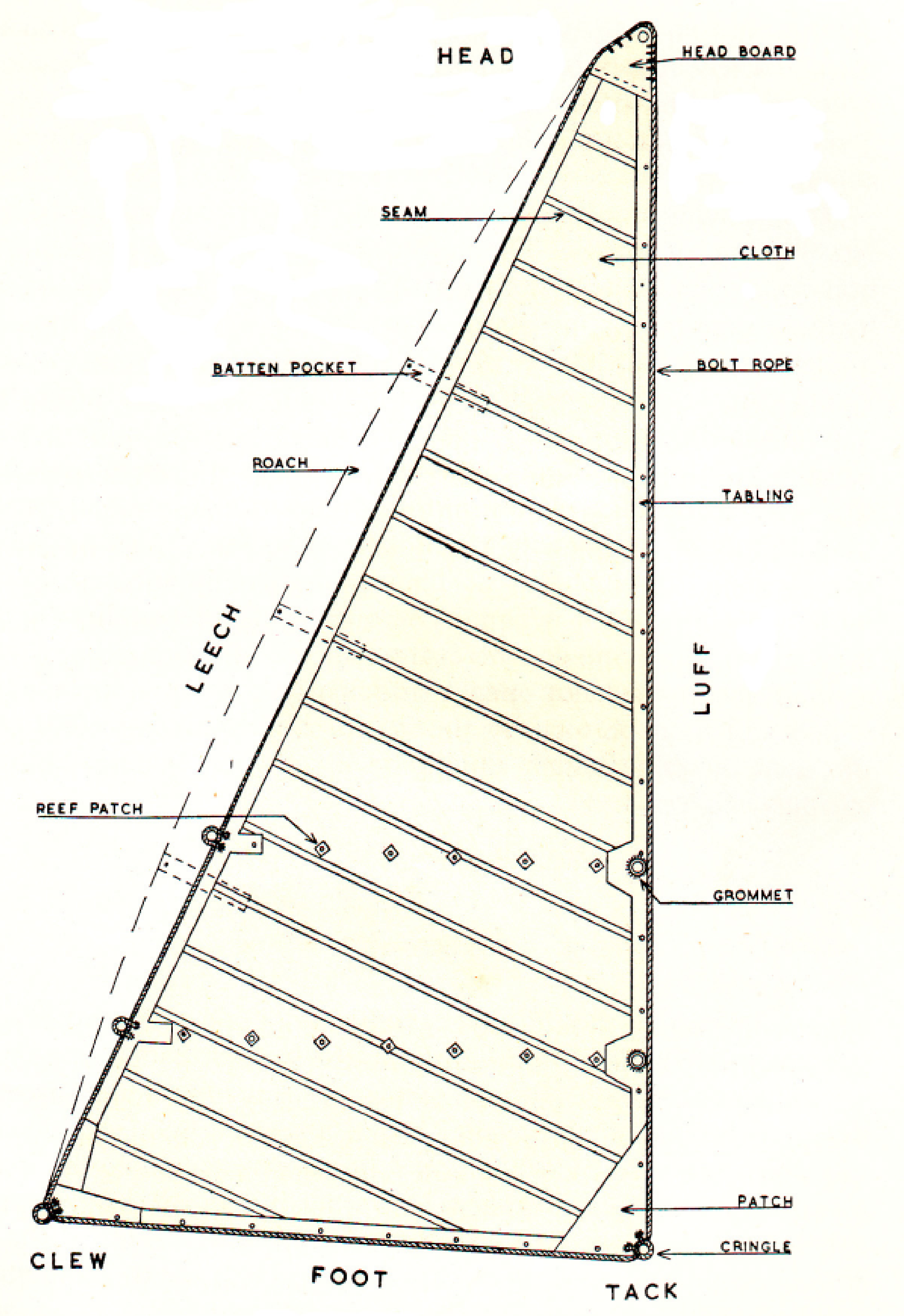
When considering your sail plan, an early decision will be needed as to what type of reefing arrangement you will be using. For the mainsail 'jiffy' reefing is the simplest and likely to give you the least problems. Most mainsails will accept three rows of reef points and a variety of arrangements can be used to secure these to the boom; permanently installed reef pennants look fine on traditional rigs.

Roller furling in the mast is a popular option however when the sail is reefed you still have the weight of a large portion of the sail high above the deck. Another arrangement is where the sail is furled on a spar attached to the aft face of the mast. In my opinion, boom roller reefing makes more sense and is a modern development of the earlier arrangement where we had a handle on the fore side of the mast and a bolt through to the boom We reefed the mainsail by rolling it around the outside of the boom. The modern equivalent of boom mainsail reefing involves having the sail roll up inside the boom. To date this arrangement is only limited by the size of boom needed to contain the rolled up sail; more sophisticated arrangements are allowing boats with larger mainsails to have in boom furling; check with your spar supplier for latest developments.

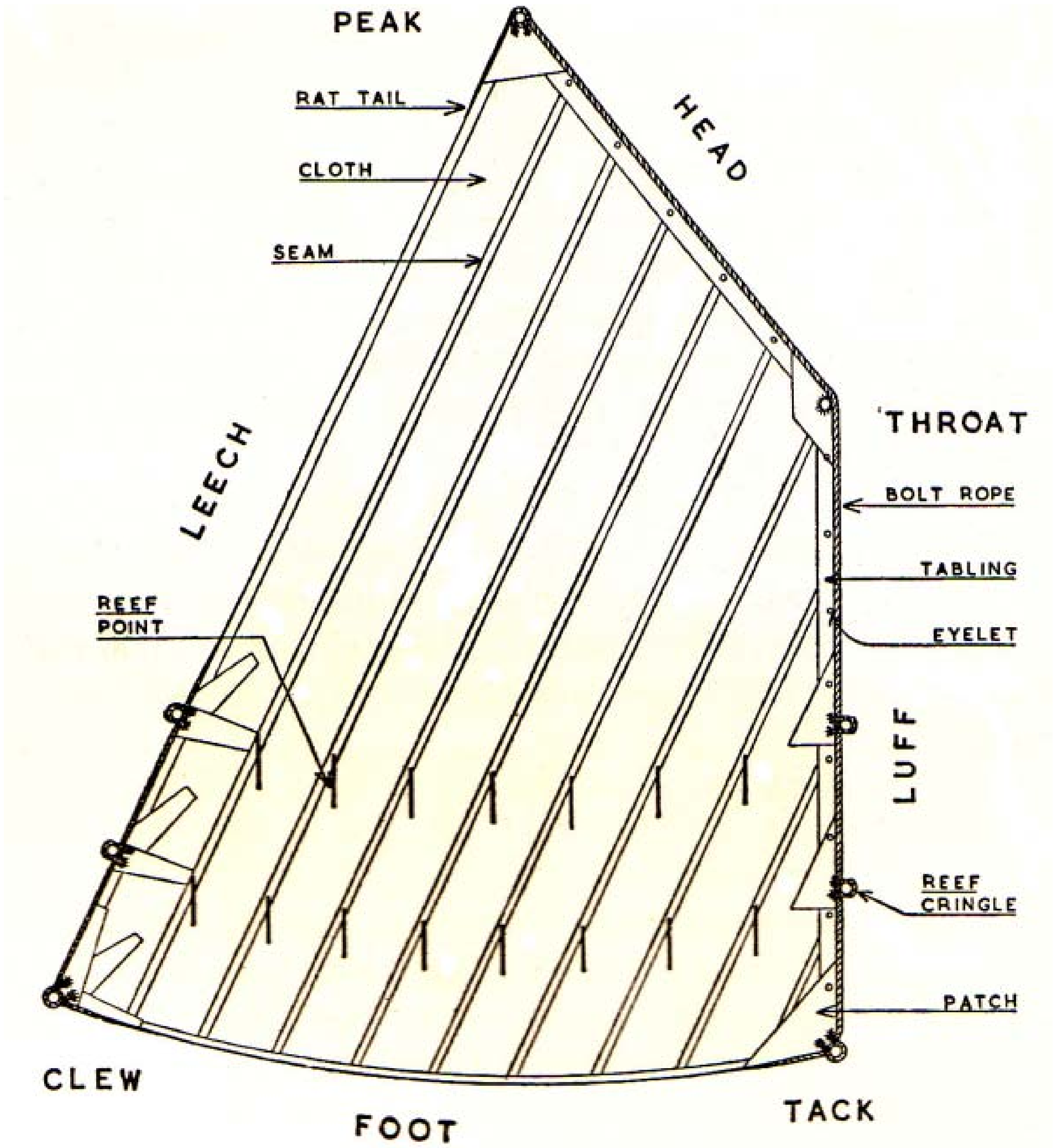
For the headsails you may wish to consider roller furling. If your cruising is mostly coastal in nature then roller furling has a lot to recommend it; the convenience of being able to reef the headsail from the security of the cockpit will appeal to most members of the family crew. For serious offshore work I do not like this arrangement. Roller furling jibs are notorious for unfurling at the wrong moment and on many occasions the headsail has to be cut down to get it under control. This arrangement also leaves the weight of the sail aloft when it would be better stowed below.

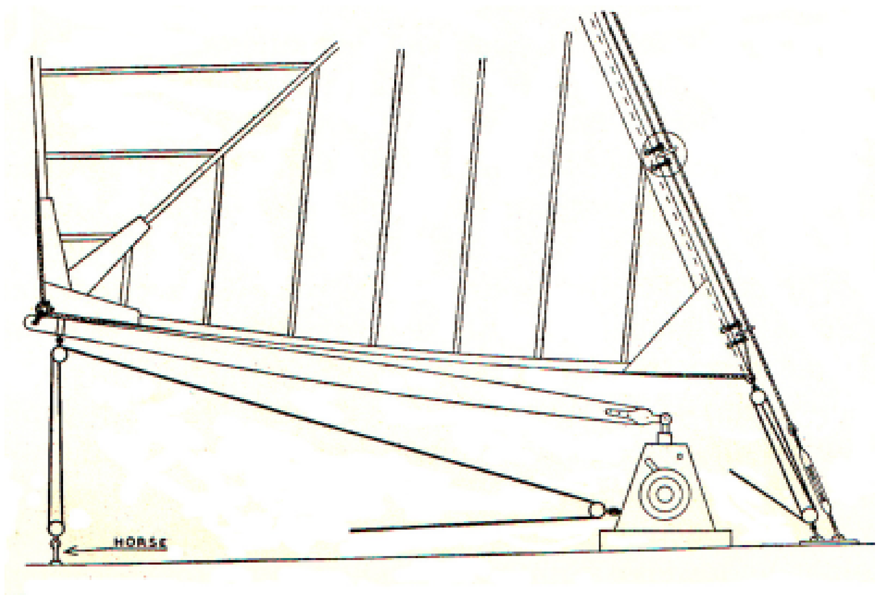
For those of you who are considering roller furling units, make sure that they have strong well constructed bearings at both top and bottom of the unit. The bearings should be obviously well made and built from stainless steel. Check that the luff extrusion is large enough to do the job; the small elliptically shaped ones are best avoided instead look for a heavy duty round section that can stand up to the rigours of cruising. Check the upper bearing will not foul the mast or become entangled with the halyard.

If you are have a roller furling headsail then it is essential that you have a back-up additional forestay to support your mast in the event of the headsail arrangement failing; there have been several



ABOVE: *This is a mainsail made is the traditional manner that would be ideal for many yearsof hard cruising. You may prefer a more modern cut sail !*





ABOVE:
This is a gaff mainsail made is the traditional manner.

LEFT:
This jib boom arrangement will work well on either a jib or staystail.

reported cases where the head-stay has broken below the roller furling drum. This extra stay may be needed to set a storm jib or other headsail in the event that for whatever reason, this action is required. Again this is a choice that should be tempered by where and under what conditions you plan to be cruising. When you know that assistance or the safety of a secure harbour will always be within a short distance your choices may be different to those you would make when you are planning long distance offshore voyaging. It is possible to have reef points in a headsail; one does not often see this arrangement but it does work especially when combined with a self tending foresail.

To summarise on the subject of reefing; for mainsails either 'jiffy reefing' or in the boom roller reefing. For headsails, roller furling is acceptable for coastal work but a good selection of individual headsails is preferred for offshore cruising.

STORM SAILS AND SPINNAKERS

Storm sails very seldom appear on modern sail plans however if you are planning long offshore passages there may be a good case for including these items in your sail wardrobe. Dedicated storm sails usually consist of a heavily constructed and reinforced storm jib and trysail. Special sheeting arrangements will have to be provided for both items as the sheets normally lead to a different deck location than the regular sails.

Spinnakers have been in and out of fashion as a cruising boat accessory on many occasions. The development of the 'Gennicker' or 'Cruising Schute' does make this item worth considering if you have a reasonably active crew (including yourself) and you like to get every ounce of performance out of your boat. Regular spinnakers are another matter, in my opinion they have no place aboard any offshore cruising boat; if you doubt my word, look at the more dramatic photos in the racing oriented sailing magazines or coffee table yachting books.

SELF STEERING

Your cruising boat's self steering ability often depends on starting with a well balanced hull and there have been many examples where the hull made a major contribution to this desirable feature. The *Spray* is one of the best known vessels with a reputation for self steering ability. With most modern and many traditional designs the sail plan will play a big part in keeping the boat on track; it is worth keeping this in mind when deciding on your sail plan and reefing arrangements. Self steering wind vanes usually work well with most rigs. A visit to any major boatshow will confirm that there are almost as many self steering devices available as there are hull types. Most of these arrangements work well and you will need to study the performance characteristics as well and construction detail before making a selection in this area. More recently one sees more boats fitted with electronic self steering devices as manufactured by Auto Helm, Navico and Seatreck. No matter how effective these wind or electrically driven self steering aids perform, there is no substitute for a well balanced hull and rig combination.

ABOVE: *The attractive deck layout is on a Spray 33 built in California.*

CHAPTER 6. Choosing a building site.

Where to build, Area required, Tool and equipment storage.

If you opt for this type of temporary shed then it is worth considering tarpaulins for the covering material as opposed to thin plastic sheeting which will not survive the first

If you decide to custom build from scratch or a hull and deck package, you will need a suitable building site; this applies equally if you are building in fiberglass, steel or wood. Depending on where you live you may have many, or a limited number or choices. If you live in a warmer area, then a simple shelter will suffice. If your boat is to be built or completed in a cold climate, then you will to need to consider a heated structure. In any case you will need some form of secure building, in which to house your tools and more valuable supplies.

When building a metal boat the need for security is relatively less than if you were building in fiberglass or plywood, this benefit only extends until you start on the interior and fitting out stage. Even if working outside, it is a good idea to keep the more valuable items out of sight or maybe in more secure storage, until they can be properly secured to, or installed in the boat. Used steel containers are available in make idea storage sheds and workshop areas and 40 ft / 12.2 m are available for $1,500 or less.

If you build in a shed like this one then you will need a larger door to allow your hull to be removed or be prepared to demolish the building shed. Some builders later sell their shed.

Part of the advantages of having your boatbuilding project located in a secure, comfortable and weather-proof building, is psychological; it will be easier to make the effort to go and work on the boat. Also if you are paying rent on a building, you are more likely to ‘get on with the job’. If you are building outside and exposed to the elements then you will often have to stop work due to weather conditions. All of the disadvantages of building outside can add months to your building program.

Depending on your finances you may opt for a hire or buy a tent structure as shown here. This tent is used to protect a Voyager 542 currently being built from a kit in California.

To determine how much space you will need to house your boatbuilding project, simply plan for a space 50 percent longer and 100 percent wider than the finished boat. For instance if you are building a 40 ft / 12.19 M by 13 ft / 3.96 M boat your space should ideally be 60 ft / 18.29 M long by say 26 ft / 7.92 M wide. When it comes to handling plate and other construction members, you will need s-p-a-c-e! You will need space for tools, materials storage as well as room to move around.

To provide yourself with an efficient working environment, plan your building site so that the minimum time is spent walking from one area to another. The positioning of benches and frequently used tools will play a major part in making a comfortable and productive workplace. Your boatbuilding project should not be too far from home and this is even more important, if you are only working part time on the project. Travelling time can eat into valuable work-time and distance can be a deterrent to getting started evenings and weekends.

Make sure that your work site is accessible to the vehicles needed to deliver long lengths of plate and other necessary supplies. If you are working outside be sure you have a flat level site. Carrying tools and building materials up even the smallest gradient can soon become a tiring exercise. Exercise, yes, you will get plenty of that!

One obvious choice is to build your boat beside your house. Many fine boats of 65 ft / 19.81 m, have been built to my design beside the owner's home. To make this a practical proposition, you need to live on a suitably sized lot or in an isolated area.

Many local authorities have building ordinances that may govern just what you can do in your own back yard. Check these before you start building a shelter or erecting boat frames beside your house. Generally speaking, the further you live from the centre of town, the better chance you have of being able to build or complete a boat on your own property. If you are not committed to a mortgage, you may consider renting a suitable house away from the town centre to build your boat. Best check with the landlord first and get permission in writing, before you sign the lease.

If you start with a hull and deck, then all you may need is a tool shed; the interior of the hull can be heated and the outside work can be completed in fine weather. Another advantage of starting with a ready-built shell is that this may make it possible to complete the boat in your own yard. Metalworking is noisy especially when building the hull and deck. If your boatbuilding project is sited in a residential area, then make sure that the noise that can be heard outside the boat is kept to a minimum.

Here are a few suggestions as to possible boatbuilding locations: in your own yard, unused corners of marinas and boat yards, fenced in but unused industrial sites, beside or in an engineering business, inside old warehouses, inside or beside an old storage barn. These are just a few of the many possibilities and these locations can often be rented at a low monthly cost.

Make sure you think ahead to the day that the boat ready for launching. Can a low loader and lifting crane get to your location to move your boat to the launching site? Have you surveyed the route? Check for low overhead wires, sharp corners in narrow streets; there are hundreds of stories about boats being lifted over houses, lifted from mountain sites by large helicopters and boats that were literally dragged through villages by willing helpers.

This Voyager 432 was assembled in Holland from one of our pre-cut kits. Here we see the finished hull being towed to the joinery shop on a low loader. Remember you need access to your building site to move your completed hull.

CHAPTER 7.

Building in WOOD

RECENT HISTORY

During the past forty years that I have been associated with the building and designing of boats, wooden boatbuilding has changed in many ways. Until the late fifties, anyone who wanted to build a boat would almost always have built it in timber. At that time, fibreglass was a relatively new material and was viewed with suspicion by most boat builders. Steel pleasure boats were definitely oddities, except in the Netherlands and a few other European countries, where steel was well accepted and often more common than timber boats were in other areas. In the late fifties through to the mid sixties, due to the reluctance to accept fibreglass and the lack of appreciation for steel, Ferro Cement gained some popularity as a boat building material. Ferro appeared appealing in its simplicity and cheapness however more recently, it has now dropped from favour, and virtually ceased to exist as a boatbuilding option. The huge number of design and structural problems plus an incredibly poor resale value contributed to its demise.

At the end of the 1939 – 1945 war there was a considerable pool of skilled labor and the technology available for building timber boats using cold moulding techniques. During the war, thousands of patrol boats and aircraft were built this manner so it was a natural transition from war to peace that many chose this material for building pleasure boats. When the war ended there was a considerable demand for pleasure boats, and thousands of cold moulded hulls were produced of which a surprising number remain in service to this day.

Until the early seventies, when the Wood/Epoxy building techniques were starting to appear, most wooden boats were either carvel planked and caulked in the traditional manner, strip planked or built using the techniques of laminating multi-diagonal plywood or veneers or straight forward sheet plywood, using urea-formaldehyde or resorcinol glues and silicon bronze and copper fastenings.

It would be wrong to discuss modern timber construction without reference to the glues or adhesives that make the various techniques possible. Amongst the earliest types were the urea-formaldehyde based glues which were claimed to be waterproof but it was found that water-resistant was a more realistic description.

Next came Resorcinol glues, which are a phenol-formaldehyde and truly waterproof and in the early 1960’s epoxies arrived on the scene; these were the breakthrough in modern timber boat building techniques that assured longevity in modern timber boats. Interestingly, although now overshadowed

This wood epoxy Roberts 434 was built in Germany and used in the charter trade. The custom designed shoal keel has worked well in the area where she operates.

by epoxies, resorcinol may be the better glue in many respects as it has superior performance at high temperatures and is less work sensitive however, the adaptability and versatility of epoxy has made it a more readily acceptable boatbuilding bonding material. Epoxies can be a glue, a resin and, with a filler, a fairing compound.

You can now buy moisture cured polyurethane glues which use the moisture in the timber to accelerate their cure without any other form of hardener. These types of glue are not suitable for all applications and not recommended for general boatbuilding use in any case check the suitability of any of these adhesives with your supplier.

By the mid seventies, fibreglass construction was becoming well established, steel small boat construction techniques were beginning to be accepted and so the scene was set for a decline in the numbers of boats built of wood. What stopped a total decline in the use of timber in boatbuilding is the rise in popularity of Wood/Epoxy construction; these new materials and techniques played an important part in retaining the modest interest in wooden boatbuilding that exists today.

It is noticeable that the continuing interest in wood is not evenly distributed around the world. In certain areas countries Germany, Scandinavia, parts of the USA, Canada and others with their own adequate timber resources, the interest in wooden boat construction is stronger than in other parts of the world where timber is scarce and expensive. Builders should always consider the availability of the various boatbuilding materials in their own area before making a final selection as to which is best for their boatbuilding project.

If you feel that building and owning a wooden boat is your type of challenge; that it is worth the extra time, effort and additional maintenance common with timber boats, that is reduced but not eliminated in wood epoxy boats; that it is worth the extra costs, as they are expensive to build, and finally, you are

This Roberts 532 wood epoxy hull was built in Brazil where fine boatbuilding timbers are plentiful. Two years after this photo was taken we received another photo of this boat rigged as a staysail schooner.

prepared to accept any disapproval from some members of the ecology minded community then a timber boat may suit you. I do agree that the 'dock appeal' of a well finished wooden boat is unbeatable. A good point to remember is that 'pride of ownership' is an important feature of building and owning any boat.

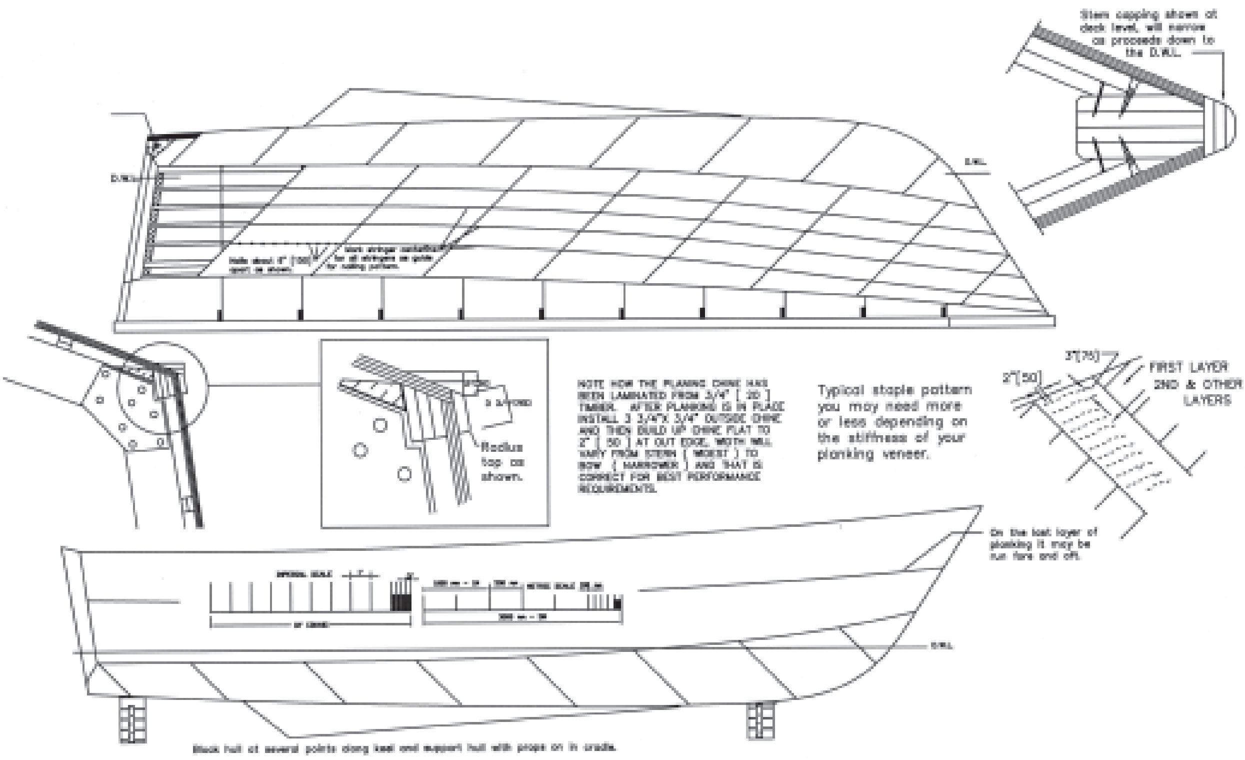
Earl Rentmeester photo. Here we see a round bilge temporary frame being assembled for a wood epoxy Roberts 434 round bilge hull.

COLD MOULDING

Cold moulding has been around for many years and is still very popular for building all types of hulls. In boat building, the process of cold-moulding is simply the practice of building a hull using laminated multi-diagonal layers of veneers or plywood over a temporary male mould, in the case of a frameless

This Roberts 532 wood epoxy hull was built in Brazil Two years after the photo on the previous page was taken we received the shot shown above of this boat rigged as a staysail schooner. Note the natural finish has been replaced by a regular paint job !

hull, or over a permanent frames and stringers where the hull is built using more traditional techniques. The easiest and most popular way to construct a cold moulded hull is to build it inverted that is upside down. After the planking is completed the hull is then turned upright and the interior is added along with the deck and superstructure. These days cold moulding and the now the more commonly used wood / epoxy techniques are combined to build a hull. This may involve using one layer of fore and aft strip planking followed by 2, or more subsequent layers of diagonal planking as described below.

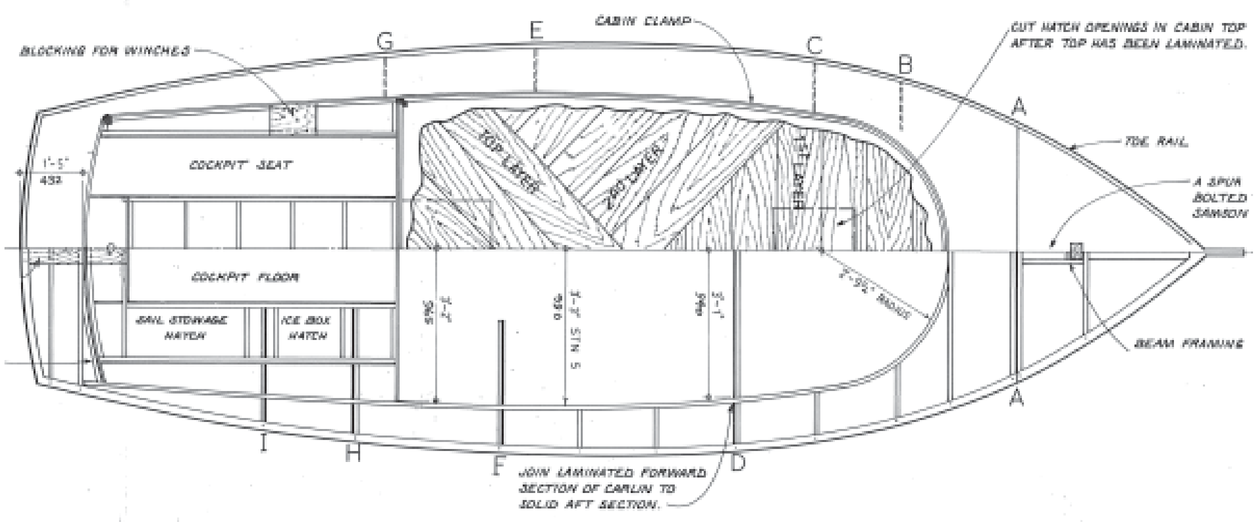


On a chine hull the plywood planking can be installed in larger strips and in some parts of a developed hull, full or partial sheets can be fitted in one piece.

Once the frames are erected and checked it will be time to start installing the hull planking. Photo by permission of Rob McGill and Nina Morissette.

After completing the temporary or permanent male mould, the first strip of plywood or veneer is fitted at about the centre of the hull and laid in place at approximately 45 degree angle and then nailed and glued or stapled in position on the mould structure. See illustrations and photographs for a clearer description of installing the veneer or plywood planks on the mould.

Each subsequent plank has to be shaped to fit next to the previous one; this is easily accomplished by using a small palm plane to trim the edge of each subsequent plank so it fits snugly against the previous one. Do not try to force a fit as this will create problems when you go to install the next layers of diagonal planking. The second layer is glued and stapled diagonally on top of the first layer, removing the staples (if used) from the first layer as the second is fitted. A hull can have 3 to 8 layers of veneer or plywood depending on the design.



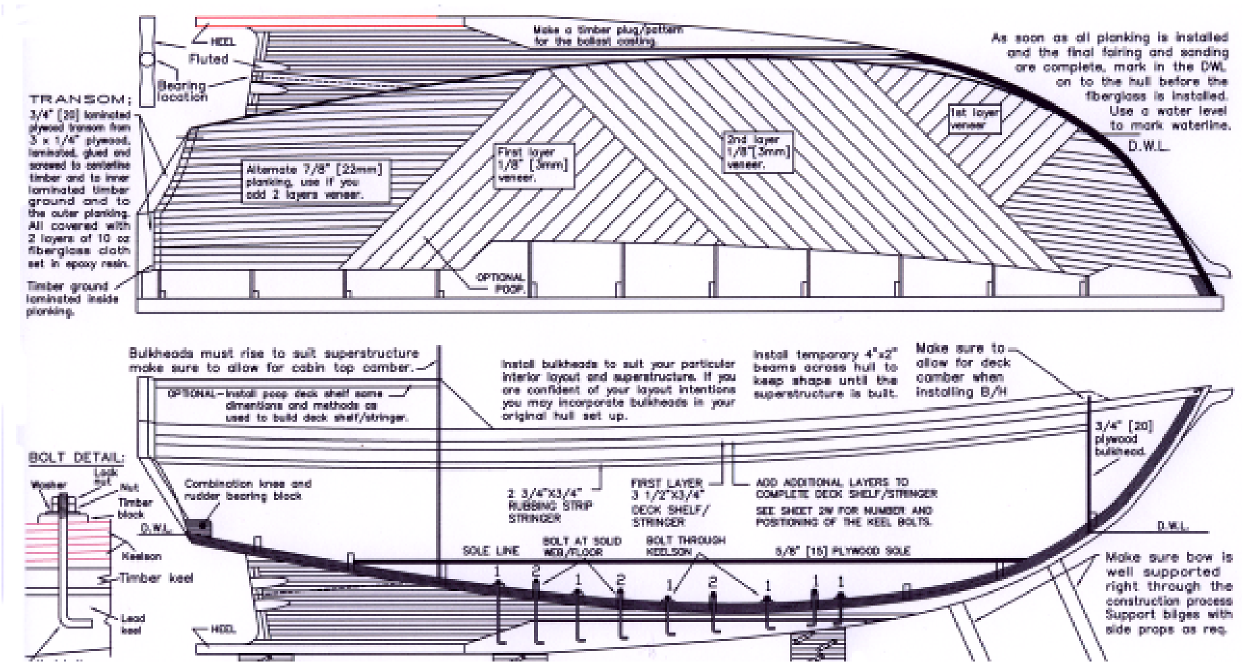
If you are building a cabin top with compound curve as in the Spray 22, then it will be much easier to plank if your use diagonal ply planking rather than try and force sheet plywood into a twisted shape; also make for a very strong cabin top.

Sometimes the final layer is laid fore an aft; this is usually the practice if it is intended to finish the hull 'natural' that is using a clear protective coating on the hull structure.

Plywood is quicker to install than veneers but is usually heavier so if you are building a lightweight racing boat veneer would be your choice and plywood may be preferred for a "not so light" cruising boat. An all veneer hull should be stronger than a plywood one; the reason for this is that in the plywood planked version there are many layers of short grain across the planks as is normal when plywood sheets are cut into strips as used for building using the cold moulded method.

When you think of veneer this material can be anything from 1/8 inch to 1/4 inch (3 mm to 6 mm) in thickness and still usable as the diagonal planking material for your cold moulded hull. I personally would veneer over plywood planking but cost, availability and your personal choice may cause you to use plywood planking. Provided you choose good quality materials and pay attention to detail, you will still end up with a fine hull no matter if you choose veneer or strips of plywood as the basic planking material.

The hull is then sheathed in fibreglass, Dynel or carbon fiber cloth which can be applied to one or both sides depending upon the design. The cold-moulding technique using veneers is commonly used in high performance multihulls and racing monohulls whereas cold-moulded plywood is more common in cruising boats. As far as the one-off builder is concerned, cold-moulding is a relatively straight forward process. Using full-size frame patterns, the basic structure goes together quickly as does the application of the veneer or plywood.



This timber hull on this Centennial Spray 38 hull is finished with two layers of diagonal planking followed by two layers of fibreglass cloth set in epoxy resin.

STRIP PLANKING – WOOD EPOXY

As mentioned above when it comes to building a timber hull there is considerable cross over between the technique known as ‘Cold Moulding’ and the Wood Epoxy building methods.

Strip Planking can be put into two categories – Traditional and Modern.

The Traditional strip planking technique relied on permanent internal frames and stringers to provide the necessary transverse strength. Internal fastenings joined the planks to the frames and edge nailed them together. This eliminated the need for caulking however very accurate tight fits were needed between the strips and availability of waterproof glues to seal the joins between the planks made the process much simpler. This traditional method of strip planking has almost entirely been replaced by the modern wood/epoxy system.

LEFT & ABOVE

This is a Wood Epoxy Roberts 246 built using the strip plank technique. As you can see the builder is making a very nice job of building this hull and deck. Note the cast lead that has been bolted to the timber keel.

With Modern strip planking, commonly known as wood/epoxy, the most common timber used is Western Red Cedar and instead of edge nailing strips together and onto frames, each strip is only temporarily fastened to the building frames and, when the process is complete and before fibre glassing, the nails are removed and the holes filled. The hull is sheathed with fibreglass both inside and outside providing the strength to replace frames and stringers. Internal fittings such as bulkheads, bunks and furniture would all be structural, and contribute to the strength. The structure is, in effect, a fibreglass sandwich panel. The weight and type of glass depends on the size of the craft and should be specified by the designer.

This is the construction shown in the area of the bow. From forward end of strong-back, installation

BUILDING FRAMES

Depending on the design you have chosen, your plans may call for permanent frames or for the frames to be used only as temporary mould formers, to be removed after the hull planking is complete. Permanent bulkheads can be utilized, as part of the setting up of the hull framework. If the frames are to remain in the hull, you will need to build them out of first grade timber or have them laminated to achieve the most strength for their size and weight. If you are fortunate, your plans will have been supplied with full size patterns and these can be laid on plywood sheets to enable speedy assembly of the frames.

THE TRANSOM

The transom can be assembled and installed at the same time as the frames or later, if you feel it is more convenient, for access to the inside of the hull. It is usually simpler if the transom is left out so we include the frame past the transom position so that the whole hull can be planked before turnover. After turnover, the transom can be fitted and the hull trimmed.

Building a boat is just a matter of performing one simple (or not so simple) task one after another. Below we show examples of some amateur boatbuilders who have succeed in building attractive and sea-worthy hulls. Our experience is that the hull is the most daunting part of the project and once you have managed to get past this part of the project then as they say ‘the going gets easier’ Good boat-building!

Once the frames are constructed they are set up and the first stringers are installed as shown on this Roberts 434 wood epoxy hull. Note the pre-laminated rib that was formed using the outside of the hull mould as a pattern; this rib will later be installed inside after the hull is turned upright. This illustrates a good case the forward thinking. Earl Rentmeester is the builder and he kindly supplied this series of photographs.

Here is another view of Earl’s frames and stringers. Note the piece of plywood lying along the stringers; this is used to check the structure for fairness. The strip of plywood represents one strip of the first layer of plywood. This strip will be laid diagonally over the stringers at various points to make sure that the frames and stringers are all fair and ready to receive the plywood planking that forms the finished hull laminate. Also note the clamping of the joins of top stringers; these are clamped together to provide a one piece stringer.

ASSEMBLING THE BASIC HULL STRUCTURE

Once you have made the frames and stem you can set up your hull, usually, on a strongback or, occasionally, on a level floor depending on the designer's arrangement. You should read the chapters in the fibreglass section of this book dealing with setting up a male mould. The techniques for building the fibreglass male mould and setting up a Wood/epoxy hull have a lot in common.

After you set the frames up on the strongback, you should install the stem and stringers or battens, depending on whether it is intended that the frames and stringers stay with the hull see under Traditional or Modern in Strip-Planking section.

Generally speaking, Wood/epoxy hulls are built over a temporary mould with reinforcing in the form of fibreglass and internal support from the furniture but they can be built with the frames and stringers in place. The idea of a lightweight shell, with a clean interior, ready to receive laminated web floors, laminated bulkhead grounds and other interior joinery has considerable appeal and is less likely to trap moisture. Today we build most modern timber hulls upside down and they are turned upright after the planking. You can install the transom at any stage before the deck is added. Usually the stem, the keelson, the deck stringer or deck shelf and transom if installed at this stage, will all remain with the hull when it is removed from the mould former.

FAIRING THE BASIC STRUCTURE

Once the frames, stem, keelson and stringers are in place, you will need to fair off the keelson and stem and other areas that need to be bevelled to receive the planking. Be careful not to over bevel any one area however, if you do make a mistake, you can glue a piece of timber on to the affected area and simply re-bevel to the correct angle.

Use a batten to check over your basic hull structure and to check that you have the bevels at the correct angles to receive the veneer or plywood planking. In the case of a chine plywood hull the setting up procedure will be similar except the chine stringers will stay with the hull even if the frames are removed. In fact, it is more usual to leave the frames in a chine hull.

INSTALLING THE PLANKING

The builder's next decision will be how he is going to install the hull skin. Generally speaking, your hull shell will be between ¼" [6mm] for say an 18 foot boat, up to a thickness of 2 inches [50mm] for a 60 foot vessel. We recommend for the smaller and lighter skinned hulls, an all timber veneer laminate. For a say 3/8" [9mm] hull skin, three layers of 1/8" [3mm] veneer would be ideal. Once the total thickness required is over say 5/8" [15mm] you may consider a combination of strip planking and veneer. You could have an all strip planked hull with at least one layer of veneer to finish off the exterior. Your plans will specify the hull thickness for the boat you are building.

Here we see Earl Rentmeester fitting and installing one of the diagonal strips in the first layer of hull planking. A small ‘palm plane’ will be useful to make final adjustments to each plywood strip to make sure that it fits snugly against its neighbour. Note the protective knee pads, always remember to wear safety gear appropriate to the work you are doing at the time.

Note the neat joins in the plywood strips which have been pre-scharphed into suitable lengths to fit diagonally on to the hull framework. If you can not obtain plywood or veneer of suitable lengths then you will need to pre-scharph the strips or have the sheets pre-scharphed by the outfit who supplies of the plywood or veneer for your wood epoxy boatbuilding project.

Next job is to install the second and subsequent layers of diagonal plywood or veneer. Note the neat first layer, all strips fitting close to their neighbours plus the strips are all neatly trimmed at the sheer line. See how the first strip of the second layer is allowed to go past the sheer; this is good practice for all strips but make sure to trim all before proceeding to the next layers of plywood or veneer.

Once the total number of layers as called for in your plans have been installed the next job is to fair the entire hull using a flexible sanding board say 3 ft – 3 ins / 1 m long by 6 ins / 150 mm wide and say ¼ in / 6 mm thick; try some different thicknesses of sanding board to find the best thickness and length for your particular hull fairing and sanding application. Fill any irregularities with epoxy filler before proceeding. Now install the stem capping as shown here. Note that the waterline has been clearly marked so that it will show through the fiberglass sheathing that will be added in the next step of the hull construction process.

Here we see the protective layer of fiberglass cloth laid out ready for installing using epoxy resin. The builder has pre-measured all the panels of fiberglass cloth so as to make for easier and more organised working conditions when installing the epoxy saturated fiberglass material. The grain of the timber and previously marked waterline will show through the clear finish created by the epoxy saturated fibreglass cloth. We do not recommend timber boats being left with a clear finish as you will need to use a special UVA protective varnish; also this finish always requires far too much maintenance for the serious cruising yachtsman.

AABOVE & LEFT: Views of the coated hull, this shot shows the stripe left to reveal the waterline marking. You will note that this area is still clear even though it is covered with the epoxy fibreglass laminate. Also note the laminated timber 'flat keel area' where the ballasted keel will later be attached by bolting it to the hull; also note the interior stiffeners and web 'floors'

BELOW: The hull is now upright and requires careful levelling to ensure that the decks, superstructure and interior joinery can be properly installed. Here we see Earl Rentmeester using a regular carpenters level but he will also be able to use a clear tube water level in other areas including the levelling of the waterline from the outside of the hull.

ABOVE: In this view you will notice that the transom is not installed. It is common practice to leave the installation of the transom until much of the interior work is completed; this allows more light to enter the work area as well as making more convenient access to the inside of the hull at this stage of your building program.

LEFT: This design can be built with minimum permanent frames. As you can see the temporary frames have been removed from the fore section of the hull and the forward bulkhead ground, stiffening web-floors and inner keelson have been added to the interior. Only remove the temporary frames as you need access to work on adding interior stiffening members etc., you want to keep the shape of your hull until the bulkheads and other interior work is as advanced as possible in any particular area of the hull

PLANKING Cont.

The completed hull is then finished with a number of layers of fibreglass, dynel or carbon fibre and epoxy resin. Two layers of cloth set in epoxy resin weighing 18 oz per sq yard or 500 grams per square metre would be about right. Larger boats say those over 36 ft or 11 m on deck, may benefit from additional layers of glass.

If you are building an all veneer hull, you could consider using 1/8" [3mm] or better still 3/16" [4mm] plywood for the first layer. Veneers are often too soft to bend evenly when not totally supported as happens when laminating over stringers or battens. The plywood will bend much more evenly and provide a better base for the following layers of veneer that make up the remainder of the hull skin. In some powerboat hulls, we recommend that you install the plywood planking in two or three or more layers as it would be virtually impossible to install the thicker plywood at one go and, because of the shape, it is often necessary to use plywood strips around the bow even if the remainder of the boat is sheet plywood. As plywood comes in large dimensionally stable sheets it is possible to plank large areas of a hull quickly and easily. However plywood can only be bent into a compound curve with great difficulty, and there are limits to how tightly it may be bent before breaking.

ROUND BILGE HULLS

For round bilge hulls, the first layer of plywood will usually be installed in strips varying in width from 3" [75mm] to 18" [460mm]. The strips or panels will usually be installed at the 45 degree diagonal. The width of the strips will vary depending on the shape of the hull as tight curves will call for narrower strips and flatter areas will allow the use of wider strips. Up near the bow should be the area with the least curve and so the strips can be wider. Only trial fittings on your hull will tell you how wide the strips can be on the different areas of your hull.

No matter where you start the planking, make sure that you install both sides simultaneously. Under no circumstances plank all one side before starting on the other as you will end with a twisted hull. For best results, apply one strip on one side then one on the other side working your way along both sides, forward or aft, in this manner.

TRIMMING THE PANELS

You will find that each strip or panel has to be fitted snugly to its neighbour. It is not just a matter of cutting the sheets of plywood or veneer into strips and laying them side by side at a 45 degree angle. You will discover that as the panels are laid around the hull, they twist slightly and each new panel will need a little bit of trimming. Fortunately, this is a quick and simple matter to rectify by trimming off the excess material where the edges overlap the previous panel. After first attaching the strip to the keel, the excess can be gauged and trimmed off with a small hand plane, or if the overlap is considerable, it can be marked and removed for trimming using band saw or jig saw.

Make sure you get a good fit, because if you force the panels into place by pushing them sideways they will not want to lay flat and you will never achieve a smooth hull finish. Any forcing a fit may result in a hull that will have a series of lumps and bumps that will be hard to remove when you install the subsequent layers; the fit of the first layer is very important. The idea of using plywood for the first layer is set up a smooth skin to receive the remaining layers but, if the designer specifies a certain sequence then, that should be followed regardless.

Glue and nail the first layer to the stem, keelson and the deck stringer. If the intermediate stringers are to stay in the hull, then the panels can be nailed and glued to them as well. If the stringers or battens are to be removed, then you staple the strips only and these staples are removed before the next layer is attached. There is no need to edge glue the panels as on subsequent layers, the glue will seep through and create a bond between the edges.

Before you start to install the second layer of veneer or plywood, you should check for any gaps between the strips and, if any are found, tape inside the join to stop any glue seeping through and running down the inside of the hull – saves a lot of work later.

When you have completed the installation of the first layer, the next step will depend on the required number of layers for your hull. If the plans call for the installation of three layers, it is possible, for the second layer, to use wider strips as long as they lay flat. If you find that wider strips are hard to fit, revert to the narrower diagonal strips as used for the first layer but in a diagonally opposite direction.

CHOICE OF ADHESIVE

These days, we assume most builders will be using epoxy glue between the layers however, there are some drawbacks to using epoxy compared to some other adhesives. For instance, some glue's may not have the ultimate strength of epoxy resins, but are more forgiving when it comes to working in less than ideal conditions. To make the most of the qualities of the true Wood/Epoxy techniques, you should be working in an environmentally controlled area. Temperature control is important as is the absence of high humidity. You will need to decide how your building site will measure up and choose your glue accordingly. See: "Recent History"

MARK STRINGER LOCATIONS

It is always wise to mark the positions of the stringers and keelson on each layer of veneer/ply panels. This will give you their location when installing subsequent layers of plywood or veneer and it will also be necessary to have a person inside the hull with a "dolly" to make sure you are getting a good tight fit as you nail or staple the first layer to the stringers, stem, deck shelf and keelson. Any bouncing or spring back as you nail or staple will often prevent a good join. The marked stringer locations will give you the positions through which to staple or nail the second layer to the first and so on. You should either nail or staple the first layer to the keelson and nail or staple to the stringers depending upon whether the mould is permanent or temporary. If the first layer of plywood or veneer curls a bit at the edge as it passes around the bilge area, you will usually find that the second diagonal layer will pull it into place.

SELECTING THE FASTENINGS

Over the years we have used several types of staples, one being the common galvanised wire type and the others stainless or silicon bronze. It is always sensible to remove steel or galvanised staples whereas the stainless or silicon bronze types could be left in the hull but better removed.

Some builders opt to lay the final layer in a fore and aft direction. Unless you are going to finish the hull clear, I don't think it matters which way you install the various layers as long as you have a good bond between the veneers. A balanced lay up is essential and by balanced I mean that all the layers do not run in the same direction. The plans you are using should give you precise instructions as to the procedure and sequence for applying the hull skin.

FAIRING AND FINISHING THE HULL

Once the hull has been planked the next job will be to fair off the stem and fit a trim strip. Then, dress off the bottom of the keelson to accept the laminated timber keel. Any raw end grain of the plywood should always be covered by a timber facing such as at the stem where the trim strip will take care of that exposed area. The timber keel can be laminated in position and can be reinforced with copper bolts. Next, give your completed hull a good check over and dress off any unfair areas before you sheath the entire hull, keel and the skeg with a layer or more of fibreglass or Dynel using epoxy resin.

TURNING THE HULL

Next job will be to turn your hull upright. As the methods are similar you should read the chapter covering the subject of turning over fibreglass hulls. Once the hull is upright and level on all planes your plan may call for applying epoxy resin to the inside of the hull before you are ready to continue with the fitting out of the interior and the installation of the decks and superstructure. The operation of turning the hull is similar whether your hull is built of timber, fibreglass or steel so please read the relevant chapters for additional advice on this important operation.

SOLID FLOORS – WEB FLOORS

Solid floors also known as web floors; these terms do not refer to the area you would walk on, they are in fact structural members. These 'floors' are installed athwart-ships at the lower end of frames under the sole (the area you do walk on) and usually have a function of assisting in tying the bottom of the hull to the keel area; they add strength where it is needed at the between the hull and keel. You may find it easier to fit the solid floors during the framing of the hull, rather laminate them in place later. Our plans have used both methods and each approach has its advantages and disadvantages. Your plans should guide you as to the best sequence for your particular design.

It is usually preferred in chine type hulls to attach the floors to the frames in such a way that they can be faired off with the stringers and the rest of the framing and then the hull skin can be laminated directly on to the floors. On round bilge hulls involving a "bolt on keel" it may be best to laminate leaf spring type floors into the hull after turning the hull upright. Again, your plans should guide you as to the best sequence for your particular design.

TRADITIONAL AND NOT SO TRADITIONAL PLANKING

Before leaving the subject of building your hull, we must give some consideration to the traditional strip planking technique. Today, if you are thinking of building in timber, then you really only have a choice between strip planking and cold moulding using plywood. Both methods are relatively straight forward and do not demand particular skills that would be the case with even more traditional timber building techniques and, the final decision should rest with the availability of suitable building materials. If you are strip planking the timber is cut to ¾" to 1 ¼" [20 to 30 mm] thickness and can either be square in section or a little deeper for example ¾" thick x 1 ¼" deep [20 x 30 mm]. The planks are "edge glued" one on top of the other. Traditionally, strip plank boats are built upright however I have seen this type of hull built upside down.

The framing for traditional planking is somewhat larger than used for more modern wooden boatbuilding techniques. Watch out for the conservationists if you choose this method!

Note the heavy keel timbers, heel, stern tube, steam bent frames and temporary stringers that will be removed as planking proceeds.

Bow area of a traditionally planked Spray hull, note bent ribs, stem and outer planking.

FRAMING

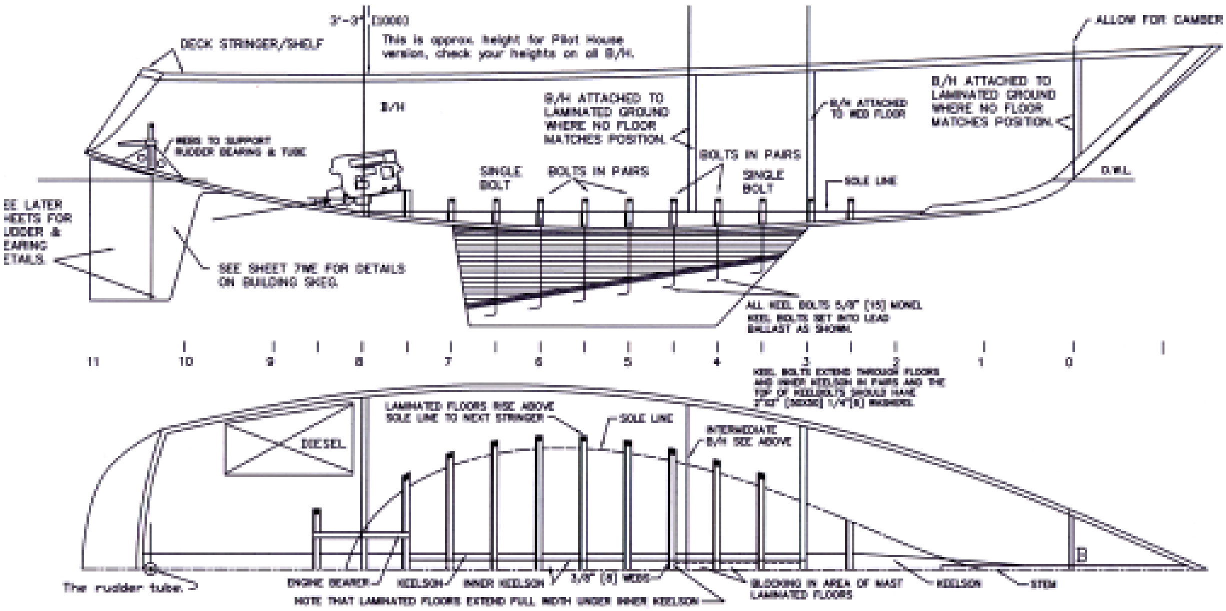
You will require temporary or permanent framing made up of sawn or laminated frames similar to those used for any mould. Sometimes when the hull is built upside down, the method is to install the planking up to the keelson and then a laminated keel is fitted in the manner described earlier in this chapter.   With traditional strip planking, the planks are fitted one on top of the other and are edge nailed and glued one to the other.   This method of construction provides a strong hull that needs the minimum of interior framing.   The planking timber may be dressed with square edges or may be machined to a concave section on the top and convex on the bottom.   This machining of the planks allows them to lay one on top of the other and to follow the curve of the hull frames with a minimum of dressing of each plank.   When using square edges, it is usual to dress off the top of each plank after it has been installed to provide a surface square off the frame on which to lay the next plank.   Either method is satisfactory although, as the planking will usually not go on up the hull in an even manner, it will be necessary to spile in short planks in certain areas. Some advantages of the specially milled timber are lost when you have to do this.

BALLAST KEELS ON WOODEN BOATS

For sailboat builders using any timber building method, there is one critical area common to strip planking, moulded plywood and other timber method in that you will need a separate keel casting of either lead or iron as ballast and this will have to be attached with keel bolts through the keelson.

If you are building a traditional strip plank hull, you will set up your ballast keel and the timber keel first and work upright from there.   The mould frames are set in place with the stem and transom.   The planking starts at the keel with the first plank let into the rabbet and the remainder of the planking installed as described above. If you are using Modern timber methods, you will build you hull upside down in the usual manner and attach the ballast keel after turnover.

The ballast has been fitted in the Spray 38. It makes sense to me to form the mould for the ballast as part of the laminated timber keel structure and then cut out the part where the ballast is to be located and us this part as the mould for the lead ballast. By permission of Rob McGill & Nina Morissette.



This drawing from the Roberts 345 plans shows the keel ballast bolted in place. Also not the web floors to accept the plywood sole.

STRIP PLANKING THE HULL – TRADITIONAL METHOD

Building upright, the first plank that connects to the keel is called the garboard and this plank may need to be somewhat wider than the rest. As the garboard plank sets the stage for the remainder of the planking, it is best if it is wide enough to be shaped on the bottom to fit the keel and to have a level top face as this starts the strip planking off on an even surface. As the planking proceeds up to the bilge area, it will often be necessary to taper the planks or lay in a few stealers in the centre of the bilge area otherwise you would finish with the planking too dished in a fore and aft direction by the time it reached the deck. The idea is to reach the deck level with one long continuous plank, rather than a series of short ends of planking towards the bow and stern of the hull. The methods you use to ensure that the planking is level when it reaches the deck will depend on the design you are building. In general, the beamier the design, the more stealers you will need to ensure a neat and efficient planking job. Before you start the planking you will have decided whether you are going to be using square edge planking or the convex, concave variety. As mentioned earlier, the planks can have a greater depth than thickness. It is a fact that the planks bend into place better if they are rectangular in section rather than square. Usually the depth is best at 1.5 times the thickness.

FASTENINGS

There are two basic choices for the adhesive, epoxy or resorcinol. As for the nails, you can use a combination of copper and silicon bronze. Usually copper nails can be used to fasten the strips but, if a harder nail is required, silicon bronze is the answer. The main function of the nails is to hold the timber together until the glue is set so it may be wasteful to pay the considerably extra cost for silicon bronze nails if copper will do the job. As with many decisions you must make during the building of your boat, the depth of your pocket will have a bearing on your final choice.

LEFT: This photograph shows from left, one of the ribs, a partial bulkhead, the inner keelson, web floors and a covered portion that is where some of the tankage will be located under the sole area.

BELOW: Another view of the same area as shown in previous photograph. Note the inner keelson, laminated ribs, web floors and the partially installed cabin sole. This is a good time to ascertain where the lowest point of hull is located; make sure you provide for drainage of any bilge water from the ends of the hull to area where you will install the main bilge pumping system.

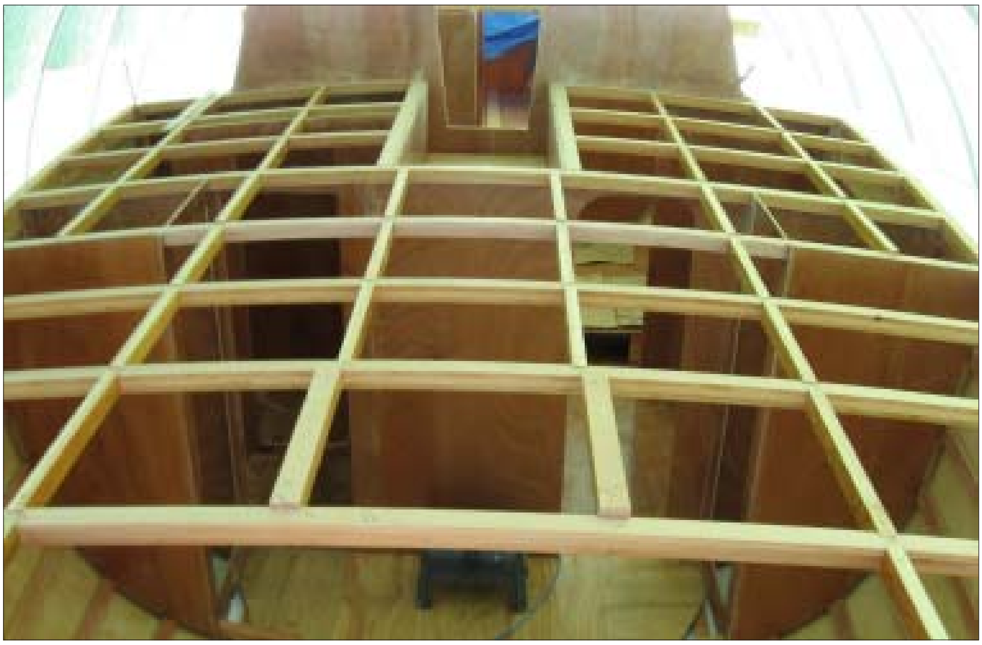
LEFT: The cabin sole should be installed in such a way so in cases of emergency that at least the centre section is removable. The installation of large joined up panels of sole plywood that finish under some permanently installed joinery such as settees etc., is not recommended. In any case all sole areas must have inspection panels and can often provide stowage areas for tinned goods etc. This photograph also shows one of the bulkheads with top area shaped to take the cabin sides and cabin top.

BOTTOM: Here we see more of the bulkheads shaped to take the decks, cabin sides and cabin top. In this view you can clearly see the substantial laminated sheer stringer as well as various bulkheads that are used to divide the interior into usable living space such as the head(s) galley etc. Finally you can see Mary Rentmeester who is surveying the size of the Roberts 434 interior.

Time to check the room in the various accommodation areas; Mary Rentmeester agrees that there is sufficient elbow and headroom in this head compartment. If you have room in your boat it is advantageous to have individual and separate head and shower compartments each fitted with a small hand basin and then perhaps one general head with a combination of all elements included in the one area. This is generally preferable to two or more all purpose compartments.

Looking aft - the pilot houese is already in place in this photo - see more of pilot house in later pages by Earl Rentmeester

We are looking forward to where the pilot h ouse will be installed - note the pilot house raised sole.



Here we see the laminated deck beams in the flush deck area; note the fore and aft intercostals that are added between the beams. This area will gain much of its strength from the laminated layers of plywood that are used to form the deck structure.

INTERIOR FRAMING

Once the hull has been completely planked and cleaned off, then the temporary framework can be removed and any laminated frames that are specified in the plans can be installed. Generally there are laminated frames where the bulkheads are to be attached to the hull and in some larger designs, a series of laminated frames may be specified throughout the hull. Sometimes the setting up, frames or formers, are laminated frames that remain with the hull. This system of permanent frames is usually reserved for boats of over 50 feet [15 meters].

Any intermediate floors not previously installed as part of the setting up process are now fastened in place. The bulkheads may be installed and it is often best to leave them standing up square well above the sheer so that the plywood can be marked out with the side deck width, cabin lay-in and cabin top camber. The interior may be roughed out at this stage and any large items such as engine, tanks and large panels of plywood required for the interior, should be in the hull before you start work on the decks and superstructure.

The cabin sole can be fitted, keeping in mind you will need access to the area of the keel where the keel bolts are and, in any case, it is always prudent to have removable sole panels. At this time you will need to decide if you are going to use transverse or longitudinal deck beams. In the days of wooden boats, all deck beams had to be installed transversely because the deck planking ran fore and aft. Now that we have plywood to use for decking you may find it easier to use longitudinal deck beams or a combination of both longitudinal and transverse beams. At the same time as you are installing the beams, you should frame up for the cockpit coamings and hatch openings.

If you are planning a laid timber deck on top of the plywood sub-deck, then it would be better to use transverse deck beams so that you will able to through fasten the timber deck planks unless, the deck itself was thick enough to take these fastenings. Even if you use longitudinal beams and later decide on a laid deck, you have the option of using the diagonal or herringbone design to pick up these beams. Before you can fit any deck beams or decking, if not already in place, you will need to install the deck shelf around the inside of the sheer.

After the camber is cut, you may decide to attach a transverse beam to the top of each bulkhead and at the deck line before installing beams. This applies regardless of whether your main deck framing is transverse or longitudinal. Even with transverse beams you will need a few short longitudinal beams such as for the cabin top in way of the mast step and one in the fore deck, known as the king plank, in way of the positioning of the mooring bitts, anchor winch or fore deck cleat. Fore and aft king planks can be wider and shallower and can be checked into the transverse beams.

If you are installing transverse beams, these can either be sawn or laminated. A typical beam would be 1 ¾" wide [45mm] by, say, 2 ¾" [70mm] deep. This beam can be made up of laminations of 1 ¾" [45mm] wide by ½" [12mm] with one thicker layer to make up the odd amount. The layers of timber can be set up in a purpose made jig or made over a master beam assembled on the widest bulkhead. It is a good idea to make up the beams well in advance.

These beams can be laminated, daily or weekly and set aside until needed – when made, be careful to store them out of the sun and the longer you can leave the beams on the jig, the less spring back you can expect. Once you have fitted all the deck framing , check it over and dress off any unfair areas. Make use of a batten laid diagonally across the surface of the deck framing to make sure you have no lumps or hollows which will give you problems when you start to fit the plywood decking.

This photo shows the anchor locker bulkhead, deck carlin attached to the inside of the hull and cabin side carlin where the side deck beams will be installed. This series of photos and those on following pages are by permission of Rob McGill and Nina Morissette

This photo side and fore deck beams in place. Note the space in the bow area where the anchor locker hatch will be located.

Close up on the deck beams.

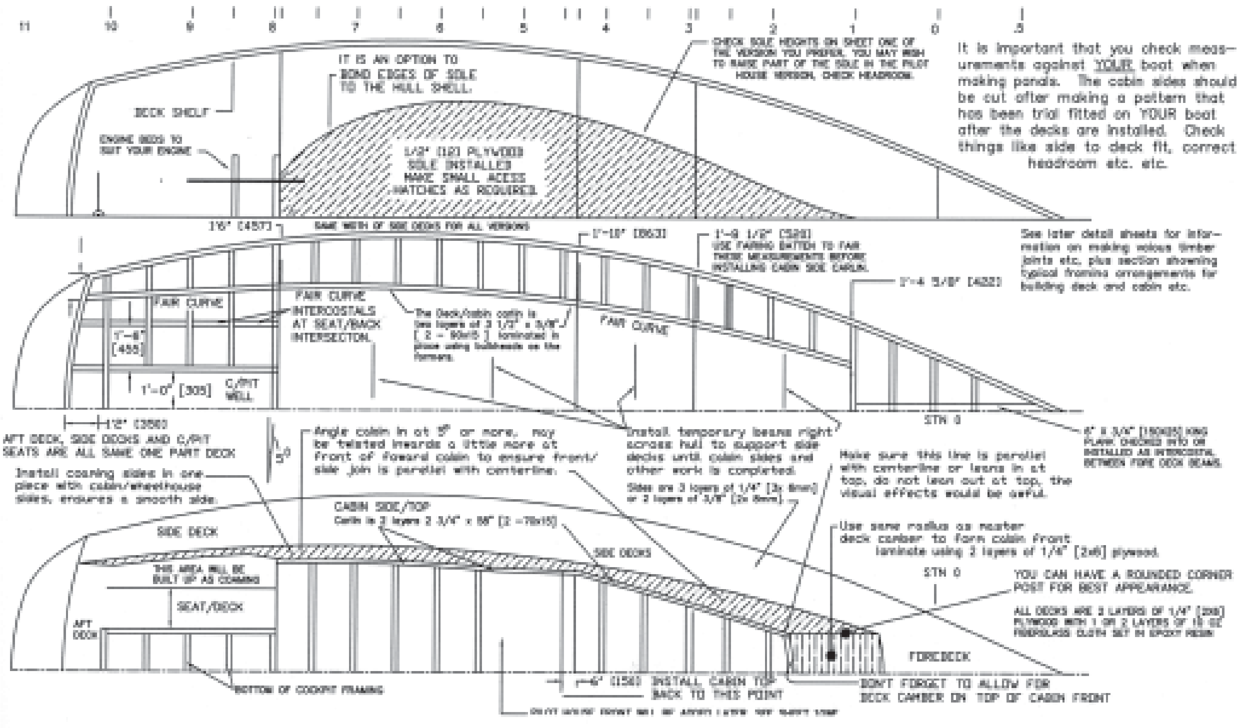
Cabin top beams that were pre-varnished before the cabin top was installed.

PLYWOOD DECKING

When you are satisfied the framework for your deck is ready, you can you can start to install the plywood decking. Your plans will tell you how many laminations of plywood will be needed to make up the total thickness required. The first layer is nailed and glued to the deck framing and the second and subsequent layers are glued and stapled to the first. At this stage, you can save a lot of time with the use of air tools to fasten the decking.

Be careful not over nail the first layer to the beams. Remember the nails are only effective until the glue has cured. In the case of the staples, these should be removed after the glue has set and between layers.

When finished, you will need to cover the plywood decks with fibreglass as they cannot be left unprotected and simply painting them would not offer sufficient protection. After the fibreglass has cured the decks and cabin tops can be sanded and painted and a non-skid surface applied.



This drawing from the Roberts 345 wood epoxy plans shows the steps in setting out the sole, side decks, decks and cabin sides.

LAID DECKS

A laid deck can be structural or decorative. For a laid deck to be considered as contributing to the structural strength of the vessel, the planking would need to be at least ¾” [20mm] thickness and the planks should be set in mastic or polysulphide and screwed to the beams or decking. The screws heads should be at least ¼” [6mm] below the surface of the planking and protected with timber plugs. If you install a structural laid deck, you can reduce the plywood deck to compensate for the strength of the overlay.

If you are intending to install a laid deck, it will need to look like a traditional installation, regardless of whether or not it is only intended as a decorative non-skid finish. There are a number of ways to accomplish this finish including buying pre-made decking, which can come in sections like plywood sheeting with the grooves cut in to one side or, pre-prepared teak deck planking from specialists that you can lay yourself or have their artisans do the job.

Before you decide to tackle the installation of a laid deck, be advised that it is a very labour intensive operation and either you or your hired labour will take several days to install even a modest sized deck. The planking can be laid in several ways. Traditionally, it would follow the curve of the sheer or it could run fore and aft parallel to the centre line or a combination of the two or, may even be installed diagonally at a 45 degree angle. Use silicon bronze or stainless screws, depending upon the deck type, with the heads set below the surface to allow for a timber plug to hide the screw.

SHEATHING PLYWOOD DECKS AND SUPERSTRUCTURE

The best method of protecting plywood decks and superstructure is to sheath them with fibreglass or Dynel cloth using epoxy resin. Polyester resin can be used but, if you want the best long lasting job then, epoxy is the way to go. We have used polyesters for many years with satisfactory results but, when there is a better product that is not too much more expensive, why not use it. Generally speaking you need to use two or more layers of sheathing set in epoxy resin to get the best results. Two layers of cloth weighing 18 oz per sq yard or 500 grams per square metre would be about right. Larger boats say those over 36 ft or 11 m on deck, may benefit from additional layers of glass.

Before starting to sheath plywood decks and superstructure, you should fill all nail and staple holes and any other blemishes. All holes should be filled flush with the face of the plywood and all corners must be rounded to accept the fibreglass. Use a filler, compatible with the resin you are using, to create a radius for the fibreglass sheathing to smoothly progress from cabin sides to decks, coamings to decks and anywhere else that it is required.

After you are satisfied the decks and superstructure are ready to accept the fibreglass sheathing, give the whole area a coat of thinned resin and allow this to cure before proceeding with the sheathing.

Any excessive moisture content in the plywood will prevent you achieving a lasting bond between the fibreglass and the plywood decks and superstructure so be sure that the plywood is dry and the humidity level acceptable. Even if you plan to install a laid fibreglass deck over the plywood, it is still advisable to install at least one layer of fibreglass between the plywood and the laid timber deck. A fibreglass finish will form an excellent seal for the cabin sides and other areas where there is no laid decking. If you follow our advice on the above matters, you should have a totally waterproof deck that will last indefinitely. Once the sheathing is complete and the resin has cured it will be necessary to apply a non-skid finish to all horizontal surfaces.

The pilot house and cabin sides are now in place - note the fore and aft beam at top of sides that will accept the ends of the cabin top beams which are notched into this timber.

The pilot house top is now in place along with the framing, mullions and cabin top grounds for the PH windscreen. Earl Rentmeester photos.

The plywood planking is now nearing completion on the pilot house and forward cabin. The corners will be rounded to give an attractive appearance and the whole structure will be sheathed with fiberglass cloth set in epoxy resin.

TOP:
Here we can see the bulkhead attached to the pre-laminated bulkhead ground that is in turn attached to the hull stringers.

BELOW:
The overall view of the pilot house top and aft poop deck.Note that some hatches have already been cut to let in some light.

ABOVE:
Earl wanted to use a bit more lay-in in the pilot house sides so found that there was not enough 'meat' left in the top carlins so he solved the problem by using bracket knees as is and was used in the aircraft industary and elsewher; Earl Rentmeester photos.

Roberts 370 - Builder Graham Andrew - Australia

This is the start of a sequence of photographs showing the Roberts 370 wood epoxy sailboat being built by Graham Andrew in Australia. This view shows the forward anchor locker bulkhead tabbed in place, see the fairing of filler around the perimeter used to make the later layers of bonding fit in such a way as to add extra strength to the attachment between the bulkhead and the hull. Always avoid sharp corners between areas when working with fibreglass materials.

Graham Andrew had access to some local timber which he had milled to the correct sizes to build his wood epoxy Roberts 370







Above we see Graham taking off the frame shapes from the full size patterns and getting started on setting up the hull framework.

Make sure the floor and strong-back are level in all directions carefully check that each frame is installed level and upright; use adequate bracing as necessary.

Close up view of the frames set on the strong-back. Your plans will give you advice as to how to set the frames up so that no bevelling is required; a great saving on work at this stage.

This is a good time to have a helping hand. I think that those surf boards will remain idle for awhile !

This photograph shows the deck shelf which is located below the sheer-line and provides for a bulwark to rise above the side decks. Also see the shaping of the bulkheads ready to receive the cabin sides and cabin top as well as one temporary superstructure former that will assist in forming the cabin structure; see later photographs.

Another view from inside the pilot house showing the deck beam with the official number and length of the vessel carved into the beam. For those who are not aware of this long standing tradition; it was and generally still is mandatory in any vessel to have size and identifying number carved into a beam. The official number is the registration number of the vessel on the National shipping register and it is mandatory that it along with the length of the vessel be permanently fixed to the vessel in a way so that removal will deface a structural part of the vessel. Some Jurisdictions require the weight of the vessel also. Graham Andrew's boat is an Australian registered ship which allows him to sail it out of Australia and affords all forms of Consular help when overseas if need be.

ABOVE:
Here we see the sheet plywood installed on the poop deck as opposed to the strip planking used to plank the cabin sides and top.

RIGHT AND BELOW:
The bulkheads and web floors are tagged in place and the radius filler added to make sure that the fibreglass bond between the hull and the relevant areas will not have any sharp corners where glass bonds are known to be put under excessive strain and often fail if not radiused at the corners.

These web floors are destined to become part of the tankage system.

Note the baffles dividing up the tank into sections; always make sure there are adequate baffles to avoid the liquids sloshing around in a seaway and putting abnormal loads on the structure of the tanks.

Here we see that tank tops are in place and the pipes installed ready for connection to where the liquids will be used.

More tanks with top and pipes in place.

Here we see the sole framing in the raised area in the pilot house. There will be considerable useful room under thes sole area so do not forget to allow for adequate access via hatches.

Another view of the pilot house sole area with the forward cabin bulkhead in place; the framing of the pilot house windscreen is just visible at the top of this photo.

Graham Andrew elected to use strip planking techniques to build the decks and cabin structure; our plans call for plywood over a timber framing to be used in these areas but Graham is an experienced and enterprising builder and he chose the strip planking method for the exterior of the entire boat.

Here is another view of the temporary framing with the strip planking being installed to the cabin sides and top. Note the plastic protecting the edges of the temporary framing; this will allow the frame to be removed without damaging the inside of the planking.

The strip planking is made over-length so that the cabin front can be installed after trimming the excess. The front can either be flat in profile or build up as a pre-laminated curve made oversize and then spieled to make a fit to the existing cabin-top and sides. A tip here is that if you are missing a rounded template for cabin front or for that matter for a transom; generally the deck camber pattern can be pressed into service to form a curve that will look pleasing in both areas.

Here is a close up of the pilot house framing. Note the areas in the mullions and the area surrounding the window aperture that have been rabated ready to receive either armour plate glass or high quality Perspex or Lucite glazing.

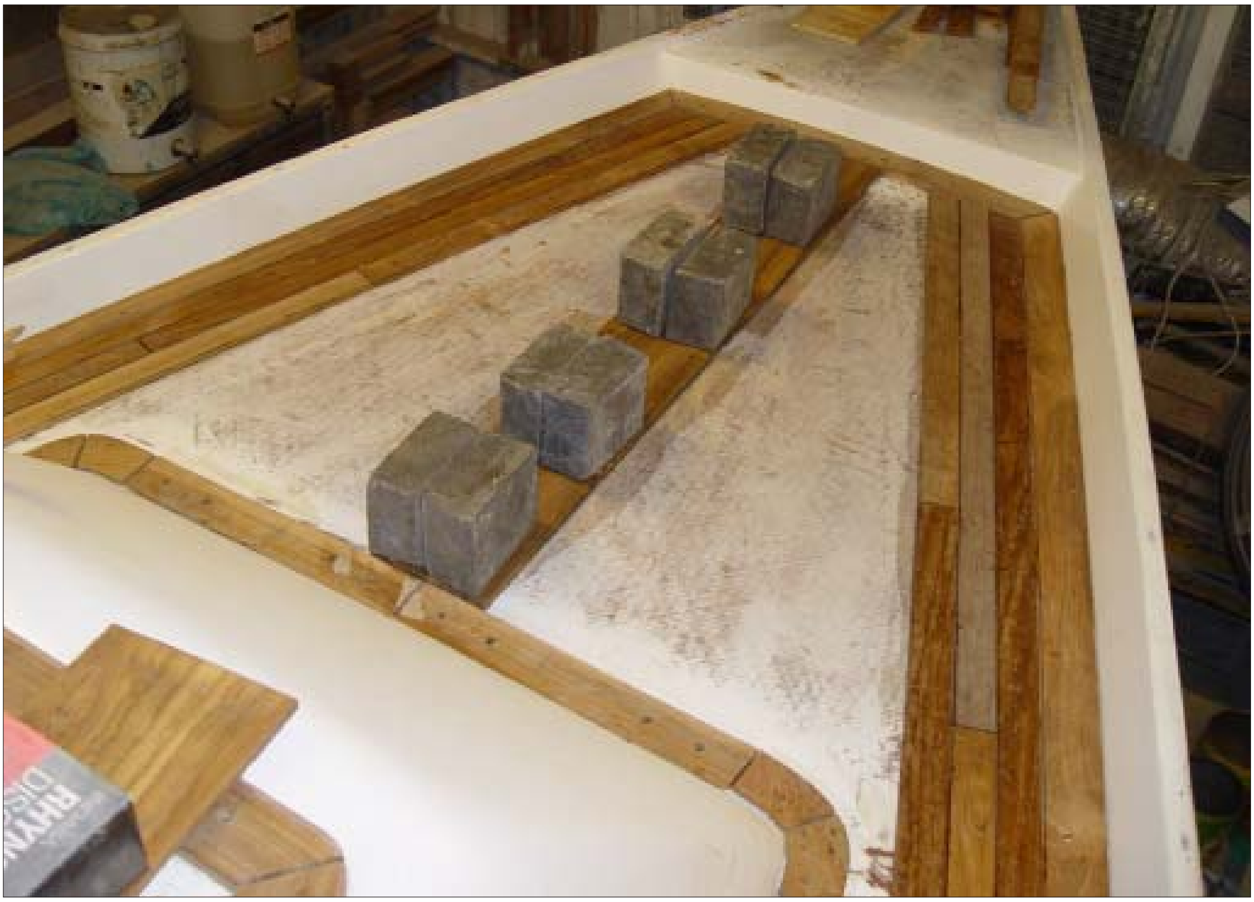
Here is another view of the pilot house, bulwark and trunk cabin. Note the fine finish that has been achieved by Graham Andrew in building and finishing this Roberts 370 strip plank hull.

Next the strip plank was covered with two layers of fibreglass cloth set in epoxy and sanded to a fine finish. A little 'elbow grease' or as much as is needed can pay hansom dividends as will be seen in the fine finish shown in this photograph.

Graham is beginning to install the teak deck. The margin planks are the first to be installed all round the perimeter of the decks and cabin top

This photograph shows the side deck planking proceeding at a steady pace. Graham Andrew worked over the weekend to take these shots and allow us to see most of the deck planking in place.

All the margin planks are now in place and the installation of the laid deck can proceed.



The centreline 'king plank' is shown here and the blocks of lead you see at the top of the photograph are used to hold this wider plank in position while the adhesive sets and ensures that the plank remains in place.

Here is a close up of the mitred join in the margin planks fitted to the cabin top. To assure a professional finish remember to always use similar joins at the corners of margin planks and similar areas. NEVER fit teak decking without using margin and king–centreline planks. Study other boats, take photographs and note how the professionals finish the planking in the various areas of deck, cabin tops and cockpits etc

The king plank has now been 'nibbed' to accept the side and foredeck planks as they intersect the centreline plank.

This section has the caulking material applied - Later all will be sanded to give the desired finish.

Here we see the completed side and cabin top laid decking - All that is left is to add the caulking.

Here we see some of the interior joinery. Note the neat bulkhead attachment to the hull; if properly thought out and carefully installed the lockers, berths and other interior joinery can add an enormous strength to the hull of any boat.

The toe rail and poop cap rail put a nice and practical finish to the appearance of the Roberts 370

ABOVE: Time for the first of the finish coats.   BELOW: Laid Decks are almost completed

ABOVE: View of side deck and fore-cabin top. BELOW: View as fore-cabin top nears completion..

ABOVE: General view side deck and fore-cabin top. BELOW: Rubbing strip and cap rail.

ABOVE: Aft end of the side decks and step to poop. BELOW: Closer view of the foredeck area.

Here we see part of the coaming that has been arranged as storage as well serving its other purposes including providing a base for sheet winches etc, Note how the curved areas were achieved by using plywood strips. Sometimes you can create curves like this by scoring the plywood and then bending to shape, any gaps in the outer surface of the curve can be filled with epoxy putty and sanded to a smooth even rounded surface. Of course you can also laminate thin layers of plywood or veneer into just about any curve or shape that you desire to incorporate into you boat construction programme.

ABOVE:
We have seen this coaming grow from the laminated structure through fiberglassing and now with the top covered with the teak decking. See previous page.

LEFT:
Here is an overview of the main hatchway, sliding hatch and hatch 'garage'

RIGHT:
Here is a closer view at the shiding hatch and garage.

ABOVE:
Here is a small sample of the sole area complete with teak planking. Note the mast support which will be trimmed with timber or similar.

TOP and LEFT:
The decking on the cabin top and decks is now completed, sanded and ready for use !

For the Spray enthusiasts here is - Building a timber Spray

Wood / Epoxy, Plywood, Strip plank, Round bilge timber.

You have a wide choice of materials when you decide to build your own Spray. The first few Sprays that were built from our plans utilized fiberglass as the primary building material. It was not long before we were asked to re-draw the plans to enable the Spray to be built from other materials; in this case we decided that multi chine would be the most practical hull form but we later prepared round bilge plans for this material. Plans for multi chine plywood soon followed and the latest Spray plans include versions that can be built in strip plank timber.

MULTI CHINE PLYWOOD

Spray designs are available for building in multi-chine plywood hull form. The Spray 22, Spray 22, Spray 28, Spray 33, Spray 36 are the designs that area available as plans and patterns to build in this manner. The advantage of using this building method is that if you are familiar with wood working techniques and marine grade plywood is readily available in your area, then this may be the boatbuilding method to suit you. One thing to remember is that while plywood construction costs about the same as fiberglass and more than steel; the resale value of plywood boats is less than with other materials. If you plan to keep your boat for a considerable period and you want to get sailing as quickly as possible; then you may want to choose that method.

Multi chine plywood Spray 27 hull.

ROUND BILGE, STRIP PLANK, LAMINATED TIMBER AND COLD MOLDING.

Firstly I would like to pay tribute to Blair Boats - The New Zealand boatbuilders who have done such a fine job of building the Centennial Spray 38 for Rob McGill & Nina Morissette. A truly beautiful boat by competent and artistic builders.

For many years we were asked for ‘Wood Epoxy’ Spray plans. We would offer the Multi-chine plywood plans as described above but many builders wanted ‘The real thing’ that is round bilge Spray plans that could be built in strip plank, cold moulding or a combination of these techniques. In certain areas countries including Germany, Scandinavia, parts of the USA, Canada and several other areas with their own timber resources, the interest in wooden boat construction is stronger than in other parts of the world where timber is scarce.

COLD MOULDING & DOUBLE DIAGONAL PLANKING.

Cold moulding has been around for many years and is still very popular for building all types of hulls. In boat building, the process of cold-moulding is simply the practice of building a hull using laminated multi-diagonal layers of veneers or plywood over a temporary male mould, in the case of a frameless hull, or over a permanent frames and stringers where the hull is more traditional. After building the male mould, temporary or permanent, the first strip is nailed and glued or stapled in position and each subsequent strip has to be shaped to fit the previous one – this is easily accomplished with a small palm plane.

The second layer is glued and stapled diagonally removing the staples (if used) from the first layer as the second is fitted. A hull can have 3 to 8 layers of veneer or plywood depending on the design. Plywood is quicker and easier than veneers but is usually heavier so if you are building a lightweight racing boat veneer would be your choice and plywood for a “not so light” cruising boat. and ideal for the Spray. The hull is then sheathed in fiberglass, Dynel cloth which can be applied to one or both sides depending upon the design. The cold-moulding technique using veneers is commonly used in high performance multihulls and racing monohulls whereas cold-moulded plywood is more common in cruising boats.

As far as the amateur builder is concerned, cold-moulding is a relatively straight forward process. Using full-size frame patterns, the basic structure goes together quickly as does the application of the veneer or plywood.

Frames are cut from 1”X 8” - 25 mm x 200 mm timber or 3/4”- 20 mm plywood if preferred.

The two photos below are by courtesy of Rob McGill & Nina Morissette.

Wood Epoxy hulls are normally built inverted and rolled over after planking is completed.

First and second layers of diagonal planking in place on this round bilge Centennial Spray 38 hull

STRIP PLANKING – WOOD EPOXY

Strip Planking can be put into two categories – Traditional and Modern. The **Traditional** strip planking technique relied on permanent internal frames and stringers to provide the necessary transverse strength. Internal fastenings joined the planks to the frames and edge nailed them together. This eliminated the need for caulking however; very accurate tight fits were needed between the strips and waterproof glues to seal the joins made the process simpler. This traditional method of strip planking has almost entirely been replaced by the modern wood/epoxy system.

Today most stems are laminated our as shown above but occasionally they may be cut from solid flat boards and then laminated so that the laminations appear when you look down on the stem. Deck and cabin top beams are laminated in a similar manner as shown above. **Photo by and permission of Rob McGill & Nina Morissette.**

MODERN STRIP PLANKING

With **Modern** strip planking, commonly known as wood/epoxy, the timber is instead of edge nailing strips together and onto frames; each strip is only temporarily fastened to the building frames and, when the process is complete and before fibre glassing, the nails are removed and the holes filled. The hull is sheathed with fibreglass both inside and outside providing the strength to replace frames and stringers. Internal fittings such as bulkheads, bunks and furniture would all be structural, and contribute to the strength. The structure is, in effect, a fibreglass sandwich panel. The weight and type of glass depends on the size of the craft and should be specified by the designer.

BUILDING THE FRAMES

Depending on the design you have chosen, your plans may call for permanent frames or for the frames to be used only as temporary mould formers, to be removed after the hull planking is complete. Permanent bulkheads can be utilized, as part of the setting up of the hull framework. If the frames are to remain in the hull, you will need to build them out of first grade timber or have them laminated to achieve the most strength for their size and weight. If you are fortunate, your plans will have been supplied with full size patterns and these can be laid on plywood sheets to enable speedy assembly of the frames.

ASSEMBLING THE BASIC HULL STRUCTURE

Once you have made the frames and stem you can set up your hull, usually, on a strongback or, occasionally, on a level floor depending on the designer's arrangement. The techniques for building the fibreglass male mould and setting up a Wood/epoxy hull have a lot in common

Modern strip plank hulls are planked with the hull inverted.

'Stealer' planks are often required to keep the planking on an even keel.

***Photographs of the Centennial Spray 38 on this page are by permission of the owners* Rob McGill & Nina Morissette**

Many times your plans will call for either strip plank, double diagonal planking or a combination of the two as is shown here.

After you set the frames up on the strongback, you should install the stem and stringers or battens, depending on whether it is intended that the frames and stringers stay with the hull see under Traditional or Modern in Strip-Planking section.

Generally speaking, Wood/epoxy hulls are built over a temporary mould with reinforcing in the form of fibreglass and internal support from the furniture but they can be built with the frames and stringers in place. The idea of a lightweight shell, with a clean interior, ready to receive laminated web floors, laminated bulkhead grounds and other interior joinery has considerable appeal and is less likely to trap moisture. Today we build most modern timber hulls upside down and they are turned upright after the planking. You can install the transom at any stage before the deck is added. Usu-

The transom is often fabricated off the hull and added before or after turn-over, check your plans for details.

ally the stem, the keelson, the deck stringer or deck shelf and transom if installed at this stage, will all remain with the hull when it is removed from the mould former.

Once the frames, stem, keelson and stringers are in place, you will need to fair off the keelson and stem and other areas that need to be beveled to receive the planking. Be careful not to over bevel any one area however, if you do make a mistake, you can glue a piece of timber on to the affected area and simply re-bevel to the correct angle. Use a batten to check over your basic hull structure and to check that you have the bevels at the correct angles to receive the veneer or plywood planking. In the case of a chine plywood hull the setting up procedure will be similar except the chine stringers will stay with the hull even if the frames are removed. In fact, it is more usual to leave the frames in a chine hull.

THE TRANSOM

The transom can be assembled and installed at the same time as the frames or later, if you feel it is more convenient, for access to the inside of the hull. It is usually simpler if the transom is left out so we include the frame past the transom position so that the whole hull can be planked before turnover. After turnover, the transom can be fitted and the hull trimmed.

INSTALLING THE PLANKING

The builder's next decision will be how he is going to install the hull skin. Generally speaking, your hull shell will be between ¼" [6mm] for say an 18 foot boat, up to a thickness of 2 inches [50mm] for a 60 foot vessel. We recommend for the smaller and lighter skinned hulls, an all timber veneer laminate. For a say 3/8" [9mm] hull skin, three layers of 1/8" [3mm] veneer would be ideal. Once the total thickness required is over say 5/8" [15mm] you may consider a combination of strip planking and veneer. You could have an all strip planked hull with at least one layer of veneer to finish off the exterior. Your plans will specify the hull thickness for the boat you are building. The completed hull is then finished with a number of layers of fibreglass, Dynel or carbon fibre and epoxy resin.

If you are building an all veneer hull, you could consider using 1/8" [3mm] or better still 3/16" [4mm] plywood for the first layer. Veneers are often too soft to bend evenly when not totally supported as happens when laminating over stringers or battens. The plywood will bend much more evenly and provide a better base for the following layers of veneer that make up the remainder of the hull skin. In some hulls, we recommend that you install the plywood planking in two or three or more layers as it would be impossible to install the thicker plywood at one go and, because of the shape, it is often necessary to use plywood strips around the bow even if the remainder of the boat is sheet plywood. As plywood comes in large dimensionally stable sheets it is possible to plank large areas of a hull quickly and easily. However plywood can only be bent into a compound curve with great difficulty, and there are limits to how tightly it may be bent before breaking.

This jig was constructed to laminate various part of the boat. If you plan ahead you can make the jig multi-purpose; here it is being used to laminate part of the transom. Photograph by permission of Rob McGill and Nina Morissette,

ROUND BILGE HULLS

For round bilge hulls, the first layer of timber veneer or plywood will usually be installed in strips varying in width from 3” [75mm] to 18” [460mm]. The strips or panels will usually be installed at the 45 degree diagonal. The width of the strips will vary depending on the shape of the hull as tight curves will call for narrower strips and flatter areas will allow the use of wider strips. Up near the bow should be the area with the least curve and so the strips can be wider. Only trial fittings on your hull will tell you how wide the strips can be on the different areas of your hull.

No matter where you start the planking, make sure that you install both sides simultaneously. Under no circumstances plank all one side before starting on the other as you will end with a twisted hull. For best results, apply one strip on one side then one on the other side working your way along both sides, forward or aft, in this manner.

TRIMMING THE PANELS

You will find that each strip or panel has to be fitted snugly to its neighbour. It is not just a matter of cutting the sheets of plywood or veneer into strips and laying them side by side at a 45 degree angle. You will discover that as the panels are laid around the hull, they twist

It takes considerable wood-working skill to create a transom like this one shown here on a Centennial Spray 45 being built in Slovic Republic It also takes a lot of experience to create a smooth flawless finish as is apparent on this beautiful example of the wood workers craft.

slightly and each new panel will need a little bit of trimming. Fortunately, this is a quick and simple matter to rectify by trimming off the excess material where the edges overlap the previous panel. After first attaching the strip to the keel, the excess can be gauged and trimmed off with a small hand plane, or if the overlap is considerable, it can be marked and removed for trimming using band saw or jig saw.

Make sure you get a good fit, because if you force the panels into place by pushing them sideways they will not want to lay flat and you will never achieve a smooth hull finish. Any forcing a fit may result in a hull that will have a series of lumps and bumps that will be hard to remove when you install the subsequent layers; the fit of the first layer is very important. The idea of using plywood for the first layer is set up a smooth skin to receive the remaining layers but, if the designer specifies a certain sequence then, that should be followed regardless.

Glue and nail the first layer to the stem, keelson and the deck stringer. If the intermediate stringers are to stay in the hull, then the panels can be nailed and glued to them as well. If the stringers or battens are to be removed, then you staple the strips only and these staples are removed before the next layer is attached. There is no need to edge glue the panels as on subsequent layers, the glue will seep through and create a bond between the edges.

PLANKING THE HULL

Before you start to install the second layer of veneer or plywood, you should check for any gaps between the strips and, if any are found, tape inside the join to stop any glue seeping through and running down the inside of the hull – saves a lot of work later. When you have completed the installation of the first layer, the next step will depend on the required number of layers for your hull. If the plans call for the installation of three layers, it is possible, for the second layer, to use wider strips as long as they lay flat. If you find that wider strips are hard to fit, revert to the narrower diagonal strips as used for the first layer but in a diagonally opposite direction.

CHOICE OF ADHESIVE

These days, we assume most builders will be using epoxy glue between the layers however; there are some drawbacks to using epoxy compared to some other adhesives. For instance, some glue's may not have the ultimate strength of epoxy resins, but are more forgiving when it comes to working in less than ideal conditions. To make the most of the qualities of the true Wood/Epoxy techniques, you should be working in an environmentally controlled area. Temperature control is important as is the absence of high humidity. You will need to decide how your building site will measure up and choose your glue accordingly. See: "Recent History"

MARK STRINGER LOCATIONS

It is always wise to mark the positions of the stringers and keelson on each layer of veneer/ply panels. This will give you their location when installing subsequent layers of plywood or veneer and it will also be necessary to have a person inside the hull with a "dolly" to make sure you are getting a good tight fit as you nail or staple the first layer to the stringers, stem, deck shelf and keelson. Any bouncing or spring back as you nail or staple will often prevent a good join. The marked stringer locations will give you the positions through which to staple or nail the second layer to the first and so on. You should either nail or staple the first layer to the keelson and nail or staple to the stringers depending upon whether the mould is permanent or temporary. If the first layer of plywood or veneer curls a bit at the edge as it passes around the bilge area, you will usually find that the second diagonal layer will pull it into place.

The series of photos above show the process of shaping and laminating the timber keel. Later photos will show the ballast added after turn-over. Photographs shown above by permission of Rob McGill and Nina Morissette

SELECTING THE FASTENINGS

Over the years we have used several types of staples, one being the common galvanised wire type and the others stainless or silicon bronze. It is always sensible to remove steel or galvanised staples whereas the stainless or silicon bronze types could be left in the hull but better removed. Some builders opt to lay the final layer in a fore and aft direction. Unless you are going to finish the hull clear, I don't think it matters which way you install the various layers as long as you have a good bond between the veneers. A balanced lay up is essential and by balanced I mean that all the layers do not run in the same direction. The plans you are using should give you precise instructions as to the procedure and sequence for applying the hull skin.

FAIRING & FINISHING HULLS

Once the hull has been planked the next job will be to fair off the stem and fit a trim strip. Then, dress off the bottom of the keelson to accept the laminated timber keel.

Any raw end grain of the plywood should always be covered by a timber facing such as at the stem where the trim strip will take care of that exposed area. The timber keel can be laminated in position and can be reinforced with copper bolts.

Next, give your completed hull a good check over and dress off any unfair areas before you sheath the entire hull, keel and the skeg with a layer or more of fibreglass or Dynel using epoxy resin.

Final fairing completed the hull is now ready for turn-over.
Photograph by permission of Rob McGill and Nina Morissette

TURNING THE HULL
Next job will be to turn your hull upright. Once the hull is upright and level on all planes your plan may call for fibre glassing the inside before you are ready to continue with the fitting out of the interior and the installation of the decks and superstructure.

SOLID FLOORS
You may find it easier to fit the solid floors during the framing of the hull, rather laminate them in place later. Our plans have used both methods and each approach has its advantages and disadvantages. Your plans should guide you as to the best sequence for your particular design.

It is usually preferred in chine type hulls to attach the floors to the frames in such a way that they can be faired off with the stringers and the rest of the framing and then the hull skin can be laminated directly on to the floors. On round bilge hulls involving a “bolt on keel” it may be best to laminate leaf spring type floors into the hull after turning the hull upright. Again, your plans should guide you as to the best sequence for your particular design.

TRADITIONAL AND NOT SO TRADITIONAL
Before leaving the subject of building your timber hull, we must give some consideration to the traditional strip planking technique. Today, if you are thinking of building in timber, then you really only have a choice between strip planking and cold moulding using plywood. Both methods are relatively straight forward and do not demand particular skills that would be the

If you have ideas of building an exact Spray replica; best check out these photos first !

case with even more traditional timber building techniques and, the final decision should rest with the availability of suitable building materials.   If you are strip planking the timber is cut to ¾” to 1 ¼” [20 to 30 mm] thickness and can either be square in section or a little deeper for example ¾” thick x 1 ¼” deep [20 x 30 mm].   The planks are “edge glued” one on top of the other.   Traditionally, strip plank boats are built upright.

This is the pattern for the keel of the

Here we see the hull upright, note the notch in the keel in preparation for fitting the ballast keel. We recommend that you actually laminate the wooden section of the keel where the ballast will be located and then before turn-over saw out the section that represents the ballast; this portion can then be used as a mould for the actual ballast casting.

Photographs on this page by permission of Rob McGill and Nina Morissette

External cast lead ballast bolted in position.

FRAMING

You will require temporary or permanent framing made up of sawn or laminated frames similar to those used for any mould. Sometimes when the hull is built upside down, the method is to install the planking up to the keelson and then a laminated keel is fitted in the manner described earlier in this chapter.

The planking timber may be dressed with square edges or may be machined to a concave section on the top and convex on the bottom. This machining of the planks allows them to lay one on top of the other and to follow the curve of the hull frames with a minimum of dressing of each plank.

When using square edges, it is usual to dress off the top of each plank after it has been installed to provide a surface square off the frame on which to lay the next plank. Either method is satisfactory although, as the planking will usually not go on up the hull in an even manner, it will be necessary to spile in short planks in certain areas. Some advantages of the specially milled timber are lost when you have to do this.

BALLAST ON WOODEN SPRAYS

For Spray builders using any timber building method, there is one critical area common to strip

In my early boatbuilding days I always melted my own lead and cast either the ballast in one piece or in sections depending on the type of method of installing the ballast - bold on ballast in one piece and ballast was cast in ingots or layers to be installed in 'envelope keels' as on fiberglas or steel boats.

planking, moulded plywood and other timber method in that you will need a separate keel casting of either lead or iron as ballast and this will be attached with keel bolts through the keelson.

When building a traditional strip plank hull, you will set up your ballast keel and the timber keel first and work upright from there.

The mould frames are set in place with the stem and transom.The planking starts at the keel with the first plank let into the rabbet and the remainder of the planking installed as described above. If you are using Modern timber methods, you will build the hull upside down in the usual manner and attach the ballast after turnover.

FASTENINGS

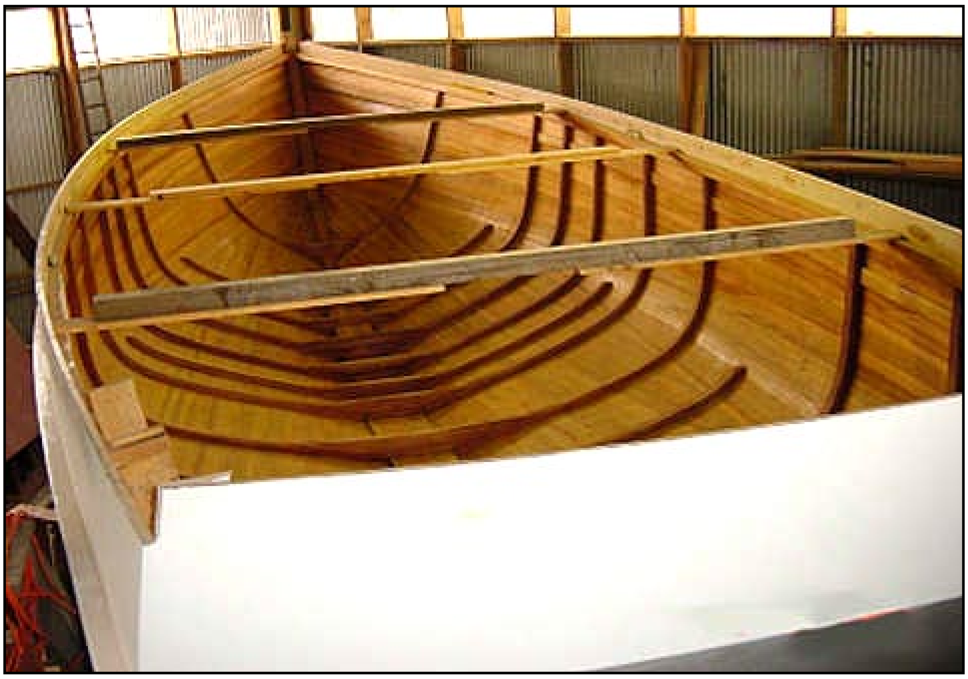
There are two basic choices for the adhesive, epoxy or resorcinol. As for the nails, you can use a combination of copper and silicon bronze. Usually copper nails can be used to fasten the strips but, if a harder nail is required, silicon bronze is the answer. The main function of the nails is to hold the timber together until the glue is set so it may be wasteful to pay the considerably extra cost for silicon bronze nails if copper will do the job. As with many decisions you must make during the building of your boat, the depth of your pocket will have a bearing on your final choice.

INTERIOR FRAMING

Once the hull has been completely planked and cleaned off, then the temporary framework can be removed and any laminated frames that are specified in the plans can be installed. Generally there are laminated frames where the bulkheads are to be attached to the hull and in some larger designs; a series of laminated frames may be specified throughout the hull. Sometimes the setting up, frames or formers, are laminated frames that remain with the hull. This system of permanent frames is usually reserved for boats of over 50 feet [15 metres].

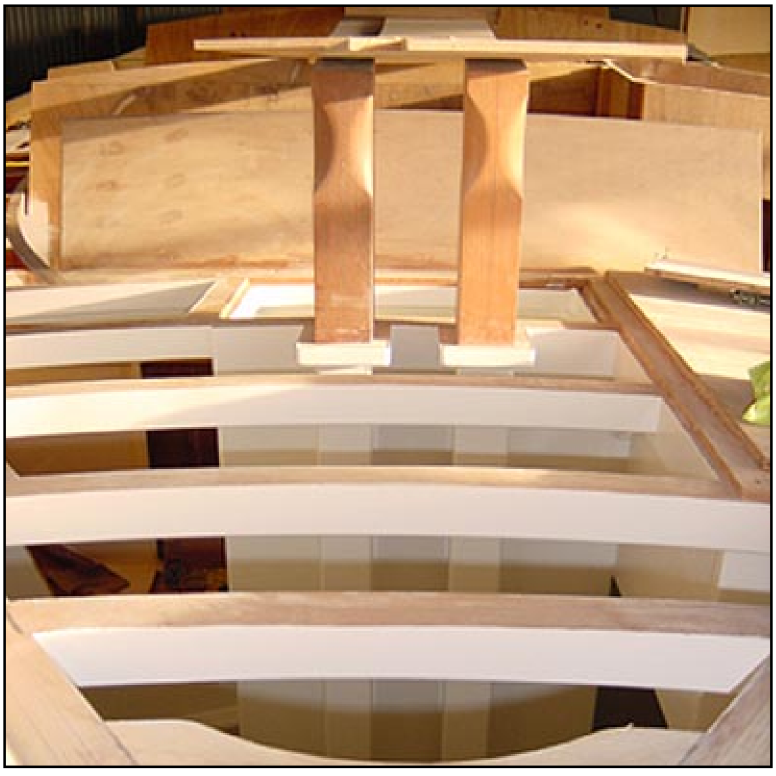
Any intermediate floors not previously installed as part of the setting up process are now fastened in place. The bulkheads may be installed and it is often best to leave them standing up square well above the sheer so that the plywood can be marked out with the side deck width, cabin lay-in and cabin top camber. The interior may be roughed out at this stage and any large items such as engine, tanks and large panels of plywood required for the interior, should be in the hull before you start work on the decks and superstructure.

The cabin sole can be fitted; you will need access to the area of the keel where the keel bolts are and, in any case, it is always prudent to have removable sole panels.



When you have turned the hull upright now you will want to fair off the interior before laying out any framing including bulkhead grounds, solid web floors and sole bearing stringers etc.

Note anchor locker (on left), forward bulkhead and side deck beams in place and faired ready for plywood decking to be installed.



Anchor 'bits' extend down to keel and are bolted to bulkhead and also have attachment to deck beams. A very strong and secure arrangement.

Photographs on this page by permission of Rob McGill and Nina Morissette

Install bulkheads with access cut-outs where doors will later be installed; the bulkhead will be easier to handle if not too flexible due to excessive openings at this stage. Note correct cabin side lay-in has been cut at this stage, could be later if preferred.

Cabin sides and cabin top beams installed on bulkheads; cut-outs can now be enlarged. Cabin top carlins are now in place ready to receive remainder of cabin top beams.

Photographs on this page by permission of Rob McGill and Nina Morissette

Cabin top beams are installed and checked for fairness in all directions. Cabin sides were laminated out of two thicknesses of plywood, glued and nailed, nail-holes filled. You may want to pre-laminate the sides or use other methods if you plan to finish the cabin sides 'natural'.

Much of the interior of your hull will either be the inside of cabinets or on view so make sure to clean up the interior of the planking, sand and apply finish coats of either varnish or paint as you prefer.

It is a good idea to varnish the beams before the plywood decking in glued and nailed in place; varnishing at this stage is much easier than after the deck is in position. All glue 'dripples' can be avoided by masking the beams or using other protective measures when installing the deck.

The cabin sides and bulkheads are installed ready for installation of the cabin top beams etc.

It is also recommended to paint to a finished stage any areas that will be difficult to access later. For instance you should mask the underside of the foredeck where it will be attached to the beams and then paint the underside of the first layer of the decking so that when the plywood is glued and nailed in position you will have a completed area that will need no further attention for some considerable time.

Cabin sides, cockpit well framing and cabin top beams all installed. Note framing for the various hatchways.

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Side deck planking being glued in position. Note the spacers inserted between the planks.

Aft deck planking; note covering boards and fine example of cast polished bronze fittings such as the mooring fairlead. You can make patterns and have these items cast in bronze or find an example and use a pattern.

Photographs on this page by permission of Rob McGill and Nina Morissette

Note the deck prism set in place; these prisms let in an amazing amount of light and are recommended where you want light but where a hatch location would be inappropriate.

Fore-deck planking including king plank in place. Note anchor bits which not only look right on this boat but are a very practical solution to securing an anchor line or towing hawser should the need arise.

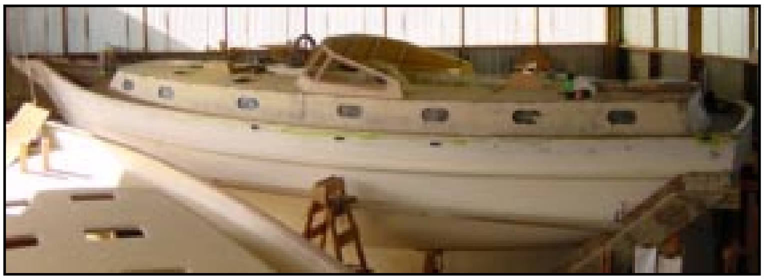
Another photo of the fore-deck with planking completed and bowsprit, mooring fairleads etc all in place. You may want to study these photos to get ideas for finishing your own Spray.

Photographs on this page by permission of Rob McGill and Nina Morissette

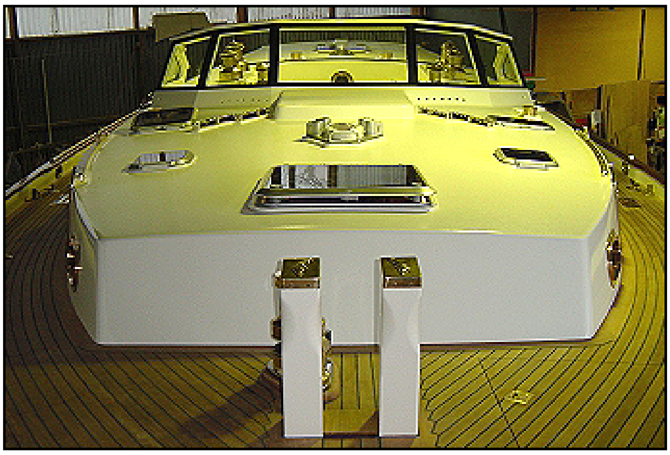
Please note that all of the photographs of this Centennial Spray 38 are by permission of the owners Rob McGill & Nina Morissette - Construction by Blair Boats in New Zealand

Decks, cabin structure, cockpit well and seats all completed and protected with a layer of fiberglass and epoxy resin.

Ports and windscreen have been added as well as substantial rubbing strip. Below we see the finish coatings in place and decks are now ready to receive the fittings and deck hardware.



Note the quality of the bronze hardware. Some of these items can be purchased 'off the self' or you can make your own patterns and have the items cast. Avoid 'cheap' fittings of this type as they may fail under load.



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Here we see some more examples of the fine cast bronze hardware that has been installed on this Wood Epoxy Centennial Spray 38

Cast bronze and polished whisker fittings.

Here we have a birds eye view of the completed decks and cabin structure on the beautiful example of the Centennial Spray 38

Photographs on this page by permission of Rob McGill and Nina Morissette

Below and left is shown the methods to laminate the trail boards for this Centennial Spray 38. First step is to temporarily fasten cleats in place to accept the first lamination of timber.

Laminated timber in place to form the shape of the trail boards.

Trail boards marked to shape and trial fit for final trimming to shape

Photographs on left and above by permission of Rob McGill and Nina Morissette

The finished trail board, carved with attractive traditional pattern and ready for final finishing and attachment to the bow.

The rudder timbers are laminated around pre-prepared stainless steel webs that are welded to the rudder shaft.

High build finish is applied to the competed rudder
.

Rudder installed on this Centennial Spray 38

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Make sure to lay out your engine room so everything is readily and easily accessible. It is usually best to install the engine and associated equipment before the deck beams and deck are installed. An access hatch can be arranged if you wish but I am of the opinion that these are prone to leak and it is best to cut access through cabin top or cockpit sole if engine ever needs removal. Advice never fit a used engine in your Spray !

Side panels are great when they allow access to the engine room from a 'walk-through' as is often possible in a center cockpit vessel.

Vacuum bagging is often useful when laminating wood epoxy or fiberglass parts on your Spray.

Completed cabin sides, ends and top.

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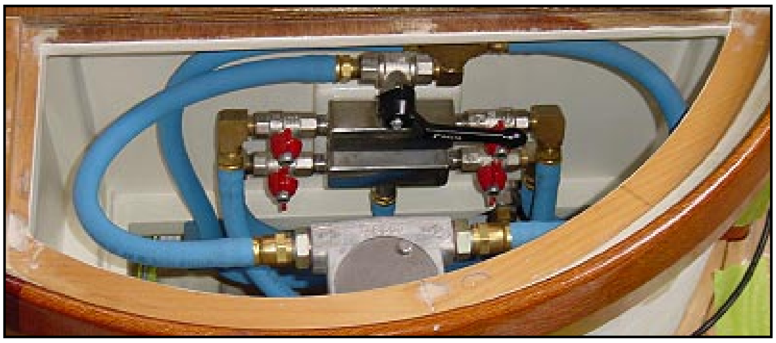
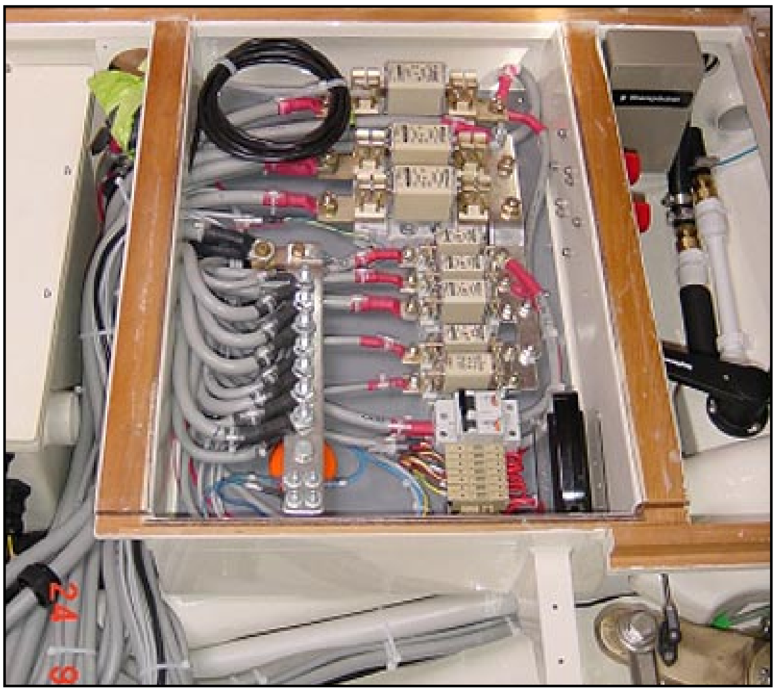


Fuel manifold allows for switching tanks and filters without having to stop the engine. A twin filter system is recommended as this prevents a clogged filter from stopping the engine at an in-opportune moment !

On a sailboat is it often difficult to find a suitable location for the various electrical junctions. In this case the builders have chosen to locate this gear under the double berth in the master cabin; provides a good solution to the problem



Another view of part of the electrical installation shown above

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From top left: Sole in aft cabin, steering arm and emergency steering key, copper ground plate, cut-outs for navigation instruments, beams were varnished before deck was installed.

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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 ½ times the weight of the mat.

This is what chopped strand mat looks like.

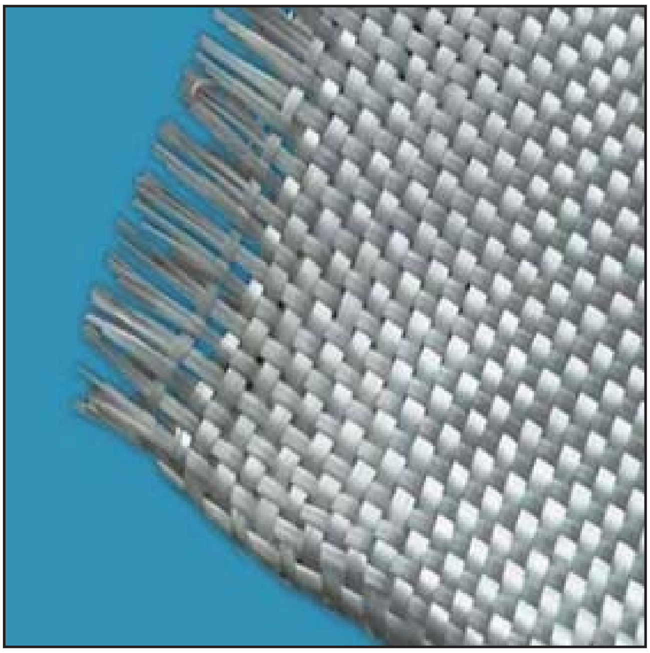
CONTINUOUS ROVING

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.

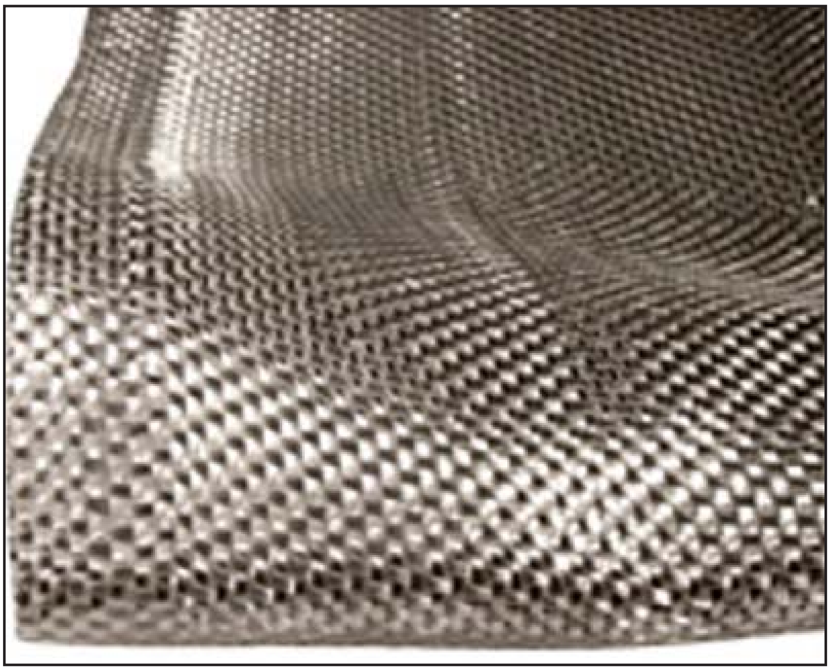
Woven roving is stronger than CSM in all respects and you should make sure your fibreglass hull contains a sizeable proportional amount of this material.

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/m 2] to 27 oz. per square yard [900 g/m 2], 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

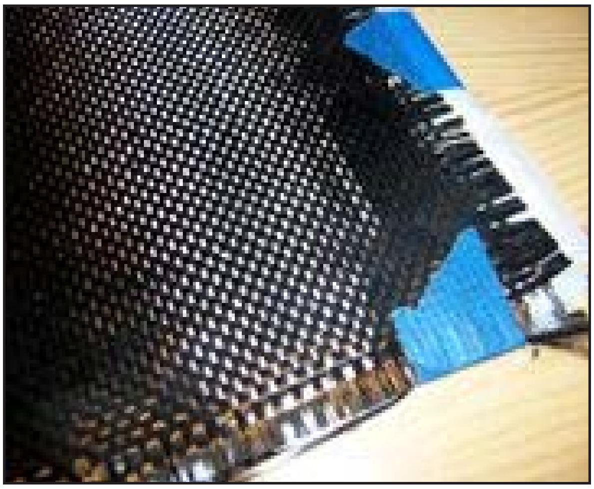
Some glass fibre fabrics are available with a thin layer of mat already attached. This makes it one "easy to install fabric" especially for hand laying as is can be applied quicker and more evenly than separate layers of the mat and roving. You should check with your local fibreglass supplier to see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

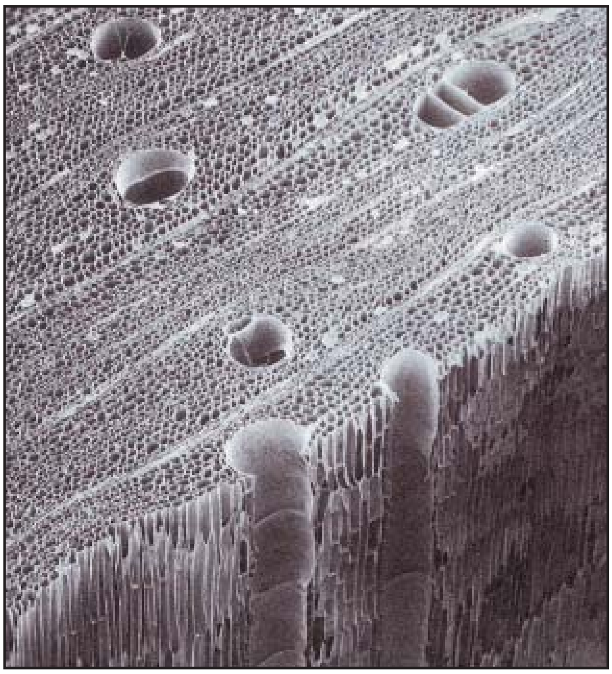


CARBON FIBRE

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. Not withstanding 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.

This female moulded Spray 28 was built in *the UK.*

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 you 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 piece 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

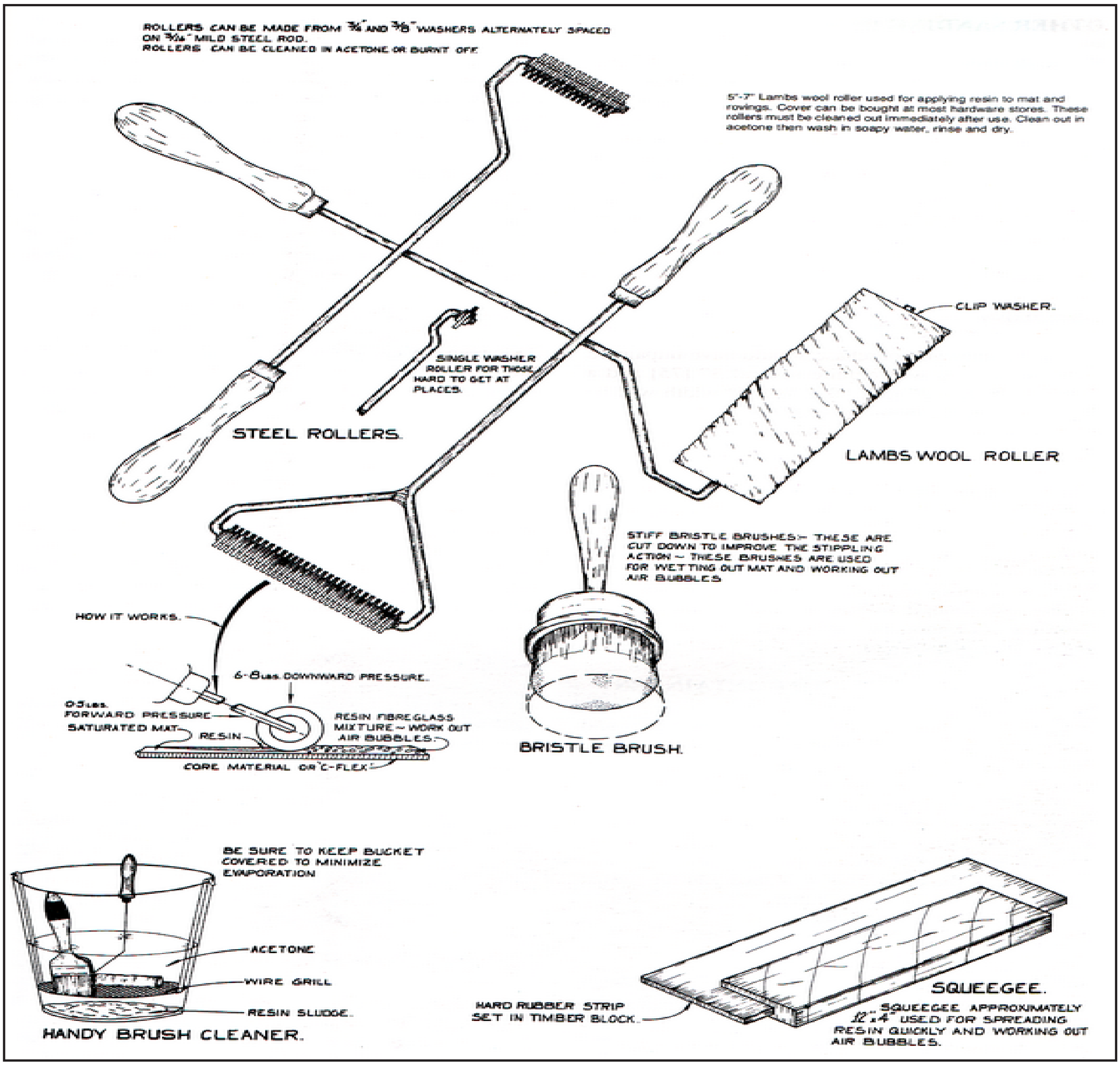
Your feet are the easiest things to protect. A lot of fibreglass workers wear sneakers/sand shoes and although these aren't the ultimate protection they do a good job in this environment. When gun laying sneakers are very useful as they can be slipped on and off without hands which is useful when you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

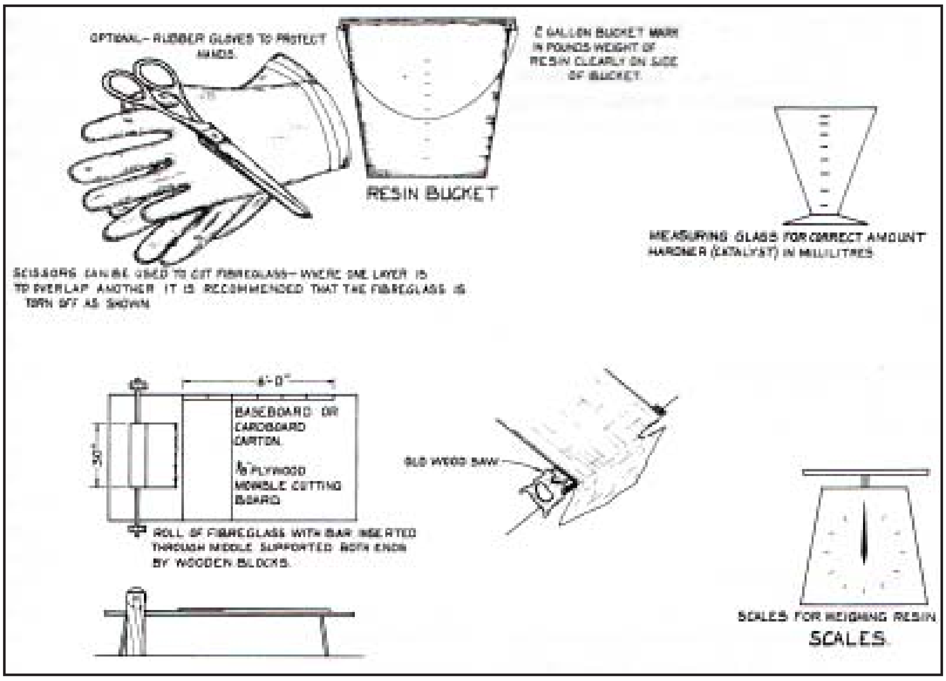
You will need a selection of sanding blocks and boards. One particularly board is a piece of plywood 4' 6" [1.37m] x 6" [150mm] x ½" [12mm] thick which when fitted with handles and sandpaper attached makes an excellent device for obtaining a good finish on a hull or deck The board is handled with long 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

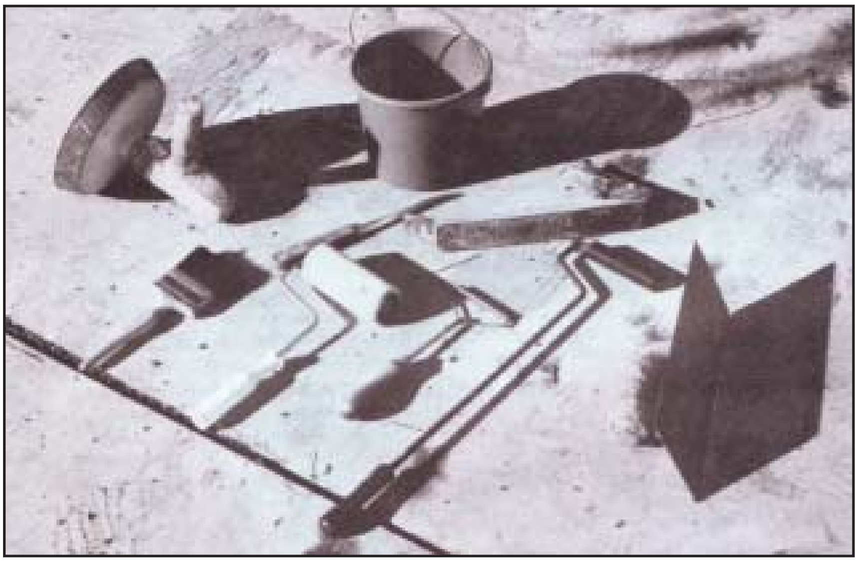
For mixing resin save all suitably sized plastic containers and have your friends save theirs too. You should also be able to buy ice cream container "seconds" from your fibreglass suppliers. You may also purchase some small plastic buckets. Half gallons [2 lit.] and one gallon [4 lit.] will be the best 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

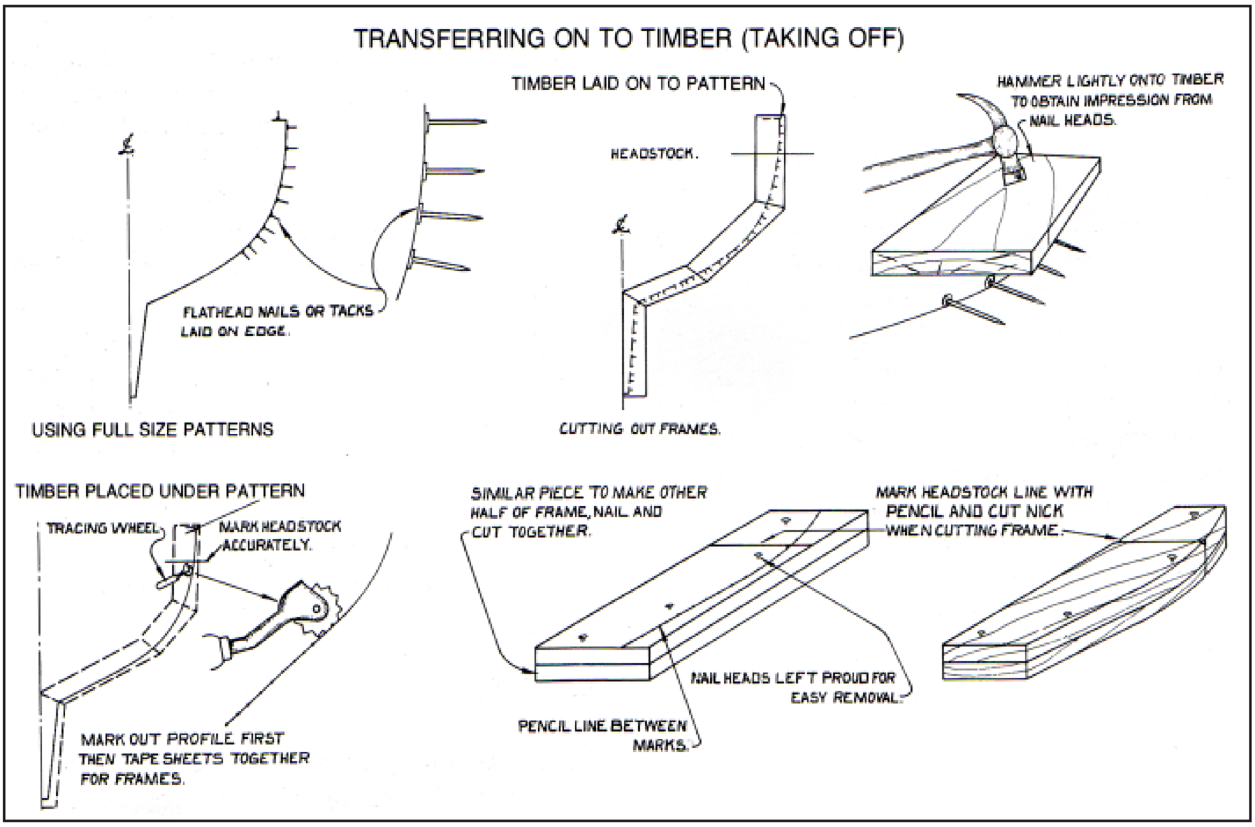
Most full size patterns are plotted or traced on 24" [610mm] or 30" [760mm] or perhaps even 36" [1 metre] wide paper or Mylar film. These sections are laid side by side wallpaper fashion to reveal the complete set of fames, stem pattern and other elements of your boat that are supplied full size.

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.

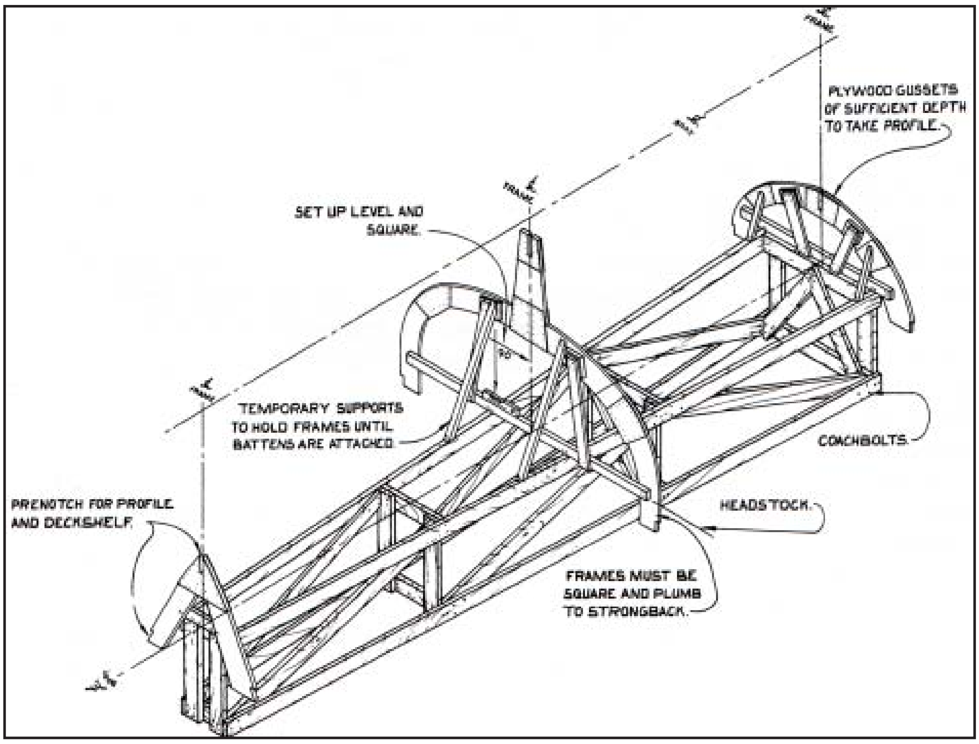
Before you attempt to assemble the complete frame, measure directly from the patterns, the width of each frame at the headstock line; sheer line and waterline and make a check mark on the opposite side of the frame patterns and include the frame number. Now you have three reference points to make sure 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 the 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

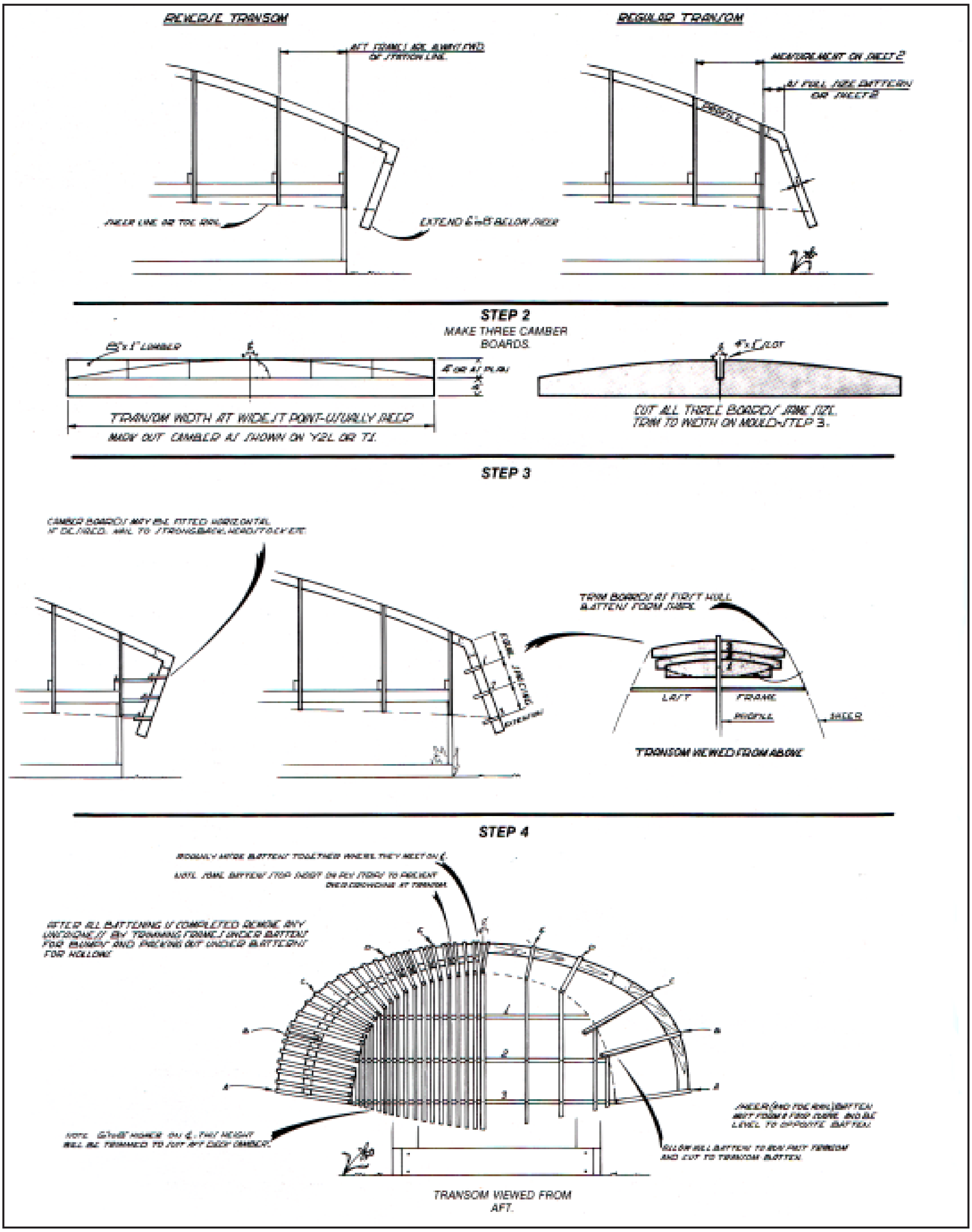
Usually, the bed-logs or strong back are made from 6" x 2" [150mm x 50mm] or similar sized timber, depending on the size of the vessel. Your plans should give guidance on the scantlings and assembly method for the setting up base. The size of the strong back, which is the width and length, will be decided 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

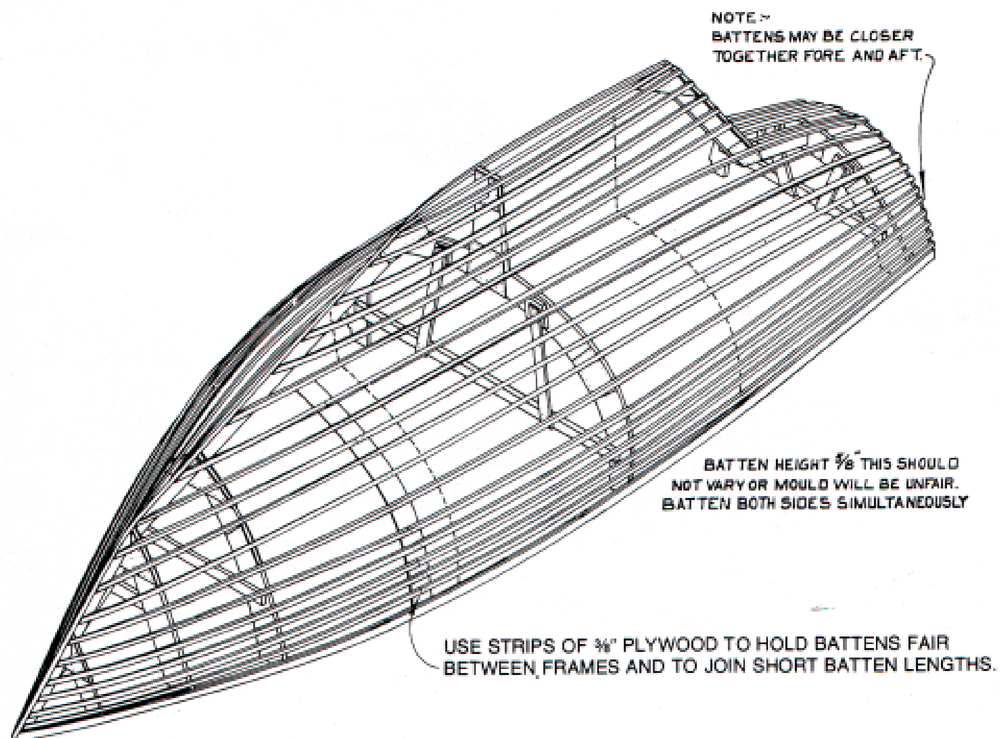
The next step is to install the stem and backbone. Fit these parts in the slots that have been pre-cut to receive them. The stem will need temporary support until the battens are installed. Take check measurements to make sure the stem is in the correct position, relative to the sheer line and the centre 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



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.

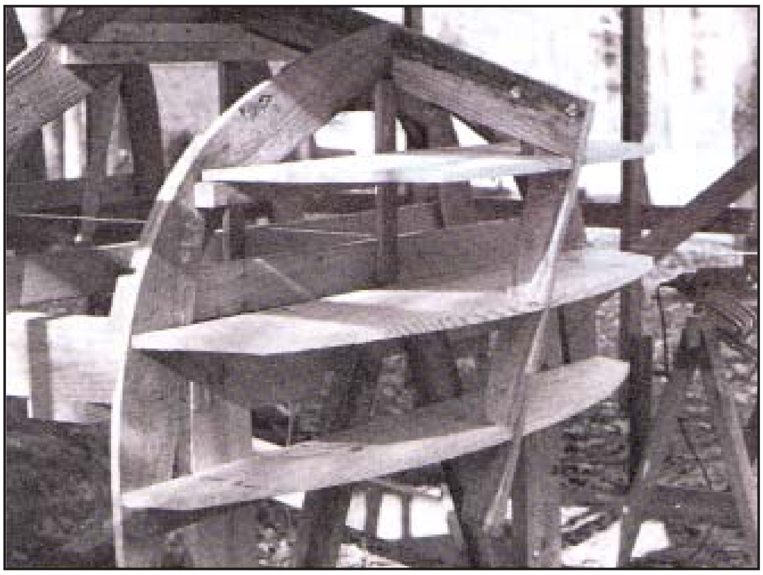
This batten mould for a fibreglass Spray 33 was built in California and illustrates how complex shapes such as the hollow heel at the transition of hull and keel are easily handled using this male mould method.

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

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.



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.

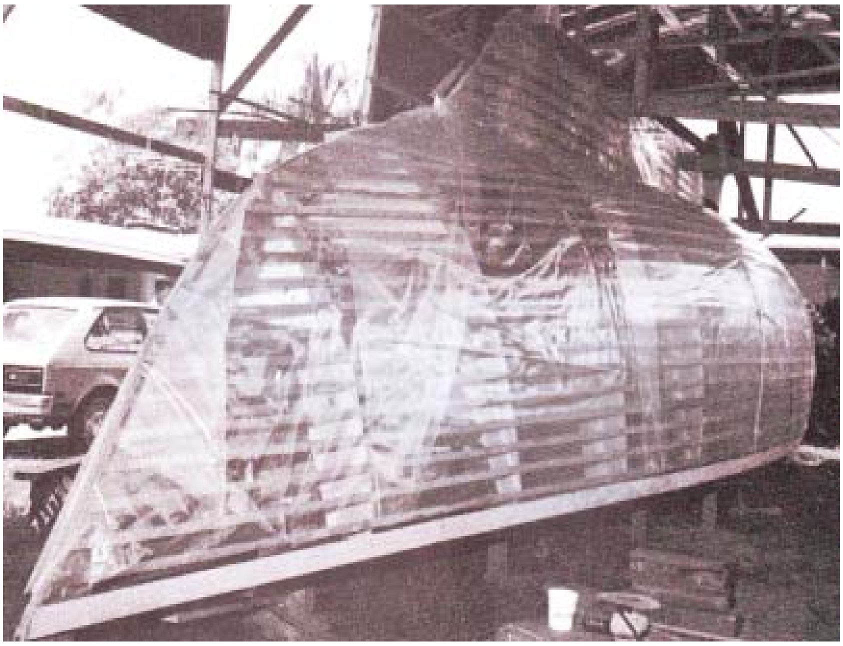
Thia photo was taken in about 1968 - there is still no better method of fairing battens as described in the text and is shown here.

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 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.

Here we see a fine example of a completed mould for the Roberts 532 sailboat. Note the fairing strips seen behind the battens, the first part of the foam core near the keel plus the bottom the keel is sheathed in hardboard as no core material is recommended in this area.



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.

You can use the open form mould method to laminate either single skin or cored hulls as described in the text. This photo shows the technique of applying the first pre-formed laminate on the battened mould.

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.

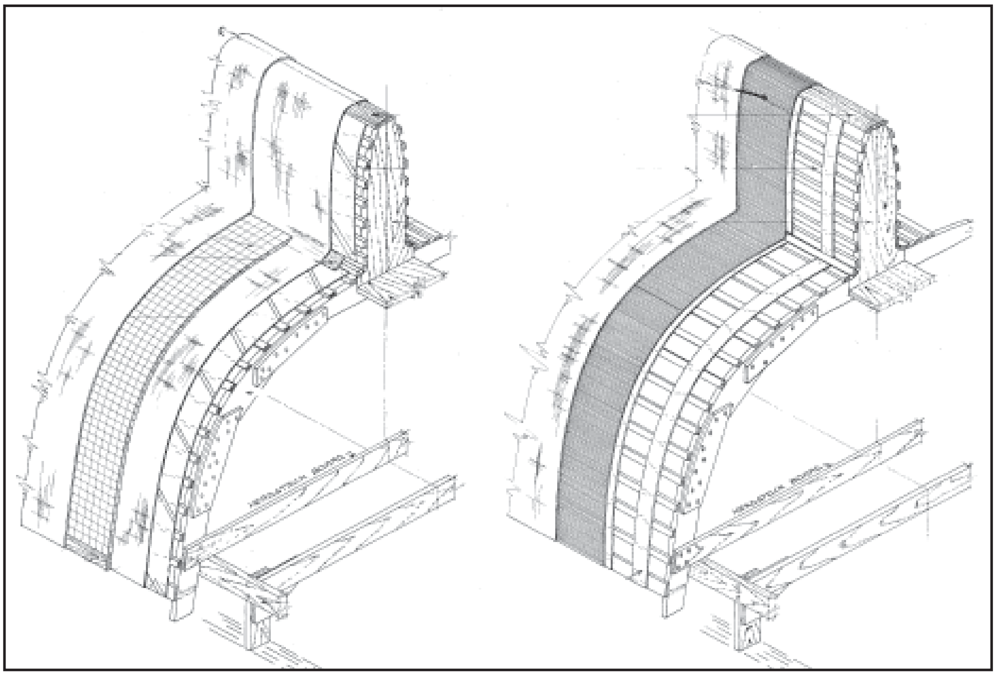
You may prefer to laminate the plywood transom in place. In this case, install the first layer by screwing from inside the mould and then laminating the other layers of plywood on to the first, by gluing and stapling from the outside. You should fit the transom so that the plywood overlaps the core on 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

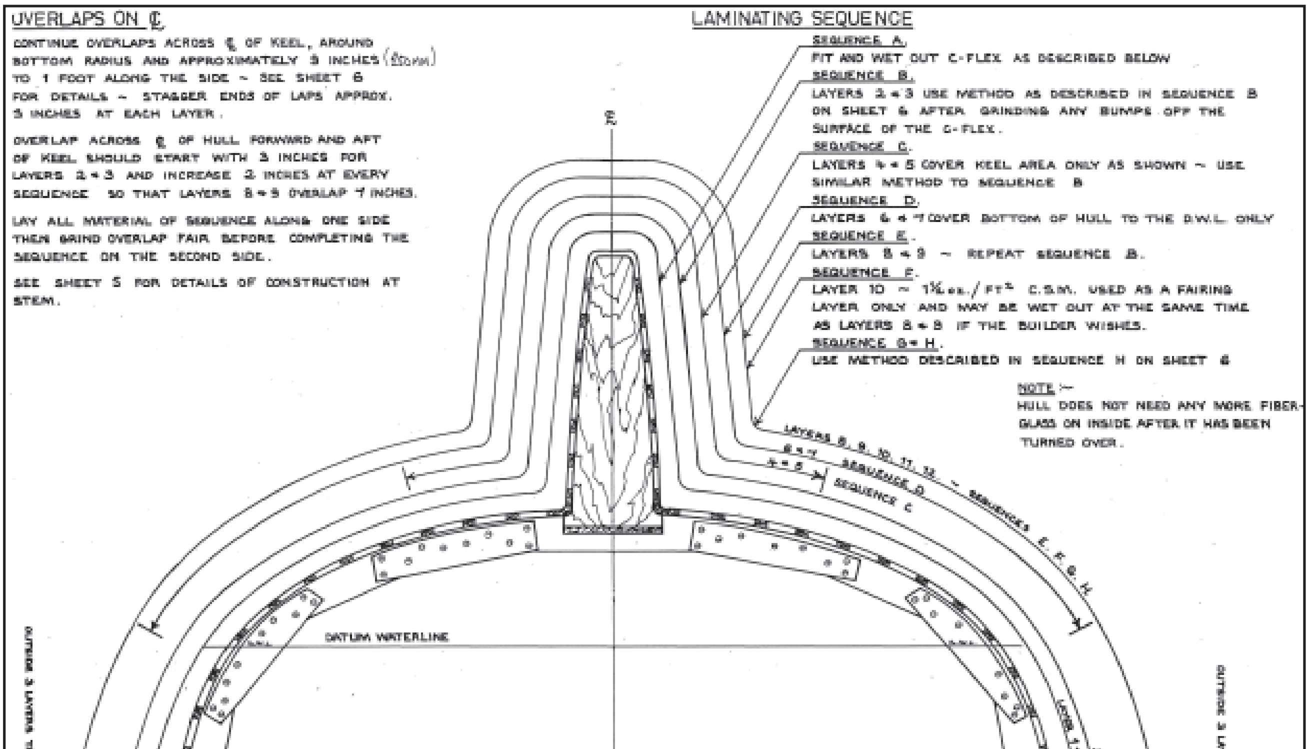
After installing the core, the next job is to apply a prime coat of the resin and then you should go over the whole hull checking the fairness and applying resin putty or fairing out any imperfections, where necessary. It is important when building a fibreglass boat on a male mould to see that it is 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 jig saw 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 you 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 that 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 to 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 through 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.

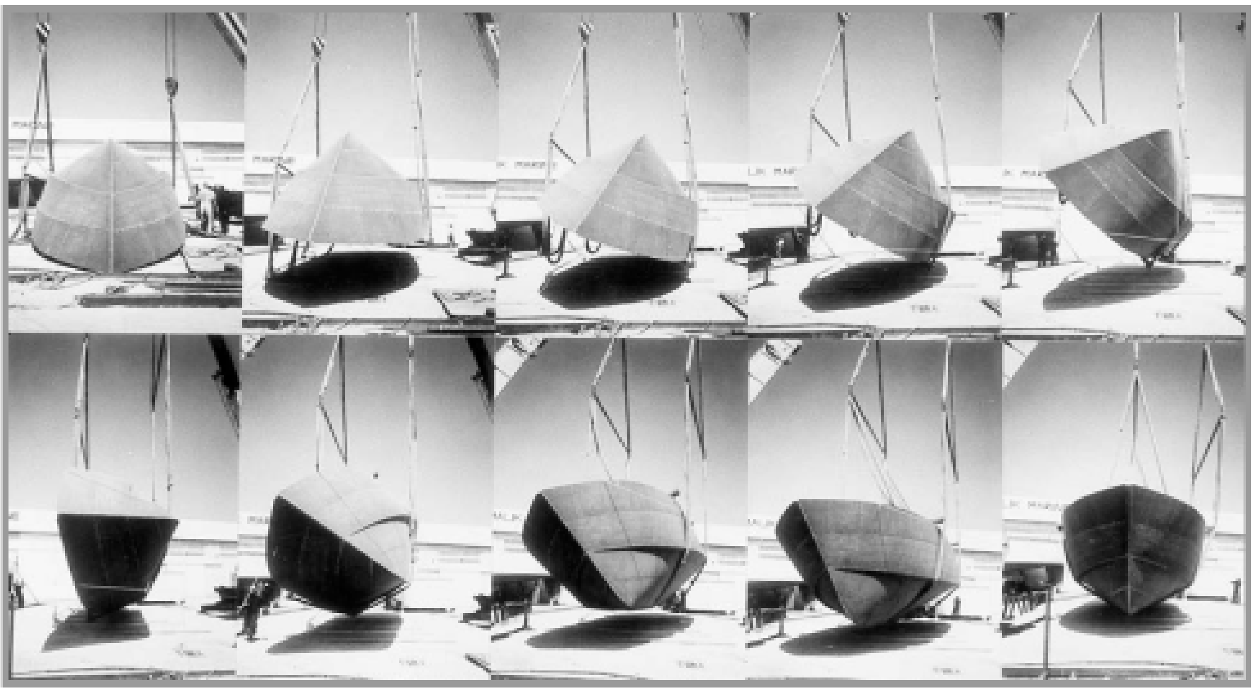
There is a wide selection of paints that are suitable for protecting the outside of a fibreglass hull - some for above the waterline, some for below. The method of application of your finish coating, will depend upon which material you select. If you believe your hull surface is sufficiently good to 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.

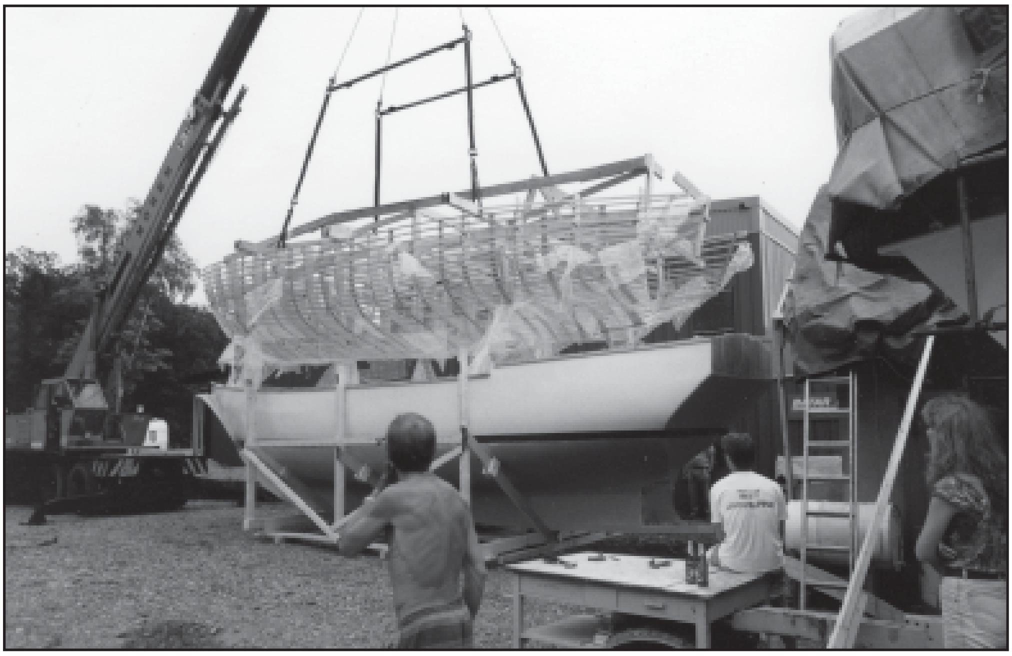
PREPARING FOR TURNING HULL UPRIGHT

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.



Once you have the hull upright the first job is to remove the mould; this can be done as shown or piece by piece as is illustrated.

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.

You can lift the main mould out in one piece, you may have to remove the keel and transom mould out in pieces.

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.

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.

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.

Adam & Barbara Szczurowski

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.

Here we see the mould lining installed in a chine hull mould.

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.

INSTALLLING 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/m 2]. 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

Disposable mould used by Thai-Kiwi Marine to build the Bruce Roberts designed Cat 35 Trawler for an Australian client. Thai-Kiwi Marine intend to use the first set of mouldings built using the panel methods as a plug to take off female moulds for the Power Sailer Cat 35 .

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.

Here we see a fiberglass bulkhead being laid up on a laying-up or laminating table. Once you get the idea of laying up individual panals you will find many and varied uses for the laying-up table.

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.

This photo shows the fibreglass Power Sailer Cat 35 being laid up using the panel methods described in the text.

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.

Please excuse the quality of this photo taken in the early 1970's. Bruce Roberts-Goodson (on right) discusses the progress with Len Freestone (left) of the fibreglass hull being laid up in a disposable split mould. Note the heavy fibreglass stringers.

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.

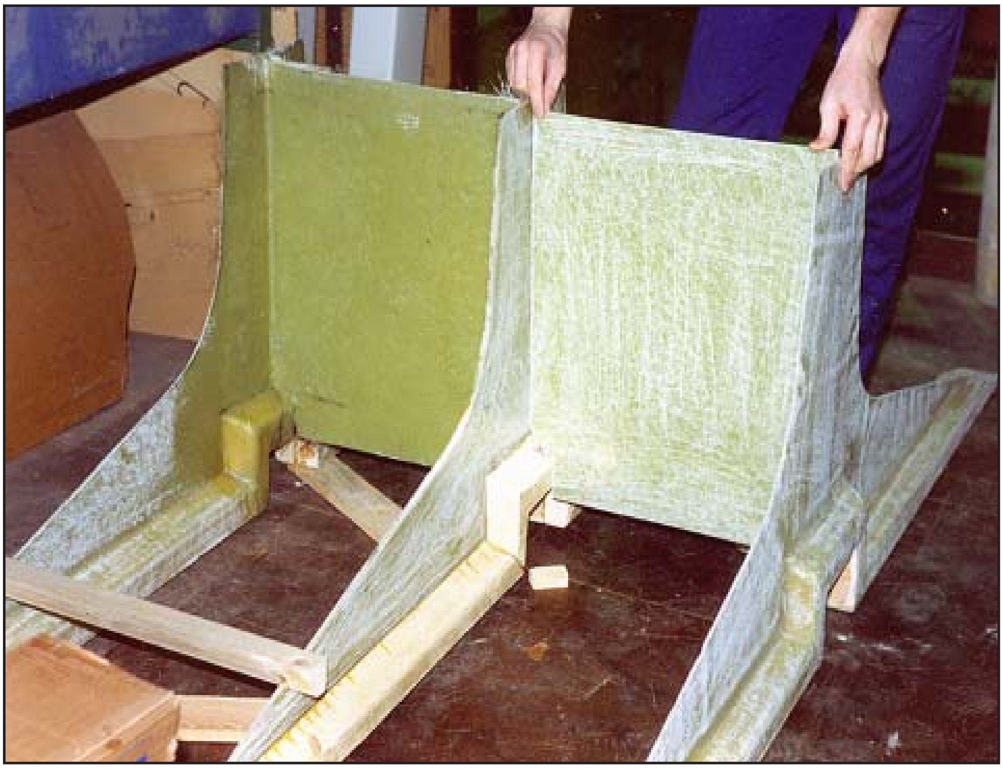
Here we can see the foam core for stringers and ribs being installed in a fibreglass hull..

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.



Some builders will find it convenient to prepare the web floors outside the hull and will install them by laminating into the hull. You will need to make accurate patterns of the webs to ensure that this method is worthwhile.

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.

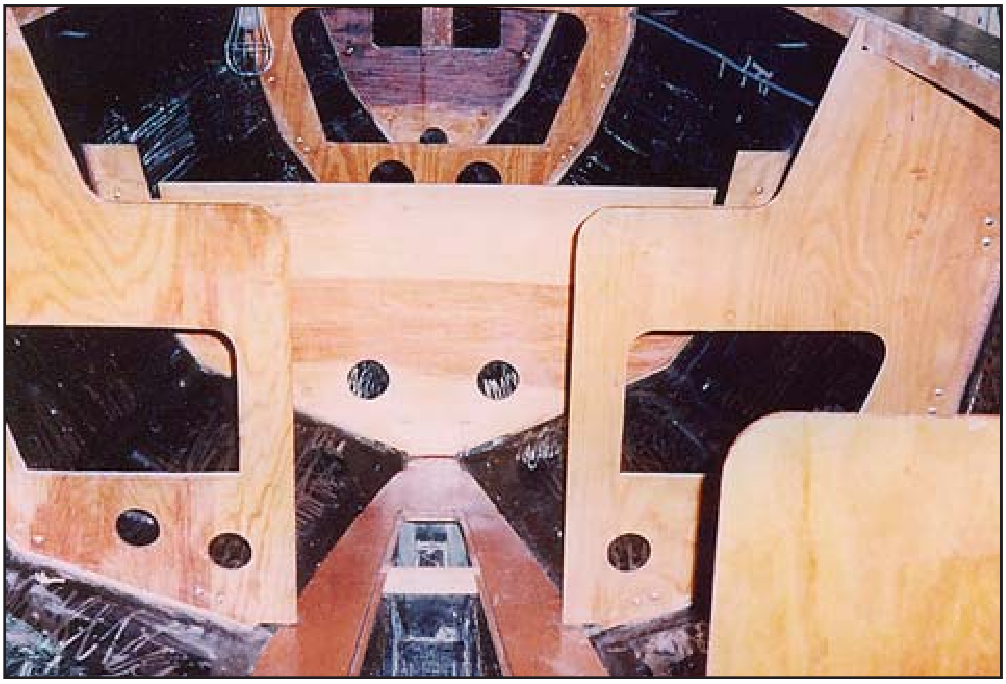
BULWARKS

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 temporally 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



This set of plywood bulkheads is in place including some filler where bulkheads join the hull and cut-outs already in place for various trunking that elements will be required.

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 in fusion 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 cabins 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

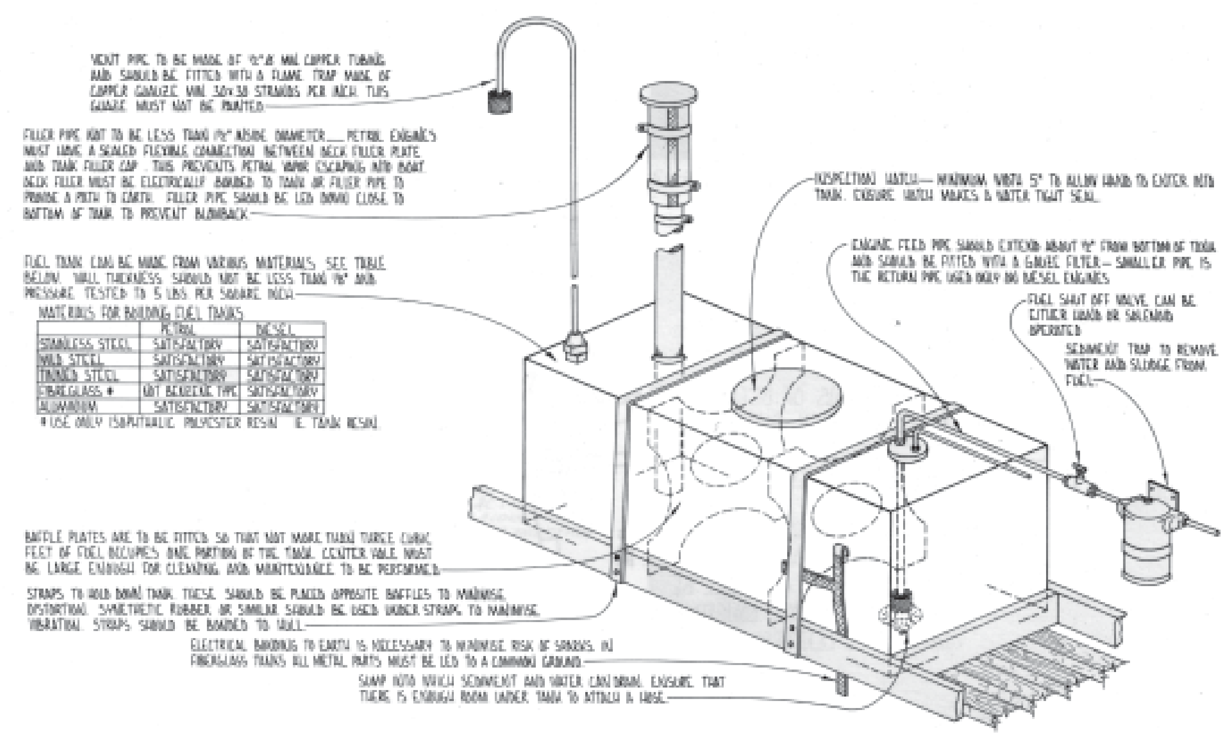
It is wise to install all of the bulky items into your hull before the deck and cabin top are fitted, so your next steps should be to rough out the interior furniture, fit the tanks, install the engine, ballast and bring aboard any large items that may be difficult to bring through the hatch at a later 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 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.

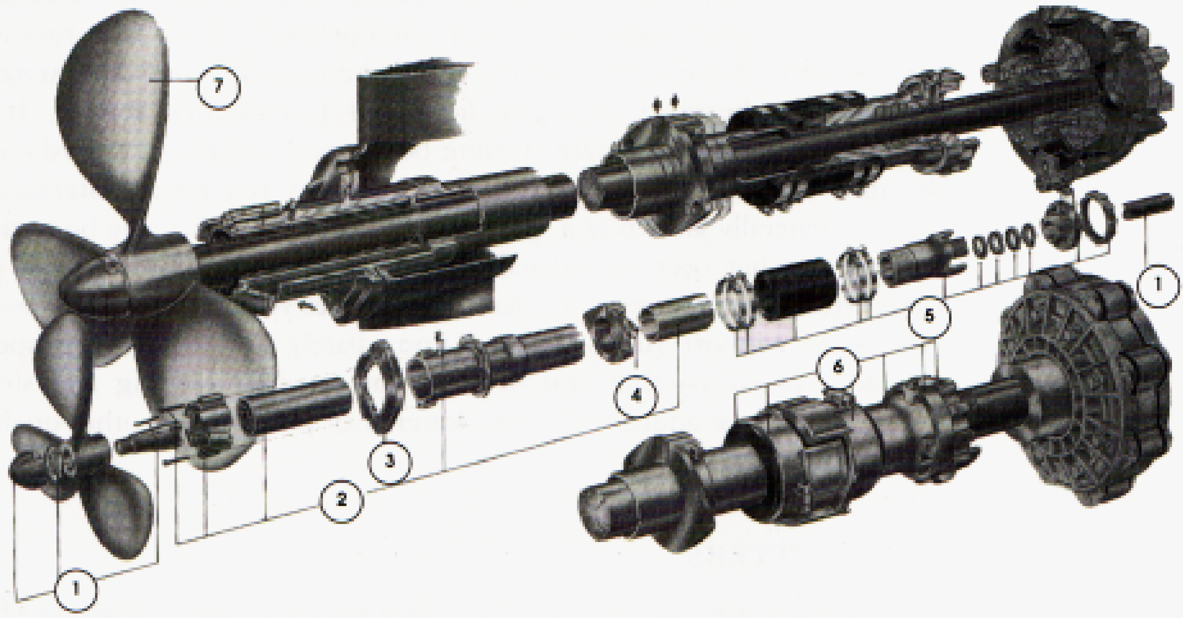
This is the new Voyager DS 440 hull featuring our answer to problems with skegs. Not only is the skeg considerably strengthened but the propeller is protected from odd lines and kelp that can cause problems at the most inopportune moments. This safety skeg arrangement will feature on all new sailboat 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.

VETUS COMPLETE STERN ASSEMBLY

These shaft assemblies protect the environment (no grease in the water) Remanit 4418 shaft material: – 60% stronger – smaller shaft diameters. All shafts of ø 40, 45 and 50mm are always supplied with the flexible stuffing box (5) with torsion protection (6).



A VETUS propeller-shaft assembly consists of:

1 Tapered, straightened and polished stainless stell propeller shaft with keyway, thread, fairwatercap, lock washer and key.
2 Outer bearing (with incorporated rubber bearing) soldered to bronze stern tube.
3 Mounting flange for outer bearing.
4 Mounting flange (adjustable) for stern tube.
5 Flexible stuffing box with rubber sleeve for shaft 25, 30, 35mm diameter.
6 Flexible stuffing box with rubber sleeve and torsion protection for shaft 40, 45, 50mm diameter.
7 Propeller.

This is a Vetus stern tube-shaft-propeller combination. If you are able to use a matched set of stern gear this will save you considerable time and expense in assembling this equipment from separate sources.

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.

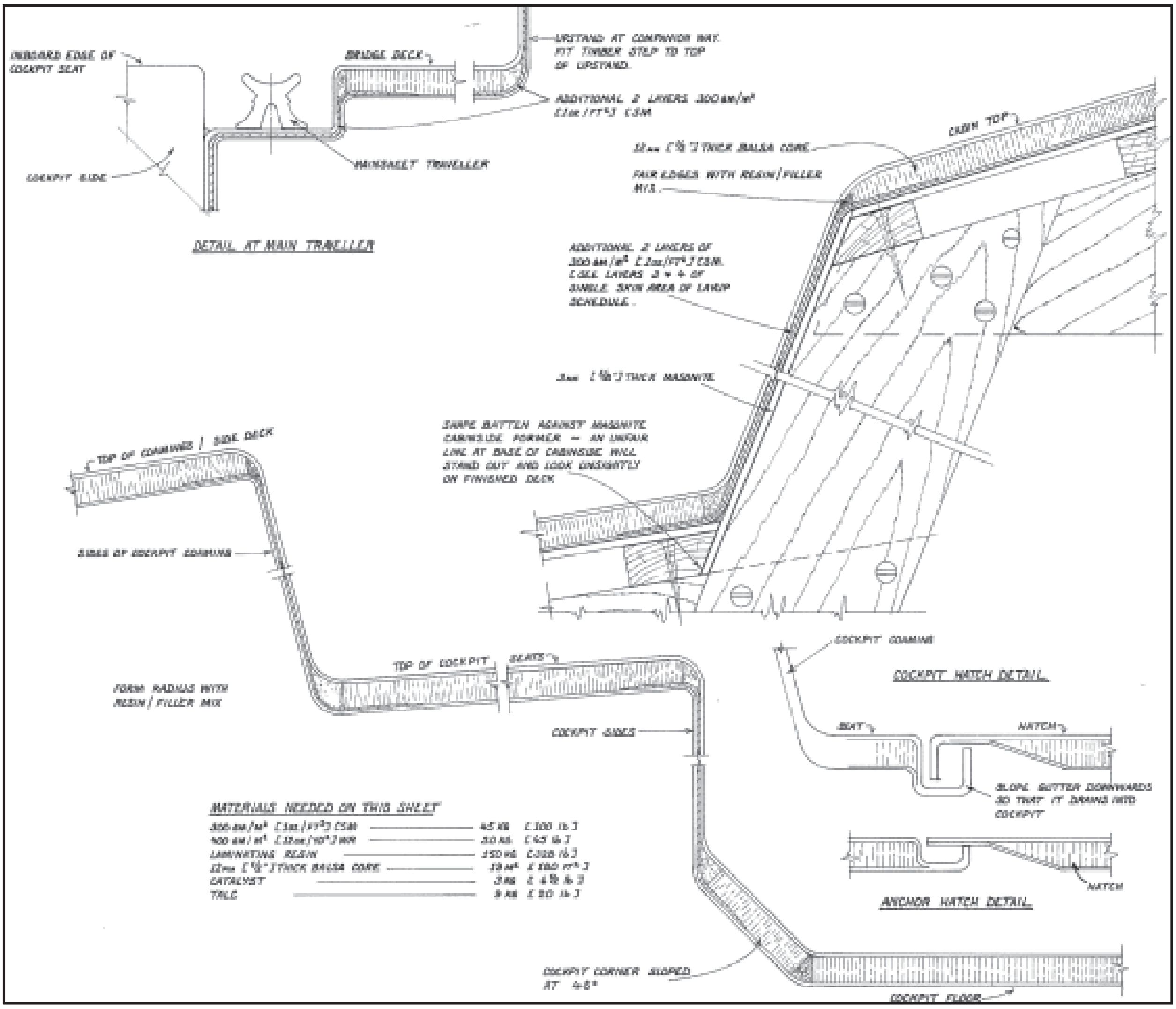
Nails should be kept to a minimum when fastening the hardboard to the framing for the in-place deck mould. Any nail heads will show (unless covered with a lining material) on the finished laminate from inside. Fasten the hardboard to the framing using contact glue.

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 form work 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.



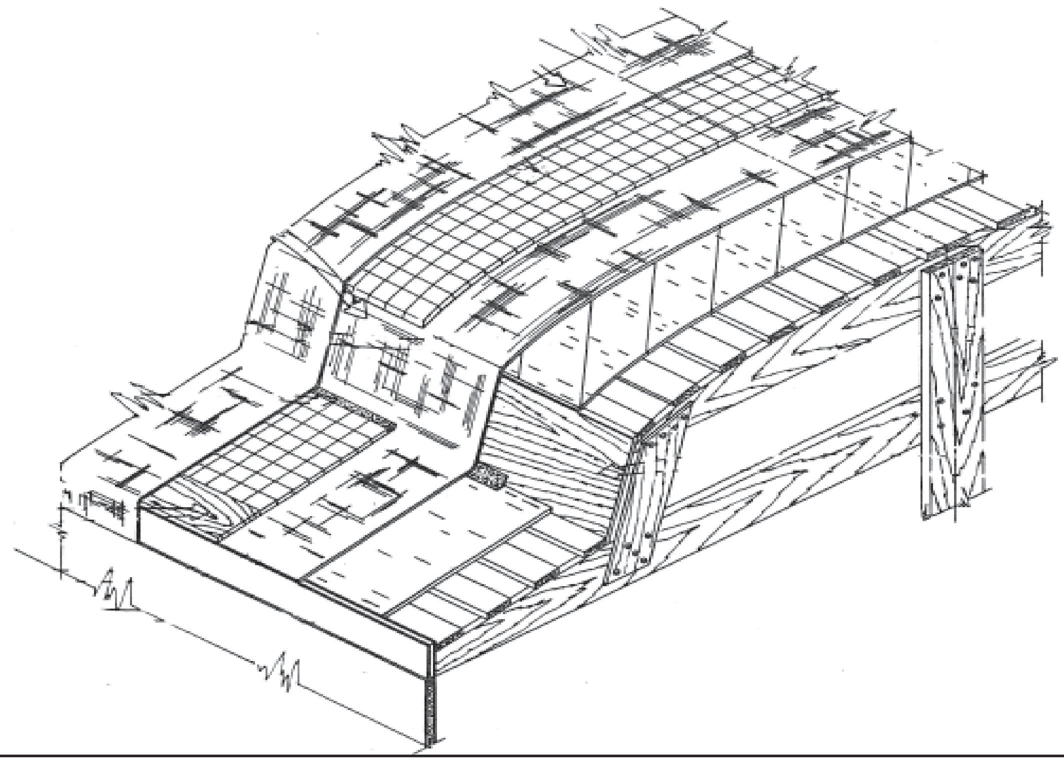
These sketches illustrate several areas of the temporary deck and superstructure mould and later mouldings including several areas where the inner laminate come together and the use of core material is not appropiate.

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 adjacent to 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 joins 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 under side 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.

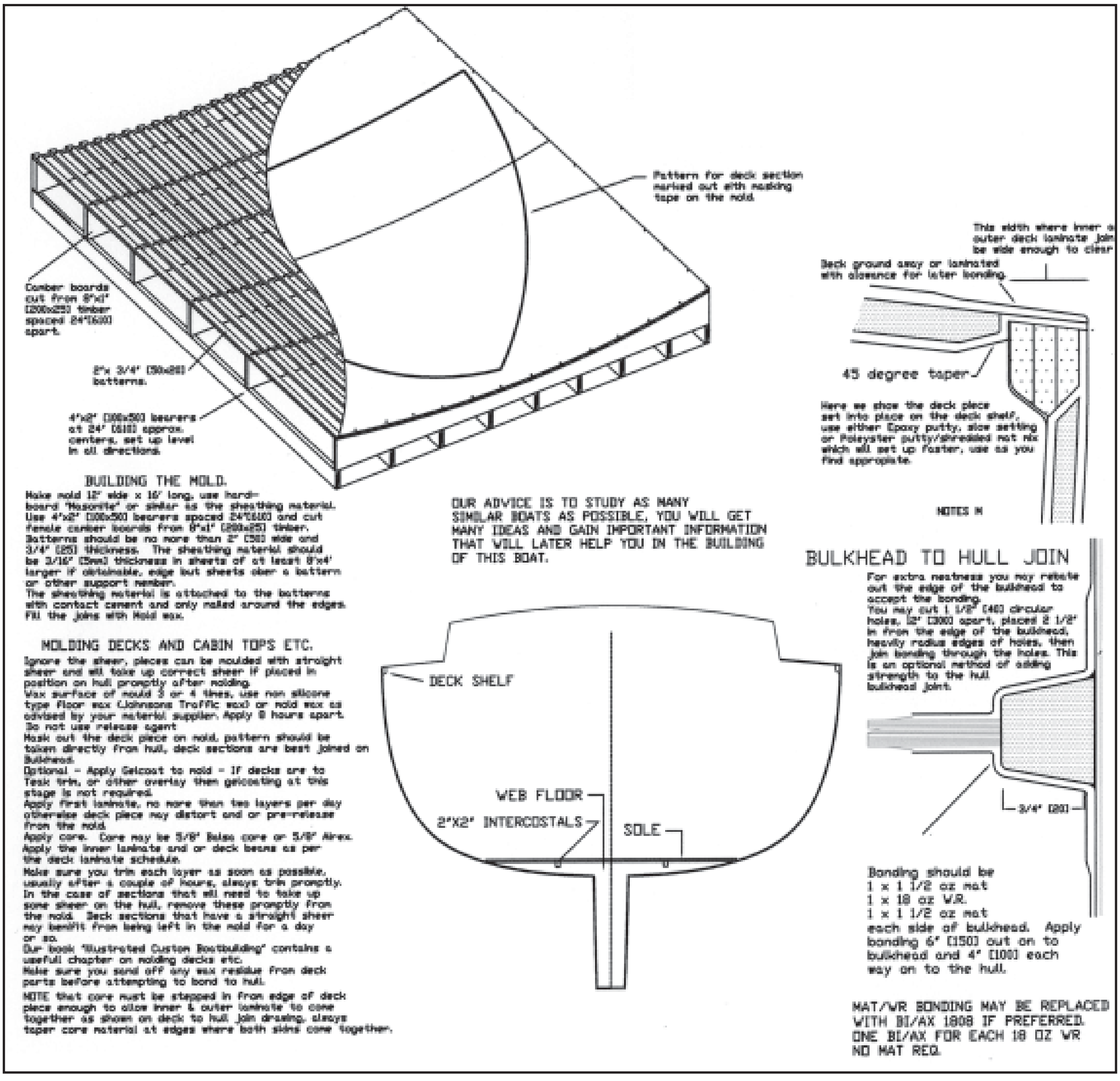
The length of the master deck mould should be a few inches longer than the longest panel required but, as panels can be joined, 16 feet [4.9 metres] long is sufficient for most boats up to about 65 feet or [20 metres]. Build the deck mould without sheer (fore and aft camber) as when first moulded, the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

Note the reinforcing on this fibreglass mould. Remember that some hull shapes will demand that you use a split mould.

***This hull was laid up in the mould pictured. Note the moulded rubbing strake, this alone would demand that a split mould be required*.**

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, horrible 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 loose 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.

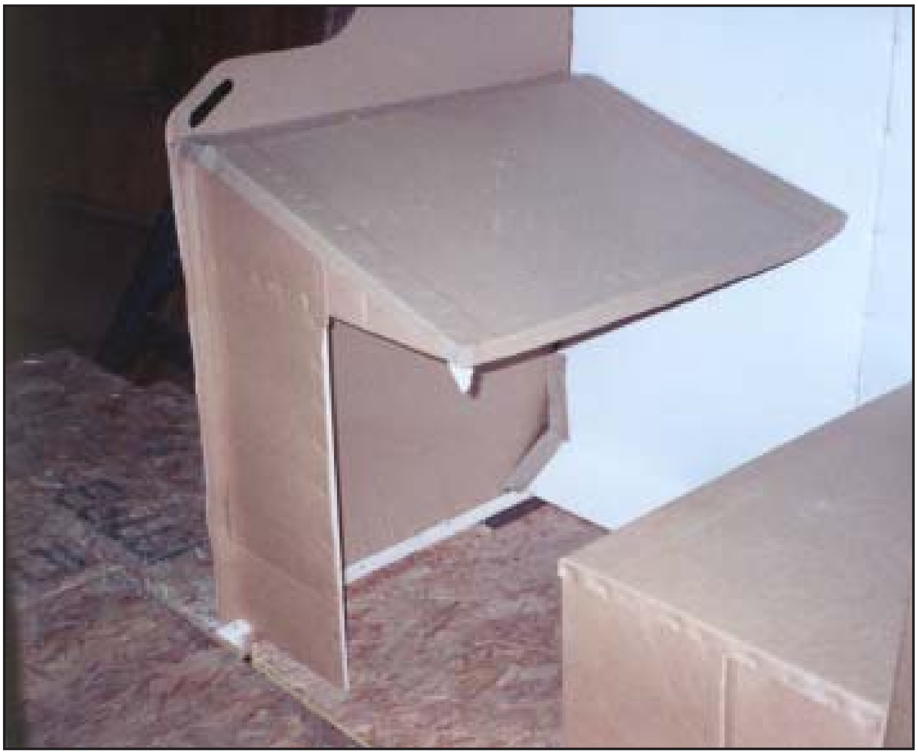
Next mark out the cabin top camber and the lay-in of the cabin sides and you now have a sectional view of the side decks and cabin structure. Note: the cabin top camber is usually greater than the camber used for the decks as too much deck camber may lead to more problems than having too little. You 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 boats 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 wote "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

CHAPTER 9.
Building in METAL

There are two main ways to build a metal boat see below:

1. Custom build / Build from scratch

2. Build from a pre-cut KIT or Cutting files.

Below I will explain the difference between the above two methods. ***You can NOT build a boat from a KIT or a set of cutting files for a boat that is designed to be build from scratch.*** ***You can NOT build from scratch a boat that was designed to be CNC cut and built from either cutting files or a KIT.*** *Not withstanding the above, it is possible to have us draw plans or provide kits and or cutting files for scratch build boats but this is more expensive than choosing an existing kit boat.*

BUILDING FROM SCRATCH:

Many thousands of owners have built their metal boats from scratch. These determined individuals have selected a design, purchased plans and basic materials, and built their own hulls, decks, and superstructures. Depending on the size of your boat, and whether you are building part-time or full-time, this process will take longer but cost a little less than starting with a kit. If you feel you would like to build from the ground up, don't be put off by the size of the project, but keep in mind that you should never build more boat than you need. Choose a design that has been especially drawn for the less-experienced builder; some designers, including ourselves, provide full-size patterns for the frames and other parts of the hull structure.

One Roberts 53 steel sailboat, including the hull, deck, and superstructure, was built and equipped ready for sailing by one Australian man and an occasional helper in the unbelievable time of 10 months. We have to assume that this person purchased many items readymade. Another builder of the same design took 10 years part-time, but he made everything himself, including the sails. This tenacious builder even made patterns for his cast winches, and then finished them himself. Photographs taken while he was sailing his 53-foot (16.15 m) boat off the Australian coast show a happy couple enjoying their boat and cruising far from home. In fact, this builder then completed a circumnavigation of the world and before returning home to Germany.

In our records there are hundreds of letters from builders who fall between these two extremes. There have been many attempts by others and us to try and calculate building times for individual boats. In most cases this has proven a futile exercise. Factors such as starting from scratch versus buying a kit, cutting files, or a ready-built hull; the amount of help available from your partner and friends; how many hours a week you can devote to the project; and just how badly you want to get the job done all play a part in how long it will take you to complete the project.

STARTING FROM A KIT:

It is now possible to purchase a kit of parts that have been precut from plate. Your job then is to assemble them into a hull, deck, and superstructure. Some designers (including this one) have the ability to prepare a special computer disk with the parts "nested" to allow more economical cutting. It's necessary, of course, for the company producing the kit to have the automatic, computerized cutting devices. This service costs more, but if you can afford it, you will find this a practical and perhaps even economical way of getting your project off to a quick start. Recent cost comparisions have established that building from a precut kit or cutting files does not involve additional costs when considering all the aspects of assembling your hull deck and superstructure (often referred to as the *shell*).

You alone can tell if the additional initial cost is justified; discuss these matters with the designer and with the company supplying the kit or cutting files. The best of these precut kits are cut from shotblasted and primed steel that has been coated with a specially formulated weld primer. This coating doesn't give off fumes when you're welding. Another benefit of the weld primer is that there is little cleanup after welding; all you need to do is lightly grind the welds and then touch up the primer by hand in these areas. One thing is for sure: you'll save a great deal of money, and end up with a boat that you are totally familiar with and can then easily maintain. If you plan any extensive cruising, it's imperative that you be familiar with every aspect of your vessel. What better way to learn about your boat than to work on the construction? After studying all of the options, you can personally select all the equipment you need to complete your vessel.

YOUR CHOICE: OK the choice is yours ! See design chapters 13 +

HISTORY

Metal boats have a long and distinguished heritage stretching back 200 years. The first recorded instance of a small metal boat was a 12-foot (3.66 m) iron hull built on the banks of the River Fosse, in England, in 1777. Ten years later, the next known example, a 70-foot (21.33 m) iron canal boat, was built using ⅝-inch (13 mm) riveted plates laid over a timber frame. In 1818, the first all-metal commercial boat was built in Scotland. The *Vulcan* was 63 feet (19.20 m) in length overall (LOA) and had a beam of 13 feet (3.96 m). This boat, with its flat-bar frames and riveted iron plates, was the forerunner of hundreds of boats and ships built using similar techniques.

As suitable timber for boatbuilding became increasingly hard to find, designers and shipbuilders turned to metal. In 1834, a violent storm drove hundreds of wooden boats and ships ashore in England, marking a milestone for metal boats. Most of the boats were totally destroyed, but one exception was the 125-foot (38.10 m) all-metal *Gary Owen*. After being driven ashore, this boat was able to withstand the severe pounding until the storm subsided. It did not go unnoticed that the *Gary Owen* suffered only a few scrapes and scratches, and that she returned to port under her own power. Another boost for metal ships occurred when the first all-metal liner, *Great Britain*, came to grief on the Irish coast and was later floated off to resume active service. The Great Britain went on to have a long and successful career and the restored vessel is now on permanent display in Bristol Harbor in England. These incidents did much to popularize all-metal vessels, so that gradual acceptance turned into a flood of orders for builders of metal ships.

Shipowners soon found that metal ships were more resistant to the stresses of the sea in all weathers, and better able to keep schedules. Many wooden ships had been lost with all hands because some of the fastenings let go under extreme weather conditions. Shipowners found that although fire can occur in boats and ships constructed out of any material, metal vessels are better able to stay afloat, giving the crew more time to control the fire. As early as 1853, a survey of sailing ships operating in the Far East trade revealed that to build and operate metal ships cost as little as 80 percent of the cost of wooden ones. Comparing equal-sized vessels, it was proved that metal ships, because of their greater interior volume, smaller frames, etc., were able to carry as much as 25 percent more cargo than otherwise identical wooden vessels. The published results of this extensive survey gave a great boost to metal shipbuilding, and no doubt helped Great Britain become the largest builder of commercial shipping until World War II.

In 1858, the all-metal *Great Eastern* was built in the UK; at the time it was the world's largest ship—700 feet (213 m) long with a beam of 85 feet (25.91 m). In a world where trade was increasing at a great rate, this proved that there was virtually no limit to the size of ship that could be built using metal. It's interesting to compare this early metal ship with the longest wooden ship ever built, the *Dunderberg*, which was a mere 377 feet (114.91 m) long.

METAL SHIPS

Steel

This steel Spray 40, Mirounga*, was built in Germany by Ulrich Kronberg.*

Up to the early 1860s, all metal ships were built of wrought iron, but thereafter a new material became available: steel. Steel was lighter than iron, but this new wonder material had one major drawback: it cost four times as much as the iron it would soon replace. Economy of scale soon prevailed, however, and steel became affordable. That, together with the fact that it was available in large sheets, soon established steel as the premium shipbuilding material. The giant liners of the past were built from steel, including the *France*, which was 1,035 feet (315 m) long and displaced over 70,000 tons. The liner *United States* holds the fastest passage time for a North Atlantic passenger ship, having made the trip between Europe and North America in only 3 days and 10 hours, averaging 35.59 knots for the crossing. High-speed ferries and other similar vessels are challenging this record. More recently, a large number of new giant liners entering the charter trade have spawned a great revival of steel shipbuilding.

Steel warships and oil tankers dwarf the famous passenger ships of the past. The aircraft carrier USS *Nimitz* displaces 95,000 tons, and the oil tanker *Seawise Giant*, which is 1,504 feet (458.52 m) long and 225 feet (68.58 m) wide, weighs in at 564,763 tons.

While this revolution in building large ships moved almost all construction of commercial shipping out of the timber era and into steel, small boats continued to be built of wood, except in Europe—and there, mainly in the Netherlands.

This situation prevailed until the early 1960s when the advent of fiberglass changed the pleasure-boat scene forever.

Aluminum (or Aluminium)

This metal is refined from the natural material bauxite. Although it was discovered early in the nineteenth century, it was not until 1886 that the first practical refining methods were developed in France. As early as 1894, an aluminum alloy was

The Tom Thumb 26 is ideal for building in steel or aluminum. It would make a great first project for the novice metal boat builder.

used in Switzerland to build the power yacht *Alumina* for Prince Wilhelm zu Wied.

The designers of the liner *United States* made extensive use of this metal, saving over 27,000 tons compared to a similar-sized all-steel vessel. Today, aluminum is used to build sailboats and power yachts of all sizes. This material is especially useful where weight saving is the most important factor.

Copper-Nickel

In electro-chemical terms, copper is one of the most noble metals in common use. It has excellent resistance to corrosion in the atmosphere and in salt water. The British Royal Navy introduced copper cladding to wooden warships in the eighteenth century to prevent the hulls from being eaten by marine borers and fouled by other marine growth. The hulls of the *Cutty Sark* and other famous clipper ships were clad with copper. These vessels were required to make fast passages, and the copper ensured that their bottoms remained smooth. In 1893, the America's Cup defenders *Vigilant* and *Enterprise*, and other Cup defenders of the period, had hulls of Tobin bronze, fastened with rivets of the same alloy.

The practice of cladding the hulls of wooden ships and pleasure boats with copper was common until the mid-1950s, when modern antifouling paints came into common usage. Copper cladding was the forerunner of modern copper-nickel alloys that combine superior resistance to corrosion with excellent antifouling properties. Copper-nickel is sometimes used to clad the underwater sections of commercial vessels but for several reasons—including difficulty in obtaining the material, difficulty of welding, and great expense—it is not suitable for constructing pleasure craft.

SMALL BOATS

It is only in recent times that steel and aluminum have been considered mainstream boatbuilding materials. Metal boat building has come a long way in a few years, and even as recently as 1965 very few small craft were built from these materials.

In the early 1970s, in Brisbane, Australia, I knew every small craft in the area. Out of some 200 boats, only 3 were built of steel. By 1974, when I started to design in metal, there were still fewer than 10 steel boats in Brisbane. What a difference today, when metal boats are much more widely accepted, and are regarded by many as the best for serious offshore cruising. It's common for our office to receive from cruising people letters that read: "We are anchored off [a popular cruising area] and there are 20 boats here, and 12 are built from steel." A rare dash of modesty prevents me from quoting the large percentage of these boats that are to my design!

Steel

Steel is the most commonly used boatbuilding metal. It has many advantages including great strength, low cost, and ease of fabrication. There are great numbers of experienced welders in all parts of the world. Add to this the ease of repair, and the availability of a wide selection of suitable plans designed especially for building in steel, and it's easy to see why this material has become so popular with the cruising fraternity. Successful steel cruising boats can be small, too—as little as 25 feet (7.62 m) in length. The Dutch even build steel dinghies of around 15 feet (4.57 m) and use them as tenders on their barges and other commercial craft.

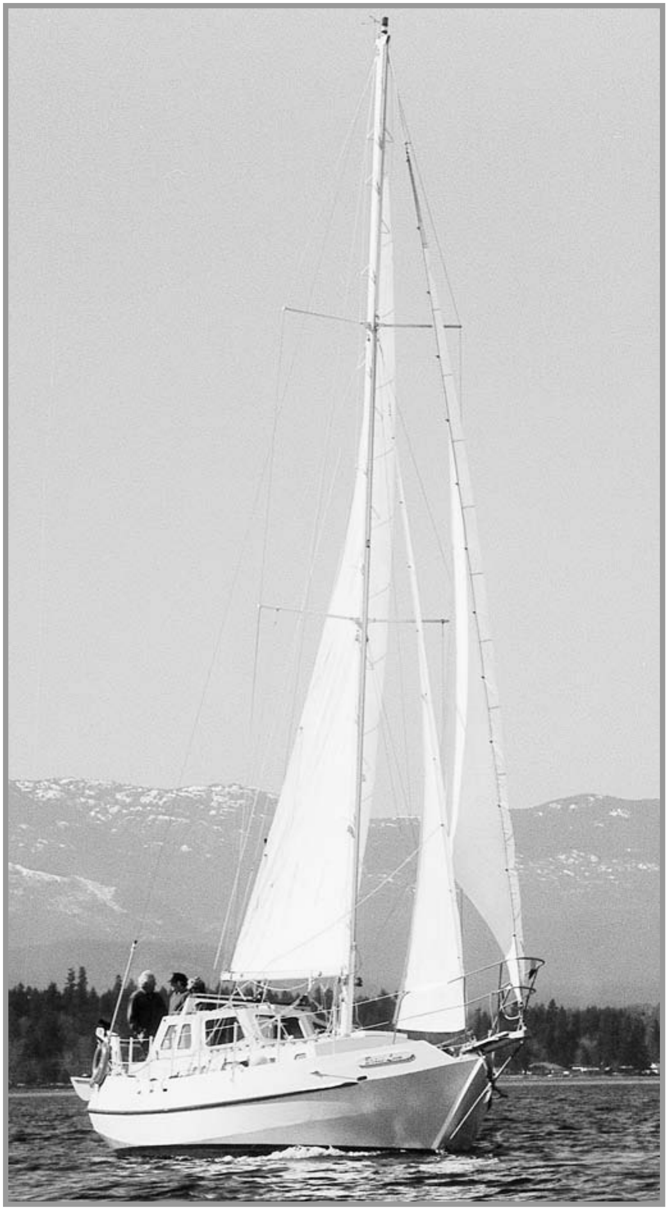
Steel is heavier than other boatbuilding materials, but that hasn't proved to be a disadvantage in cruising sailboats or powercraft. Steel needs some care and attention, but modern coatings have greatly reduced the chances of rust forming. As the owner of several steel boats, I must confess I have found it hard to find any serious disadvantages in building, owning, and maintaining a steel boat.

This tidy pilothouse would look equally attractive on a sailboat or a powerboat.

Aluminum

Now widely accepted as a boatbuilding material, aluminum has the advantage of being about one-third the weight of equal-size steel, although this is partly offset by the fact that you need a thicker material for boatbuilding. Aluminum is easy to work with. In fact, you can use hand tools on aluminum, even some woodworking ones. It's ideal for decks and superstructures where its light weight can be used to advantage. In some areas of the world, aluminum has become popular for building commercial craft and fishing boats; when the correct marine grades are used, the entire boat can be left unpainted.

The disadvantages include greater cost and relatively greater susceptibility to galvanic corrosion. Aluminum requires expert fabricators and experienced welders who are used to handling it.



Aluminum was the material chosen by Leuder Kerr for his Spray 33 Brass Loon. *This strong hull has successfully withstood contact with many deadheads (near-submerged floating logs) in the Gulf Islands of British Columbia, Canada.*

When it comes to repairs, experience won't be a problem if you have built your own aluminum boat. Aluminum should be used where its benefits can be exploited to the full. For instance if you are considering building a fast, planing, metal powerboat, then aluminum will be worth your consideration. Another instance is where a vessel has a high superstructure; then aluminum may be used for the constuction of those areas where its light weight will add to the posative stability of the vessel. Seek your designer's advice on this matter. It is a waste of money to use aluminum to build moderate to heavy displacement boats; steel is preferable as a construction material for these heavier hulls.

Copper-Nickel

In 1938, a 45-foot (13.72 m) motor cruiser, *Miss Revere*, was built in the United States using an alloy of 70 percent copper and 30 percent nickel, welded over framing of the same alloy, and fitted with aluminum bulkheads. Between 1938 and 1965, many U.S. Coast Guard motor whaleboats were sheathed at the waterline in copper-nickel. In 1968, the pleasure yacht *Asperida* was built, using 70-30 copper-nickel hull plating over framing of the same material; this boat is still in service today.

The first of several copper-nickel commercial fishing boats was built in 1971. The hull of the 67-foot (20.42 m) *Copper Mariner* was constructed from a $\frac{1}{4}$-inch (6 mm) alloy containing 90 percent copper and 10 percent nickel, installed over steel framing. More recently, several other trawlers and general-purpose fishing boats have been built using copper-nickel alloys.

One interesting example of copper-nickel construction is the sailboat *Pretty Penny*. I inspected this boat in Faversham, England, after she had been removed from the water for the first time in 16 years. *Pretty Penny* was also scrubbed once a year, and there were only a few barnacles present when she was hauled. I was most impressed with her condition.

All the advantages of steel accrue also to copper-nickel, which has the additional benefits of being resistant to corrosion and fouling by marine organisms. Copper-nickel requires neither painting nor anodes. It's a natural antifouling element. These benefits may make it the choice of those who can afford the costly material. Another advantage is that you will never be short of conversation with your peers if you choose copper-nickel.

The disadvantages of copper-nickel include the shortage of boatbuilders with experience in handling this metal, much greater cost, and the sense of being a pioneer when you decide to build a copper-nickel boat.

Another attractive pilothouse. This one graces the steel Roberts 370 Tensile.

The Cost of Metal Boats

Steel is the cheapest metal suitable for boatbuilding. It's considerably cheaper than fiberglass or the materials used in wood/epoxy construction. Steel is definitely today's bargain boatbuilding material. Aluminum comes next in price, then fiberglass or wood/epoxy. Copper-nickel costs about 10 times more than any other material and hence is the most expensive of all.

But you have to remember that the cost of the hull (meaning hull, deck, and superstructure) represents only about 33 percent of the total cost of the vessel. Thus, a good argument can be made for ignoring the cost of the hull. If your budget allows this, then choose the material that is most suitable for your needs. After you have examined the building techniques explained in later chapters, you will be in a better position to make an informed decision. Quite frankly, even if steel were the most expensive material, which it is not, because of its great strength advantage, you could still make a good case for choosing steel as the primary boatbuilding material.

CHOOSING A SUITABLE BOAT

Before your decision-making process gets into top gear, you would be well advised to get your partner and family involved. Over the past 30-odd years, we've seen many boating projects come to grief because the senior family member failed to consult with, or listen to, the wishes of the others. You'll have to forgive us if we repeat this advice elsewhere; we feel it is worth the telling.

You'll find many fine designs for sail and power in Chapters 6, 16, and 17. But don't be tempted to buy or build a boat that is larger than you need. Reaching this decision is harder than you may imagine. If you have children who will accompany you throughout your boating adventures, make sure you think through the options. For instance, if you have teenagers, the chances are that within a few years they will be doing their own thing and not interested in accompanying their parents. It's a fact, though, that many families cruise with young children. Home schooling, and other concessions to your young crew, can turn cruising into a wonderful experience for the entire family.

What type of boat is right for you? Power, or sail, or perhaps a 50-50? That's a decision you may already have reached before you discuss the options with your spouse and other family members. Age has a bearing on this decision; if you're under 40, then you will most probably opt for sail; up to 50, it may be a tossup; and over 50, power may be your choice. There are many exceptions to the above but it's my experience that the happiest boaters fall into the age/sail/power categories outlined above. We are currently preparing a custom sailboat design for a client who has just turned 50; he admits that his next boat will be a trawler.

Many people enjoy the comfort, convenience, "level playing field," and perceived safety of powerboats. They don't particularly like preparing meals and generally keeping house at varying degrees of heel. If more sailors chose cruising powerboats, or at least comfortable sailboats like the Spray type, they and their families would be (and would remain) more enthusiastic about serious boating. Introduce your partner to boating in a sensible way. Do not choose the roughest day to show off your boating skills; if you do, then from then on you may boat alone.

That's our idea of the comfortable cruising lifestyle. In the many years we've spent designing and supervising the construction of hundreds of boats of all types, we have met many families before, during, and after their boating adventures. Our suggestion is that you give stability and comfort some serious consideration before you make a decision about which boat will suit you and your family. Most modern "off-the-shelf" sailboats sail to windward at considerable heel; in our case we prefer to design boats that sail with minimum heel. Surprisingly (to many), when tested under actual passagemaking conditions, these boats often out perform so-called performance cruisers.

Western Grace, built by Christensen Yachts in British Columbia, is a very successful charter vessel. See www.bruceroberts.com for details.

If you're new to boating, you may want to consider a boat that's suitable for weekend and holiday cruising as opposed to a fully equipped liveaboard cruiser. That would be jumping in at the deep end. Again, your age will have a bearing on your decision; the younger you are, the more time you will have to correct any mistakes of judgment you may make when choosing your boat. Most people who enjoy boating will own three or more boats in their lifetime. You'll need to consider if your first boat is truly "the" boat or just a stepping-stone in that direction.

A metal weekend cruiser can be as small as 25 feet (7.62 m) in length or as large as you can afford or handle with your family for crew. *My advice is never to own a boat that cannot be handled by a crew of two.* Most boats that are used regularly, as opposed to those that languish in the local marina, are crewed by a couple. How big is too big? We have many Roberts 53-foot sailboats successfully cruised by healthy and active (not necessarily young) couples. Neither crew member is required to have an outstanding physique. Modern equipment makes it possible for small persons to handle the sails and associated gear comfortably.

Before deciding on the size and type of vessel that will best suit your needs, you may wish to read more on the subject. See Appendix 1 for a list of books that can help you to make an informed decision.

BUYING NEW

If you're considering owning a powerboat in Europe, you will have a wide choice of metal boats. There are many builders of fine steel cruisers in Holland, Britain, and elsewhere in the European Union (EU). The off-the-shelf motor cruisers built by the Dutch used to be mainly intended for coastal and canal work. The quality of hull

Frank Ozannes built this steel Roberts 36 from scratch.

construction, interior joinery, and general finish is first-class. With the advent of the EU Norm rules for marine craft, the cruising capabilities of the boats built in Holland and elsewhere in Europe are superior to those built elsewhere. The strict and comprensive rules of construction and general engineering ensure safe, seaworthy boats. All the boats designed and built by my own company in Holland are Class A, which means they are classified as suitable for unlimited offshore ocean cruising.

In the United States and Canada, there are a few builders of metal boats, many of whom build fine vessels. Fortunately, the shoddy builders soon disappear; but make sure you are not one of their customers before they quit the scene. You may wish to contact one of our offices for a current list of builders and kit manufacturers in your area. Visit our website at www.bruceroberts.com for additional up-to-date information

BUYING USED

Buying a used metal boat is another option, but the purchase of any secondhand boat can be fraught with traps for the unwary. The term "buyer beware" is never more apt than when buying a used boat. With any boat, age has its potential problems, so younger is usually—though not necessarily—better. Naturally, there are cases where a well-built and maintained older metal boat is superior to a jerry-built nearly new vessel. Nevertheless when buying a used boat try to consider only boats that are less than 5 years old. This advice applies to any boat, no matter what material was used to build the hull.

Older boats with teak decks are to be viewed with added suspicion. In fact, *any* boats with teak decks should be inspected with the utmost care. Assume you may have to replace or extensively repair the decks, and factor this into your offer. Remember that a boat that needs extensive repairs and renovation will cost you nearly as much as—or often more than—building a new one, and the result will still be an older boat with a doubtful resale value.

Now, having painted that picture of doom and gloom, let us say that there are some fine used metal boats out there, but you'll have to sort through a considerable number of undesirable examples before you find your dream boat. We have owned many boats, mostly new, but the last two were used steel boats. Both these boats were under 5 years old and had been only lightly used before we purchased them. With one of our previous boats, *K*I*S*S*, a 28-foot (8.53 m) steel Spray design, we were able to recover all of our investment after two years' use.

If you're able to deal directly with the owner, you may avoid some of the pitfalls associated with this type of purchase. You must make sure you are absolutely satisfied *before* you hand over your money. Always hire a qualified surveyor to check out your boat; also the report may be used to help with the price negotations depending on what the suveyeror finds. Again make sure you have all the facts before you part with any substantial amounts of cash.

In the United States, boats are often documented with the Coast Guard, which proves ownership. Another way to check ownership is to contact the yacht's insurers and the harbormaster where the boat is kept. It's as well to remember that if you buy a boat from someone who doesn't have legal title to the vessel, and it's later reclaimed by its lawful owner, you may lose both the boat and your money. There's always a chance that the boat you're considering buying may be subject to a loan agreement, or it may form part of a legal dispute, or there may be some impediment in the title. Carefully check builders' certificates, bills of sale, and any other documentation that's offered to prove the current ownership.

Surveys are essential when you're buying a used boat. You'll have to bear the costs of hauling for a full survey, but before you commit to that, here's a tip. To cut your potential costs, conduct a very detailed inspection of the interior, galley equipment, pumps, heaters, batteries, mast(s), rigging, sails, dinghy, and electronic equipment before you commit yourself to a full survey. Do it yourself, and don't be rushed. Take your time, and don't be afraid of being a nuisance. If you have trusted and knowledgeable friends, seek their help and advice at this early stage. Don't ignore advice because you've fallen in love with the boat. Assemble your facts, and on no account part with your cash before you are in possession of all the information about the boat's condition.

Build carefully if you wish to emulate this Spray 40 sailed to the Antarctic by her owner-builder, Alan Sendall.

CUSTOM BUILDING

Many of you will be considering having your metal boat fully or partially built by professionals. But most owners of metal boats are better informed than owners of vessels built from other materials, and many are capable of building or supervising the construction of their new vessel.

If you opt for a custom-built metal boat, you'll need the services of a competent naval architect or boat designer who is familiar with your chosen material. Fortunately, there are several designers who have either specialized in, or had experience in, designing boats in steel or aluminum.

A custom-built boat need cost you no more than one from a production run. One way to save money is to act as your own contractor. You rent the building space and hire local workers to do the work. And here you reap another benefit of building in metal: any competent welder with experience in your particular metal can build a metal boat, given a kit or a detailed plan. All the materials and equipment, engines, electrical gear, and everything you need to build and equip your vessel can be purchased locally. If you go about this in the right way and buy most items at trade prices, you can save a great deal of money; perhaps this will enable you to afford a larger boat. A letterhead with your "Boatbuilding Company" name and address will go a long way toward convincing suppliers to give you trade discounts; make no mistake, they want your order, so make it easy for them to supply you at trade or discount prices.

STARTING FROM A KIT

It is now possible to purchase a kit of parts that have been precut from plate. Your job then is to assemble them into a hull, deck, and superstructure. Some designers (including this one) have the ability to prepare a special computer disk with the parts "nested" to allow more economical cutting. It's necessary, of course, for the company producing the kit to have the automatic, computerized cutting devices. This service initially costs a little more, but if you can afford it, you will find this a practical and perhaps even economical way of getting your project off to a quick start. Recent cost comparisions have established that building from a precut kit or cutting files does not involve additional costs when considering all the aspects of assembling your hull deck and superstructure (often referred to as the *shell*).

You alone can tell if the additional initial cost is justified; discuss these matters with the designer and with the company supplying the kit or cutting files. The best of these precut kits are cut from shotblasted and primed steel that has been coated with a specially formulated weld primer. This coating doesn't give off fumes when you're welding. Another benefit of the weld primer is that there is little cleanup after welding; all you need to do is lightly grind the welds and then touch up the primer by hand in these areas.

HULL AND DECK OPTIONS

Many metal boat owners start with a hull, deck, and superstructure that have been built to their order and delivered to a suitable site for them to complete. Again, the owners buy all the equipment and finishing materials and then undertake as much of the labor as they wish. It's still a good idea to print your letterhead, as mentioned earlier, and buy at trade prices.

There are many books for those who want to build or partially build their own boats; you'll find some suggestions in Appendix 1. If you don't want to do some jobs yourself, you can hire local electricians, mechanics, and other tradesmen to do them for you. You're in charge; you decide just how much or how little you want to do yourself. One thing is for sure: you'll save a great deal of money, and end up with a boat that you are totally familiar with and can then easily maintain. If you plan any extensive cruising, it's imperative that you be familiar with every aspect of your vessel. What better way to learn about your boat than to work on the construction? After studying all of the options, you can personally select all the equipment you need to complete your vessel.

BUILDING FROM SCRATCH

Many thousands of owners have built their metal boats from scratch. These determined individuals have selected a design, purchased plans and basic materials, and built their own hulls, decks, and superstructures. Depending on the size of your boat, and whether you are building part-time or full-time, this process will more than double the overall building time.

There are many of you who have some welding experience. If you feel you would like to build from the ground up, don't be put off by the size of the project, but keep in mind that you should never build more boat than you need. Choose a design that has been especially drawn for the less-experienced builder; there are many designers who can provide you with suitable plans. Some designers, including us, provide full-size patterns for the frames and other parts of the hull structure.

We're often asked how long it takes an amateur to build a boat. Here are a couple of extremes. One Roberts 53 steel sailboat, including the hull, deck, and superstructure, was built and equipped ready for sailing by one Australian man and an occasional helper in the unbelievable time of 10 months. We have to assume

This steel Spray 40 shows several attractive and sensible features, including substantial pipe guardrails (stainless would have been nice) and a nicely laid teak deck. Note the wide covering board around the edge, a sturdy pair of stainless steel bollards on the foredeck, a timber rubbing strip "stood off" the hull, a pair of stainless steel bow fairleads, and a well laid out fore-cabin top.

that this person purchased many items ready-made. Another builder of the same design took 10 years part-time, but he made everything himself, including the sails. This tenacious builder even made patterns for his cast winches, and then finished them himself. Photographs taken while he was sailing his 53-foot (16.15 m) boat off the Australian coast show a happy couple enjoying their boat and cruising far from home. In fact, this builder then completed a circumnavigation of the world and before returning home to Germany. In our records there are hundreds of letters from builders who fall between these two extremes.

There have been many attempts by others and us to try and calculate building times for individual boats. In most cases this has proven a futile exercise. Factors such as starting from scratch versus buying a kit, cutting files, or a ready-built hull; the amount of help available from your partner and friends; how many hours a week you can devote to the project; and just how badly you want to get the job done all play a part in how long it will take you to complete the project.

FINANCE, OR PAY AS YOU BUILD?

Unless you are financially independent, you'll have to consider how you're going to pay for your new boat. If you buy a new or a used vessel, you may decide to finance *part* of the purchase. Many finance houses will give you a loan, perhaps as a second or refinanced mortgage on your home. Of course, you'll pay for this in interest, loan setup fees, and so forth. You may get a more favorable interest rate if you obtain a marine mortgage, as opposed to a simple bank or finance company loan. Many banks, savings and loan associations, and similar lenders will give you a loan for 10, 15, or 20 years to purchase a new boat. But before you sign any finance agreement, make sure you're aware of all the interest and other expenses involved.

Paying as you build is our preferred option, and means not only that will you save on the overall cost of the boat, but you'll also avoid interest and other associated charges. We've seen thousands of fine boats built or completed by owners who, on launching day, have had the extra thrill of knowing that their pride and joy was debt free. Some builders even have it both ways—they build as much as they can afford (paying cash), and then they raise a loan, using the partly built boat as security.

BUILDING SITES

If you decide to build your own boat from a kit, cutting files, hull-and-deck package, or from scratch, you'll need a suitable building site. If you live in a warm area, a simple shelter will suffice. If your boat is to be built or completed in a cold climate, you'll need to consider a heated structure. In any case, you'll need some form of secure building in which to keep your tools and valuable supplies. Fortunately, when you're building a metal boat the lower perceived value of the materials will mean the need for security is relatively less than if you were building in fiberglass or plywood. This benefit lasts only until you start on the interior. Even if you're working outside, it's a good idea to keep your more valuable items out of sight, or maybe in more secure storage, until they can be properly installed in the boat.

Part of the advantage of building in a place that's secure, comfortable, and weatherproof is purely psychological; it will be easier to make the effort to work on the boat. Also, if you're paying rent on a building, you're more likely to get on with the job. If you're building outdoors, exposed to the elements, then you'll often have to stop work because it's rainy, cold, or windy. The disadvantages of building outdoors can add months to your building program.

To determine how much space you'll need to house your boatbuilding project, plan for a space 50 percent longer and 100 percent wider than the finished boat. For instance, if you're building a boat 40 feet long by 13 feet wide (12.19 by 3.96 m), your working space should ideally be 60 feet long by, say, 26 feet wide (18.29 by 7.92 m). When it comes to handling plate and other construction members, you'll need plenty of space

This Roberts 342, built in Europe, is a fine example of what you can achieve using the radius-chine technique to build in either steel or aluminum.

for tools and materials, as well as room to move around.

For maximum efficiency, plan your building site so that you spend as little time as possible walking from one area to another. The positioning of benches and frequently used tools will play a part in making a comfortable and productive workplace.

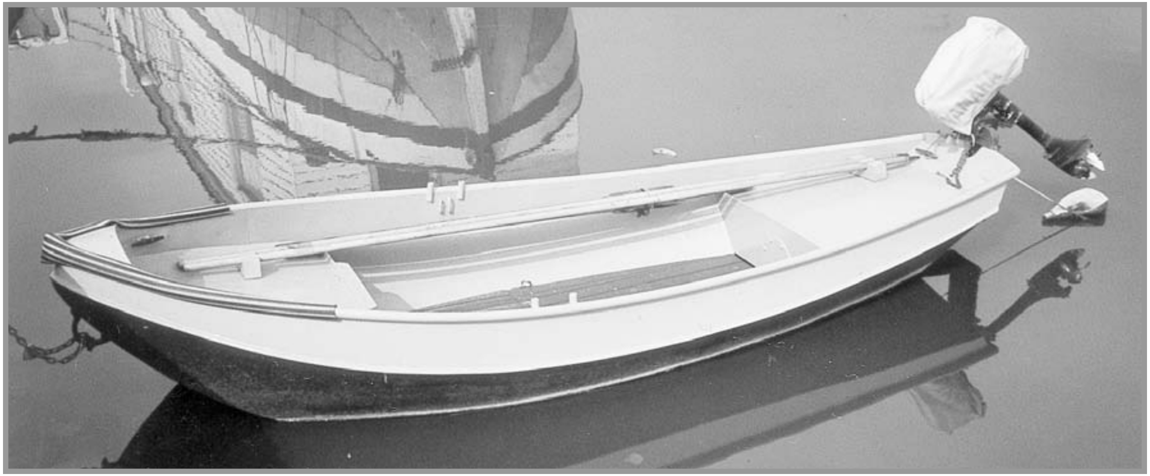
Your boatbuilding project should not be too far from home; this becomes even more important if you're only working part-time on the boat. Travel time can eat into valuable work time, and distance can be a deterrent to getting started evenings and weekends. Make sure also that your work site is accessible to the large trucks needed to deliver long lengths of plate and other necessary supplies. If you're working outdoors, be sure you have a flat, level site. Carrying tools and materials up even the smallest gradient can soon become a tiring exercise. And you'll be getting plenty of that already.

One obvious choice is to build your boat beside your house. Many fine boats of 65 feet (19.81 m) have been built to our designs beside the owners' homes. To make this a practical proposition, you need to live on a large lot or in an isolated area.

Local building ordinances may govern just what you can do in your own backyard. Check them before you start building a shelter or erecting boat frames beside your house. Generally speaking, the farther you live from the center of town, the better chance you have of being able to build or complete a boat on your own property. If you're not committed to a mortgage, you may consider renting a suitable house away from the town center and building your boat on the grounds of your rented property. Obviously, you need to check with the owner first and get permission in writing before you sign the lease.

If you start with a hull and deck, all you may need in the way of a building is a toolshed; the hull can be heated, and the outside work can be completed in fine weather. Another advantage of starting with a ready-built shell or kit is that you may be able to complete the boat in your own yard. Metalworking is noisy, especially when you're building the hull and deck. If you're building in a residential area, make sure the noise that can be heard outside the boat is kept to a minimum.

Here are a few suggestions for boatbuilding locations: your own yard; unused corners of marinas and boatyards; fenced-in, but unused, indus-



The Dutch love to build everything out of metal, as is evidenced by this attractive steel dinghy.

trial sites; beside or in an engineering business; inside old warehouses; inside or beside an old storage barn. These are just a few of the many possibilities and these locations can often be rented cheaply.

If you are building from a precut kit, you may want to consider using an "own-your-own container" for transporting the kit from the supplier to your building site. If you are not constructing your boat in a secure building, the container makes a fine lock-up tool- and storage shed. These containers cost about $1,500, so you and your insurance company may consider this a worthwhile investment.

Make sure you think ahead to the day that the boat is completed and ready for launching. Can a low-load trailer and lifting crane get to your site and move your boat to the water? Have you surveyed the route? Check for low overhead wires and sharp corners in narrow streets. We've seen it all; there are hundreds of stories about boats being lifted over houses and hoisted from mountain sites by large helicopters. Some boats have been literally dragged through villages by willing helpers.

STEEL

It bears repeating: steel is today's bargain boatbuilding material. If possible, you should choose preshotblasted and primed materials. The terms *sandblasting*, *gritblasting*, and *shotblasting* have similar meanings. The process for all three involves blasting the steel plate and bar stock with a grit to remove the impurities from the surface and preparing the material to receive the prime coating (see Chapter 9, Gritblasting and Priming). If you're building outdoors, you'll lose some of the precoating. But the benefits of pre-prime-coating are so positive that it's worth your consideration. Preprimed steel not only provides a cleaner working environment, but it will encourage you to arrange a temporary cover. When you're welding prime-coated steel, you should wear a protective mask to avoid inhaling the fumes released as the prime coating is burned off around the weld. If you use a kit that is coated with Sigmaweld MC primer, there are very few fumes; it is always advisable to wear a protective mask and other protective gear when building any boat.

One of the main benefits of using shotblasted and primed materials is that when you have completed the hull and deck, you should not need to shotblast or gritblast the interior. This part of the blasting process is the most time consuming and expensive. If you can avoid it by using primed, painted steel, it's worth the cost and effort of obtaining this material and keeping your project under cover. You may wish to consider using self-applied shotblasting and priming your metal before you start construction. Make sure you use weld primer that is specially formulated for use on the plate to be welded. One brand is Sigmaweld MC primer; other manufacturers should have similar products.

We used to think that building outdoors and using unprepared steel was a good idea; the theory was that the weather removed some of the mill scale and other surface impurities. But, as you will have gathered, we've changed our mind. It may take longer than originally planned to build a boat with unprepared steel, and the wastage of metal through rusting could be a sizable factor in its life expectancy. Our advice: NEVER allow your boat to get rusty during construction.

Steel Plate

When ordering the plate, make sure you specify *plate-mill* and not *strip-mill* plate. Plate-mill stock is plate that has never been coiled. Strip-mill is plate that has been rolled into large coils after manufacture; later, the steel is unrolled and sold as flat plate. But it has a "memory," so it won't be absolutely flat and unstressed before you start to bend it. If you're forced to use strip-mill material, try to ascertain the natural curve of the plate, and use it to your advantage.

Our choice for steel boat building is plate with a low to medium carbon content. You'll find there are many different grades of steel, but we recommend low-carbon steel with a carbon content of between 0.15 and 0.28 percent. The highest carbon content acceptable to most classification authorities is 0.28 percent, so we recommend you stay within the range quoted above. Low-carbon steel is available in various shapes, strips, and plate, and has good welding characteristics. As code numbers vary from country to country, you should seek advice from your steel supplier to ensure that you receive the correct materials as suggested above. Lloyd's A-grade shipbuilding steel will be one of your preferred choices if you live in Europe, or build from a precut kit that is cut from Lloyd's-approved steel.

The plate thickness will be specified in your plans. Remember that it's harder to avoid distortion when welding materials that are thinner than ⅛ inch (3 mm). Even this thickness should be restricted to decks and cabins, as well as to hulls on boats under 35 feet (10.66 m) in length. Your designer will specify the plate thickness recommended for your boat. When you're building small steel boats, it's better to reduce the amount of framing than to reduce the plate thickness. Some builders increase the plate thickness without consulting the designer, which, in a steel boat, can have disastrous results. If you are unable to obtain plating as specified in your plans, always contact the designer for advice. Changing the plating thickness may require rescheduling the spacing and sizing of the framing.

As you may be responsible for the quality of the steel being used in your boat, you should be aware of the common defects. Check for "wavy" areas in the sheet. This defect can appear as small, uneven areas with a wavy appearance. Another defect is rolled-in mill scale, which is caused when impurities on the surface of the plate are rolled into the surface. Buckles or kinks in the plate can be caused by improper handling after manufacture. You may also find thin areas in the center and ends of pipe.

Table 3-1. Mild steel plate in pounds per square foot and kilos per meter.

Thickness	Pounds per sq. ft.	Kilos per sq. m
3 mm	—	24.5
⅛ in.	5.10	—
10 gauge	5.52	—
9 gauge	6.10	—
5/32 in.	6.37	—
4 mm	—	33.5
8 gauge	6.75	—
7 gauge	7.30	—
3/16 in.	7.65	—
6 gauge	7.97	—
5 mm	—	39.5
5 gauge	8.70	—
7/32 in.	8.92	—
4 gauge	9.14	—
6 mm	—	48.5
3 gauge	9.77	—
¼ in.	10.20	—

Cor-Ten

Avoid materials such as Cor-Ten or high-tensile steels; they have limited or no boatbuilding applications. Some designers have recommended Cor-Ten in the past, but this steel contains traces of copper, which tends to encourage corrosion in salt water rather than inhibit it. Cor-Ten was developed for use in industrial applications such as water tanks on farm properties. While it resists corrosion in a salt-free atmosphere, it doesn't have good corrosion resistance when it's immersed in water, especially seawater.

Cor-Ten is more expensive than mild steel and it needs to be welded using copper-clad, continuous-feed electrodes and argon-arc. We do *not* recommend Cor-Ten or other specialty steels for boatbuilding.

Stainless Steel

Occasionally, we're asked about the possibility of building a boat of stainless steel; the simple answer is: Don't! This material has no place below the waterline on most boats including those built from nonmetallic materials. The problem is *shielding* corrosion caused by oxygen starvation, which, in turn, will promote crevice corrosion. The important factor is the amount of oxygen in contact with the surface of the steel; one part of the steel must not be starved of oxygen while another part has it available. This phenomenon is known as the *oxygen differential*, and it will set up an electrochemical cell that will lead to rapid deterioration of the metal.

Stainless steel is ideal, however, for deck fittings, chainplates, and stanchions. Stainless is also required as a liner in areas where dock and anchor lines would soon wear off the paint. On items such as stanchions, always paint 2 inches (50 mm) onto the stainless area to prevent galvanic action between any defects in the painted mild steel and the uncoated stainless fitting.

The types of stainless steel most commonly used in boatbuilding fall into the 300 series, namely 302, 304, and 316. The 316 grade is considered the best for marine use and should be used wherever ultimate strength and freedom from corrosion are required.

When the quoted number is followed by the letter "L," it indicates a low carbon content; this feature allows welds with good corrosion resistance by avoiding loss of chromium at the grain boundaries. The free-machining grades, type 303 or 303e, should never be used in seawater because they corrode. These specialized steels contain sulfate particles that facilitate the machining operation; however, the particles create a surface with numerous built-in alloys to particle galvanic cells. (See Chapter 12, Corrosion Prevention.)

Buying Plate

The price of steel plate varies from supplier to supplier, so shop around. Generally speaking, the more you buy, the lower the price, by weight. We recommend that you order all the plate, stringer materials, other flat bar, and angle at one time. Many designers supply a material list with the plans and it's wise to compare this list with the drawings, so you'll have a better understanding of the construction procedures. Use your material list to obtain quotes from as many suppliers as possible. In most cases, 20 percent should be allowed for wastage.

Stock sizes of sheet are 8 by 4 feet (2.50 by 1.25 m) and 6 by 3 feet (2 by 1 m) but some stockists can supply sheets 10 or 12 feet (3 or 3.50 m) long. (Note that the metric sizes here are rounded out to the most likely available sizes.) Another consideration is that the steel supplier may make additional charges for larger or unusual sizes of plate, and the delivery costs may also be higher. The size of your boat and the steel-handling equipment you have available may decide the sheet sizes for your project. We cut our kits from 20-foot (6 m) sheets or longer, depending on the size of the vessel and the type of shipping used to transport the kit. Some kits are transported in 40-foot (12 m) containers so even longer sheets can be used. The big advantage of this is that it eliminates welded seams in areas such as the side of the hull. You can easily arrange a gantry arrangement to handle these longer plates so keep this in mind when ordering your kit or basic plate material.

It's better to tack-weld your plates into as long a length as practical before installing them on the hull—you'll achieve a much fairer hull by following this practice. The same advice applies to stringers and other longitudinal framing

Steel Framing

Framing includes the transverse frames, stringers, chine bars, stem, and backbone. For small-to-medium-sized boats, you can make the framing from flat-bar stock. For the deck beams and cabintop beams, it's preferable to use L-angle or T-bar (flange down) as this provides a suitable cavity for the insulation material and also allows the lining materials to be fastened to the inside or underside of the flange as applicable.

Hull frames may be flat bar or L-angle. Our objections to angle used to be that it was more difficult to keep the rust out of the angle. More recently, however, we recommend that all hulls be built from pre-prime-coated steel and have sprayed-in foam insulation. Where the sprayed-in foam is installed, there's much less chance of rust forming around the frames. Because of weight considerations alone, we would not recommend angle frames in boats under 30 feet (9.14 m). Heavy-displacement boats and larger vessels can carry the extra weight and also will benefit from the extra strength of the angle frames. We have just completed plans for a new Spray Pilot House 40, and in this case I have suggested L-angle or T-bar frames be used throughout. The presence of the flange will assist in the lining and fitting out process. On flat-bar frames, timber strips are screwed to the frames to accept the lining materials.

As mentioned above, the stringers, stem, and backbone will almost always be fabricated from flat-bar stock. Occasionally, solid round bar is used for the hull chines; there will be more on this subject elsewhere in this text. Web floors (also known as solid floors or gussets at the bottom of the frames) should be cut from plate that is the same thickness as the frames.

BRONZE

Bronze is an alloy of copper, tin, and varying small amounts of other elements. It's a fine boatbuilding metal and it has been used in marine applications from time immemorial. In Roman times, bronze was a prized alloy and had many uses. The exact combination of metals used to make the bronze alloy will depend on its intended use. Copper is the main ingredient, and tin usually accounts for 5 to 10 percent of the mix. Bronze will often take its name from the third metal in the alloy; for instance, phosphor bronze contains about 5 percent tin and 0.5 percent phosphorus, and it is suitable for use in the marine environment. Alloys of aluminum bronze, or nickel-aluminum bronze, are often used for propellers.

MARINE ALUMINUM

Aluminum has been available for over a century, but it's only in the past 40 years that it has been widely used for boatbuilding. Pure aluminum is a soft metal and not suitable for most commercial applications, let alone boatbuilding. There are many aluminum alloys for various applications but only a few suitable for marine use.

Some of the metals alloyed with aluminum are chromium, copper, iron, manganese, magnesium, and zinc. Small amounts of these metals are used to improve the industrially pure aluminum. For marine use, the main addition to pure aluminum is 4 to 5 percent of magnesium.

Because there's no universal grading system for aluminum, you should check with your local suppliers for advice. The table shows some type numbers and their recommended usage. We have grouped them into UK and U.S. areas; most of the rest of the world follows one system or the other.

The 5000 series and, in particular, material with the 5086 designation, is the metal most commonly used for boatbuilding. There are several different numbers in the 5000 series and it's worth checking with the aluminum manufacturer in your country so you get firsthand advice. Don't be fobbed off by unscrupulous suppliers or merchants who may try to sell you what they have in stock.

The 5000 series has excellent resistance to salt water, is ductile, and retains its high strength when welded. In some cases, you may choose

Table 3-2.
Weights of aluminum plate, etc.

	UK	U.S.
hull plate	BS 1477 NP8	5086 H116
frames and stringers	BS 1476 NE8	5086 H116
superstructures	BS 1470 NS6	—
decks cabin structures	—	5086-32

Weight of aluminum plate in pounds per sq. ft.

1/16 in.	0.90
1/8 in.	1.76
3/16 in.	2.64
1/4 in.	3.52
5/16 in.	4.53
3/8 in.	5.44

	Steel	Aluminum	Copper-Nickel	Fiberglass	Wood
yield strength in PSI	36,000–42,000	18,000–40,000	15,000	10,000–15,000	12,000–20,000
tensile strength in PSI	60,000–70,000	23,000–47,000	40,000–78,000	15,000–34,000	16,000–27,000
compression strength in PSI	60,000	32,000	45,000	Fair	2,000–13,000
shear strength in PSI	23,000	17,000	20,000	Low	700–3,000
modulus of elasticity ($\times 10^6$)	30	10	19.6–22	2.8	0.7–2.3
hardness (Mohs' Scale)	7	4	5.5 approx.	1	1–3

Table 3-3.
Comparative strengths of different materials.

aluminum with one designation for hull plating, another for framing, and still another for decks and superstructure.

When you're ready to order your aluminum materials, it's always recommended that you make one bulk purchase. As with other metals, and indeed all your boatbuilding requirements, it's always best to buy in bulk. If you can find another builder with similar requirements, then a group order is recommended.

At the same time as you are ordering your aluminum plate and framing materials, you should order the filler wire for your MIG welder. The most common wire is 5356, which is compatible with most aluminum alloys used in boatbuilding, including 5052, 5086, 6061, and 6063. The 5386 wire can be used to weld these alloys to themselves or to dissimilar alloys. (See notes about spool sizes in Chapter 5, Welding.) It's most important to keep your welding wire clean and to use the spool as soon as it is opened. Store the wire in a dry area, and discard any dirty or contaminated material.

In this book, we'll mainly consider welded aluminum, as this covers the method by which most boats are built from this material. There are other building methods, however, including small boats pressed out of a single sheet; these are popular in Australia, where they're affectionately known as *tinnies*. Riveted construction is still used to build some smaller aluminum boats. Aluminum boats have also been formed by explosive techniques, but this and other offbeat methods are outside the scope of this book.

For transverse frames you may choose either flat bar, L-angle bar, T-bar or flat/round-top bar. The latter is sometimes used for longitudinal stringers. For longitudinal framing, stringers, and chine bars (if fitted), we prefer flat bar, but the final choice of scantling sections should be left to the designer of your particular boat.

COPPER-NICKEL

Copper, one of the most noble metals, has excellent resistance to corrosion in the atmosphere and in freshwater. When combined with nickel to form copper-nickel, it has superior resistance to saltwater corrosion. These features, coupled with its excellent antifouling properties, make it suitable for building hulls, however its huge cost and difficulty of welding will discourage most of us from seriously considering this material for boatbuilding.

BRASS

Brass, an alloy of copper and zinc, has no place as a structural member on any boat, and should never be used in place of bronze. You may have a

Two young men looking for adventure built this steel Roberts 38 in New Zealand. The interior is as attractively finished as the exterior you see here.

few decorative items—lamps and the like—that are made of brass. You will know what they are because you will be continually polishing them to remove the tarnish that quickly forms in the marine environment.

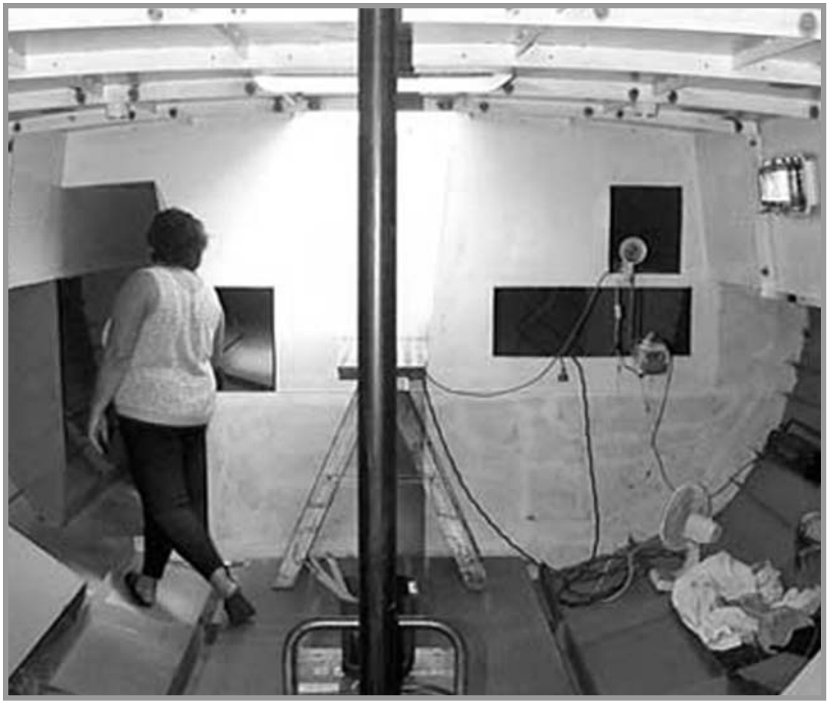
Brass made of 60 percent copper and 40 percent zinc loses all its surface zinc in saltwater, and is soon reduced to a useless mess. Beware of cheap fittings imported from the Far East. They may be sold as bronze, and look like bronze, but they often aren't bronze. If in doubt, select only materials from known U.S. manufacturers.

OTHER BOATBUILDING METALS

Monel Metal

The ultimate marine metal is Monel metal. It's rather expensive, otherwise it would be more widely used. It's not used for building complete boats but it's perfect for fittings where ultimate strength and machinability are required. There are two main alloys, including the regular version that contains 67 percent nickel and 28 percent copper. This alloy is ideal for propeller shafting, where its corrosion resistance and durability are best appreciated. There may be some doubt about the use of Monel shafting in steel boats, however, and it may be better to use 316 stainless for your shafting requirements.

The variant "K" is nonmagnetic and is often used for special purposes. Often, Monel is used as the main propeller shafting on minesweepers. They can afford it. It's also used to protect compasses on boats and aircraft. When more boats were built of timber, and before the wood/epoxy technique was developed, Monel screws were sometimes used on the finest craft, either to fasten the hull planking or in other important parts of the structure. The alloy contains aluminum and titanium as well as nickel and copper. It's a great metal, but it's not important to amateur builders of metal boats.



Make sure to thoroughly paint the interior of your metal hull before you start the fit-out. Most corrosion in steel boats starts on an unprotected interior surface. Pre-prime-coated steel can give your hull a great start in life.

Magnesium

Freshwater anodes are made from magnesium. It may surprise you to learn that protection from galvanic and other corrosion is necessary in *all* types of water, including salt-free environments. Anodes of zinc are not as effective as those of magnesium in fresh water. Conversely, if you move your boat from fresh water to salt water for more than two or three weeks, you will need to change to zinc anodes; the magnesium ones will rapidly disap-

RIGHT:
This view of a Roberts 532 steel hull reveals all the welds that have been used inside the hull. Some light grinding and smear of filler will take care of the outside appearance.

LEFT:
This is the view of the underside of the aft deck of the Roberts 532 pictured above. The hull has been turned upright before the deck was installed and the transom will be installed at a later date.

RIGHT:
Here we see the completed Roberts 532 radius chine hull deck and superstructure. I happen to know that this turned into a magnificent cruising sailboat !

Because of today's emphasis on working safely, you'll want to consider what tools and equipment you need to build, maintain, or repair your metal boat. One of the best and least expensive safety items is a clean work area. Avoid leaving anything lying about that is not in use or needed in the immediate future. These are the things that can trip you up, slash you, or otherwise cause bodily injury. Working with metal naturally produces hazards of varying degrees, but you can protect yourself by having the correct safety equipment. Under no circumstances sell yourself short in this area.

PROTECTIVE CLOTHING

Always wear a proper industrial safety helmet. You never know when something may fall, or be dropped on your head. Safety goggles are a must. They should have side guards to protect you against flying metal particles when you're cutting, grinding, or chipping. You'll need a face shield and the various lenses. Don't forget your ears; remember that good earmuffs are essential. A respirator is required. Invest in good coveralls or a boiler suit. A leather apron and gloves with cuffs are definite requirements. One of our customers built a steel Roberts 38 in a Florida nudist colony. We often wondered how he dealt with the weld splatter. Wear steel-toed shoes or boots, not sneakers, around your metal boat building project.

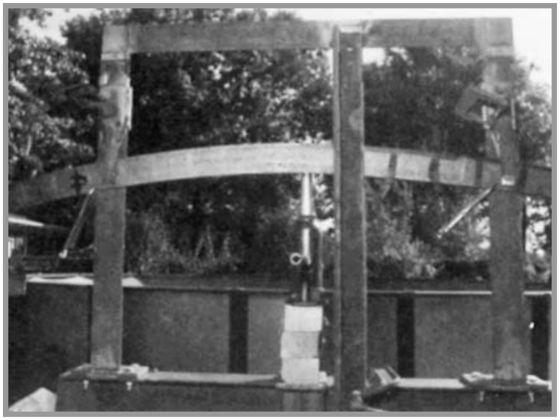
Protective hand cream and an adequate first-aid kit are essential. Have the first-aid kit handy because you can't anticipate when it may be required in a hurry; its presence may save your life or at least prevent a minor injury developing into a major one. Make sure you have plenty of eyewash on hand. A good-sized fire extinguisher and an industrial vacuum cleaner are other essential items of safety equipment.

Arc welders are relatively safe pieces of equipment, but potentially lethal alternating-current electricity powers them, so you can't afford to treat them casually. Your alternating current (AC) supply will be 110 volts, 220 volts, 240 volts, or perhaps a larger three-phase supply. Make no mistake: all these voltages can be lethal.

Watching the arc with the naked eye is not recommended. Even if you look at the arc for a

This builder of a Tom Thumb 26 found an angle grinder ideal for cutting the plates. Accuracy of 1⁄16 inch (1 mm) was achieved with most cuts.

short period with unprotected eyes, you can get arc eye, which is very uncomfortable and feels like sand around your eyeballs. Assuming that you, as the welder, *always* use a mask, then it must be the assistant or casual onlooker who will need protection.



For bending deck beams, stem, and frames as required, you can make this simple device from a hydraulic jack and an H-frame formed from angle bar.

TOOLS FOR BUILDING STEEL BOATS

Many of the tools you'll require for building in all types of metal are those common to steel boat building, so we'll look at this list first. Later, we'll follow up with information on the additional tools you'll require for building in aluminum

If you have more-than-adequate funds, no doubt you'll find many exotic and expensive labor-saving devices to keep you happy. Fortunately for the rest of us, a modern metal boat can be built with relatively few inexpensive tools, most of which are readily available in all parts of the world. The metal used to build a steel or aluminum boat is relatively thin, so it can be easily handled, cut, formed, and welded. Many tools are common to the three main metals. The few specialized tools required by each type are available and familiar to those who possess the necessary skills to work with that particular material.

A check of the yellow pages of your telephone directory will provide sources for all the tools and equipment you need. Another source is the "For Sale" sections of local newspapers. Perhaps a "Wanted" advertisement in the correct classified section will bear fruit. Flea markets, jumble sales, and yard or garage sales, are all good sources of reasonably priced tools.

In the case of radius-chine hulls, we recommend that you have the relatively small amount of radius plating rolled by a professional metal shop. This service is available in most areas.

Our plans include details of tools that you can make yourself. Most builders make many of their metal-handling tools, often inventing new ones as required.

A simple tool that you can make yourself will

John Reid built this Centennial Spray 36 in England. Reid used a garden roller to roll the plates—no mean effort, even considering his considerable boatbuilding experience. This perfectly fair hull was being fitted out at Iron Wharf Boatyard, in Faversham, Kent, England.

serve well to bend deck beams, the stem, and other smaller parts that need to be formed. This bending device is made up of a suitably powerful hydraulic jack and a simple H-frame formed from angle bar.

Included in the list of small tools you'll need, are a variety of metalworking hammers and mallets, (including chipping hammers), an assortment of clamps (some of which you can make yourself), bolt cutters, a metalworker's vise and a selection of sawhorses. A good portable drill is essential and a drill press will be useful. You'll need a large selection of high-quality metal bits, cold chisels, and metal files. Other tools include a bench grinder, a crimper, a power hacksaw, a jig saw, a straightedge, and tinsnips.

Oxyacetylene Equipment

There are several ways to cut steel and most other metals. Steel was traditionally cut with a gas torch, or oxyacetylene torch, and although this method is still widely used, more sophisticated and affordable methods are now available. Nevertheless, the oxyacetylene torch and its associated bottles and gauges will find many uses around a metal boat building project, although it's not a necessity. The gas torch is quick, efficient, and low in operating costs. With this equipment you'll need a light- to medium-duty kit with a 90-degree angle, and specialized cutting tips.

The basic oxy kit consists of the cutting torch, tips of various sizes, a set of gas regulators, a flint lighter, goggles, a special wrench, couplings for oxygen and acetylene tanks, and two lengths of hose to lead from the tanks to the torch. This package could cost less than $400 (£230) if you're able to pick up used equipment at a favorable price. A small cart to hold the bottles would be useful; you can either buy one or make one yourself. The cylinders are usually leased from the gas supplier and you'll only need to pay for the refills.

The oxyacetylene torch cuts metal through a rapid oxidization process in two continuous steps. While the torch heats a small area of metal to a cherry-red color (about 1,500 to 1,600°F), a small stream of pressurized oxygen is directed from a central tip within the torch against the hot metal. The stream of oxygen causes the metal to "burn" rapidly and the metal separates as the torch is moved along the line of the desired cut. There are many different cutting tips and they can be used to influence the size, speed, and accuracy of the cut. A special plate-cutting, drag-step tip can cut steel plate from ⅛ to ¼ inch (3 to 6 mm) thick with precision at the rate of about 2 feet (61 cm) per minute. The resulting cut using this tip will be between 1/16 and 3/16 inch (1.5 and 4.5 mm) wide. Using this equipment is something of an art form, and considerable experience is required to achieve the type of fine cutting that is required when plating your hull.

The main drawback is that torch cuts are rough around the edges and usually need some cleaning up before they are suitable for welding to other parts. You should avoid the disgusting habit of some low-cost builders who plate the hulls oversize and simply torch off the overlaps at the chine. The oxyacetylene torch can also be used for some specialized welding operations, but for boatbuilding it's better to use the other equipment discussed below, such as arc (stick), metal inert gas (MIG) or tungsten inert gas (TIG) welders (see Chapter 5). Reserve the oxy equipment for cutting where precision is not required.

Angle Grinder

You should buy the best-quality angle grinder you can find; it will get a lot of use. This is a much-used tool in boat construction and can perform a variety of jobs, ranging from cutting lengths of flat and round bar to smoothing out the edges of torch-cut plate. You can use this tool to bevel thicker plates by grinding off the excess metal before welding. Fitted with wire brushes, it can be used to clean off rust, mill scale, and weld splatter. Another use is to smooth off the welds on the hull topsides and superstructure. (Take note, though, that we, along with most classification societies, do not recommend grinding welds below the waterline.)

When you fit your angle grinder with a special wheel, it can be used to cut the slots in the frames to accept the stringers. Another use is to make many small cuts in metal bar. This feature is useful for making frames, snaping the ends of stringers, and similar tasks. Don't use your grinder for heavy-duty cutting; the grinding/cutting wheels don't last very long. For instance, when you use it to cut ⅛-inch (3 mm) plate, you can expect to get only about 12 to 15 feet (3.5 to 4.5 m) from a single blade. When you use it for cutting, consider your angle grinder to be more of a convenience tool than a fully fledged cutting device.

Buy a 7- to 9-inch (178 to 228 mm) heavy-duty, commercial-grade angle grinder. Make sure it has heavy-duty switches and a high-efficiency cooling fan. Don't order this item by mail. You need to hold the grinder, see how it balances in your hands, and feel the weight. You'll be holding this tool for many hours, so make sure it feels right if you want long and trouble-free service.

Nibbler

A nibbler will cut thinner plate, but it's an expensive tool, especially considering its limited use on most boatbuilding projects. You could rent one if you really find it useful. This tool is like a pair of electric scissors, and it slices through thin metal by taking small nibbles, hence the name. The nibble is an up-and-down punching action and makes a cut about ¼ inch (6 mm) wide. When it's used by an experienced operator, this tool can produce a smooth cut with clean edges. The cutting rate will vary, depending on the thickness of the metal, but on ⅛-inch (3 mm) steel it can cut about 2 to 4 feet (60 to 120 cm) per minute.

Plasma Cutter

A plasma cutter is ideal for cutting plate and other steel and metal sections, so rent or buy the best you can afford. This device cuts without distortion and can be used to trim plates in position. In the hands of an experienced operator, the plasma cutter produces a clean, sharp cut without any sign of distortion. The cutting action is very fast, and steel plate up to 5⁄16 inch (8 mm) in thickness presents no problems for this device. It is not suitable for aluminum, however. The narrow cut of ⅛-inch (3 mm) makes for neat and efficient cutting. Be forewarned, however, that the plasma cutter uses a fair amount of electricity, and the cutting tips do not have a long life. This tool is especially suited to cutting plate, and it finds

This radius-chine Roberts 434 was built by Topper Hermonson in Florida. This boat has cruised extensively, including a complete circumnavigation and several Atlantic crossings.

angle and other shapes something of a problem, so alternative cutting methods should be used for those sections.

In the United States, Hypertherm manufactures the portable Powermax600, which, it is claimed, can cut all metals up to ⅝ inch (16 mm) thick.

TOOLS FOR ALUMINUM BOAT BUILDING

You can usually cut aluminum either by sawing it or by shearing it. For straight cuts of material up to ¼ inch (6 mm) thick, you can use the same power guillotines used for cutting steel. Remember to replace the holding-down pads with plastic ones that won't mark the softer aluminum. Pay particular attention to keeping knives sharp; blunt cutters will burr the edges of the metal. Nibblers can be used to cut aluminum up to ¼ inch (6 mm) thick.

Band Saw

A deep-throated band saw fitted with a narrow (say ½-inch or 12 mm) blade will be capable of cutting a wide range of thicknesses. The band saw should be set to run at 2,000 to 5,000 feet (600 to 1,500 m) per minute; the slower speeds will be needed for the thicker plates. A band saw with variable speeds is preferred, but the older heavy types used for cutting timber are satisfactory.

Many tools you'll need for building in metal can be made or converted from other uses; wedges and steel dogs like these will find many uses.

Table Saw

For cutting straight lines, a regular table saw fitted with carbide-tipped blades will give perfect results. Be sure to provide lubrication with a kerosene-oil mixture or suitable vegetable oil; this will make the cuts easier and also increase the life of the blade. A portable jigsaw can also be very useful for making on-the-job cuts. Remember, a spray of lubricant will make the cutting go easier for most tools.

Power Handsaw

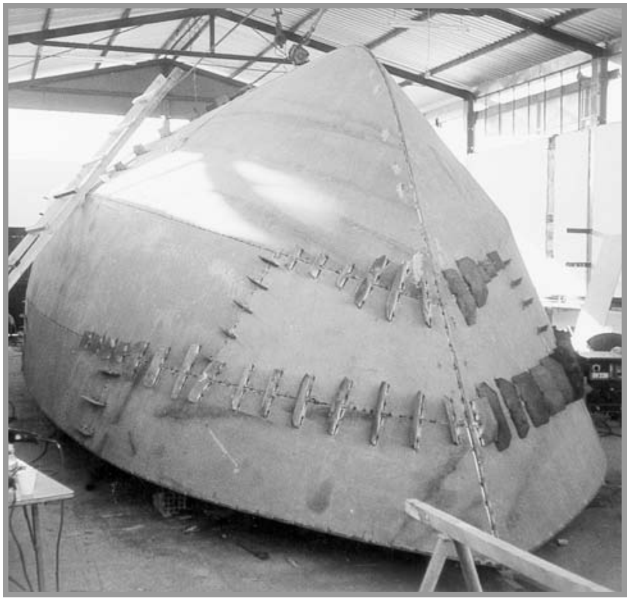
A hand power saw or Skilsaw can be a most useful cutting device when working with aluminum. Fit your saw with a special blade designed for cutting this metal. This blade will have a tooth face rake angle of zero degrees. If you use a guide clamped in position, you can make long straight cuts with this saw. For cutting sheet or framing to length, and in fact for almost all shell and frame cutting, this is a most versatile tool. Treat the hand power saw with utmost respect; the chips thrown off the sawn material are not only hot, but also sharp. Always wear a full-face mask when working with this tool. Make sure that the remainder of your body is suitably protected from flying chips. Use kneepads if you're kneeling while operating this saw. You'll need to take extra care when you're cutting 3⁄16-inch (4 mm) or thinner plate; the blade will tend to jump out of the cut, especially at the beginning. It's best to do a plunge start just inside the first part of the cut. This allows the blade to enter the material along the line of cut, and can avoid the kickback.

Router

You'll find a router fitted with a single-flute, carbide-tipped cutter useful for cutting uniform holes such as lightening holes. You'll discover that this tool has many uses in the building of your aluminum boat. As with all powered equipment, though, it has to be handled with care. A small electric router, or an air-powered one, is usually used for gouging out the back of welds or removing contaminated ones.

Planes

Planing is possible with either a carpenter's hand plane or an electric hand planer with carbide-tipped cutters. Any edge can be planed, and this is a useful feature where a sawn edge would show on the finished boat and planing will provide a superior finish. A plane can also be most useful in beveling the edges of plate.



Pieces of metal tacked and stitched across a join in the plates can help you produce a fair seam weld.

Press Brake

For forming aluminum, hand folders will handle the thinner gauges, but for serious bending you need a press brake with a bed of about 8 feet (2.4 m). The press brake is a strong, hydraulically or mechanically powered forming machine used to crease or bend metal. This machine comes in a variety of sizes and is found in most professional metal shops. The benefit of using this machine is that it can reduce the number of welds required. For instance, a cockpit bottom and sides could be formed in one piece. If you're building a one-off aluminum boat and you don't own a press brake, you'll need to find a subcontractor to handle this work. Never forget that when you're building in aluminum it makes sense to take advantage of the easier handling of this material. Forming up large multisurfaced parts by bending sheet into various angles can save a lot of welding and grinding.

Plate Rolls

Bending rolls are used to form plate into a permanent curve and can be operated by hand or power. A typical roll consists of two lower power-driven rolls and one adjustable upper idler roll. As the shape suggests, this type of roll is called a pyramid roll and is widely used in building round-bilge boats. The method of operation is that the metal is inserted between the upper roll and the lower two rolls. By adjusting the pressure on the upper idler roll, you can vary the resulting amount of curvature in the plate. Although these rolls operate at slow speeds, remember that loose clothing or carelessly placed limbs can get caught. This could be extremely dangerous especially in the power-driven versions.

Explosive Forming

This method has been used to form various aluminum shapes including boat hulls. Briefly, the process consists of making a concrete or steel mold and using explosives to force the metal into the correct shape within the mold. This method was used in the United States as far back as the 1960s and in Australia as recently as the late 1980s. As with many other exotic building methods, government money (taxpayers' dollars) was used to pay for these experiments. The process proved not to be cost effective, however, so explosive forming has passed into history. We include it here because occasionally a client will inquire about the viability of this method.

It is beyond the scope of this book to teach you how to weld. I've included suggested uses of various welding equipment and actual welding techniques to show what is involved, not to teach you the art of welding. If you're not already a proficient welder, and you intend to undertake this work yourself, you should seek instruction and advice from an appropriate local source. There are many full- and part-time teaching institutions where the craft of welding can be learned from experts.

Nevertheless, if you're a complete beginner, you might find it easier to understand this book if you know a few basic details about welding.

First, when metal is heated to the melting point for welding, it distorts. So most metal boats are not welded continuously. They are mostly *tacked* together with small, intermittent welds at intervals. The exception, of course, is the plating of the hull, decks, and superstructure, which must be absolutely watertight. Tack-welding is perfectly strong. In fact, too much welding locks in the stresses caused by distortion, which can actually make your boat weaker. Typical tacks are 2 inches long and spaced at 10-inch intervals, but your plans and/or kit assembly text will give you precise instructions. We now recommend that you tack-weld the entire hull before running any final continous welding. When assembling kits, you should tack-weld the hull, deck, and superstructure before any final welding.

Tack-welds are usually laid down in two ways, a *chain weld* or a *staggered weld*. If you were welding a vertical plate to a horizontal plate, you could lay down tack-welds along one side of the join, and then back them up with identical tack-welds on the exact opposite side of the join. That's a chain weld.

Alternatively, you could lay down tack-welds along one side of the join, and then space other tack-welds alternately on the other side, not backing up the original welds, but falling in between them. That's a staggered weld.

In boatbuilding, you'll need two basic types of welds. *Butt welds* join material end-to-end. *Right-angle welds*, as their name implies, join two pieces of metal touching at right angles, or nearly so. The bead of weld laid down in the right angle is known as a *fillet*. Heavy plates are usually ground off at an angle of about 45 degrees on each side where they join, and a V-groove weld replaces the simple fillet weld.

To control distortion of the metal during welding, you have to lay down your welds in the correct sequence. For instance, if you tried to butt-join two steel plates by starting at one end and working straight across, you'd find the plates spreading apart as you did so. There would be a large gap between them by the time you reached the far end. So you have to start with a tack-weld in the middle, then alternately lay down other tack-welds to the left and right of the center. It also helps to alternate the direction of your welding each time. This is known as *back-step welding*. It's a very important principle, and one that's followed throughout the building process on a larger scale. Thus, after you've welded a frame to the shell on the port side, your next move would be to weld a frame to the shell on the starboard side. And, of course, you'd start in the middle of the boat and work outward toward the ends.

At this stage, you don't have to worry about what kind of weld goes where. Your plans and or building instructions will tell you where to use the various types of welds.

ARC WELDING

You can use arc welding for steel construction. In this method, an electrode is used to create an electric arc that melts the metal to be welded. The electrode is a metal rod that simultaneously produces the arc and is melted to contribute filler metal for the joint. There are many different types of arc welders, and it's difficult to decide which one to buy. It's important to make sure that the welder has sufficient capacity for your project. Don't make the mistake of buying a welder that's too small. The difference in price between a welder of adequate capacity and one that is underpowered for your job won't be great, but your irritation certainly will be enormous if you make a mistake and buy a lightweight machine that is not up to the job.

If you're building your boat on a nonindustrial site, you'll need a welder that will run off your normal domestic electricity supply. In the case of the most powerful machines, a higher input voltage will be required, but with good fortune on your side you should be able to obtain a suitable machine to run off the local power source.

Welder Amperage

You must consider the output rating of the welder, which is measured in amps. The higher the amperage, the thicker the plate that can be welded by that machine. The thickest plate you are likely to be using will be in the order of ¼ inch (10 mm), and this thickness can be handled by an arc welder with an output rating of 140 amps. If you are using thicker plate, say for the bottom of the keel, you can manage by beveling the edges of the thicker plate and using more than one run of weld. You may think that because your plans call for 3⁄16-inch (4 or 5 mm) plate that you can get away with a welder that puts out only 110 amps. Don't be tempted. As a minimum, choose between a 140- and a 200-amp machine.

Arc welders of greater than 140-amp capacity cannot be run from the normal 15-amp domestic supply, so you'll need an alternative supply. If possible, you should try to arrange a 30-amp input supply. Heavy-duty supply is obtainable in the United States by way of the three-phase wiring supplied to domestic washing machines and electric dryers. No matter where you are planning to build or undertake a major refit on a metal boat, you will need to ensure an adequate power supply of the correct voltage and amperage for your particular needs.

The maximum input required can usually be obtained from the welder instruction manual and is often quoted in kilovolt-amps (kVA), which equals 1,000 volt-amperes times a power factor of 0.8. For example, the amperage calculation for a 140-amp welder with a maximum input of 4.2 kVA at 240 volts would look like:

$$\mathrm{V} \times \mathrm{A} \times 0.8 = \mathrm{kVA}$$
$$240 \times \mathrm{A} \times 0.8 = 4{,}200\ \mathrm{VA}$$
$$\mathrm{A} = 22$$

So, in this case, a 25- or 30-amp input supply is recommended. Some better-quality welders can be run at varying input voltages; this feature may be appreciated when you consider the voltage drop resulting from a long lead. As part of your selection of the boatbuilding site, you should consider this possibility and make allowances for any deficiencies in the power supply. A voltage meter can be used to test the voltage at the actual location where you'll be operating your welder. A 10 percent drop in voltage could put paid to a successful welding job. Input wires will need to be heavy, and a single run of cable is best because joins at outlets and sockets can result in a considerable voltage drop. As mentioned above, the alternative is to equip yourself with a welder that will accept varying voltages.

While we're on the subject of leads and cables, you'll find that the output cables supplied with your welder will seldom be long enough for your type of work. You'll most likely have to replace them with longer leads. Make sure the replacements are of good quality and thick enough to carry the loads without an accompanying and unwelcome drop in power. The earth clamps are usually spring-loaded. You may find it advantageous to replace them with the threaded-clamp type, which has a more positive grip. Also along the same lines, your electrode holder will most likely be spring-loaded; be warned that it should not be too heavy. The many hours you will spend welding can put a strain on your wrist and arm. This is especially so if this is your first major all-welded project. A little weight saved in the holder can make all the difference.

Air or Oil Cooled

Arc welders come in two main types, air cooled or oil cooled. Oil-cooled versions have are capable of long continuous usage without overheating, which means that they have much longer working lives than air-cooled arc welders. Even if you're building only one boat, you may want to take your welder with you when you go cruising as a means of earning additional funds. Oil-cooled welders also have a higher resale value. Against these advantages, you'll find that oil-cooled versions are much heavier and need to be stowed with care as the oil can drain out of the vents if the unit is not kept upright.

Air-cooled versions are about half the price of oil-cooled welders, so you'll need to make your own value judgment. This is only one of many you will be making throughout your boatbuilding project. Make sure the unit you select has some form of automatic thermal cutout, so that if it overheats it will shut down before it self-destructs. Summer and winter temperatures will have an effect on the amount of time you can use your air-cooled welder before you have to take a rest and let it cool down. If there's more than one person welding and using the same unit, extra thought will have to be given to the selection of a suitable unit.

On some of the better air-cooled models, you'll find a dial to control the amperage setting. This works throughout the output range, and this choke control can be handy when you're tackling a variety of welding conditions. A proficient welder can tune the output to suit the job at hand. Finally, no matter what type of arc welder you choose, don't buy a cheap unit; it's unlikely to remain in working condition long enough for you to complete your boat.

Electrodes

Although electrodes are consumables, rather than tools, it seems practical to include them here with arc welders. There's a wide range of electrodes in all appropriate materials. In some cases, there's more than one type of rod available to suit a particular job. You'll need to undertake some experimentation to find the rod that gives you the best results. The choice of electrode will be governed by the sequence of the work, your welding position, the equipment powering the electrode, and of course, the material you're welding.

The electrodes must be compatible with the base metal. The low-hydrogen variety is recommended for better quality and a stronger weld. This type reduces porosity and prevents hydrogen embrittlement, which causes hairline cracks. Porosity would allow water to pass through the weld and promote corrosion as would the cracks caused by hydrogen embrittlement. Although I do not feel that is necessary to dye test every weld, it is important to make sure that you don't rely on filler to keep the elements out of your boat.

There is some disagreement between various experts as to which rods, electrodes, or consumables (these terms mean the same thing) are best for a particular job. You may need to study this subject and seek local advice from suppliers and those more experienced than yourself. Running practical tests with different types of rods will often assist you in choosing the correct rods.

Low-hydrogen electrodes require a little more skill on the part of the operator. Avoid electrodes that are promoted as high-speed, single-

Table 5-1. Welding rods.

Mild Steel	Low-Hydrogen Mild Steel	Special-Purpose Rods
E6010: A good beginner's rod, use in all positions for general applications; good for tacks; will give good penetration, flat beads, and light slag.	E7014: Can be used in all positions; produces medium to heavy slagand is useful for high-speed work.	E9018s: For high-tensile steels, medium penetration, low hydrogen, and porosity; often used for weldingcastings, fittings, and pipes.
E6011: A good beginner's rod; OK for all positions; can be used on galvanized steel; produces light slag.	E7024: Especially good for down-hand welding and fillet welds; high speed but produces very heavy slag.	E308, E309, E310, E312, E316, E317, E320, E330, E347, and E410: Are all for welding stainless steels.
E6012: A general-purpose rod for all positions; moderate penetration, medium slag, recommended where fit is poor.	E7018 AC: An AC electrode that produces little slag and can be usedon either low-, medium-, or high-carbon steels.	—
E6013: Another rod recommended by some builders.	E7028: Can produce X-ray-qualitywelds; a very fast rod that ispreferred for welding very heavy sections.	—
E6020: Use for flat and horizontal positions; ideal for single-pass, deep-groove welds.	—	—
Note: All of the above 6xxx series electrodes are subject to hydrogen embrittlement.	—	—

pass types; they produce a weld that has low ductility and should not be used in important parts of the boat. If you are building "to survey," or to pass U.S. Coast Guard inspection, then certain rods may be *required*. Check this out if you are building to a classification society rule, or under similar circumstances. No matter what rods you are using, you must store them properly. Ensure that the rods are kept in their sealed packets, dry and free from all contaminants.

As this book covers boats built all over the world, it's difficult to recommend specific brands and part numbers of welding rods for specific purposes, so please use the rod numbers shown in the table *only* as guides. When you're fabricating a steel boat you'll be using mild-steel rods, but it may be useful to have a few gouging rods on hand. They let you cut plate with an electric welder, and although this will not, and should not, be your common cutting method, there may be times when these rods will come in handy. To use gouging rods for cutting, the plate is heated using high amperage, then the rod is pushed through the plate and drawn along the desired line, thus effecting the cut—and a surprisingly accurate one.

If you are not already familiar with the terms *slag*, *flat beads*, *fillet welds*, etc., that appear in this chapter, please refer to Appendix 2 for a complete glossary explaining these and other welding and boatbuilding terms.

For North American readers, the table shows details of a few of the more popular rods and their uses. Note that each number in the letter designation has a special meaning. For instance, the E signifies electric welding; the first two numbers relate to tensile strength, and the next number shows the welding position. One equals all positions, and the final number signifies the special manufacturer's characteristics. Unless you already have considerable welding experience, make sure to seek local advice.

MIG WELDING

Because aluminum is more reactive than steel, arc welding doesn't provide enough protection against contamination. In many cases, aluminum boats are built using metal inert gas (MIG) welding, in which an inert gas such as argon is blown over the surface to shield the weld and prevent oxidation. MIG welding is fast and has the lowest distortion of any method; it can also be used to weld steel and copper-nickel. With the availability of less-expensive machines, this method is becoming more popular for metal boat construction. The electrode for MIG welding consists of a thin continuous wire led from a spool. Many welders claim that this type of welding is easier to learn than arc (stick) welding, and since better results can be achieved you should give this system serious consideration.

MIG welding machines operate on DC current and can be adapted for use underwater. The usual output is between 200 and 300 amps, which is sufficient for most operations. The dials on the machine are used to set amperage and wire speed. An easily handled gun is used to feed the wire and deliver the current.

There are many advantages to MIG welding, including a smaller (and consequently lower) heat-weld puddle, low distortion, and a slag-free bead. Its main disadvantage is its higher initial cost, but less-expensive machines have recently appeared on the market. As with the better-quality, higher-priced arc welders, you can recoup more of your investment if and when you decide to sell the equipment. MIG can be used to weld stainless steel to mild steel, a common requirement when building a good-quality metal boat.

Generally, the standard equipment as purchased has only a 12-foot (3.66 m) main lead to the gun. You can overcome this by rearranging the equipment so that you can use the gun with the machine up to 50 feet (15.24 m) away from the main unit. With all gas-shielded welding you must ensure that the workplace is free of air movement, including wind. This almost makes it mandatory that you are in a fully enclosed workplace when using MIG equipment.

The MIG welding filler wire comes in rolls of two readily available sizes. The smaller roll, generally about a 1-pound (450 g) spool, is designed to fit on the special gun. The larger, 10-pound (4.5 kg) spool runs off the normal wire feeder. The smaller spools are much more expensive but some builders consider the convenience outweighs the extra cost.

TIG WELDING

In tungsten inert gas (TIG) welding, an alternating-current (AC) or direct-current (DC) arc is struck between a nonconsumable tungsten electrode and the material being welded. The filler rod is fed independently. Flux coatings are unnecessary, as the arc itself cleans the electrode and the weld, and a shielding inert gas prevents reoxidation. The operator has control of the amount of heat and wire feed and has better control of penetration than is obtainable with MIG or other methods.

TIG can be used to fabricate aluminum as well as steel and copper-nickel. However, for various reasons, including cost and degree of difficulty, it's often the last choice associated with boatbuilding. TIG is favored for unbacked joins, where welding is possible only from one side and where good penetration is required. Where complex welding is needed, it's possible to make some passes with TIG and complete the job using MIG.

WELDING STEEL

The great advantage of welding is that the weld has the potential to be stronger than the materials it joins. Make sure your welds always fall into this category. Good welding requires proper preparation, correct weld joints, careful use of welding positions, correct weld size, and perfect root. Inadequate root penetration, the presence of slag, porosity, and cracking are common faults. When you're using arc welding, you're more likely to have these problems and you'll also find it harder to control these faults. MIG welding, with its shielding gas, will give you a cleaner and stronger weld.

Cracking is caused by excessive local stress brought about by improper conditions such as voids, not enough allowance for shrinkage, and rapid cooling. This latter problem can occur in colder than usual weather. Poor or inadequate back gouging can also result in cracks appearing in an otherwise healthy weld. Preventive measures include preheating to slow down the cooling rate, back-step welding, and the use of low-hydrogen electrodes.

Slag trapped in the weld consists of nonmetallic material separating the weld metal from the base metal. It's the result of improper location of the weld, inadequate cleaning, or chipping of slag from previous passes of weld. It's virtually impossible to eliminate this problem altogether, but there must be no more than a minimal amount of foreign material in the finished weld.

Porosity is the result of improper welding current and length of arc. Low-hydrogen electrodes require a relatively high welding current and a short arc. Porosity can be found in the base metal itself, so carefully examine your materials for this and other defects.

Light steel plate of ⅛ inch (3 mm) thickness should be spaced with a gap similar to the thickness. The 3⁄16-inch (4 to 5 mm) plate will need to have its edges beveled at around 30 degrees. In the heavier plates, where the 30-degree V-bevel is required, you'll need to make one or more passes: one or two outside the V, and one inside to complete the weld. This should not be done consecutively; to avoid excessive heat and the resulting distortion you must use intermittent welding techniques.

When you're welding steel plates whose edges fall on a longitudinal stringer or chine bar, you can weld them more robustly than you can weld other thin plates that merely butt against each other. In any case, plates should be welded from both sides; as with all rules there are exceptions to this one, but keep them to a minimum. Each weld must fully penetrate the joint. Where plates fall on a stringer or chine bar, they should either be spaced or beveled, depending on thickness, so that the weld achieves good penetration from the single side that is available for welding. You should weld plate butt joints—and plates to stringers and chines—with staggered welding techniques, using short staggered passes and then returning to fill in the spaces.

We don't recommend overwelding the frames to the plate but you may weld using (maximum) 2-inch (50 mm) long welds on 8-inch (200 mm) centers. Overwelding the frames to the plating will surely spoil the fair line and overall appearance of the finished hull.

Where the plates butt together, they should be joined vertically. Any one of several techniques can be used to keep a fair line in the plating at the join. One way is to assemble and tack-weld the plates into longer lengths on the shop floor. Be very careful when you're fitting these long plates; you need proper lifting equipment to handle them safely.

WELDING ALUMINUM

To weld aluminum, you need MIG or TIG equipment. In the case of MIG equipment, a special gun is required. Argon or oxygen, rather than the less-expensive carbon dioxide must be used as the shield when welding this material. Even if you only plan to use your MIG or TIG equipment for welding steel, it's worth considering the possibility of later using it to weld aluminum. For this reason alone, do not stint on quality, when purchasing your welding gear.

Experts who work with aluminum on a daily basis often disagree about the merits of MIG and TIG. If you have only minimum experience in handling this metal, you should seek advice locally. If you have no previous experience in working with aluminum, then you should either build in steel or seek professional help with the welding. You can solve a lack of experience in handling aluminum by acting as your own laborer while you hire an expert to undertake the welding. You

ADVANTAGES OF A KIT

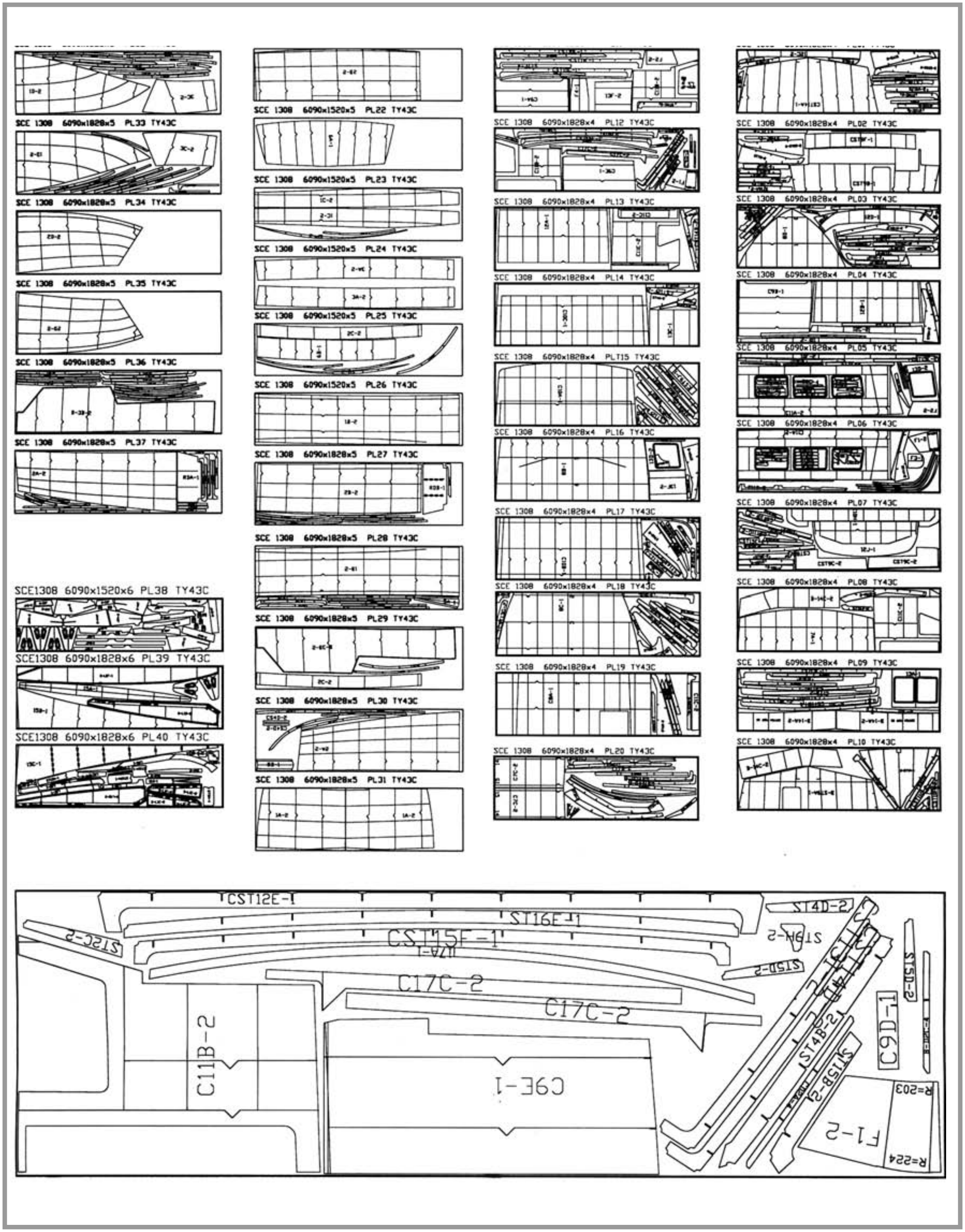
You can get your boatbuilding project off to a great start by using a precut steel or aluminum kit for any metal sailboat or powerboat. Modern kits contain accurate precut parts that you can easily assemble into a complete hull, deck, and superstructure. The latest computer software allows the designer to model the boat so that extremely accurate computerized files can be prepared to direct the cutting machines. These files contain all the information to facilitate computer-controlled cutting of all the metal parts for your boat. It may not interest the average builder, but a huge amount of work is required to turn a boat plan into a cut-to-size boat kit. Every part has to match that of its neighbor exactly, the slots need to be in the correct locations, and everything must fit together perfectly. All this is necessary to enable you to complete the assembly of the hull, deck, and superstructure with the minimum of problems. We're always amused when we receive a request from an uninformed customer that goes something like this: "By the way, now that I have the plans for your design, just send me the cutting files."

DESIGNING AND CUTTING PRECUT METAL BOAT KITS

Many of you may be surprised that it's not possible to take a regular boat plan—even one that is already prepared using the latest computer-aided design techniques—and use it for automatic computer-controlled cutting. There are many steps between creating the original design and having the boat cut out on a computerized plasma-oxygen cutter. If a particular design is to be sold as a precut steel or aluminum hull, deck, and superstructure package, then this should be decided at an early design stage. Some designs can be converted, but it is preferable to start with automatic cutting in mind.

The main steps in preparing a new design for a boat that is destined to be cut out by a computerized plasma-oxygen cutter is as follows. It is usually the customer who gets the process started by contacting the designer with a brief outline of what they have in mind. Further correspondence quickly establishes the client's wish list, which usually includes things such as type and style of boat, intended usage, and overall length and beam. Draft limitations should be specified at this stage.

Accommodation requirements, including the number of regular crew versus occasional guests, should be defined. Speed requirements are important, as is the client's attitude to fuel costs. This list may need some refining since some elements may conflict with one another. The communication ensures the client ends up with a boat that meets most if not all his or her desires and overall requirements. So far the process is very similar to what would be followed no matter which material or building method was used to construct the vessel.



Nested plate drawing. Note the number of sheets and the detail and number of the parts.

The client and designer then enter into whatcan be a simple agreement where the designeragrees to prepare preliminary plans for the pro-posed vessel for a reasonable (a relative term!) fee.In our office the preliminary plan includes linesplan, general arrangement drawings (consistingof exterior profile, deck plan, accommodationprofile, and plan views), plus sufficient calcula-tions to ensure that the final design can meet theclient's requirements.Before a preliminary plan is produced, thedesigner produces a 3-D computer-generatedmodel of at least the hull of the vessel. Once thepreliminary plans are completed and both the de-signer and the client are satisfied with the overallconcept and layout of the vessel, complete plansfor the vessel are prepared.Next, a comprehensive 3-D computer modelis completed that includes all parts of the hull (in-cluding transom, keel, and rudder), all decks,cockpits, a complete superstructure, main inte-rior bulkheads, and any other features such as aflybridge, radar arch, and exhaust stack.

Specialitems such as transom steps and other similar fea-tures are included in this model. Depending onthe complexity of the design, this process can takebetween 500 and 600 design man-hours.From this model, all the salient hydrostatics—such as detailed weight calculations to enable material requirements and final displacement—are calculated. Stability calculations arealso made at this time. During this process, fine-tuning of the model can be undertaken to makesure that the finished vessel will be match the clients requirements.

The final model, which includes all the scantlings (such as transverse and longiditunal framing, sole bearers, deck beams, and engine beds). This team separates out all the parts for the frames, stringers, engine beds, bulkheads, hull, deck, and superstructure plating, etc., and adds notches to the frames and bulkheads before nesting the parts on plates.

The design team numbers each item and draws reference lines on each part to represent frame locations, etc. (the numbers help builders identify each part, and the lines are used during the assembly process to locate frames and other structural members). The designer then works out a path for the computerized plasma-oxygen cutting machine. The path is the point at which the cutter enters the plate and starts cutting the parts. It must make sure the parts are cut in the correct order. For instance, if a window has to be cut from a cabin side, then the window aperture must be cut before the larger cabinside part is cut; otherwise any movement in

the cabin side after cutting could cause the window to be cut in an incorrect location. Several sheets of assembly drawings are now prepared. For instance, each frame is shown separately with all parts clearly numbered, and measurements are given to assist in welding up the frames. Other drawings show how to set up the building jig supplied with the kit.

The location of every part that forms the completed hull, deck, and superstructure is shown in the various assembly drawings supplied with the kit. Finally, all the parts are listed in a spreadsheet program and checked against the drawings and cutting files.

Another designer is simultaneously working on the engineering drawings for the engine room layout. Battery placement, drive train and bearing location and sizes, exhaust system, fuel tank sizes and placement are shown in these drawings.

Of course, all of the above steps have to be carefully checked and the whole design package coordinated before the cutting files are released to the client (to have the kit cut locally) or sent to the cutting shop that produces our kits. In terms of investment we figure that each set of cutting files costs us between $50,000 and $100,000 but fortunately a large part of the cost as investment against future kit orders.

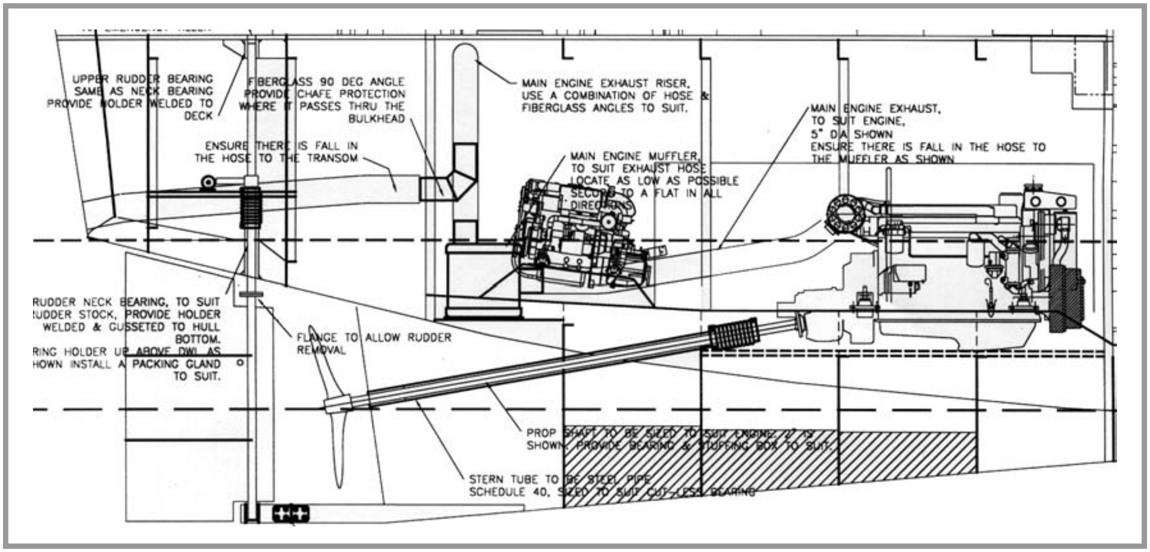
The size of readily available plate varies from country to country, so sometimes it is necessary to renest the cutting files so they fit the available plate stock. Renesting may be also required if the size of locally available cutting tables is less than that of the equipment used to cut the first kit. Fortunately it only costs a fraction of the original expenditure to renest the plates to any convenient size. As you can see from the above, the amount of careful and intense work required to turn a existing or new plan into a set of cutting files far exceeds the expense in creating the original design. It's only possible to justify these costs if a firm can expect to market several kits of similar design. Often, cutting files for a particular design can be made in such a way as to give several customers the custom items they desire. Some custom items are relatively easy to incorporate in the cutting files, while other more-complex changes require redesigning the basic boat and remaking all the cutting files.

The metal-cutting shop uses the numerical code (NC) cutting files to produce your kit. The kits are cut from preshotblasted and primed steel (or aluminum) and are delivered ready for easy assembly by any competent welder. The primer used on the steel kits is especially formulated so that it doesn't give off harmful fumes as you weld the kit together. This primer doesn't burn off on the reverse side of the metal in welded areas. It's truly a remarkable coating used to protect the steel until additional paint is applied.

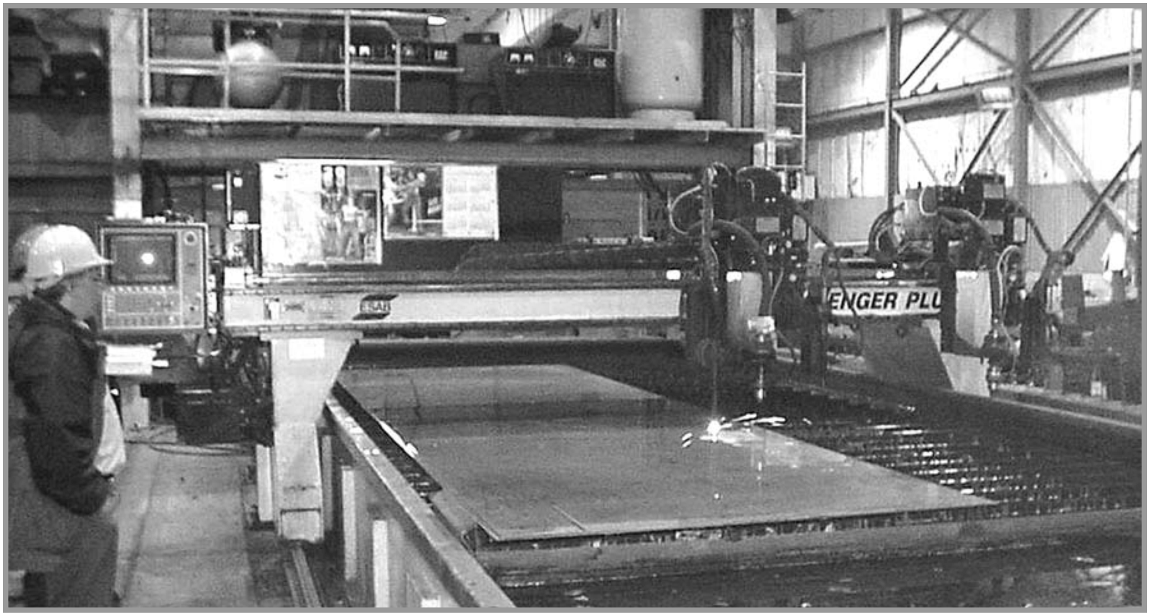
The parts are all nested, including all of the hull, deck, and cabin plating. You can easily assemble the hull, deck, and superstructure. All you have to do is to match each part to the special assembly plans you receive with the kit.Whether you decide to purchase cutting files and have the kit cut locally will depend on your location. For instance, due to the availability of excellent cutting facilities in the Netherlands, most customers in Europe opt to order a precut kit as opposed to cutting files. Conversely in countries with a high steel import duties, such as Brazil, then cutting files and plans can be purchased on a CD. The kit is then cut locally.

In our own case we have exported complete cut kits to the United States, Canada, Philippines, Russia, and many other countries, including almost all of Europe.

The tack-and-weld method described below is in many ways similar to the stitch-and-glue procedure used with plywood. It's a practical and economical way to get your boatbuilding project off to a great start. You can achieve a professional



Part of the engineering drawing showing a section of the engine room layout.



Computer-controlled automatic cutting machines can cut a complete 50-foot (15 m) boat in about 12 hours, but hundreds of expert operator hours are required to prepare the cutting files on computers.

result, especially if you already have some welding experience. If you lack welding experience, then any local person with suitable welding knowledge can help you assemble your kit. Of course, many thousands of boats have been built from a set of plans and frame patterns, so if there isn't a kit that meets your requirements, building from plans is the way to go. Nonetheless, if you can afford a kit, you'll have a hull in the least time and this alone may justify the modest additional expense. The resale value of your boat will be enhanced if you can show that the hull was built from preshotblasted, primed, and computer-controlled precut metal parts.

Steel Kits

In high-quality kits, all steel plates are shotblasted and primed with a zinc-rich primer before cutting. Cutting of plates is carried out with computer-aided lofted surfaces on an NC-driven plasma-oxygen cutting machine with a maximum plate size of 82 by 10 feet (14 by 3 m). The best material is Lloyd's-approved, "A" grade, "shipbuilding quality," or the equivalent.

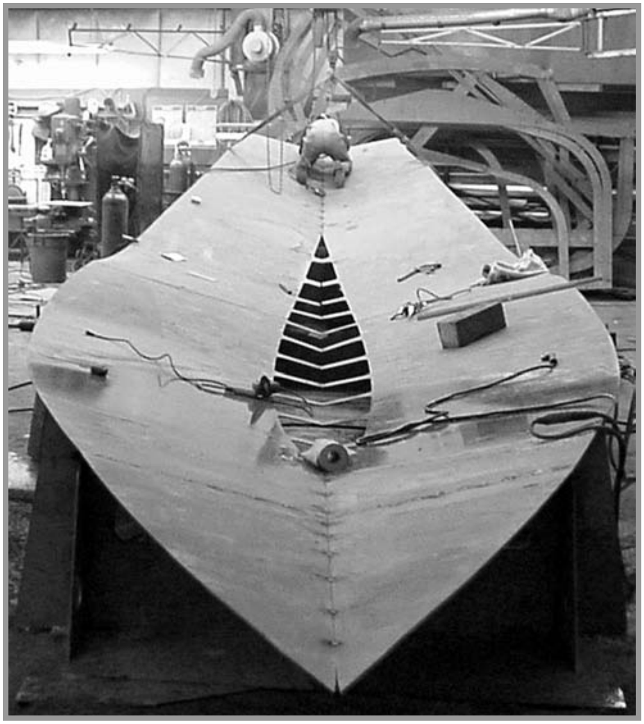
The kit includes a setting-up jig as well as detailed assembly plans. All required steel profiles are also shotblasted and primed with a zinc-rich primer. Kits are constructed from the steel product specifications mentioned above.

Normally, all the plate material is supplied as a flat pack with marking lines engraved in the plate surface (a zinc line) and part numbers painted on the surface. The maximum size is usually 19 feet 6 inches, by 6 feet 6 inches (6 by 2 m). All steel profiles are supplied in sufficient length to ensure the minimum number of joints in the plating. All parts that require forming or bending are supplied already formed to the correct shape.

Those who prefer aluminum as their basic building material will be pleased to learn that kits are available precut from marine-grade materials.

GETTING STARTED

The first thing to realize is that the kit differs in many ways from the methods you would use to build a metal boat from scratch. The kit is far superior to anything you could achieve by starting



Bottom plates, supported by jigs, are in position ready to receive the first frames. Note preassembled frames at rear.

with the plans and a delivery of raw steel plate and profile bars.

Most metal boats built from scratch are built upside down; boats built from cut-to-size metal kits are built upright. Not only is this a more appropriate way to assemble the kit, it also saves the cost and inconvenience of having to turn the hull. And here's one very important piece of advice: *You must tack-weld the complete hull, deck, and superstructure together before you run any final welds.*

If you don't follow this advice, you'll almost certainly end up with an un-fair boat requiring a considerable amount of filler. In any case *do not overweld* or try to run long welds at one time.

Your kit may arrive on a flatbed truck or in a container. Kits are normally packed on pallets and can be lifted off the transport by a small crane, front-end loader, or similar equipment. Provided your kit is on a pallet, you may find it more convenient to drag your kit from the truck or container, using a pair of planks as a ramp. Once you have unloaded your kit, you must keep it covered until assembly is under way.

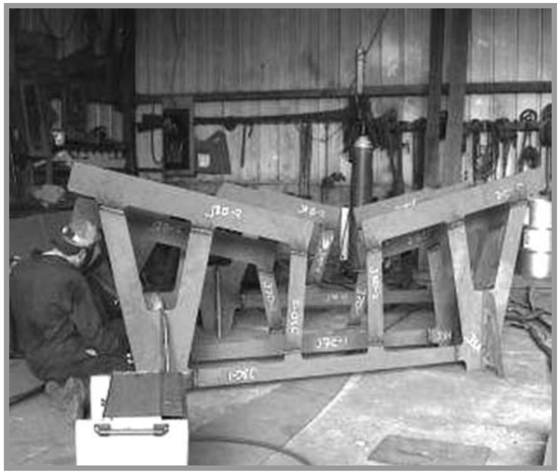
With your kit, you should receive a packing list and large-scale assembly drawings. The drawings will show all the parts as flat surfaces grouped together as they will be assembled to make the finished hull. There will also be a number of drawings showing the assembly of the frames. Each part will be numbered, so that you can check it against the packing list and the corresponding drawing.

One of your first jobs will be to tack-weld the frames together, so make sure you sort the parts and store them in the order you'll need them. On larger frames, it may be easier to tack only the bottom sections of the frames together at this time.

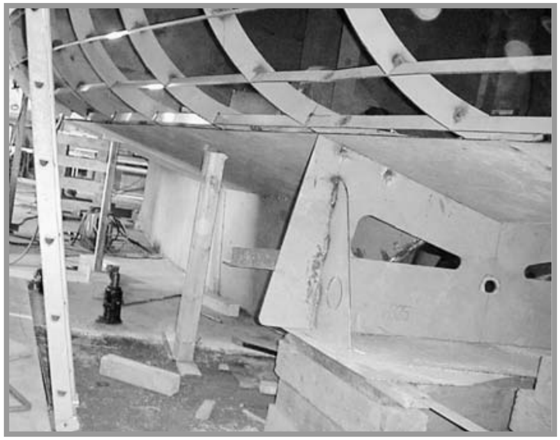
Once you've tacked all the frames together, it's time to prepare the building jig. The transverse profile jigs will be supported by the metal "castles" that come as part of your kit. The setting-up jig is merely intended to start things off. *It is not intended to support the boat during the entire building process.* Usually, however, you leave the jig in place for the entire building program so you can weld a flat strip on the top of each web to spread the load of the plate where it rests on edge of the plate web. After you have both sides of the bottom plates tacked together you should con-

The topside plates are simply pulled around to be tacked together at the bow.

Sort and check the content of your kit as soon as possible after delivery.



Most kits come with three or four setting-up jigs as part of the cut-steel package.



Another view of one of the setting-up jigs that supports the bottom plates.

sider adding extra support and bracing to the jig structure.

Set up two parallel I beams as shown in the instructions that come with your kit. These beams must be long enough to accept the number of support jigs mentioned above. Cross-tie I beams should be installed at the same location as indicated to install the support webs. Obviously, the whole support structure must be level in all directions and well braced as it will play a part in supporting the boat during construction.

Don't attempt to fully weld the plates into one length on the floor. The plate joins should only be tack-welded in three locations: one weld at the each of the ends of the join, and one in the center of the join. These tacks should be no more than a ½ inch (12 mm) long. If you weld the plates on the floor, you'll end up with a hard spot in the hull plating. Some plates of ¼-inch (6 mm) or heavier material may need to be beveled before you tack them in place. You may prefer to make the bevels after you've tack-welded the plates and before you run the final welds. In all cases, good metal boat building practices should prevail. Af-

Keels are assembled either in place of separately, as shown here; your plans will advise you of the best method to use.

ter you have both sides of the bottom plates tacked together, you should consider adding extra support and bracing to the structure.

Sailboats with long keels, such as our Spray designs, as well as most powerboats, should have the keel structure assembled at the same time as the bottom plating. Take care that you don't "squeeze in" the tops of the keel; use the webs as spacers. After you've positioned the bottom plates, the keel sections, and the transverse profile jigs, you may start to tack-weld the bottom plates to the keel sides. Sailboats with deep fin-style keels may have the keel installed after the hull is completed. The canoe body should be built from the bottom of the hull upward in a manner similar to that used to assemble a powerboat hull. The webs can be arranged so that they can be added along with the rest of the keel after raising the hull to the correct elevation.

The benefit of using this method is that it allows you to work on the hull, deck, and superstructure while the boat is lower and thus more accessible. The exact method and order of assembly depends on the availability of lifting equipment and your general work environment. Details given below are valid for the general assembly of all hulls.

With most powerboats, you can start by laying the bottom plates in the transverse profile jigs that come with your precut metal kit. The frames will soon be added at the locations indicated by the transverse lines marked on the plates.

With any hull, the first step is to set up the bottom plates and tack them along the centerline. Next, start to install the pretacked frames on the appropriate transverse lines marked on the plating. From now on, the whole structure will grow upward. The better equipped your workshop is with overhead lifting and handling gear, the easier and more smoothly your job will proceed.

If you're in doubt about your welding skills, seek the help of a suitably qualified person at the earliest stage. There is a great deal even the most inexperienced person can do to assist a qualified welder to assemble the kit. Generally, two people are required to handle the larger pieces of metal, so acting as laborer to your hired professional may be the best route for you.

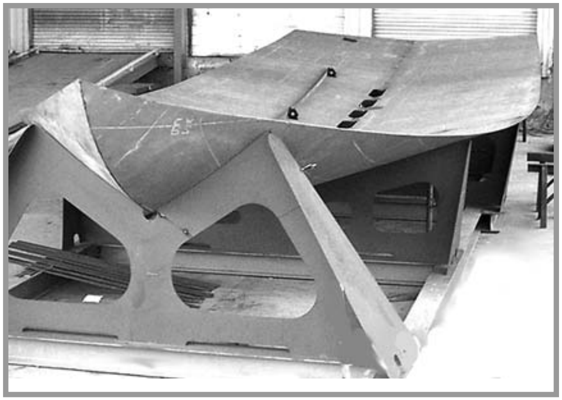
If you have moderately good welding skills, you'll find that the kit comes with enough scrap material to allow you to get in some practice before tackling the assembly of the kit. Don't try to weld aluminum or copper-nickel unless you have the proper knowledge and considerable experience in handling these materials.

The metal kits are constructed so that the strength of the finished hull comes from the buildup of the frames and stringers in interlocking sections. Heavy and continuous welding of frames and stringers should be avoided at all times. After the hull and deck is tack-welded together, the process of finish welding can proceed without fear of distortion.

The secret of creating a fair hull and deck is to use a welder of high enough amperage for the job. Welding with too little amperage, and too slowly, will create lots of heat on the spot and less penetration of the weld material in the seam. This may make for a weak weld and additional grinding to remove excessive weld material. This, in turn may further weaken the weld.

ASSEMBLING THE HULL

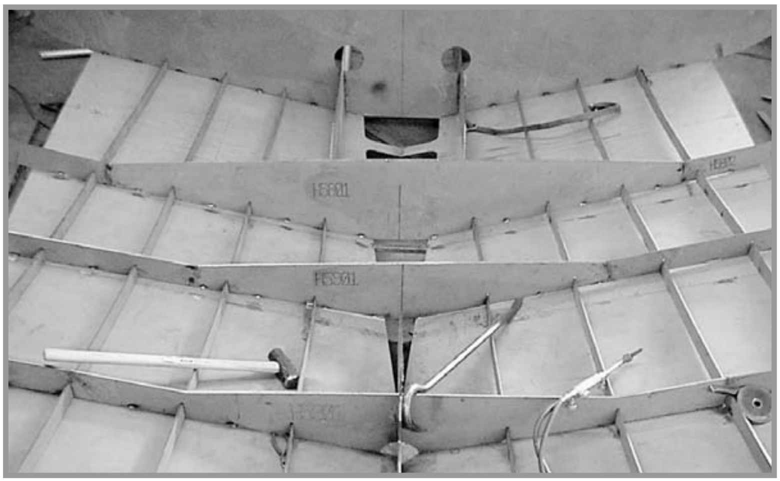
For those of you who are new to this type of boatbuilding, there is an early shock in store. Having placed the bottom plates on the jig, you may think they're not going to fit. Keep the faith! Start tack-welding in the middle of, or somewhat



Depending on the design, you may need to use some mechanical help to pull the bottom plates together. The plates on this Trawler Yacht 485 were tacked together without any problems.

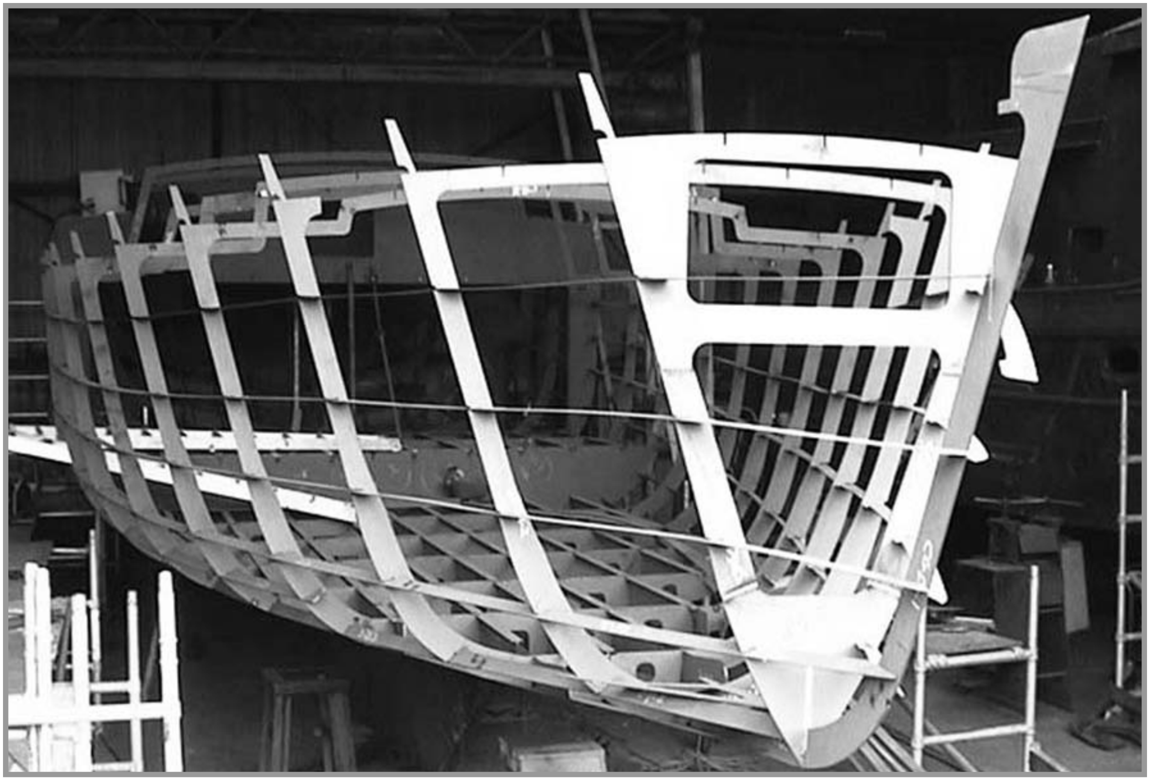
aft of, the middle of the plate. Make sure the marks on the plates are lined up at all times. As you work forward and backward from the tack-welded position, you can form the plates to shape with some human help or by using a trolley jack underneath the area of the plates where they are to join. When they touch, tack-weld them together and move along to the next position.

At the bow, you'll probably need a block and tackle to pull the sides of the plates together. Some tension will be experienced in this area. Don't forget to secure the positions of any clamps so that they cannot unexpectedly let go.

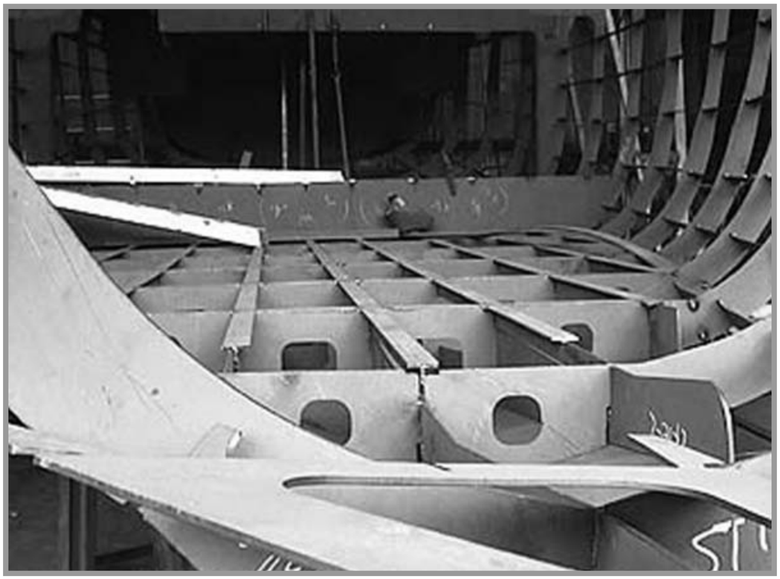


The frames are set on the bottom plate at the premarked station lines and tacked into position.

Having finished tack-welding the bottom plates together, start placing the frames in position on the bottom plates. Lines on the plate will indicate the location of the frames. You may use the scale drawings as a reference. Depending on the layout of the bottom stringers on your particular design, you may have to install some of them as you are installing the bottom frames. Study the layout of the bottom framing on your boat plans and it will become apparent



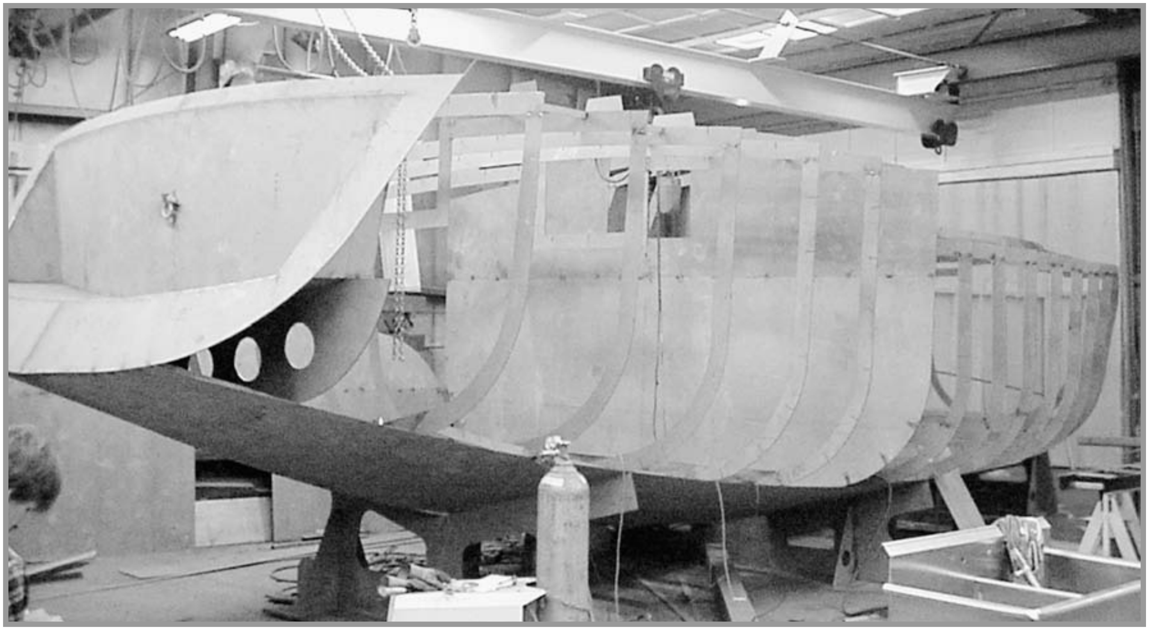
Frames have been assembled and erected. You'll find that you'll reach this stage in a few hours.



Close-up of frames shows web floors with T-bar longitudinal supports installed to accept the plywood cabin sole.

which sequence will work best for your hull.

Pull up the bottom plates toward the frames until they fit snugly and tack-weld them. Start with a frame where the plates are least shaped, and work backward and forward from there. If you've assembled the complete frames, as opposed to the bottoms only, use temporary braces, as necessary, to support the top portions of the frames. Once all the frames are installed, you may fit some of the side stringers into the slots on the frames. These stringers will assist in stiffening up the structure at this stage. Once



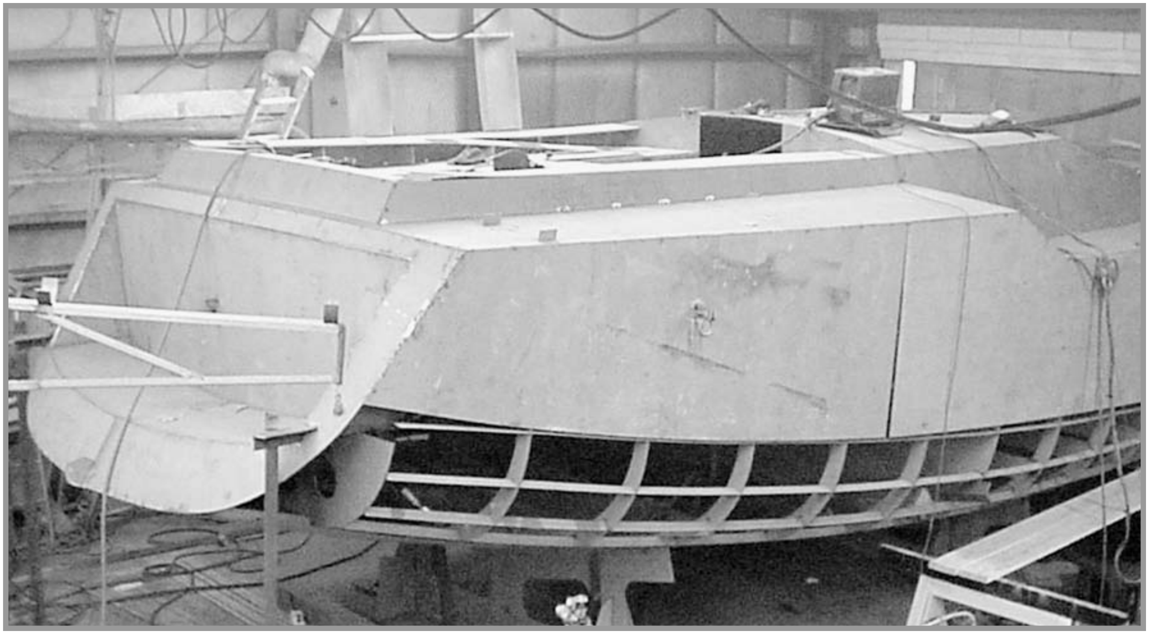
The transom in place; the next step will be to install the radius stringers. Photos on these pages were taken by Brian Smyth of YachtSmiths International of Nova Scotia, Canada. [pd]need to fix x-ref; prev. was p. 53-58

again: Use only tack-welding at this stage of the assembly process.

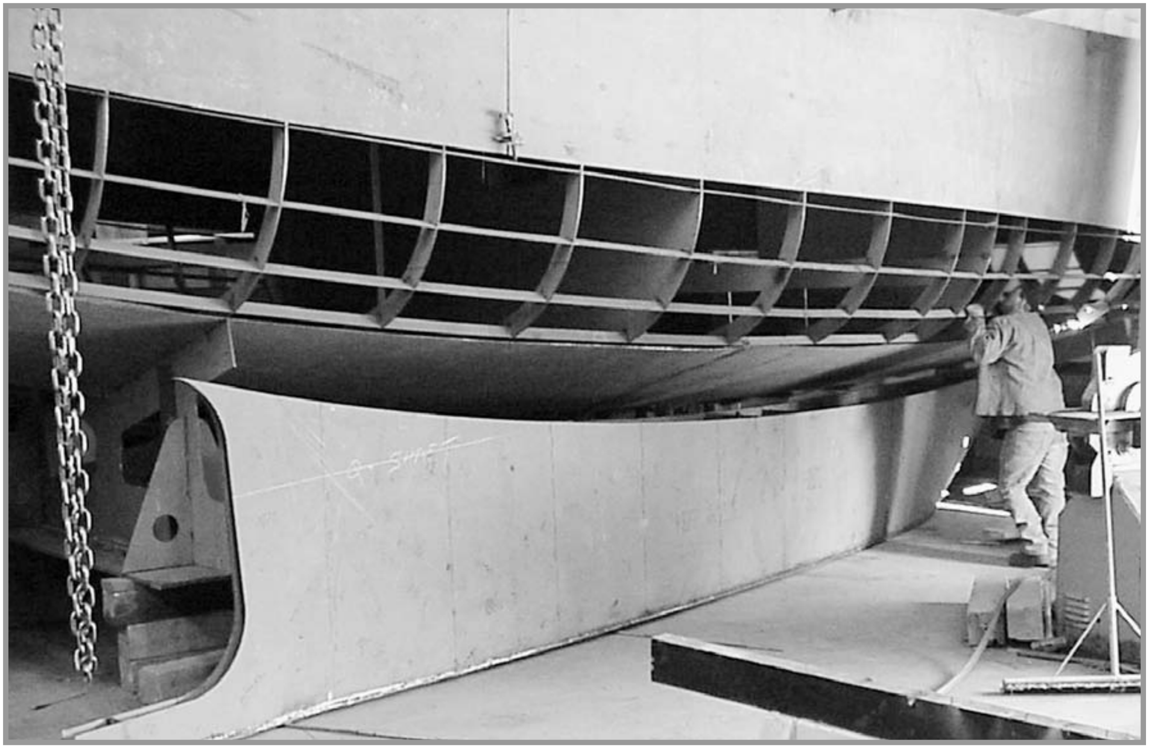
The next step is to install the side plates. This is best done by using a simple overhead gantry or a forklift truck. Pick up the side plates with a plate clamp on a chain connected to a block and tackle made fast to a forklift leg. Make sure the plate is more or less in balance while it's hanging free of the ground before you lift it into position. Use a helper to locate a matching line in the right position and tack-weld it. Continue to move the plate up or down a bit with the block and tackle until the entire side is in position and tack-welded in place. Place some tack welds on the side frames-to-plate joint as well as on the chine seam.

The side plates near the bow and the underside of the bow will show some tension, and can be pulled into place by attaching a chain on the outside of the plates. To attach a chain or a block

Note the fair line of the stringers as they are installed into precut slots.



With radius-chine hulls it's best to install both the bottom and topside plating before fitting the radius section.

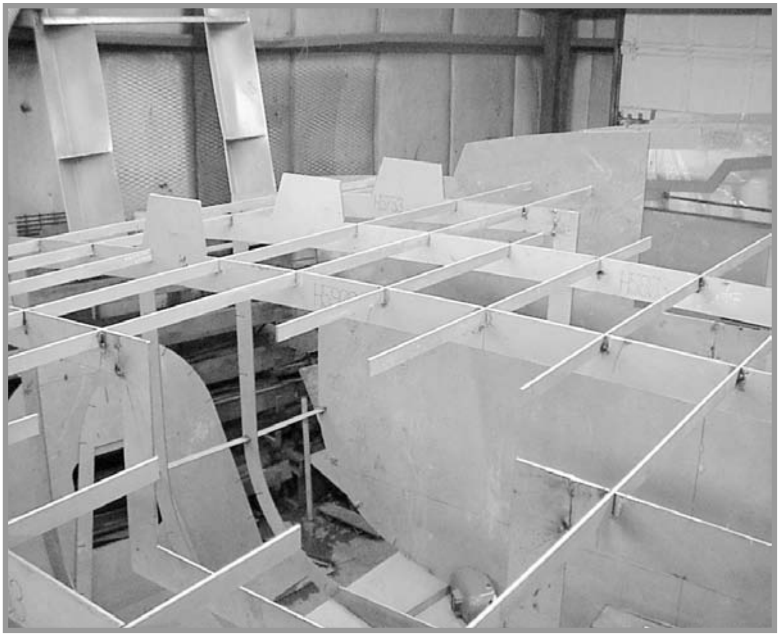


A prefabricated long keel is installed on a Voyager 495 hull.

and tackle to a plate, tack-weld a temporary eye or similar piece to the plate. By welding only one side of the eye, you can easily remove it after use.

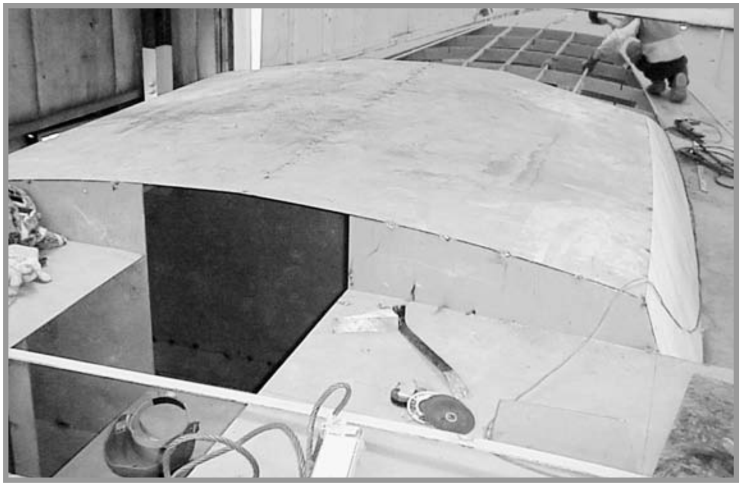
Next, the transom plates, bathing platform, stern plates, and all other plates that go into forming the hull are installed and tack-welded in position. Note that with radius-chine boats, the radius panels are installed later. Remember to refer to the drawings frequently.

Now the deck plates, superstructure, and items like a flybridge are installed and tack-welded into position. Any deck stringers and cabintop intercostals in your design

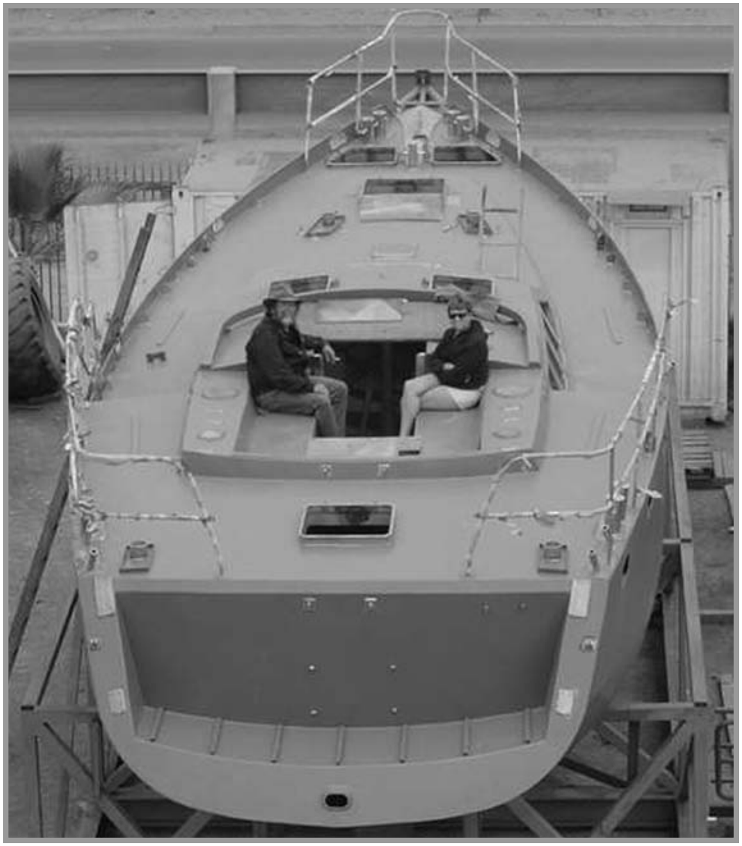


Deck stringers help stiffen the structure while the hull is being plated.

Optional twin cockpits and side deck plating installed on a Voyager 495.



View of the pilothouse looking forward from the cockpit and poop deck.



This Voyager 495 was cut in Chile using cutting files and assembled with the aid of the comprehensive plans that accompanied the files by owner/builder Bernie Loyer.

may need to be installed before the applicable areas of plating. In some cases, it may be possible or preferable to tack-weld the superstructure together off the boat and then install it as one unit. Some of the more recently designed kits allow for this option by providing special landing areas at each frame, which make it simple to line up the completed superstructure with the hull and deck.

RADIUS CHINES

After you've tack-welded the entire boat together, it's time to tackle the radius chines. We've always maintained that radius-chine hulls should be built upside down. For one-off boats built from scratch, this advice still stands. But, because all kit boats are built upright, a special approach is required to enable the radius chines to be fitted without blemish. At first, we supplied the radius plates rolled in one direction only; this is the same rolled plate you would use in one-off radius construction. We soon discovered why we had always insisted that these radius-chine boats should be built inverted. Fortunately, we were able to solve the problem. The radius-chine boats built from these kits are still built upright, but with one important difference: we now supply fully formed radius plates. They are rolled in all directions to ensure a perfect fit. This improved arrangement is available because it is now possible to have the plates fully formed and rolled from the in-

This is the standard of finish you'll be able to achieve if you take care when welding your radius-chine kit, and follow the building instructions to the letter.

formation supplied in the original modeling files. The forming cannot be accurate right to the edge of the plate, however, so each section is a little oversized at the edges, which allows for exact fitting and trimming. Your kit will contain the appropriate amount of prerolled, numbered sections to fit the area covered by the radius chines.

Now you can carefully place the appropriate prerolled section against the position on the opening in the hull. Using a helper, scribe the edges of the plate with a sharp tool or pencil and then cut, grind, or nibble the edge for a perfect fit. Tack-weld it in position and continue until you have all the radius panels in place.

FINISHING THE ASSEMBLY

The first job is to complete the welding of the frame sections and then intermittently weld the frames and stringer to the hull plating using 2-inch (50 mm) weld spaced at 6 inches (150 mm). Do not overweld and do not continuously weld on one side of the hull. Weld on a reasonable amount on one side then switch to the other side, back and forth until the entire hull is welded. Constantly working from side to side will avoid the plates pulling out of shape and general distortion that can be caused by overwelding or welding entirely on one side at a time.

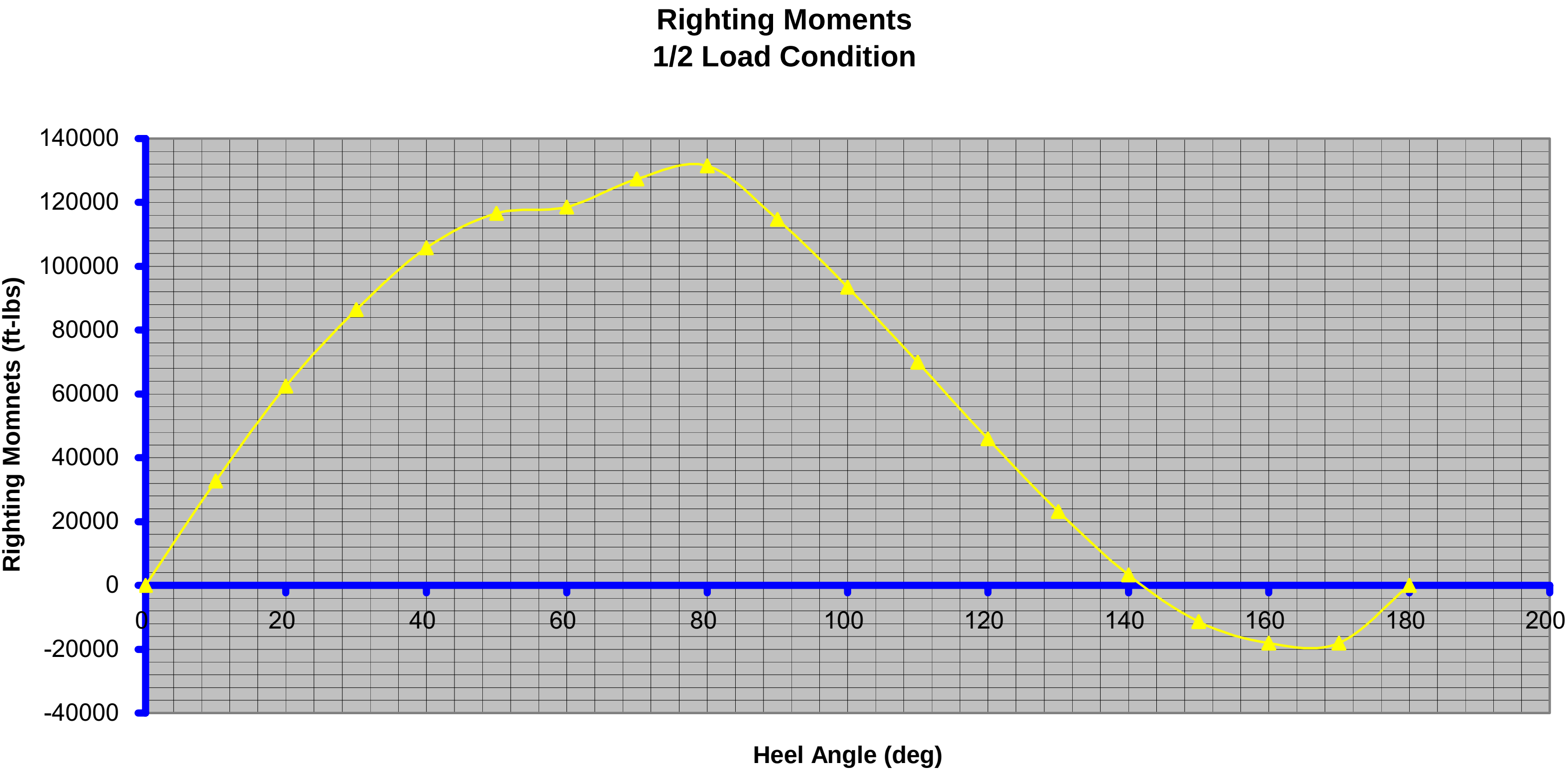
You should have made a 60-degree V between the plates, 30 degrees on each plate, but if you haven't previously prepared the heavier plates in this manner, you may do so now by running an angle grinder along the appropriate seam. Now you can proceed to run the final welds on the outside of the plates. The hull below the waterline must be welded both inside and out. Again, work from one side of the hull to the other, frequently changing sides.

You can grind off any excess weld material by first using a coarse disk and then finishing up with a softer, more flexible disk. Take advice from your materials supplier about these items.

Lastly, apply a minimum of filler to the seams and apply a coat of primer to the ground areas. You're now ready for final finishing and painting.

VOYAGER DS 440

Length - Hull	13.64 m	44’-9"
Length - Deck	12.95 m	42'-6"
Length – Waterline	13.23 m	43'-5"
BEAM	4.42 m	14'-6"
DRAFT	1.98 m	6’-6"
Headroom	2.03 m	6’-8"



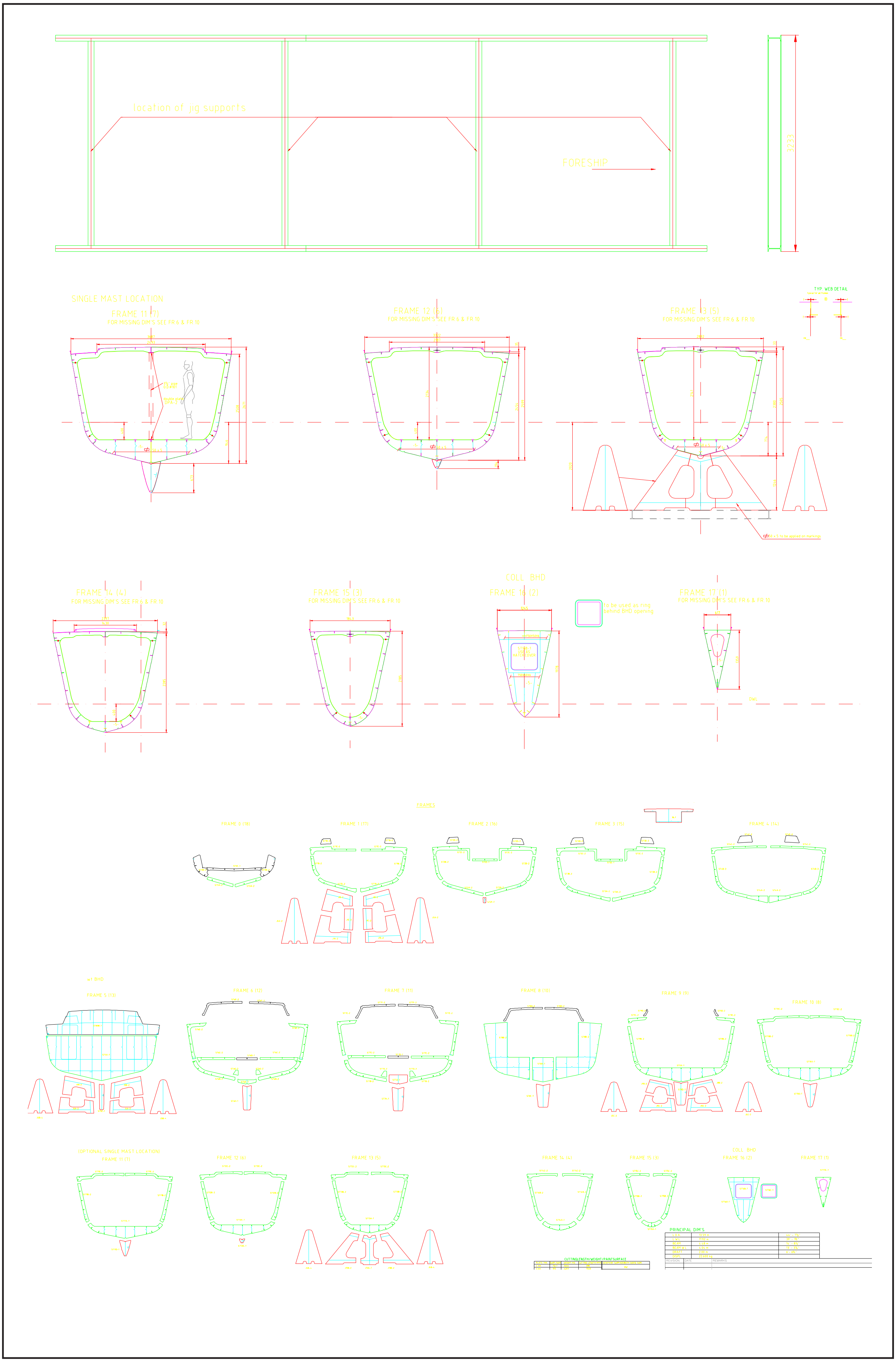
Voyager 440 DS

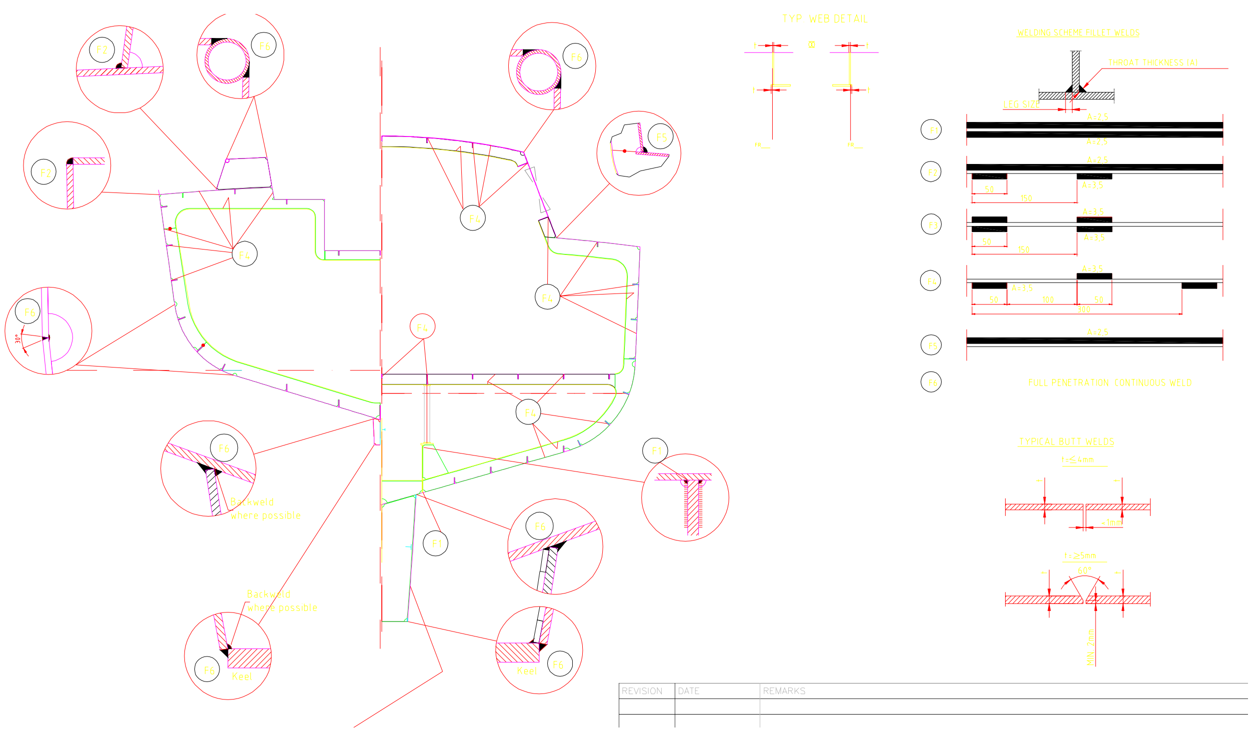
VCG= 0.08

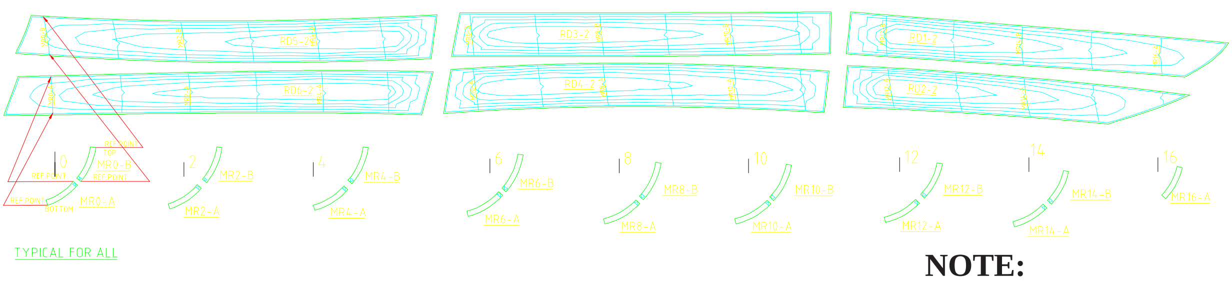
<u>Range of Stability</u>

DISP=48,850 LBS   Ballast= 11500 LBS   LCG= 21.84   142 Degrees

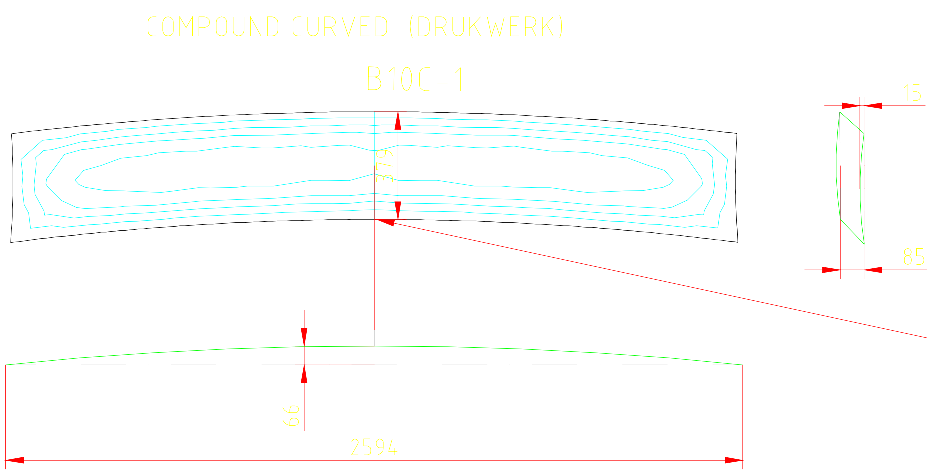
FUEL= 428 LBS   57 GAL


location of jig supports
FORESHIP
SINGLE MAST LOCATION
FRAME 11 (7)
FRAME 12 (6)
FRAME 13 (5)
TYP. WEB DETAIL
FRAME 14 (4)
FRAME 15 (3)
COLL. BHD
FRAME 16 (2)
FRAME 17 (1)
to be used as ring behind BHD opening
FRAMES
PRINCIPAL DIM'S

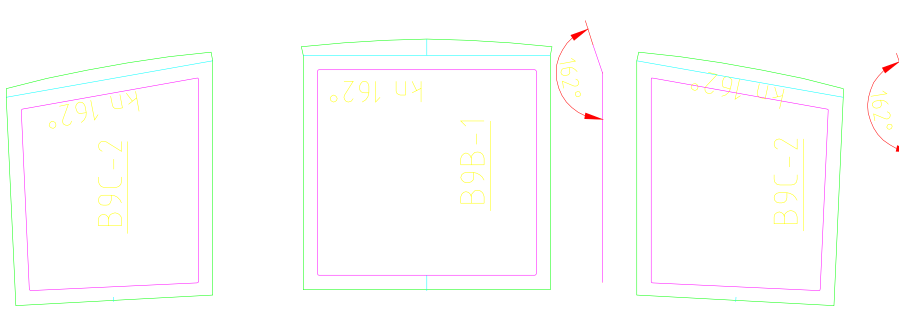




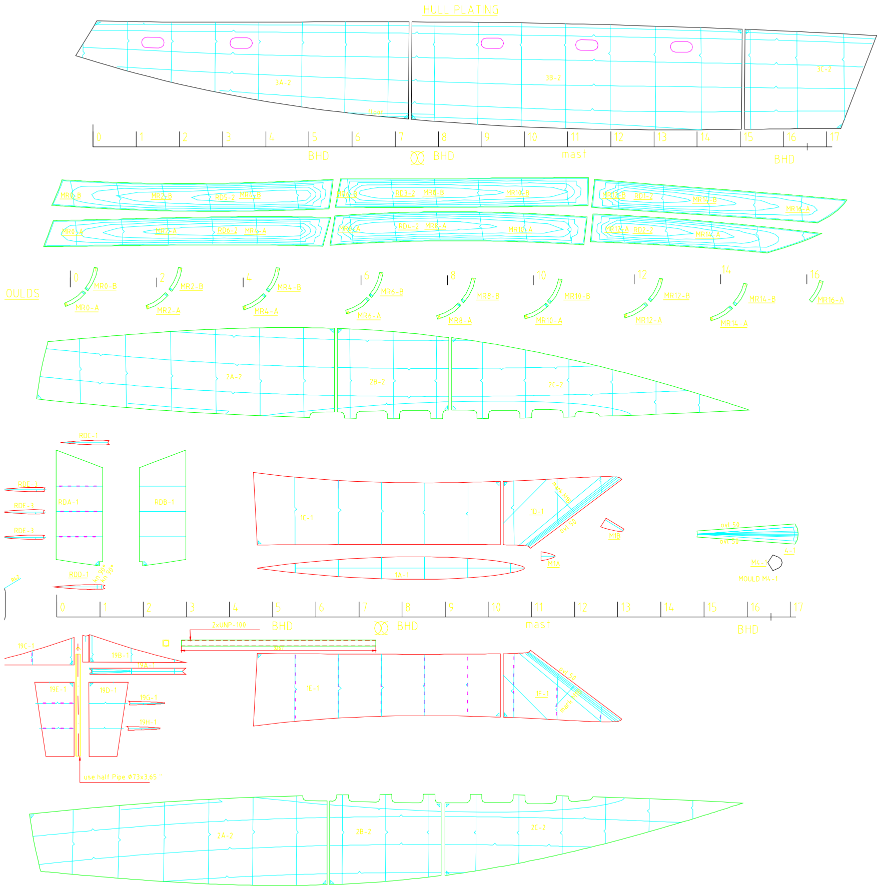
NOTE:
Due to space constraints we have only shown sections of drawings and also we have ommitted the copies notes that are normally part of these sheets which are nomally 5 times larger.



TOP:
Each set of assembly plans contains a sheet showing the number and type of welds required to assemble the hull from frames to plating etc.

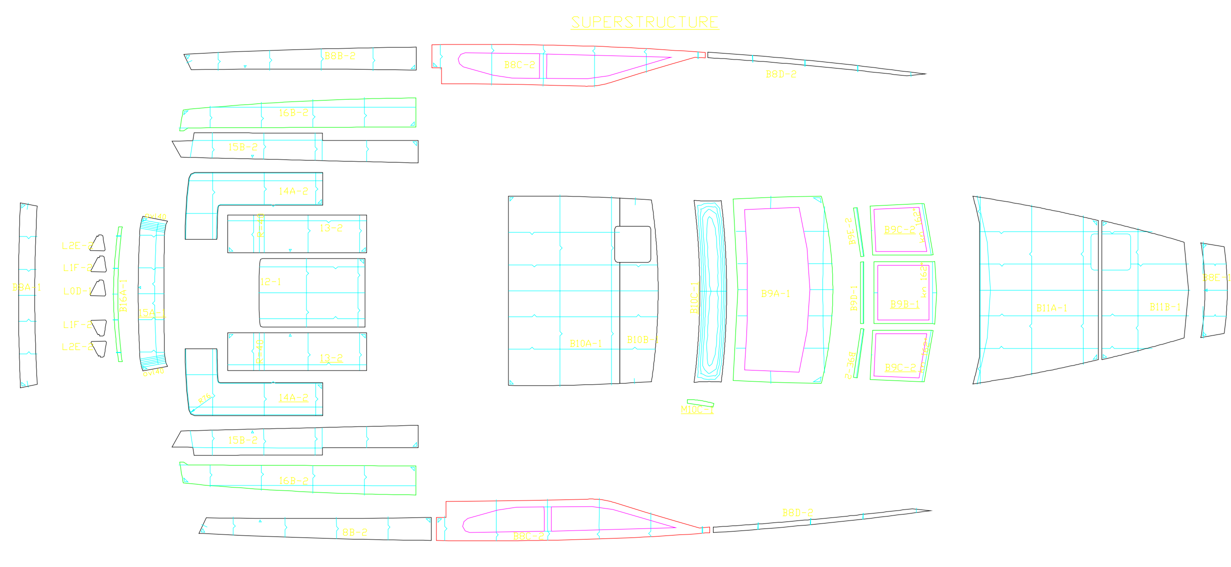


ABOVE AND LEFT:
Here we see the forming that is required to obtain the correct developed radius for the chine panels.

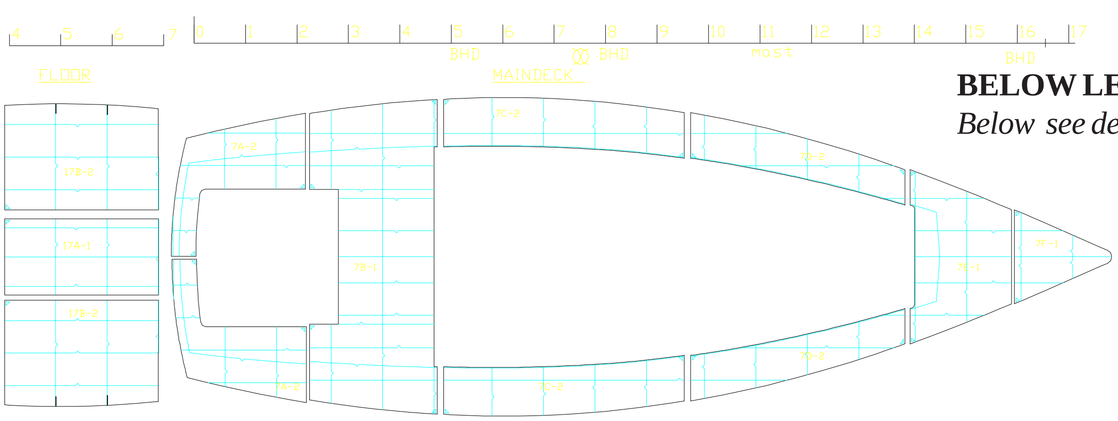


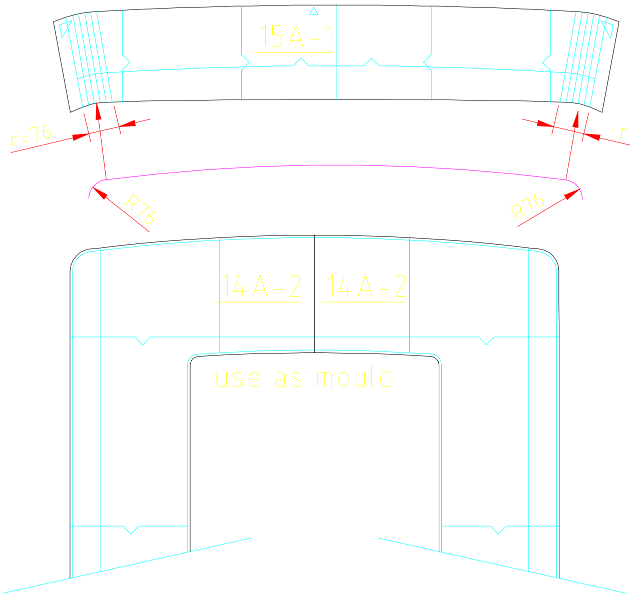
LEFT:
This is part of the sheet that will show an exploded view of the main panels. Shown are the topsides of the hull, radius panels, bottom plates, sides and bottom of keel, rudder plates and webs. Some of the plates are ommitted and the stringers and frames would be shown on another sheet.

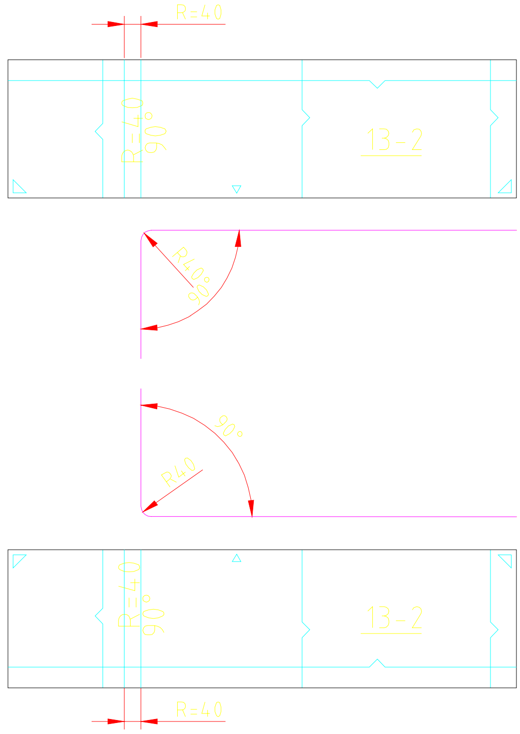
BELOW LEFT:
This is part of the sheet that will show an exploded view of the superdstucture. You can see pilot and cabin sides and tops etc.



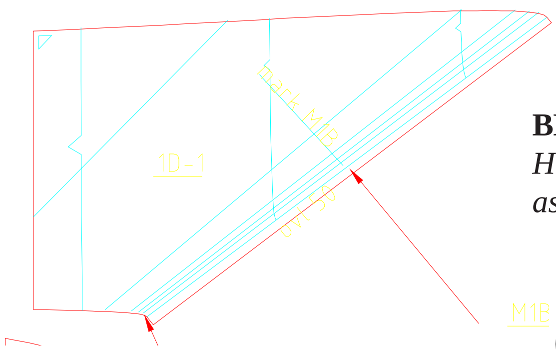
BELOW LEFT:
Below see deck panels.



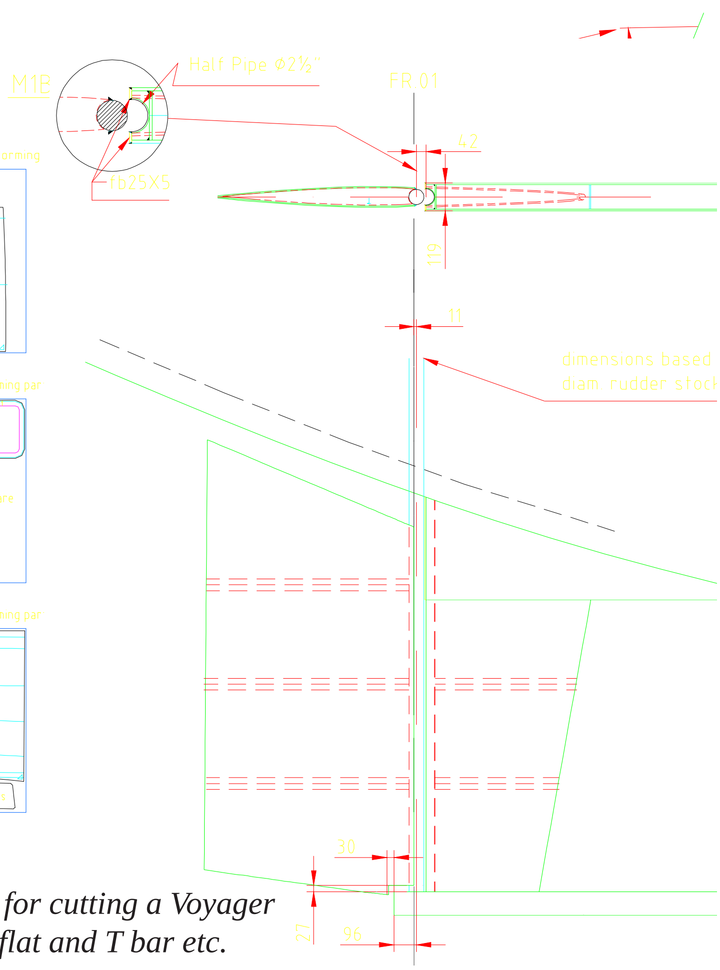


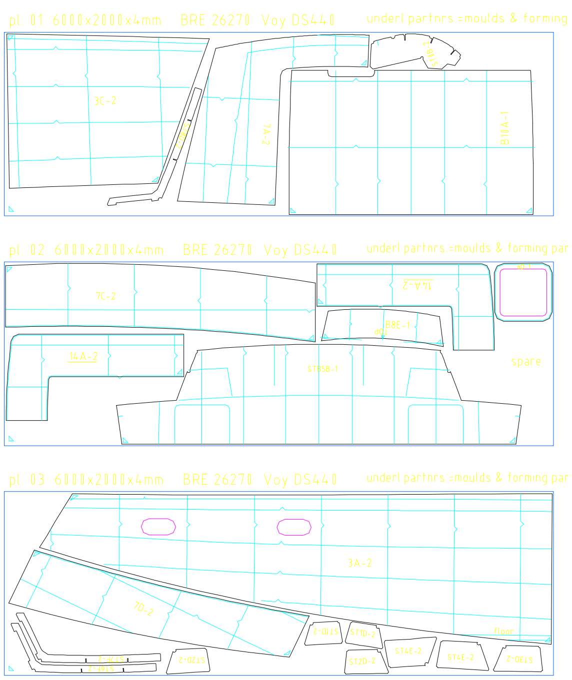


ABOVE AND RIGHT:
There is considerable pre-forning of metal plate to ensure the assembly of the kit proceeds quickly.

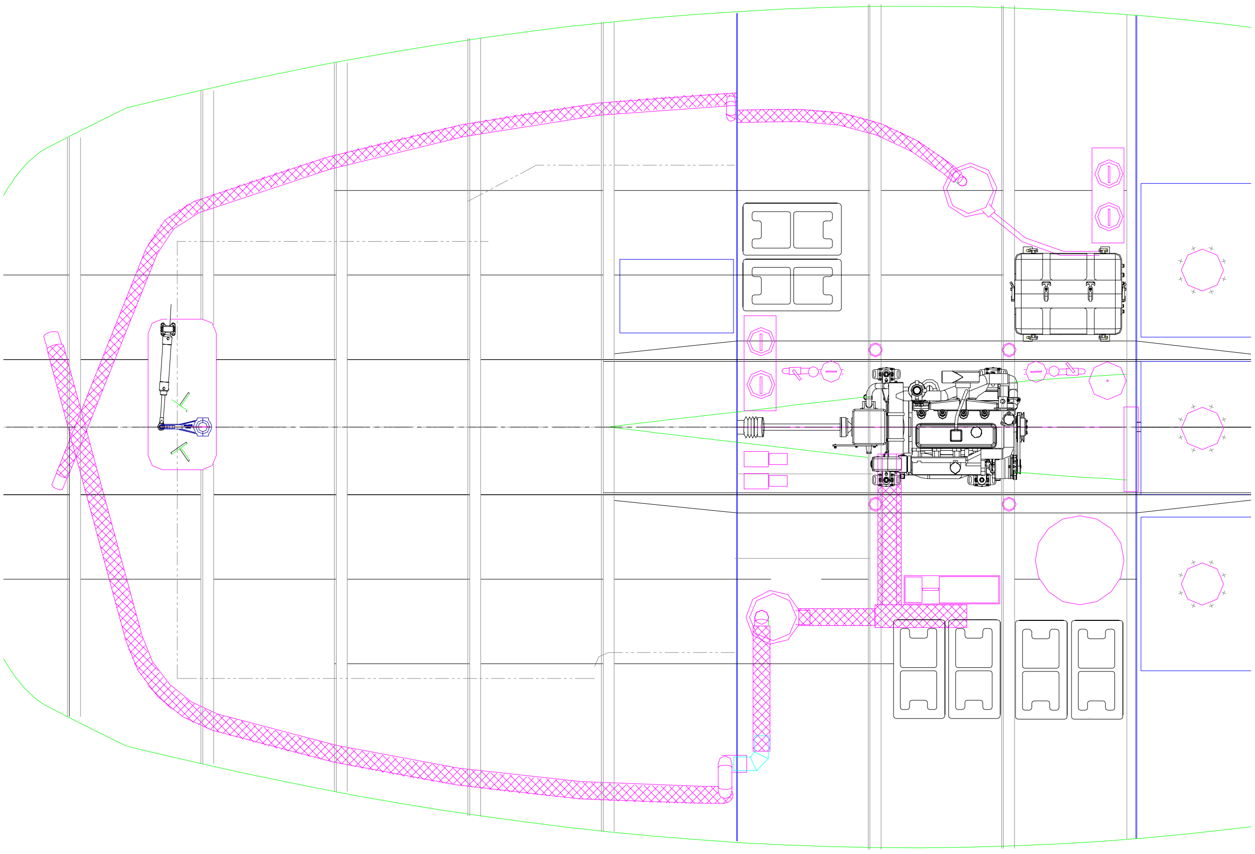


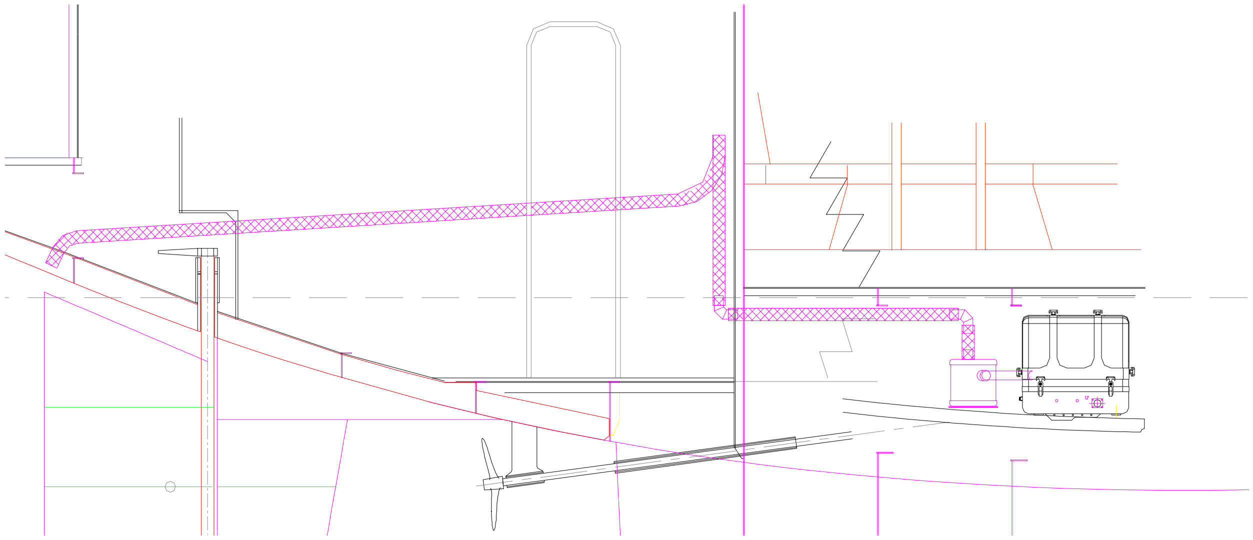
BELOW:
Here are a few details of the rudder parts and assembly that will be included in the plans.

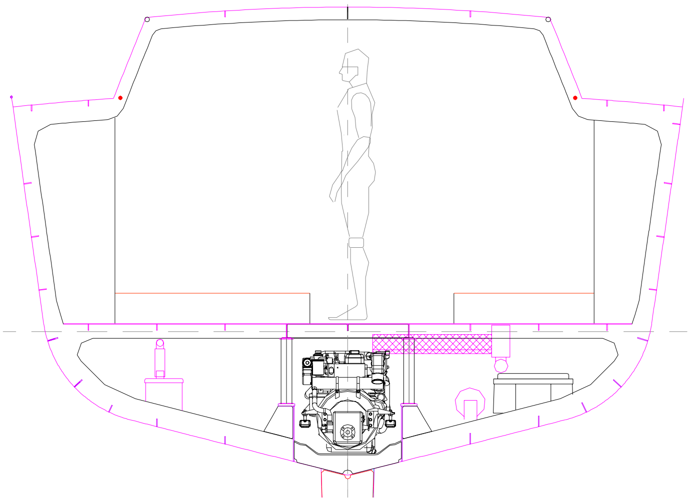




ABOVE:
Just three of the 24 sheets that are nested for cutting a Voyager DS 440 kit; Plus there are 103 lengths of flat and T bar etc.







THIS PAGE:

Shown on this page are three views of the engine installation ... this is only a part of the sheets that show full illustated details plus explanatory notes on installing the engine and fitting out the engine room.

Steel plate grade A with welding primer Sigmaweld MC

Nr of plates Weight	Length in mm per plate [kg]		Width in mm	Surface in m2 Total weight Kgs		Thickness in mm
11	6000	2000	132	4	384	4224
12	6000	2000	144	5	480	5760
3	6000	2000	36	6	576	1728
26	Plate with Sigmaweld total			312		
			11712			

Black steel plate, no primer

Nr of plates Weight	Length in mm per plate [kg]		Width in mm	Surface in m2 Total weight Kgs		Thickness in mm
2	6000	2000	24	6	576	1152
2	Black plate total			24		
			1152			
28	Total all plates			336		
			12864			

Profile, with welding primer Sigmaweld MC

Quantity Weight per meter	Length in Mtr		Type	Dimensions Total weight Kgs	Thickness in mm	
5	6	flat bar	25	5	1.00	30.0
22	6	flat bar	40	5	1.60	211.2
13	6	flat bar	50	5	2.00	156.0
26	6	flat bar	60	5	2.40	374.4
2	6	flat bar	80	5	3.20	38.4
1	6	flat bar	90	5	3.60	21.6
1	6	flat bar	100	4	3.20	19.2
1	6	flat bar	100	15	12.00	72.0
1	6	flat bar	120	5	4.80	28.8
5	6	solid rnd bar		16mm	1.63	48.9
1	6	solid rnd bar		25 mm	3.985	23.9
5	6	Pipe	1"	33.7*2.65	2.01	60.3
1	6	Pipe	2½”	73x3,65	6.5	39.0
1	6	Pipe	3.5"	108*3.6	9.27	55.6
2	6	U-channel/UNP		100 x 50 x 5	10.80	129.6
15	6	T-bar	50	6	4.44	399.6
Total	Profile steel					1708.5
102						
TOTAL						14572.5

PACKING LIST CONTAINER GSTU 361974 / 0

part ID	**FORMING (=Underlined nesting)**	**quantity**	**Part nested in plate nr**	
B11A-1		1	10	4mm
13-2	forming	1	10	4mm
17A-1		1	10	4mm
6A-1		1	11	4mm
7F-1		1	11	4mm

TOP: *Here is the plate and profile list required to cut the Voyager DS 440 kit*

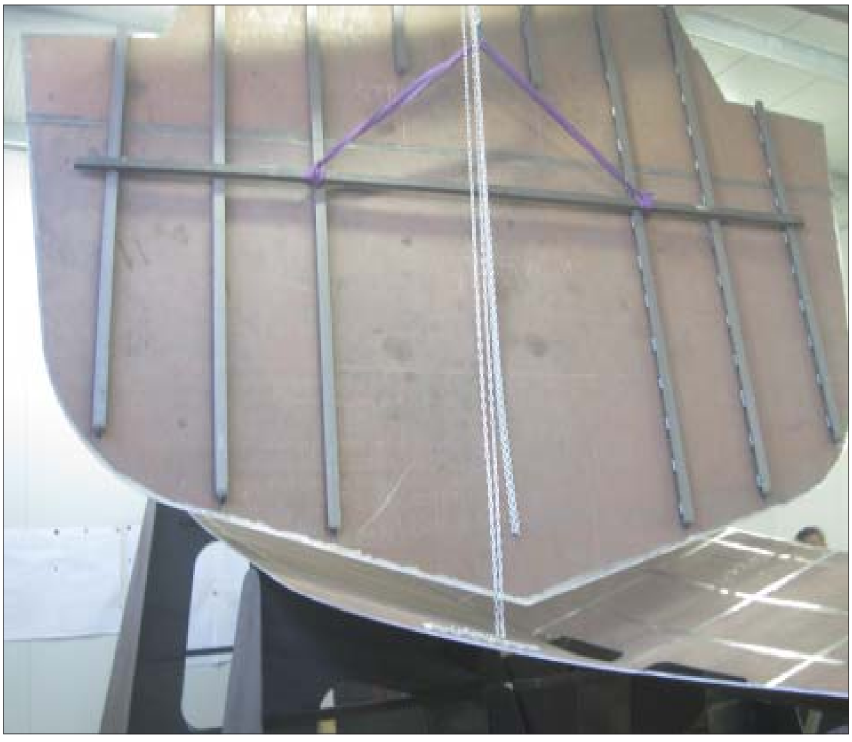
LEFT:
Here is a very small part of the several pages of the 500 cut parts

Introduction to Voyager DS 440 kit assembly sequence.

Norbert and Tamás Tóth supplied the most of the photographs shown below. This is a father and son team who are making a beautiful job of assembling the Voyager DS 440 hull. The photo sequence shows what is typical and required to set up a steel radius chine sailboat kit. All of our kits and some others are assembled in a similar manner. The other photographs, captions and general text in this chapter will give you a clear idea of just how easy it is to put these boats together.

First thing to do after unloading all of the plates and profiles is to sort and check the parts against the list that is supplied with the kit. Make sure to advise the supplier as soon as possible in the unlikely event of shortages or damage too the plates or profiles; you will find it is much easier to have any faults rectified sooner rather than later! All parts are clearly numbered and easily identified using the drawings and lists showing each individual part. Make sure that you store the parts in the order that they are likely to be required as the assembly proceeds.

ABOVE:
Here the two bottom plates are placed on to the building jig; note how these plates naturally take up the required shape and form; this is another great feature of computer design, everything fits perfectly. The plates have been tack welded along the centerline. The holes on the centerline will be required later to give access to the keel for welding and also for stowing trim ballast etc.



LEFT:
This bulkhead has the stiffeners pre-installed and these can be either L or T angle depending on the materials specified and supplied with your particular kit. Note the cross bar that has been temporally welded across the bulkhead at the balance point; this will make handling, installing and final location of the bulkhead much easier to effect than if the weight is taken anywhere but at the balance point; this rule applies to any large part you are installing on your boat.

RIGHT:

Here we see the forward 'crash' or anchor locker bulkhead. Note that the stiffeners are on the forward side and the framing is already in place for the hatch which is used to access the anchor locker from inside the boat. Several frames have now been erected and some stringers are already in place.

BELOW:

Tamás Tóth stands on one of the recently erected frames in his Voyager DS 440 hull; No doubt he is admiring his handiwork as we all do when finishing off a days work on our boatbuilding project. Note the various elements in the frame and bulkhead assembly. Norbert is standing on what will be the sole level and it is obvious that there is adequate headroom in this sailboat.

ABOVE: *This photograph shows an overview of the skeletal hull structure. Note the frame capping used to add additional strength to these important structural members. Careful study of this photo will reveal just how easily the internal framing of this boat goes together.*

ABOVE: *This close up photo of the radius section of the frames shows the pre-cut slots used to receive the stringers. Note the 'mouse hole' at the outer edge of the slots; this is cut so that the builder will be able to gain access behind the frame at this point for welding purposes.*

ABOVE: *Here we see one frame with a web floor, cabin sole bearer, bottom plate and stringers as well as part of the centerline web. Note the flat bar attached to the inside of the frame.*

ABOVE: *This photograph shows the bottom plates supported in the setting up jig. The hull could be better supported by using a strip of flat-bar across the top of the supporting jigs so as to spread the load between the bottom plates and the jig; this would also strengthen the setting up jig which will take a considerable weight before the hull is completed.*

ABOVE: *One of the side deck plates is shown here; note the tool that is used to assist in positioning the plate so it fits snugly against the cabin side stiffeners. Study this photo carefully as you can see much of the framing structure in some detail. Note the neat arrangement of floor webs and T bar fore and aft sole supports.*

ABOVE: *In some cases the deck plates will be installed before the hull is plated. Carefully check the building instructions that come with your kit so as to make sure you get the sequence in the correct order. In this photo you can see some of the cockpit framing with an L angle brace across the top; always make sure to use adequate bracing and temporary bars to support various parts of the hull as the assembly proceeds.*

ABOVE:
Here we get a good view of the entire framing structure that will support the plating and ensure you a strong sea-worthy hull. Since the event of the EU and other Classification rules becoming more strictly enforced, framing on steel and other forms of boat construction has become more substantial that may be entirely necessary; however we follow the rules and these boats are up to anything you may encounter with a 'picky' surveyor and most importantly in real world conditions that you will encounter in your future voyaging.

LEFT:
Another view of the framing and showing the deck plates in position. At this stage only use three tacks, one at top and bottom and one in the centre to join the plates.

ABOVE:
The cockpit plate is now in position. Some of these sailboats are designed with more than one possible cockpit location; this is to facilitate the design of the accommodation interior layout; cockpits sometimes intrude more than we would like into the accommodation spaces but by being able to adjust the exact location of the cockpit you are able to achieve the best balance between cockpit, deck and below deck living and working spaces. If in doubt consult the designer of your boat for additional advice.

LEFT: *The rudder has been completed wirh a flange at the top; this is used to attach the rudder to the stub steering rudder shaft that comes through the hull and will have a matching flange. Make sure that the bolts used to connect the two flanges are connected together with stainless wire so that they can not work loose over time. NEVER use dis-similar metals such as aluminum and steel in these areas; this will cause electrolyses.*

ABOVE: *Here we see one of the radius plates being fitted to the hull. Again please note that only minimum and even pressure is required to snug these plates into position. If you have to use undue force you may distort the plate and in that case it will never take up the correct shape to give the desired attractive shape to the finished hull.*

ABOVE: *The radius plates run past the transom to form the swim platform section of the hull. The small partial bulkhead at the aft end of the swim platform forms the aft end of the hull and is usually slightly rounded in plan view to provide an attractive appearance; same goes for all transoms and similar parts of your hull.*

LEFT: *Note the smooth topside plates. In this case the openings for the ports have already been cut during the plate cutting but this is optional; you can have the openings just marked, partly cut-out or fully cut as shown here. Make sure the cut-outs are done to fit a known port size and one that you can obtain in your area. Sometimes it is possible and very often desirable to have the ports and windows all delivered with your kit.*

ABOVE: *Note the substantial frames complete with flat-bar facings; as they say this boat can "shunt ice". The EU rule and the requirements of various Classification Societies such as German Lloyds etc. have been instrumental in all designers who design to the rules being required to 'beef up' their designs. Most have adapted to the various rule requirements without any problems.*

ABOVE: *The cabin sides are now in position; again I would remind you that the various elements are only TACKED together at this stage. It is recommended to NEVER fully weld the parts until the entire hull deck and superstructure are assembled and tack welded together. In this photo you can see the pipe between cabin sides and top and aft end of the cabin to sides; this is used to give an attractive rounded appearance to this area.*

LEFT:
The view of the bow shows the forward topside plates stacked in position. Make sure when assembling any steel boat that you work from side to side as you add the plates to the hull deck and superstructure; never fully plate up one side before proceeding to the other because if you do you will pull the whole structure askew and cause insurmountable problems for yourself.

ABOVE: *Here we see the bow cone and it is obvious that this type of bow gives a much improved appearance with minimum amount of additional plate forming and welding. The rounded portion is developed as a true cone and made slightly oversize so that it is easy to shape and fit to the hull.*

ABOVE: *This photograph shows the forward end of this hull and you can see the desirable results made possible by the use of computer design, careful cutting and assembly of this hull. A very small of epoxy filler will be required to make it possible to end up with a hull that exhibits a perfect finish and is a credit to all concerned. A well built hull will also have considerably more monetary value; badly built hulls usually cost as much to build as well built ones do!*

ABOVE: *Here we can see the pilot house is now completed and this photograph provides a good view of this strucure. Super strength is a feature of all these steel boats that are designed and built to the various Classification Society rules.*

ABOVE: *Rounded pipe on coaming.* **BELOW**: *Transom; boarding area and window in stern.*

ABOVE: *Rounded pipe on pilot house and coaming.* **BELOW***: Substantial interior framing !*

ABOVE: *Overview of pilot house and coaming.* **BELOW:** *Close up of coaming with pipe corners*

ABOVE: *Keel with plate on one side..* **BELOW:** *YES the engine did make it into the hull !*

LEFT: *Nice clean up in corner of coaming.*

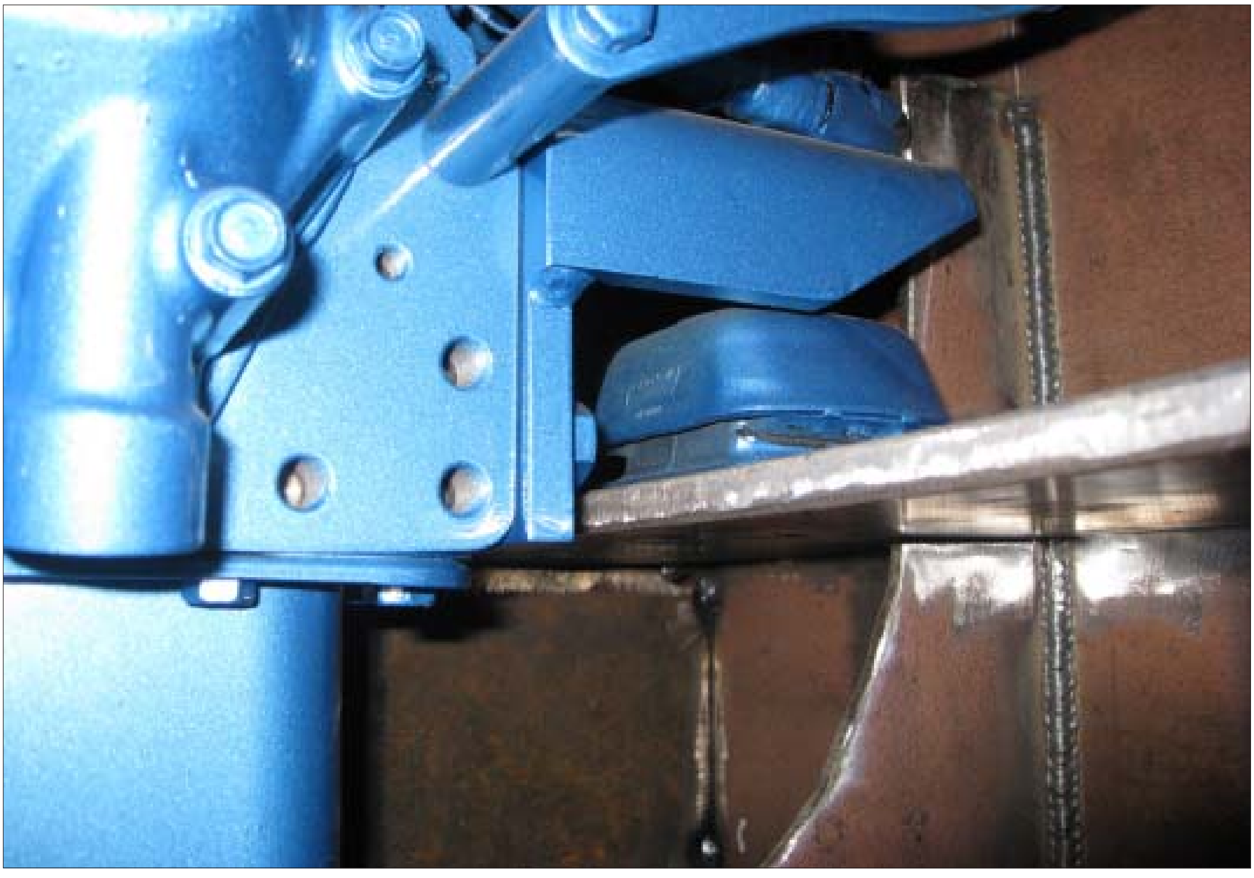
BELOW: *Close-up of pilot house window framing.*

BOTTOM: *Overview of pilot house and slim fore-cabin sides and top.*

ABOVE & BELOW: *Two views of the bow thruster tube; note the touch up of the primer to prevent rust getting a foot-hold on the welded areas of your hull. Welds will be ground above the waterline but unground below the waterline.*

ABOVE & BELOW: *Two views of the engine beds which are included in the kit and cutting files but can be modified if required to suit your particular engine.*

ABOVE & BELOW: *Two views of the engine installed on the pre-prepared engine beds. You will need to line up the engine, propellor tube and prop shaft but this is made relativly simple by following the plans that come with your cutting files or kit.*



ABOVE & BELOW: *Two views of the prop shaft and where it exits the hull via the aft end of the keel. Always study the plans that come with your cutting files or kit.*

ABOVE & BELOW: *Two more views of the prop shaft and where it exits the hull via the aft end of the keel. Always study the plans that come with your cutting files or kit.*

ABOVE & BELOW: *Two views of the rudder tube and shaft where it exits the hull (top) and sits on the bearing in the heel (bottom) ; note that the top of the tube should be above the static waterline*

TOP: *View of the rudder shaft where it exits the hull; there will be a short tube to carry the shaft.*
BELOW: *Close up view of the rudder shaft with the webs needed to spread the loads in this area.*

ABOVE & BELOW : *View of the rudder in place - sorry about the spotty top photo!*

ABOVE & BELOW: *View of the hatches and forward pilot house windows,*

ABOVE & BELOW : *Two views of the hatch frames on place.*

LEFT: *Voyager 432 on its way to the paint shop.*

BELOW: *Another view of the Voyager 432*

BOTTOM: *Overview of cockpit and coaming area on the Voyager 432*

SPRAY 370 KIT

Read below: This is how it can be when you build from a KIT when the work goes so much faster and the results are to professional standards:

FIRST EMAIL: Spray 370 A ... I have finished cutting my kit using your cutting files; I would like to thank you for the time & effort you put into the nesting. I thought it would be good but I am amazed at the ease with which the machine just chugged along and the result with all the alignment marks and part numbers etched on, brilliant! The file modifications for the aft cabin roof and the etching for the walk thru all appeared on the plate. It really is good to deal with professional people. The construction of the hull is going smoothly. I cannot say how pleased I am with the result of your cutting files ! Thanks and Regards Bill Wigan Dubai

RECENT EMAIL: Finally some pictures of her sailing! I have had a few trips up and down the coast from Fujairah and as always she behaves well. I am lifting her out later this month for antifouling and I am using Cuprotect System as it is guaranteed 5 years and purported to be a 10 year plus treatment. I will let you know how I get on with that. She now has davits on the back with a Niccollslite NN10 nesting dinghy hanging from them. On long trips I can put the dinghy nested on the foredeck. The watermaker is on the way Ultra Whisper 600 from Sea Recovery.

ABOVE & FOLLOWING PAGES: *From the arrival of the cut kit through to the completed boat; these photos are mostly self explanitory and in cases where some explanation is required I will add appropiate text.*

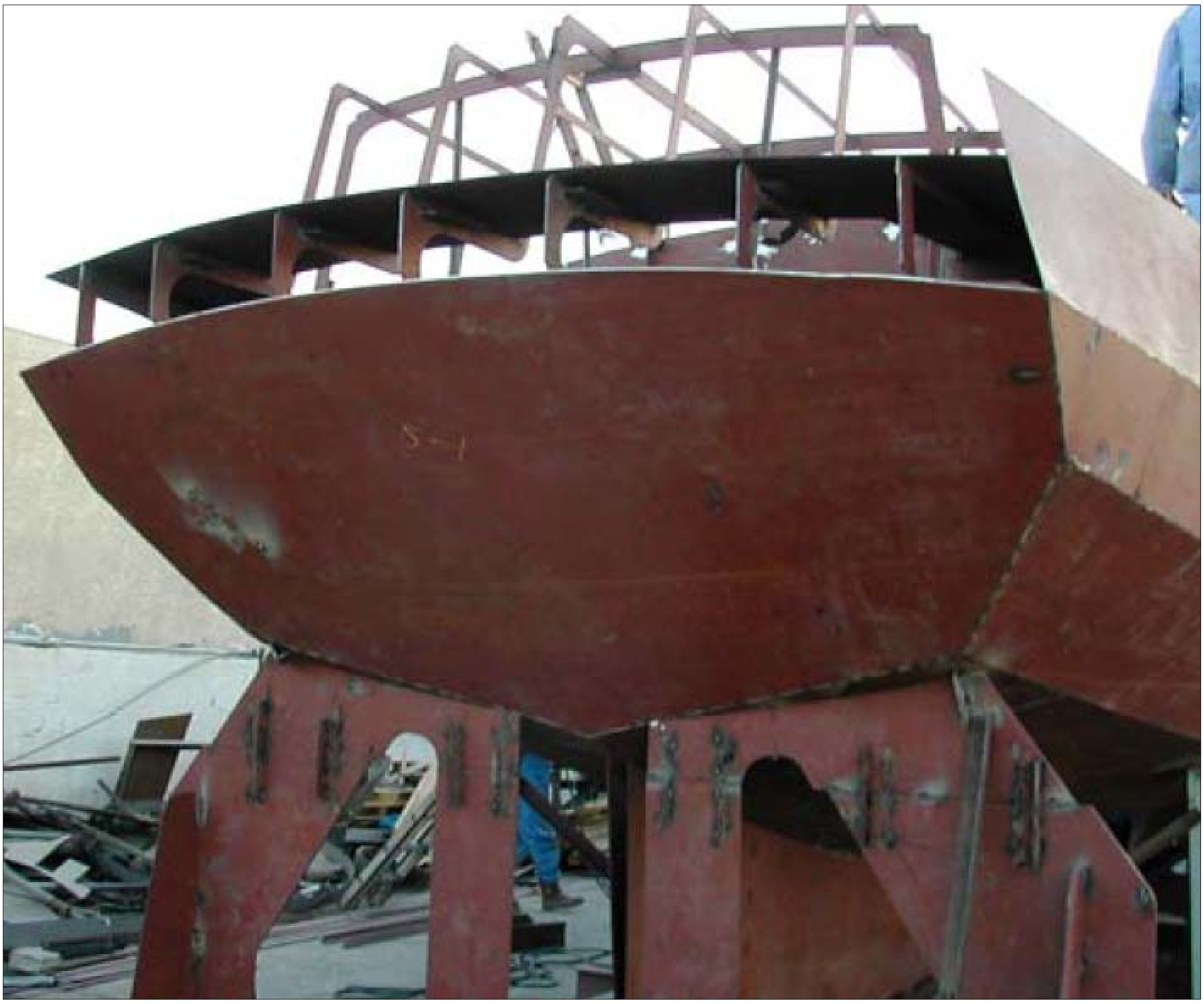
THIS PAGE:
Here we see the jig being erected on the strongback; next the stem and keel are assembled and erected on the jig.

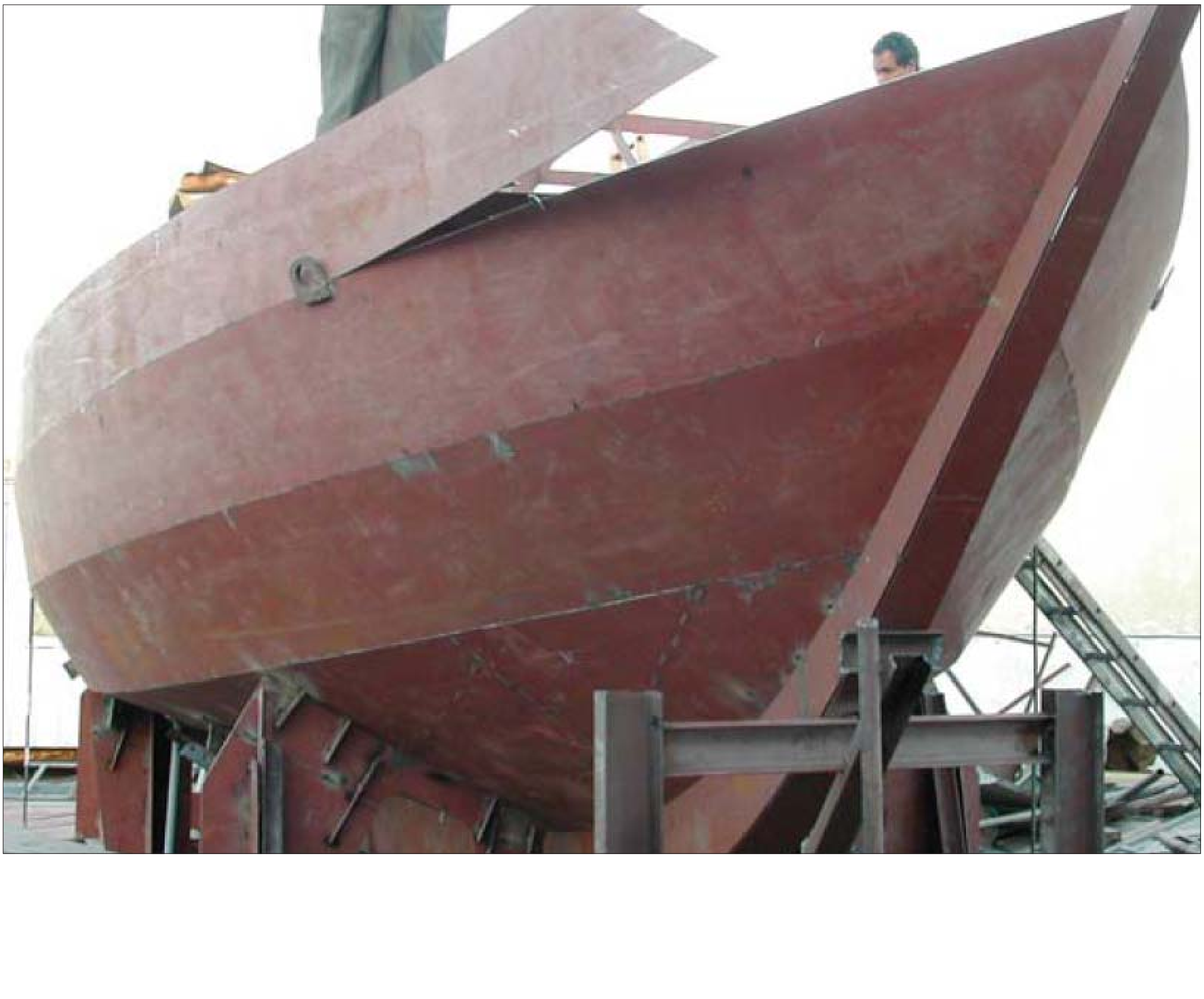



PREVIOUS PAGE: *Erecting the frames proceeds at a furious pace; everything fits first time!*
TOP: *You can make your own 'dogging' tools from the offcuts / scrap that compes with your kit.*
BOTTOM: *Note how snugly the plates fit to the stem.*

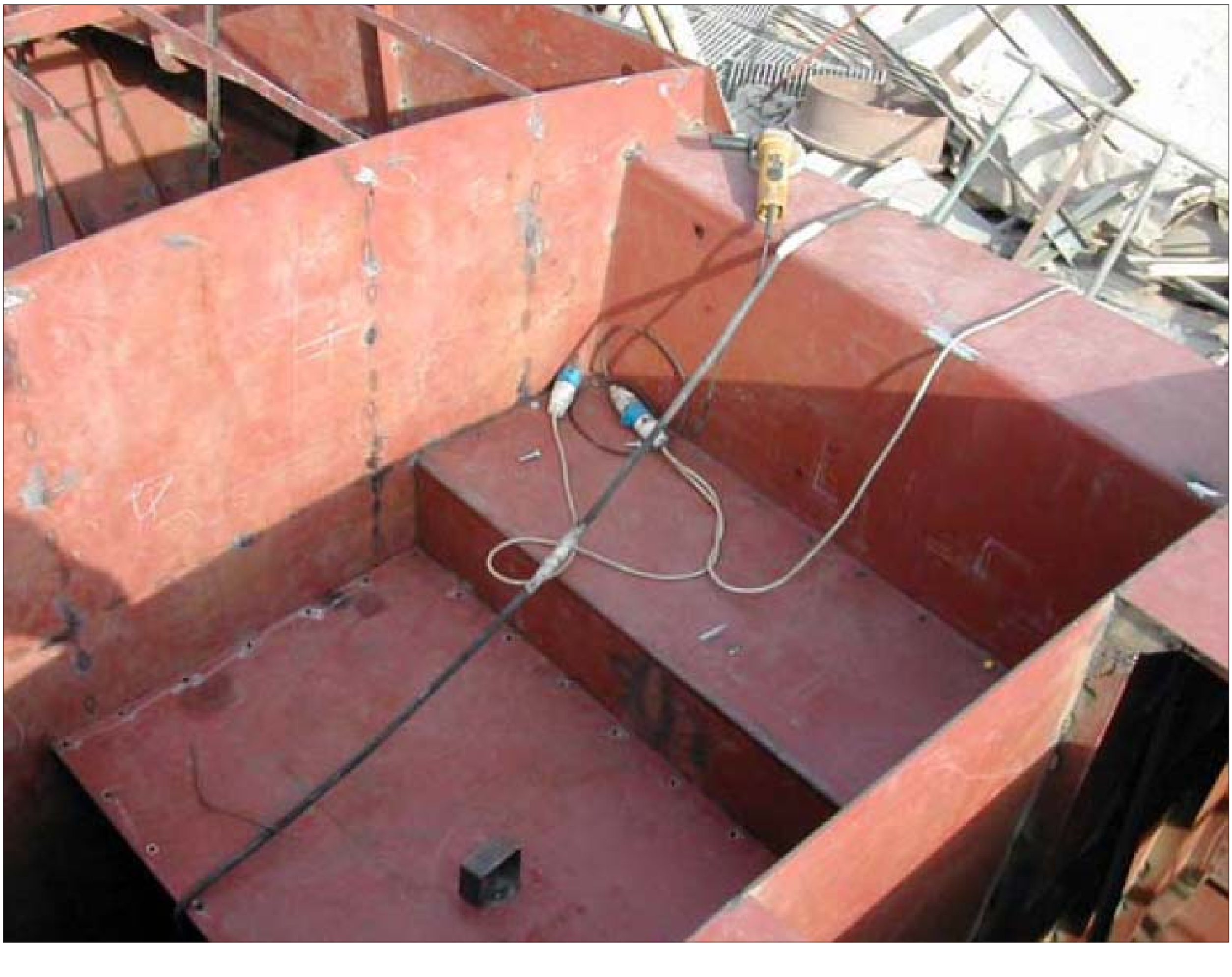
ABOVE AND PREVIOUS PAGE:

The tack welding the plates into position and the additon of fore and aft deck and cabin top stringers goes ahead quickly as everything is a perfect fit.





THIS PAGE:
The tack welding of the plates into position is now completed and the hull is ready to have the final welds run etc.



THIS PAGE:
Scrap lead can easily be converted into usable ballast. Make sure you take all the usual health and safety precautions - masks etc etc. Melting lead can be dangerious especially the fumes ! DO take care !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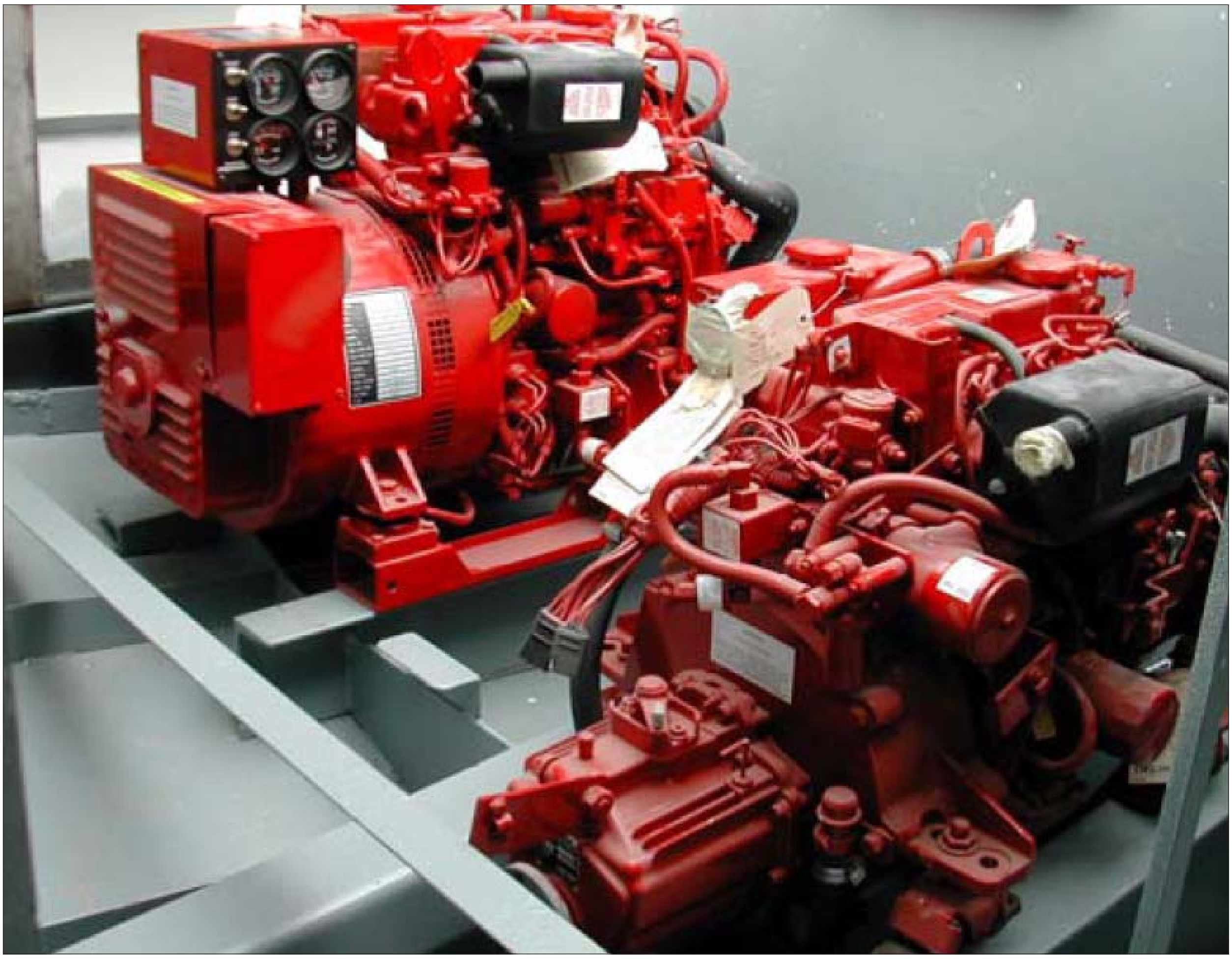

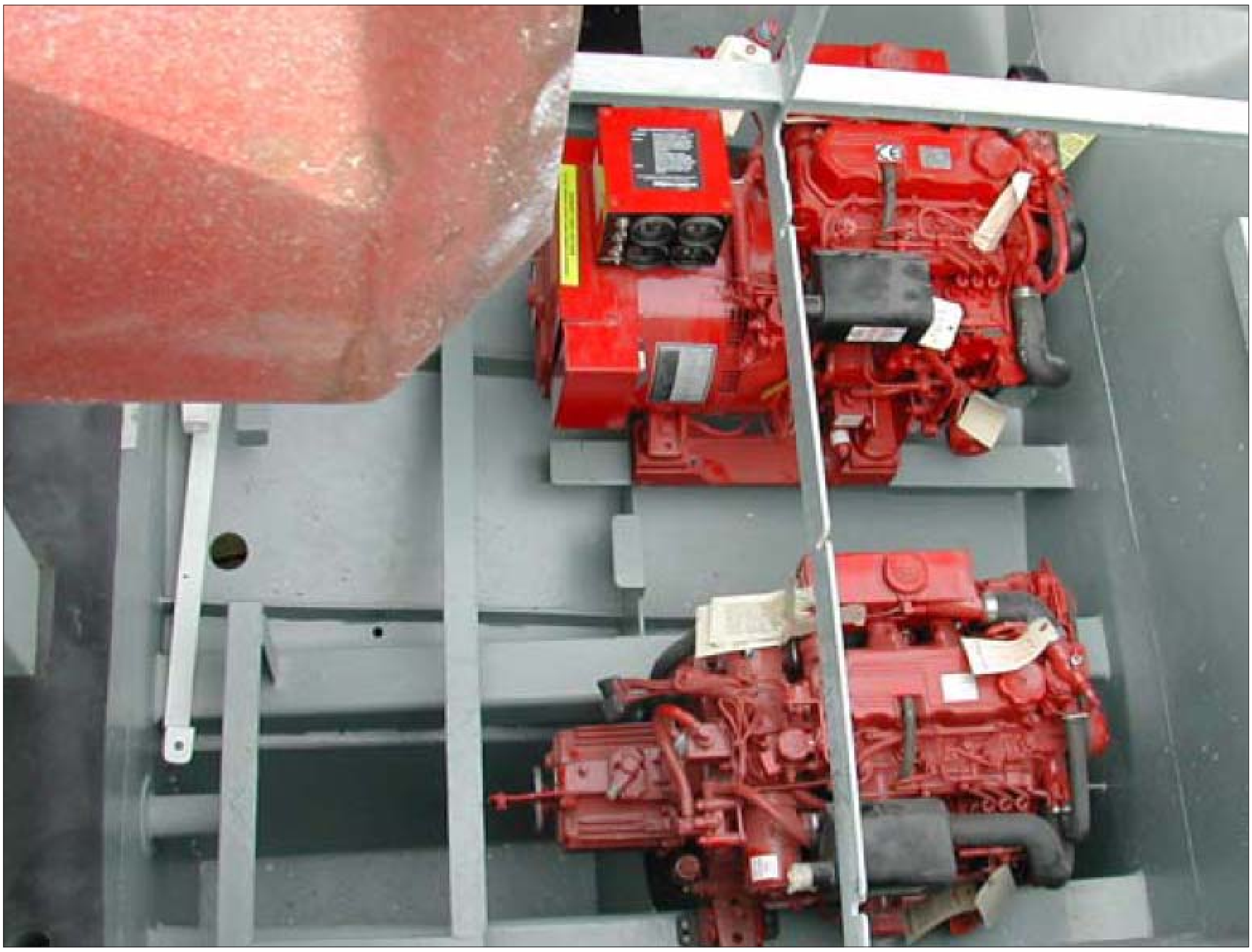

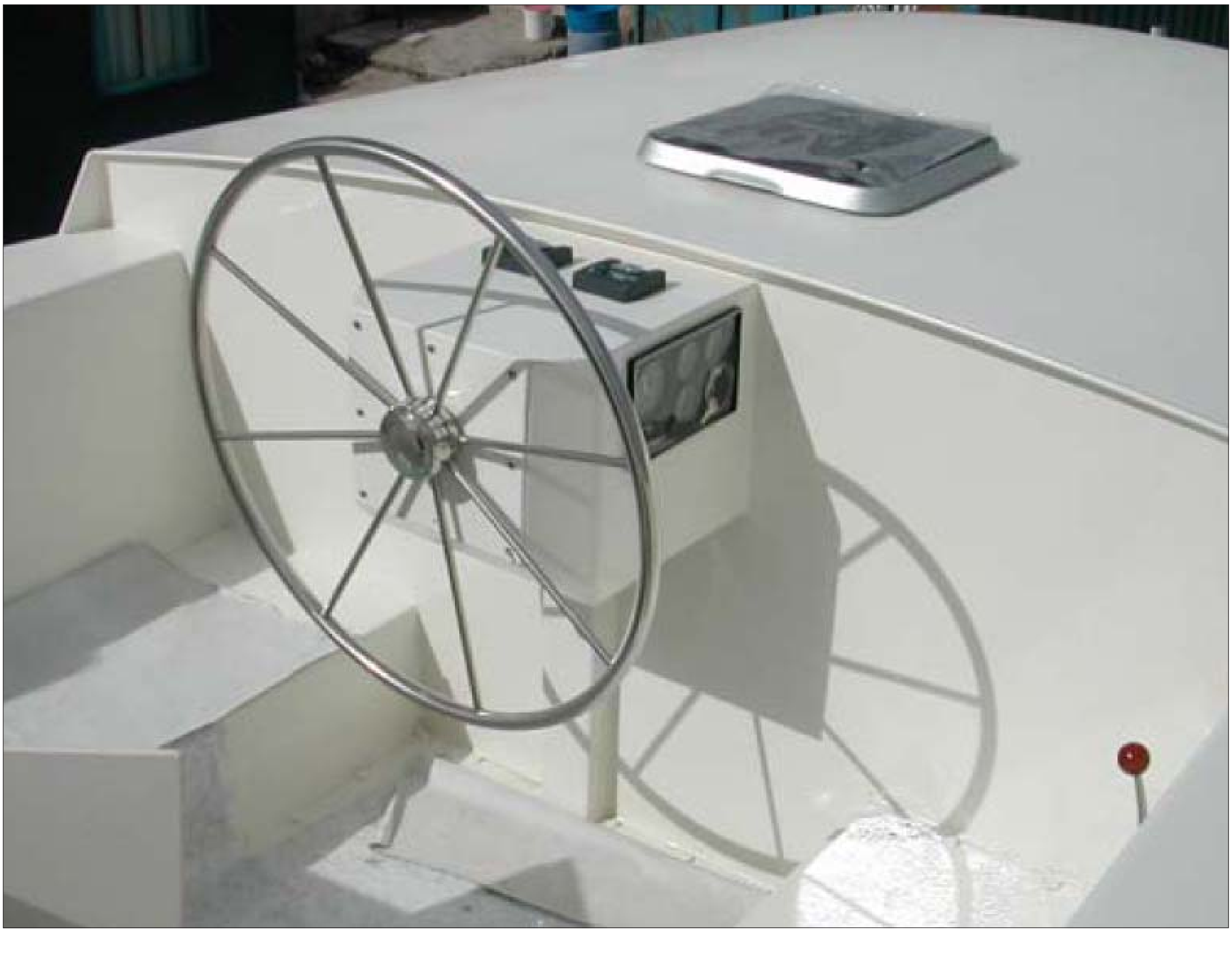

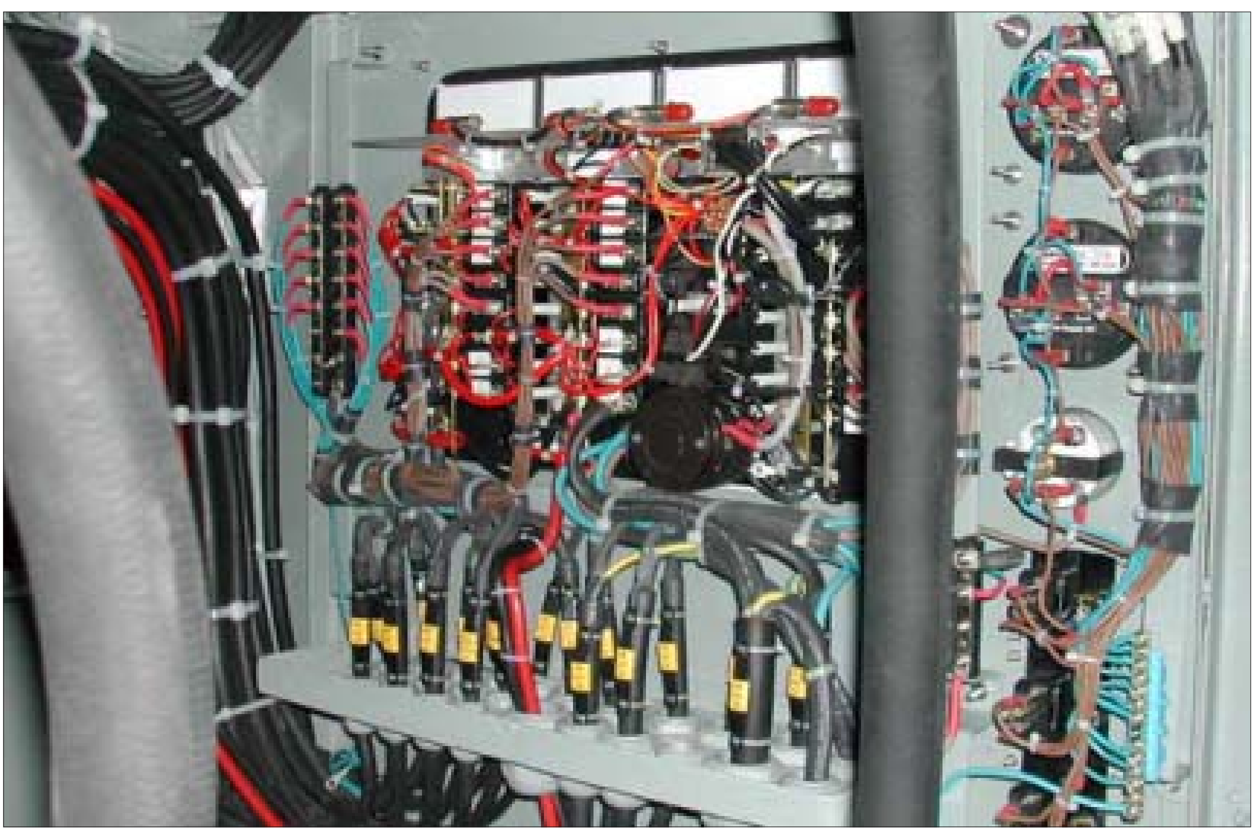

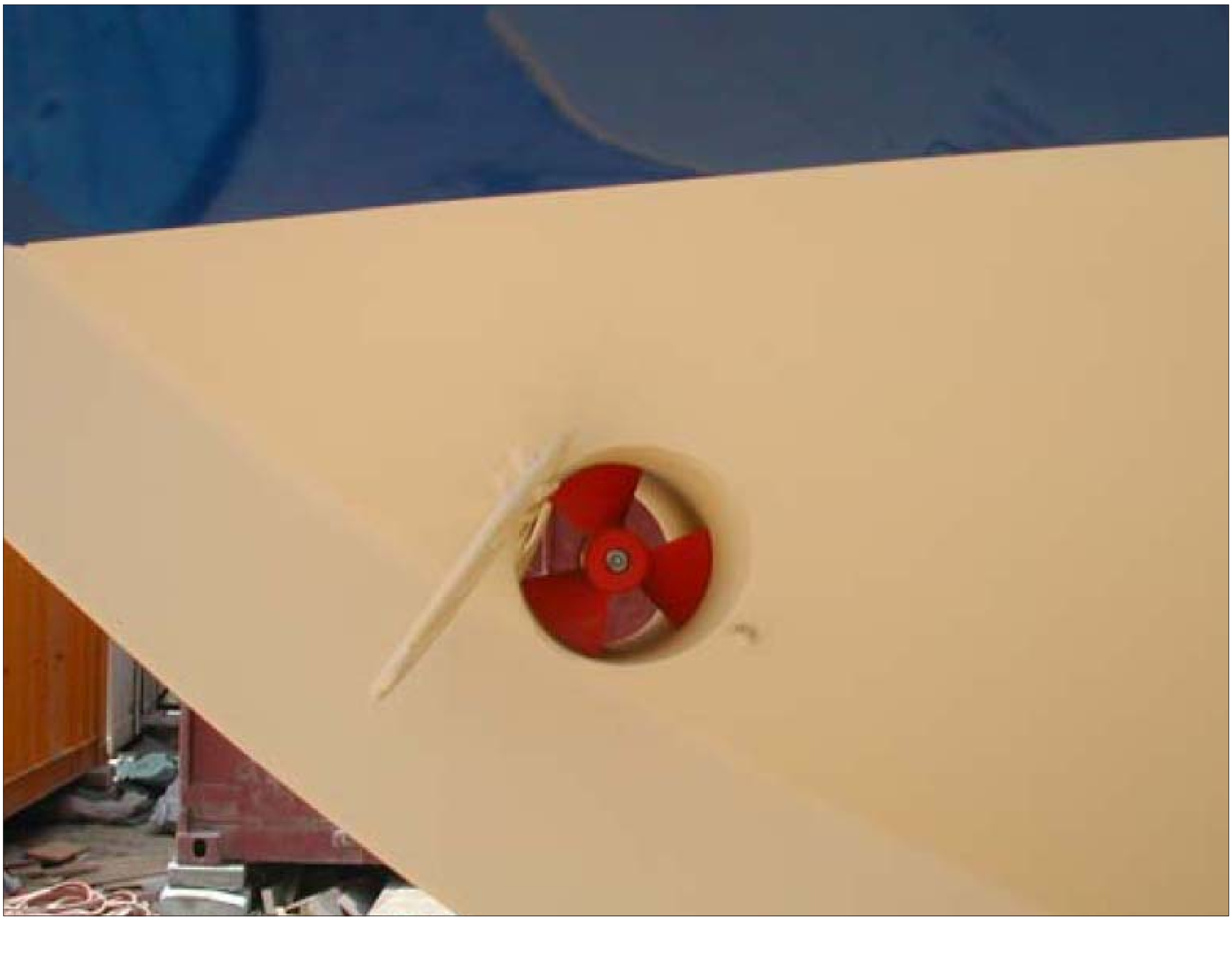


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ROWAN SPRAY

THE PLANS

To build a boat from scratch you need a set of suitable boat plans; hopefully you plans will include full-size patterns for the frames and stem. Below is a list of what our own design office supplies in this regard. With the advent of modern computer yacht design we have been able to offer the complete plans on CD. The benefit of receiving your plans and full-size patterns in this way is that you can have as many prints made of each sheet as you may need. For instance, if you are looking for quotes on either having the hull built or to puchase some piece of equipment or quotes for mast and sails, then all these suppliers will want to see the plans. You will find that having the ability to have the plans printed locally will offer many advantages during the building program. Also on the CD the designer can supply photos of similar boats under construction and other printed material that will assist you to better understand the plans and the boatbuilding process in hand. As most printed plans cover many large sheets of paper, it costs a considerable amount in postage (usually about $50 or £35) to deliver the plans and patterns from the designer to you. CDs can be mailed for a very modest cost.

Using the boat plans shown below and a collection of appropriate materials you can build a boat from scratch. You make the frames from the patterns supplied and then you make patterns for each subsequent part as you continue to build the boat.

As mentioned earlier, your plans can arrive either printed on paper or as printing files on a CD. You should receive the latest updated version of your selected boat plan, which is only possible when you order your plans direct from the designer. You will receive many construction sheets, which include copious written notes as well as the detailed drawings necessary to build all parts of your boat.

The following list is what we consider to be a complete set of plans and full-size patterns to enable you to build your boat with the minimum time spent in doubt as to how and what to do next!

- Sheet 1A (there may be several sheets covering various versions of the same design). These sheets cover the boat's general arrangement drawings, profile and plan views of the hull, deck, and superstructure, plus the deck plan. In the case of sailboats, the sail plan and measurements are usually included on these sheets.
- Sheet 1AA (there may be several sheets covering various versions of the same design). These sheets show the boat accommodation laid out and shown in plan and profile views. The several versions of the design are shown on separate sheets. Also included is a list for all the materials needed to build the hull, deck, and superstructure. In the case where the boat can be constructed of a variety of materials, these are

all listed to allow you to cost out the boat in each specified material.

- Sheet 2. The boat lines plan shows hull sections, profile including all water and buttock lines, and plan view including all water lines and buttock lines. All frame spacing, stern or transom detail, keel measurements, and rudder and skeg should all be included and all dimensions clearly shown.
- Sheet 3. This sheet will be a reduced drawing, representing what you can expect to see when you lay out the full-size boat hull patterns. We call this sheet the key to full-size patterns; it acts as a key when arranging the hull patterns and will enable you to readily understand just what the patterns contain. This sheet will help you resist the temptation of trying to lay out the patterns on your living room floor before you are actually ready to start construction.
- Sheet 4. This sheet shows you how to manufacture and assemble the frames, plus form up the stem and other parts of the basic framework. It also shows how to set up all these items on a strong back or a system of bedlogs, which forms the shape of your hull.
- Sheet 5. This sheet shows the installation of the stringers and deck shelf plus the installation of the plating in metal boats. In the case of radius-chine boats, additional information is supplied on installing these plates. Assuming you are building upside down, this sheet will show the turning-over process.
- Sheet 6. Now the boat is upright and this sheet covers the inside of the hull, and shows the installation of the floor webs, bulkheads, engine beds, and all interior stiffeners for your boat.
- Sheet 7. This sheet may show detail of the various items not covered in sheet 6. Often it takes two or more sheets to cover webs and bulkheads.
- Sheet 8. This is the engineering sheet that covers the engine installation, locating and building the fuel and water tanks, and making the rudder. Also included are details on making the stern and rudder tubes plus propeller shaft detail. Stanchions, swim platforms, and similar items may also be on this sheet.
- You may note that much of the above work can be completed before the deck and superstructure are in place. It is far easier to install the heavier items such as the engine and fuel tanks before the "top" goes on. Individual builders will have a preference in this regard.
- Sheet 9. This sheet shows details the forming and installation of deck beams, side decks, foredeck, aft deck, cockpit construction and all deck framing detail of your boat design.
- Sheet 10. This sheet shows the patterning and making of the cabin sides, cabin front, etc. In the case of the cabin sides the measurements should be adequate to enable you to make up a plywood pattern and trial fit before cutting the actual cabinside plates.
- Sheet 11. This sheet covers such items as deck fittings, additional rudder construction, etc.
- A detail folio showing how to build some boat fittings and tools plus other valuable boat construction tips is included with all plans. When the plans are ordered on CD it is often possible to include numerous photos showing a sample boat under construction and examples of completed versions.
- Sheets A, B, C, D, E, F, G, and H are the full-size boat hull frame pattern sheets that are laid together like wallpaper. The full-size patterns contain details of all frame shapes, stem, deck and cabintop cambers, and the pattern for the expanded transom. Patterns are either paper or computer files (if you have plans supplied on CD), which can be printed out by your local print shop.

This is a good time to mention that the professional who designed your boat may have spent many hours over some small detail believing that it will have an important bearing on the performance, appearance, or resale value of your boat. Respect his or her efforts, and please don't make changes casually without consulting the designer.

Making and erecting the frames is one of the most exciting parts of building any boat. Having built a few boats myself, I know the thrill of seeing the frames erected for the first time, and of standing back and admiring the line of the hull. Of course, the addition of the chine bars (if present) and a few stringers gives a better idea of the shape of the hull, but the initial thrill of seeing the frames erected is still a most memorable occasion.

MATERIAL LISTS

You will get a better price if you order in bulk, so we recommend that you order all the basic hull materials in one combined package. Your building plans may include a material lists and, if so, it usually consists of the main items required for building the hull, deck, and superstructure. On some occasions, if you calculate the total weight of the metals, you may find that there appears to be too much material. Your list should include an allowance for offcuts and other wastage. The list may also include details of the temporary bracing required to set up the hull.

Even if your plans include a materials list (including the lists included in our plans), go through the drawings carefully and "take off" the list for yourself. Don't forget to allow for wastage; 15 to 20 percent is about right. Some of this wastage material will be used to make tools, including clamps and tags. The time required calculating the quantities will be a good investment, and it will prove invaluable in your better understanding of the plans. "One hour of study can save two hours of work" is an oft-quoted truism.

Most lists do not include the materials required for the interior joinery. In some cases, this list isn't included because there may be several alternative accommodation plans. It's better to compile a timber and plywood list after you've made a definite decision as to which interior you will finally select for your boat.

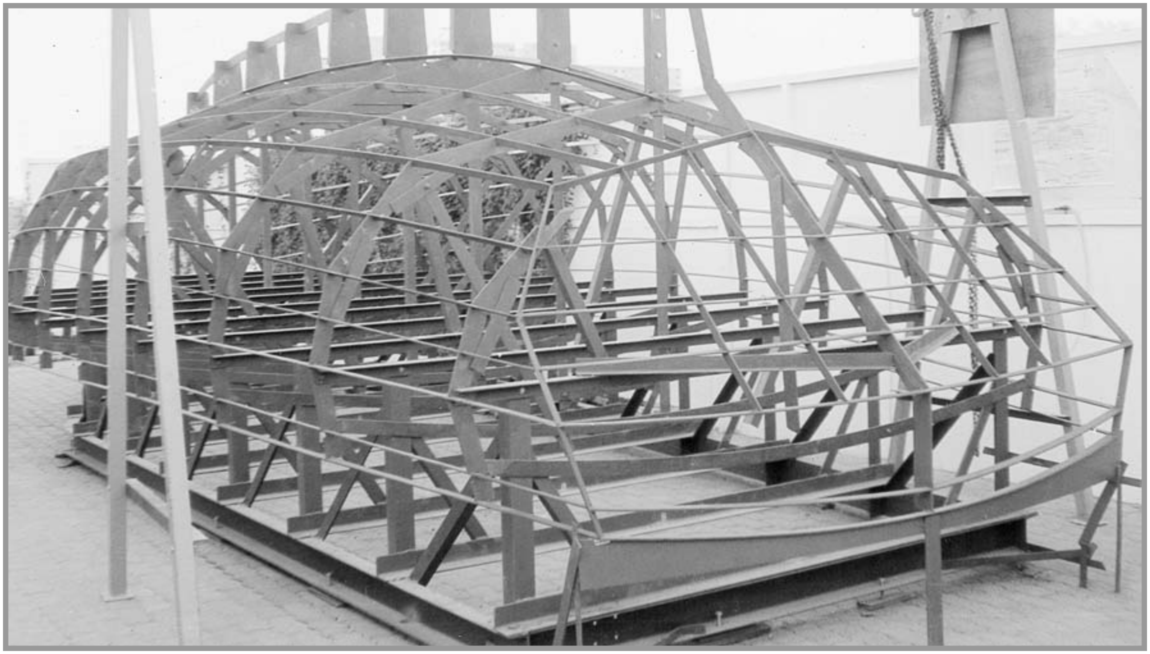
BUILDING UPRIGHT OR INVERTED?

The shape of the boat, the metal being used to construct the hull, and the particular building method you choose may all contribute to your decision to build the hull upright or inverted. Another factor could be the space and facilities available for turning the hull. There are many simple systems for turning hulls over, so this factor shouldn't play too big a part in your reaching a decision. You could decide to build two or more rings around your hull, thus facilitating working on the hull and other areas of your boat.

Advocates of the upside-down method like it because most of the important hull welding can be done in the down-hand position. In any case, some of the welding must be done from inside the hull, including tacking the intermediate stringers to the hull plating. Unfortunately, this may be a bit awkward, but at least some of this welding will have to be done while the hull is still inverted. Leaving the transom off the hull until after turnover will be of some help in gaining access to the interior of the hull. There is some justification for not installing the transom until immediately before the deck is installed.

In the case of radius-chine construction, I consider it imperative that the hull be built upside down. Building inverted makes it easier to install the radius plating. In our opinion, it's much simpler to lay the plate onto the framework from above than it is to draw or hold the plating from below until it is tacked in place. At the risk of repetition, you must always build radius-chine hulls upside down. Our preference for building upside down extends to round-bilge hulls as well.

To be fair to those who prefer to build the hull upright, the stated advantages of this method include the fact that the hull is already in a position to complete the deck superstructure. In other words, it doesn't have to be turned over. Building the hull upright offers easy access during the entire welding operation. You can overcome some of the disadvantages of not being able to lay the plate on by employing the use of adequate



The framing shown here is one of several methods used to set up a hull that is built upside down. This Spray 33 was built by John and Joan McDermott in Oman, Arabia, from where they set sail around the world.

scaffolding. There are also many tricks, such as drilling a hole in the plating and pulling it into position with chains, wedges, and threaded bolts. As mentioned earlier, whether you build upright or upside down will largely depend on your circumstances and personal preference.

USING FULL-SIZE PATTERNS

The only people who decry the use of full-size patterns are those who either don't have access to them or those with masochistic tendencies. Under no circumstances try to "improve" on the patterns by using the offsets (if available) to re-loft the boat completely. Today, most boats are designed, drafted, lofted, and provided with full-size patterns plotted from computer-generated offsets. You can't improve on that, even by completely re-lofting the boat by hand.

The patterns you receive will most likely contain full-size shapes for all the frames for one side. This is all you'll need unless you are building an asymmetrical hull. In addition to the frames, other full-size shapes may include the stem, the developed transom (the full-size transom shape when the curved transom is laid out flat—the radius will be included in the plan details); and the deck and cabintop beam cambers. Also, patterns may be included for the rudder, window patterns, and other items. These extra patterns are included when the designer feels that they will ensure that you interpret his ideas as intended. If possible, use these patterns. Usually any "improvement" in the designer's work will result in a less attractive boat.

Paper patterns are quite satisfactory, provided they are handled properly. These patterns should not be exposed to a damp atmosphere before being transferred to a more durable surface. If your plans come with paper patterns, don't open or unroll the patterns until you're ready to start building the boat. The patterns that come with our plans arrive in a plastic bag, which ensures they remain as printed until you are ready to lay out the patterns and make the frames.

You'll need a suitable surface on which to lay out the patterns. You can work either directly from the patterns (not recommended) or you can transfer them to plywood or steel plate. This working area is variously known as the loft floor, the master plate, or any one of a dozen other locally inspired names. If you are transferring the frame shapes and other patterns to plywood, you can use a dressmaker's wheel to mark the shapes through the patterns onto the surface of the plywood. This plywood could be later used in the fitting-out process, so it won't represent an additional expense. If you're transferring to steel plate, you'll need to center-punch the main points onto the steel plate and use a batten and straightedge to scribe in the shapes of the frames. In the case of shaped frames and the stem, you'll need to center-punch several points along the curve and then join the marks with the aid of a batten and the drafting weights known as "ducks." We find the plywood surface has many advantages.

The advice above applies to multichine sailboats, single-chine powerboats, and round-bilge boats of all types. In the case of radius-chine hulls, you'll don't need to transfer the radius sections from the patterns; transfer only the straight sections. You should have the radius-frame parts bent to the radius specified on your plans, and the length (as measured around each radius) that will be needed to match up to the straight sections of the frames. Allow a little extra for trimming.

LOFTING

If the plans for the boat of your choice are not available with full-size patterns, you'll need to arrange for the hull to be lofted by computer or by hand. To enable the hull to be lofted by computer, you'll need to supply the lines and offsets to be entered, faired, and then plotted as full-size patterns. Computer-lofting is available from several design offices, including ours.

Lofting by hand involves actually drawing out the entire hull of the boat full size. Don't be trapped into drawing only the frames or stations, without actually drawing out the complete boat full size; this means you will need a lofting floor equal in size to the length and and width of the half beam of your boat. You must plot out all station and waterline grid lines plus the full-size profile. The offsets are used to lay out the curved waterlines and buttock lines. You need to take great care to ensure that the frame or station measurements are correct so when you take off the full-size frame patterns and other parts, including the stem, the patterns will be totally accurate. This is not a job for the inexperianced builder. Either choose a plan with full-size patterns or have the lines professionally computer-lofted. If you do decide to tackle the lofting yourself you will need a loft floor that can consist of several sheets of plywood. The sheets are laid out to form an area of say 3 feet (1 m) longer than the overall length of the boat, or longer by half the beam if you plan to develop the transom. You should paint your loft floor with flat white paint; this will enable you to see the grid and other lines more clearly.

You'll need at least one long timber batten of about ¾ by ½ inch (20 by 12 mm). You'll also need some smaller battens, a builder's square, string or chalk line, and a set of loftsman's drafting weights (ducks), plus suitable pencils. The information included here is very basic and if you haven't lofted a boat before, you'll need a good book containing detailed instructions.

MAKING THE FRAMES

It's usual to assemble the frames over patterns that have been lofted by the builder or supplied with the plans. As mentioned earlier, you may prefer to use a plywood or steel area for this purpose. Make sure the area is level and that it will provide a firm base on which to assemble the frames.

A boat has two basic types of framing: transverse framing, generally referred to as the *frames*, and longitudinal framing, usually known as the *stringers*, which also includes chine bars, deck stringers, and the like. Here we are discussing the frames.

In metal boats, transverse-framing material may be flat bar, L-angle or T-bar. Your plans will most likely stipulate which is appropriate. For many years, flat-bar frames have been favored in steel boats. Many designers have given this advice. The reason usually quoted is that L-angle is hard to protect from corrosion, and that the angled portion adds unnecessary weight. More recently, however, we have considered angle in a more favorable light.

Against the above objections, an argument can be made for angle. The flange will provide an excellent place to attach the lining material. Corrosion problems can be overcome by using prime-coated materials and sprayed-in foam insulation, which is now common practice in metal boat hulls. Regarding the extra weight of angle, I believe that this is not a problem in larger and heavier displacement boats. All that has been said about angle can also be applied to T-bar frames. Aluminum boats will have transverse frames made of angle, T-bar, or a proprietary extrusion that has some type of bulb or flange.

Some builders may prefer to have the deck beams included as part of the original frame construction. If you prefer this arrangement, you'll find it's best used when you're building upright. Also, including the beams at this stage may interfere with the installation of the larger and heavier items (such as the engine, etc.) in the hull at a later stage of the construction. If you are building the hull inverted you will find that the deck beams interfere with access under the boat. My experience is that the deck beams are best installed after the hull is fully plated and already turned upright and the heavier items are already installed in the hull. It is easier to check for a fair sheerline before installing the beams. In some cases—for instance, if your boat has a bulwark—this last objection may not apply, To summarize, if you're building upright, then you may consider installing the deck beams as part of the original frame, but if you're building inverted, don't install the beams until after the hull is upright and preferably with the engine, etc., already placed inside the hull.

After you have established how many frames you'll need, and which material you'll be using—L-angle, flat bar or T-bar, it's now time to start cutting the correct lengths of material to form each frame. An angle grinder fitted with a suitable wheel can be used for cutting the frame material to the correct length and angle. Some builders prefer to use their oxyacetylene equipment for making these cuts, and no doubt you have your own preference. Cuts made with the angle grinder are more accurate and will be preferred by many builders. A neat trick is to make up strips of cardboard as templates for the angle joins on the frames. Use cardboard that is the same width as your frame material. Lay two cardboard strips directly over the joint on your patterns, ensuring that there is sufficient overlap to allow you to cut through both layers of cardboard using a straightedge that bisects the angle. You have now created a pattern that forms the angle required for both parts of the framing material. Transfer these angles to your lengths of framing material and now you can neatly cut each angle to provide the basis for a perfect join. You may prefer to use a carpenter's bevel-gauge or a plastic protractor to obtain the correct angles. You can always clean up your angles by using the grinder, but it's preferable to make the correct cuts in the first place.

Next, tack-weld the frames together. After checking against the patterns, make the final welds. It's worth noting that a very small incorrect angle at the chine can become a large error at the sheer or keel. The frames may be made up in two halves, or one half on top of another, and then opened up like a clamshell to form the frame. You must carefully check the fully assembled and welded frames against the patterns and one half against the other. Accuracy is vital at this stage. It's not a good idea to tack the various parts of the frame to the steel master plate or loft plate. Frames assembled in this manner can have built-in tension that will cause them to change shape when released from the loft-plate floor.

A good way to avoid distortion is to follow the same sequence for assembling each frame. For instance, place a tack-weld at the center of each angle joint and let it cool for a few seconds before tacking either ends of the angle. Several frame sections can be done in sequence, ensuring that minimum time is lost through waiting for welds to cool, before proceeding to the next step in the assembly process. The object is to keep the job moving forward, without setting up stresses in the frames, and avoiding unnecessary delays in the work schedule.

Once you've tacked the frame together, you should be able to move it about and check the accuracy against the master patterns that have been scribed on the metal or plywood loft floor. When one side of the frame is tacked together, you should turn it over and tack the other side. Again, check the accuracy against the master patterns.

You'll be installing some form of headstock across the frame. This headstock may be used to support the frame on the strongback or bedlogs (see below). Make sure you install other bracing between the headstock and the sides and bottom of the frame, otherwise it will be too flexible and impossible to set in position on the strongback.

Mark all of the important reference points on all frames. Include such points as the load or datum waterline (LWL or DWL), the sheerline, the deck line (if this is below the sheer), and any other points indicated on your full-size patterns. Finally, please follow the designer's specifications for making your frames; never overlap the ends of the frame bar where they join, in the misguided belief that you're making the boat stronger. Overlapped metal can harbor moisture and promote corrosion. It also adds unnecessary weight and looks unsightly, as well as giving your boat an amateurish appearance. On the same theme, don't add extra reinforcing plates or permanent gussets at the frame joints; these items were necessary for frames in wooden boats but add extra unnecessary weight in a metal hull.

There are several ways to make the various cuts in the frame to accept the stringers, deck shelf, and sheer stringer. One method is to divide each area between the chines into equal spaces and, using a square, mark in a notch for each stringer. These notches may then be cut while the frame is still on the loft floor. If you prefer this method, it may be better to cut the notches before tacking the frame together; cutting the notches will probably distort the frame part, so this is best corrected before you assemble the frame.

We recommend standing up the frames and then marking in all of the stringer locations on the frames, using a batten to simulate the fair curve of each stringer. The next step is to take the frames down and cut the slots. Finally, check each frame for accuracy before reinstalling it in its correct location. This method is time-consuming but it does ensure that you get a fair set of stringer notches and, in turn, a fair set of stringers. This method also makes sure that the final frame is still the shape intended by the designer, and in due course it will contribute to building an attractive and fair hull.

Drainage

This is a good time to think about drainage inside your hull. When the hull is in its correct position, there will be low points on the stringers. Careful observation will enable you to locate them at this stage. This is the area where moisture can collect inside the hull and cause rust.

If you're intending to install foam insulation, especially the sprayed-in variety, you won't have this problem because the foam should come at least to the inner edge of the stringers. The foam will provide a flush surface and leave nowhere for moisture to collect. In foam-insulated boats, any condensation that does occur will drain into the bilge. As your boat will need insulation, this is the obvious answer to a known problem.

If you're going to install preformed insulation, instead of the sprayed-in variety, you may wish to grind small semicircular holes in the low point of the stringers. Arrange them so they leave a drain hole between the stringer and the hull plating.

Some frames, too, will require limber (drainage) holes, but there's no point in cutting limber holes in the areas of the frame or keel webs where the hole will be later filled with ballast. The forward and the aft frames will need limber holes to allow water to flow to the lowest point. Check our plans and give some thought to this drainage situation.

Radius-Chine Frames

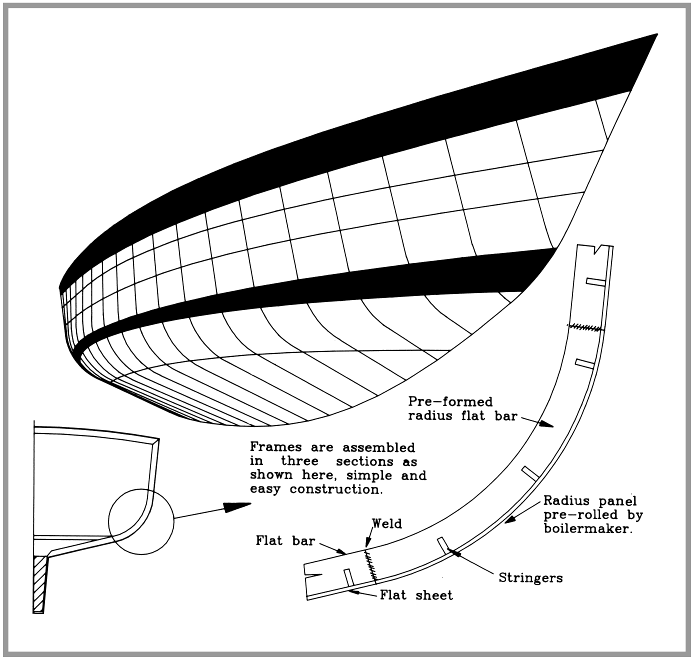
Do not confuse this type of hull with one that simply has pipe chines. True radius-chine hulls have a radius of between 24 and 36 inches (600 and 900 mm). The radius-chine hull has many benefits, including all of those attributed to a round-bilge metal hull. The fact is that the radius-chine hull is one of the easiest hull forms to build in metal. This ease of construction applies from making the frames right through to the final plating.

All true radius-chine hulls are designed, faired, and lofted in the computer, so you'll have accurate full-size patterns. Naturally, it's most important to have accurate patterns from which to make your frames, and computer lofting is the best way to achieve this end. As the radius sections are all of the same radius, it's only the amount of arc around the curve that will vary. This means that you won't need to transfer all of the radius curves to your loft floor. Transfer only the straight frame sections. Make sure that the ends of these lines are clearly defined. Use a check mark to give a clear definition to the ends. Next, simply cut the straight lengths of framing and place them in position. Now, cut the exact lengths of curved frame material that have been prebent to the correct radius.

You can either bend the radius-frame material yourself, or have it bent by an outside metal shop. Assuming that you farm out this work, we recommend that you have the radius-frame sections, stem bar, and lengths of plate all bent to the correct radius section at the same time (see Radius-Chine Hulls in Chapter 8, Plating Your Hull). The remainder of the techniques used for assembling the frames of your radius-chine hull are virtually the same as those used for the other hull forms.

Frames for "Frameless" Hulls

If you're building a "frameless" boat, that is, a hull with only a few frames, or one that has no transverse frames, then you may use angle frames as a mold, and these will not remain in the boat. When you're building the "mold" for a frameless boat, you may find it possible to eliminate every second frame when setting up the shape of the hull. When the designer prepares computer-designed lines, it's usual to have only four to six con-



At last it is possible to build a round-bilge steel boat without the great amount of time and effort (not to mention experience) that used to be required for traditional methods. Radius-chine building techniques are developed through computer fairing, which provides you with full-size patterns of all the frames, a full-size stem, and a full-size expanded transom. The secret of the radius-chine technique lies in fairing the radius through to the bow. Most other attempts at this type of hull form have tried to fade out the chine before it reaches the bow. This usually results in a flat spot, or unfair area, up forward. Previous methods have been, and still are, more difficult to build than the multichine method. Our radius-chine boats are very easy to build because of the exact way we develop these hulls on our in-house computer programs. The full-size patterns are plotted on Mylar film.

On smaller frameless designs like this one, it may be simpler for the less-experienced steelworker to build a frame from timber.

trol sections (similar to frames) and the remainder of the hull is faired through these sections. Most light-to-medium-displacement steel-chine hulls (not radius-chine) under, say, 40 feet (12.19 m), are suitable for building with the frameless technique. Contact the designer of your boat if you're interested in using this method. Ask if some frames may be eliminated, either in the finished boat or in the setting-up mold. Some frameless hulls are built over a timber framework; this may be helpful if you're building a metal hull under 35 feet (10.66 m) and have limited metalworking experience. You could build the timber framework yourself, and then hire an experienced welder to weld up the hull.

PREPARING TO BUILD

Stem, Backbone, and Keel

You'll find that metal boats use many different sections for building the stem. Some boats feature a stem that is a flat bar on edge. This, in fact, is the material specified for many of our sailboat designs. Other designers favor solid round bar, round or rectangular tube, or rolled plate. In some sailboats and many powerboat designs, we favor stems that incorporate a rolled plate above the top chine. Your homemade bending machine will come into use for bending the flat-bar stem if part or all or the stem is to be formed from this material. As mentioned above some stems may include a conical section of rolled plate.

The aft section of the backbone may be installed on-edge without your having to form it in a bending device. Some stems, such as those used in the Spray designs, may be constructed using a box section of similar construction to that used to fabricate the keel. You'll need to make plywood or hardboard patterns for the sides of the box stem, and trial-fit them before cutting any metal.

The leading edge of the keel will be flat bar, split pipe, full pipe, or rolled plate. Flat-bar leading edges for the keel are only satisfactory for very small powerboats. In most cases, a rounded leading edge—similar to the leading edge of an aircraft wing—will not only be stronger and less liable to damage, but will also offer a better passage through the water for the keel. The aft end of the keel is usually formed of flat bar on edge.

Bedlogs and Strongbacks

For hulls built upside down, your plans should include details of preparing the base needed to set up the hull frames. This base can have one of several names including bedlog or strongback. In our plans, a set of bedlogs consists of a framework of suitably sized timber or steel I beams placed on a prepared surface. The surface can be concrete, packed earth, or other similar base. If a packed-earth floor is used, you'd be wise to install strategically placed concrete pads capable of supporting the bedlogs and the completed hull. You're building a foundation, albeit a temporary one, and it has to support the hull until it is plated. In the case of a hull built upright, the strongback or setting-up bedlogs will be required to remain true until the boat is completed.

The strongback is a framework that's usually about 3 feet (910 mm) off the ground or floor. It's used to support frames on a hull being built upside down. The idea of the strongback is to have the inverted hull set up far enough above the floor so the builder could easily climb underneath the hull to undertake the necessary tack-welding of the stringers to the inner hull plating before the turn-over stage. More recently, however, we've found it easier to simply extend the frames to a common headstock or upper baseline. Using this method, we ensure that the hull will be far enough off the floor to clear the stem, and allow a welder to have easy access to the interior of the hull. In all setting-up methods, a wire stretched tightly down the centerline will be an essential part of the procedure.

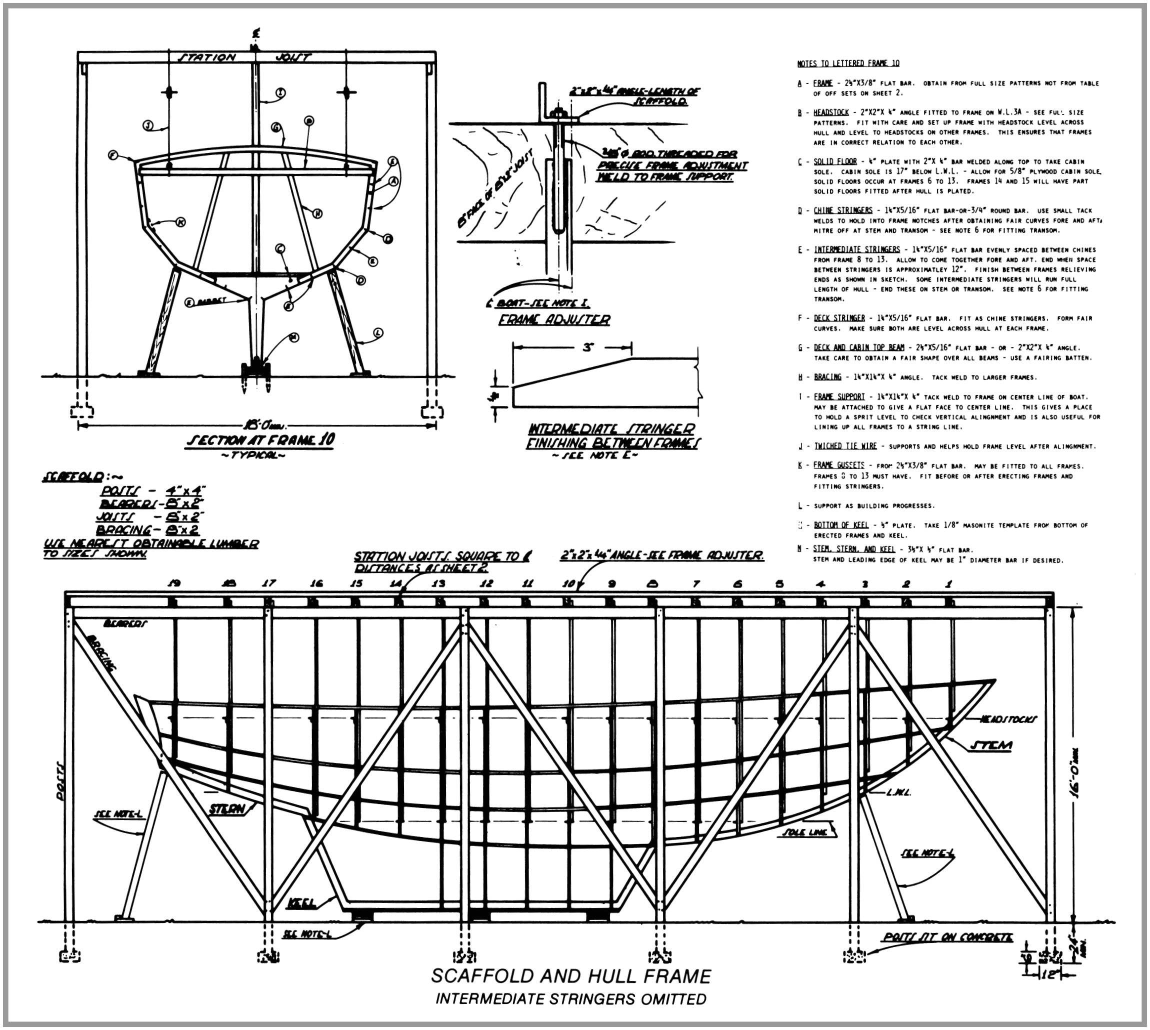
Gantry

You may consider installing a gantry that can be used to erect the frames and assist in installing the plating. If you're assembling your hull inside a commercial building, you may be fortunate in having an overhead gantry already available; otherwise you'll have to arrange your own. The track will consist of a pair of channel rails made from some U-section steel that run full-length each side of the hull. Two sets of A-frames set to run on wheels in the channel and an I beam rigged with one or more chain blocks, chain falls, or a chain hoist (all the same device), will complete the arrangement. An even simpler gantry is a tripod with an attachment point for a chain hoist. You can use it to lift the plates and other large metal sections.

Building Upright

Professional builders have many methods of setting up the frames, transom, and stem, to build a metal hull upright. These methods, while suitable for the professional, could in some cases cause problems for less experienced builders. For instance, they could allow errors to creep in, resulting in a twisted or otherwise less-than-fair hull structure. It's the responsibility of the designer, especially when dealing with a less-experienced builder, to ensure that the method of setting up the hull is well detailed in the plans. This will make things easier for the first-time builder who otherwise may be unsure of how to proceed. Experienced welders, metalworkers, and fitters who had no previous boatbuilding experience

An overhead gantry set on rails can make the handling of plate a much easier and safer operation.



Typical section of plans, illustrating one of several ways used to build a hull upright.

have built many fine metal boats but even they need some guidance when setting up the hull; so no matter how much welding knowledge you have please take care in these first steps of your boatbuilding project.

For the less-experienced builder, the secret is to have a well-prepared building frame, strongback, or similar arrangement to allow the frames to be set up in their correct locations and to avoid errors. One method we have used is to build a framework for a shed-like structure, and support the frames from overhead rafters. Another way is to build a set of bedlogs and use pipe supports to hold the frames in position until the keel, stringers, chine bars, and stem are installed. With a hull built upright, once the keel is plated the structure can be more or less self-supporting, with the weight mostly on the keel. Additional supports should be installed under the ends and sides of the hull to avoid sagging during construction.

Building Inverted

By now you will have constructed and assembled all of the elements of the framework. Now you can start to install the frames on the strongback or bedlogs. A tensioned wire marks the centerline of the building jig. This wire will remain in position until the hull is turned upright.

You'll need a carpenter's rule, a steel measuring tape (at least as long as your boat), a plumb bob, a large carpenter's square, a spirit level about 3 feet (1 m) long, and a line spirit level. Each frame must be square off the strongback, and must be parallel with its neighbor. Use the plumb bob to ensure the frame is vertical.

After you've marked out the strongback or bedlogs with the correct station spacing, you can start with station 5 or the midsection frame (the same frame in many cases) and install it firmly in position. Work alternatively fore and aft, installing the frames until they're all in place. Needless to say, you should check everything several times until you're absolutely sure the whole structure is true and fair. We have seen boats with stems that are crooked and keels whose leading edges are out of line; it's really a sad sight. Your eye will be one of your best guides to fairness; use it, and then check again by measuring and use the level, square and plumb bob to ensure you have everything set up true and fair. There is a trick to avoid having the frames cause a "starved cow" look in the final plating. The frames ahead of the midsection should have their *forward* edges on the spacing line and the frames *aft* of the midsection should be installed so their *aft* edges are on the spacing line. The result is that when the plating crosses the frame, only *one* edge of the frame touches the plating, and the plate is not fighting its way around the frame.

Next, install the stem, the aft centerline bar, and the centerline transom bar. The transom may be left off at this stage and not installed until after the plating is completed on the remainder of the hull. Generally, you don't install the keel sides or the bottom of the keel plate until after the hull is plated and has the strength to support the heavier plating that is usually specified for the keel. In some designs we have specified ½ inch (12 mm) plate for the bottom of the keel; the idea being that this forms part of the ballast. You may substitute this for ¼ inch (6 mm) plate as this will make for easier handling of the bottom of keel plate.

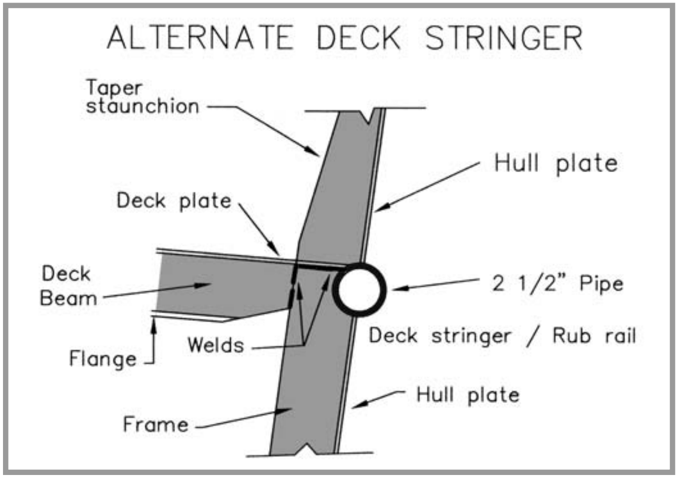
In some designs, a few of the bulkheads may be included as frames; this works fine, providing you do not change your interior plan after the bulkheads have been installed. The bulkheads at the forward and aft ends of the engine room will be metal, as will the anchor locker bulkhead (sometimes called the crash bulkhead). The aft bulkhead of the main cabin and the forward bulkhead of the aft cabin (at least above the deckline), will all be metal. In our designs, we prefer to install at least some of the bulkheads after the hull is turned over. In most cases, the bulkheads will fall on a frame. It's no problem to deal with intermediate bulkheads. Some bulkheads will be metal and others are best built of plywood. More recently, especially in powerboats, we have recommended that the sole plating above the engine room be steel as opposed to plywood.

In our designs, the web or solid floors form part of the frame structure. It's like a mini-bulkhead at each frame. These web floors generally extend up from the keel to the cabin sole, and can be used to contain and divide up tanks and ballast, and to support engine beds. There is no need to ring these web floors with framing bar; in fact, it's a bad idea because corrosion can form between the bar and the web. The material for the webs should be the same thickness as that used for the flat of the framing; this way, there will be no change in thickness where the framing and the webs are butt-welded to the remainder of the frame.

Stringers and Chine Bars

Longitudinal framing plays a very important part in maintaining the strength of your hull. After you've set up the frames, it's time to install the stringers and chine bars. We prefer flat bar for stringers. For chine bars, both solid round bar and flat bar have advantages and disadvantages. We don't recommend closed pipe for chine bars. Steel pipe can rust inside, and it's difficult, if not impossible, to paint or otherwise protect the interior of the pipe. When it's used in the leading edge of the keel, you can fill the pipe with lead.

At one time many designers and builders preferred to have the stringers stand proud of the



The alternate deck stringer shown here would double as a rubbing strake. It's best used on smaller boats, say under 35 feet (10.5 m).

frames by ⅛ inch (3 mm), thus avoiding every frame showing through the plated surface. If the frames are not touching the plating, it will be impossible to weld the plating to the frames; in our opinion this isn't a problem, especially in boats under, say, 40 feet (12.19 m). Using this method, the stringers are welded to the frames and the plating is welded to the stringers. This ties the structure together and provides adequate overall strength. While the foregoing advice is well founded, it may run foul of some of the metal boat building rules and regulations of classification societies such as Lloyd's, the EU, or the U.S. Coast Guard. In any case, follow your plans with one eye on any rule that you may be required to follow to register or operate the finished boat in your area.

Check your plans and—if necessary—with the designer of your particular boat before welding or not welding frames to the hull skin; his calculations may require one or the other practice. In any case, it is worth repeating that the frames should be set up in such a way so as to avoid their showing through the plating; frames 0 through 5 (midsection) are set so the forward edge is on the station mark; frames 6 to the stern are installed so the aft edge of the frame is on the mark.

When installing the stringers, only tack-weld them into the slots. In most designs, the plating will take a fair curve and the stringers may need to be "relieved" so they'll make contact with the plating throughout the hull. It is a fine judgment whether to pull the plate into the stringers or let the stringers out to lie neatly against the plating. By now your eye should be developed sufficiently to make it obvious which course to follow. In some places, the stringers will need to take the strain while the plating is pulled into place; again your eye will help you to make the right decision.

The order of installing the stringers and chine bars (if present) can be as follows. First, install the sheer or deck stringer, making sure that you keep the ends of the frames equally spaced and square off the centerline. Next, in the case of a chine or radius-chine hull, install the chine stringers (chine bars). Although there is room for discussion as to whether you should fit flat bar, round bar, or have no chine stringers at all, your practical choice is limited: follow the recommendations shown in your plans.

Radius-Chine Stringers

In a radius-chine hull, fit two stringers, one each side of the radius. They should be just a little inside or outside of the radius-flat joint; and as you'll need to be able to weld the plates from inside as well as outside, the stringer must be a small distance from the intersection of the radius plate–flat plate line. One reason for having these two stringers, one each side of the radius-flat intersection, is to provide a fair guide for the actual radius plate–flat plate intersection. See your plans or full-size patterns, where this line should be clearly marked.

We do not recommend having the radius-chine stringers right on the line that intersects the flat and radius section. If you choose this method, you would need to make sure that the plate-to-stringer weld attains full penetration from outside. Also this welding from one side only may contravene the appropiate classification societies' rules.

Intermediate Stringers

After you have installed the sheer, deck stringer (if it's present as a separate item), and chine stringers, check your hull for fairness. Again, use your eye (and perhaps the eyes of other more experienced builders) to ensure that the hull is progressing without being pulled out of line. Now install the intermediate stringers. The number of intermediate stringers in each chine panel will depend on the size of the hull and the particular metal being used. In most cases, a minimum spacing of 12 inches (305 mm) will be adequate.

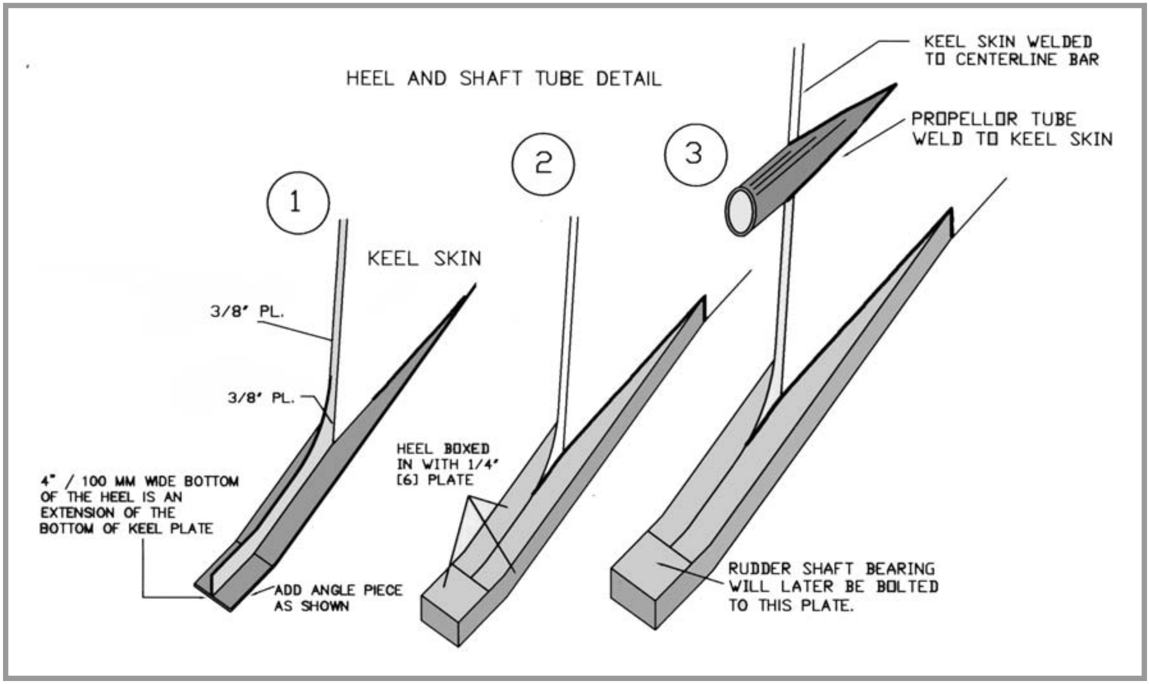
Under no circumstances should you permanently weld the intermediate stringers into their slots at this time. You may want to release them later, to allow the stringers to take up the same line as the plate.

This is a good time to give you the first warning: *We strongly recommend that you tack-weld the entire hull, including the plating, before running any final welding; don't do any finish welds until the whole structure is completed.* In the case of hulls built inverted, you need to complete the welding before turning the hull over; in boats built upright, you can assemble and tack-weld the hull, deck, and superstructure before running the final welds.

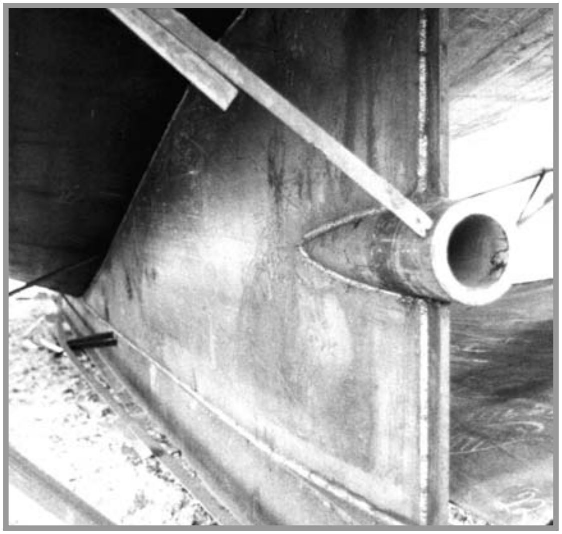
When all the chine bars and stringers are in position, the next job is to check over the structure again to ensure that it's fair in all aspects. A timber batten, sized approximately 1 by ½ inch (25 by 12 mm) and about 6 feet (2 m) long, can be laid diagonally across the hull at various locations, and your eye will probably give the best indication of the overall fairness up to this point. Check over the whole structure and make sure there are no unfair areas. On a round-bilge hull a longer batten will be needed to achieve the same results.

Stern and Rudder Tubes

Before you start plating you'll need to decide if you're going to install the stern and rudder tubes at this stage. It's reasonable to install the rudder



These sketches show a simple way to build a "heel" to support the rudder and incorporate the tube for the transmission shaft so as to allow the maximum amount of water to reach the propeller.



This stern tube arrangement is recommended and will allow adequate flow of water to the propeller.

tube(s) before the plating is in place. The stern tube(s) for the propeller(s) are more difficult to place correctly at this stage. If your hull is upside down, you need some very accurate calculations and measurements to get the correct angle and position for the stern tube. It may be better to leave it until you've completed the plating and turned the hull. In hulls built upright, it's easier to figure out where the engine beds are located and where you should install the stern tube.

plating will have a half-oval shape around the stern tube, and the water flow to the propeller will be much cleaner and less turbulent than it would be with a wide stern bar.

On a well-designed metal boat, many of the potential problems associated with plating multi-chine, radius-chine, or round-bilge hulls have been eliminated by the naval architect preparing your plans. If the plans and patterns for your hull have been faired by a computer, conically developed, or specially prepared for round-bilge construction, then you can lay the plating on, or pull it, or raise it into position without undue problems. The curvature in all directions should be gradual, to allow the bending of the plate by methods and devices employing simple mechanical advantages.

This also is a good time to review your safety procedures; this is especially important in the case of steel and copper-nickel, where you may be handling heavy plate. Make sure of the integrity of the weld when you're using various pad eyes, "dogs," and other devices to lift heavy plate and other sections.

If you're building upright, plating the keel and installing part of the ballast may be one of the first operations you'll consider before plating the hull. If you're building the hull inverted, you should leave the plating of the keel until you've plated the remainder of the hull and built up sufficient strength in the structure to support the heavy keel.

PLATING TOOLS

You'll need a variety of special tools and devices to assist you to plate the hull. Fortunately, most of these labor-saving tools are simple in nature. You can make them from scrap plate and bar. As mentioned earlier, a simple gantry from which to suspend your chain-block lifting device will save you many hours of lifting plate and other materials by cruder methods. In the case of steel and copper-nickel, while the material is still on the shop floor the heavier plates can be moved about on pipe rollers. Aluminum, being softer and lighter, will need to be handled more carefully to avoid scratching the face of the plate. Lifting eyes can be tack-welded to the plates, but make sure there's sufficient strength in the weld to take the load.

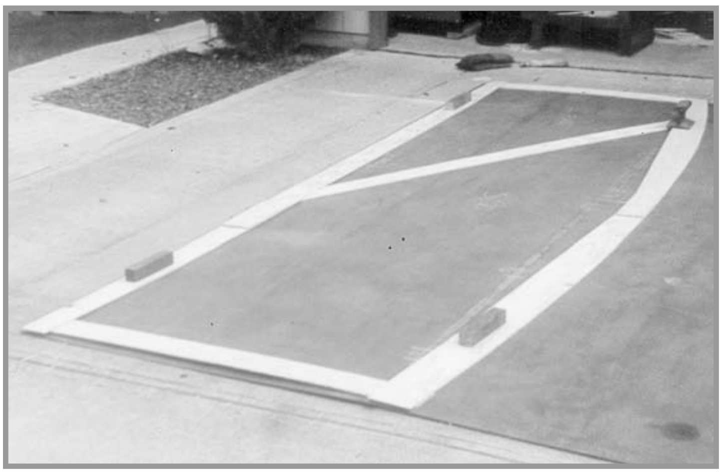
Plate can be moved sideways using a "come-along" or a pipe lever. Every time you have to move a plate, there's a mechanical device or aid that can help you. These simple devices multiply your muscle power many times and will take much effort out of installing the plating and other heavy parts of your boat. In metal boat building you should try to work smart rather than hard. We have on our records the case of one builder with no previous metal boat building experience who, with the assistance of a simple tackle and gantry, successfully installed full-length plates on a 53-foot (16.15 m) sailboat that he built to our design. A great deal can be achieved with a little forethought and preparation.

PLATING THE KEEL

One of the many advantages of a metal sailboat is that the keel will almost certainly be of the "envelope" type, and your ballast will be fully enclosed and protected within the hull. Needless to say, there are no keel bolts to worry about.

If you're building upright, you may plate the keel first. We recommend that you install a percentage of the ballast during the construction of the keel. It's much easier to install a fair proportion of the ballast in the keel now, while you simply have to lift it into the partially plated keel. This is a good time to remind you that the sides and bottom of the keel form part of the ballast. Remember to deduct the weight of the keel structure from the overall recommended ballast before proceeding further. In our designs, we recommend you install 75 percent of the total ballast (including the weight of the keel structure) before launching. The remaining 25 percent can be installed as trim ballast after preliminary sailing trials are completed.

You can use inexpensive plywood or hardboard to make patterns for the sides of the keel. The leading and trailing edges, and the keel webs, will already be installed. It will depend on the actual type and design of your keel as to whether you can plate the sides in one piece. In a deep keel, you may have a problem reaching down far enough to weld the lower ends of the webs and the inside side-to-bottom intersection. In this case you may prefer to have a longitudinal join, say 12 inches (305 mm) above the bottom of the keel, or some other suitable distance. On occasion, you may find it necessary to cut slots in the keel side plating so you can plug-weld through to the webs. Your plans should give you some guidance in these areas. If you're building the hull inverted, you'll follow similar procedures for building the keel, but you'll undertake this work after the other parts of the hull are fully plated.



Your plating pattern should lie flat on the plate; this is a test of its ability to lie evenly on the hull framing.

PLATING HULL CHINES

After you've carefully checked over your hull to ensure that it's fair, you may start to prepare patterns for the plating. The plating patterns or templates are made from a number of 6-inch (150 mm) strips of inexpensive ¼-inch (6 mm) plywood or hardboard. The outer edges of the templates represent the outer edges of the plate. It is seldom necessary to use a complete sheet of plywood or hardboard for a template. Usually, these patterns are made up of straight strips and corner gussets, like a frame, and made to fit the particular area to be plated. To strengthen large areas, cross-brace your templates by nailing on reinforcing pieces where necessary. The templates are built right on the hull by clamping the strips in place in between the chines. The length of each panel may vary; you want the patterns as long as possible, but not so long as to be unmanageable. Do not end a template on a frame, otherwise your plate will have a bulge in that area; always end a pattern between two frames. The ends of the patterns are always vertical; this helps in getting one pattern to join to the next with the minimum of error.

After you've formed the outline of the pattern, you can trim it to exact shape with a grinder or jigsaw, or, in fact, any tool that will help you achieve a perfect pattern. Check and double-check the template to ensure that it's a neat fit. After you're satisfied with the pattern, you can mark in the frame locations and use them as guides when you're positioning the sections of plate. See the welding details on your plans to decide on the welding gaps between the various plate edges. After you're satisfied that you have an accurate template, lay it on the floor. It should lie flat if the plating is to lie on your hull in a fair manner. Successive sections of patterning templates can be joined to make a pattern for one long plate. The longer the section of plate you intend to have in one length, the more accurate your patterns must be. Small discrepancies are greatly magnified over the length of a long plate. The patterns can contain other information, including stringer locations and any other information that you feel will help you to match the plate precisely to your hull framework.

It's usually best to pattern the largest panel first, then the pattern can be trimmed and used for the next section. This will save on patterning material. You should start at the keel and work either downward or upward, depending on the aspect of your hull. Make the patterns as sturdy as you can, and they will serve you well.

PREPARING THE PLATE

You must decide how long each plate will be before it is installed on the hull. Some builders prefer a plate as long as possible. The actual length will depend on the size of your hull, your previous experience, and the capacity of your scaffolding and lifting gear. Panels that are welded to full length on the shop floor where they will lie flat will be easier to install in a fair curve. This helps in eliminating any humps and hollows in the finished hull plating. On smaller boats, say under 30 feet (9.10 m), you should be able to plate the full length in one operation. Larger boats will require more sections. For instance, one man with a helper plated a 75-foot (22.86 m) hull using three 25-foot (7.62 m) panels. In general, use the longest sections you can comfortably handle. Builders of aluminum hulls will have some advantage here, as the material weighs only about one-third that of steel or copper-nickel and is therefore much easier to handle. You can transfer the outline of the template to the steel plate by laying the pattern on the plate, (it must lie flat), clamping it in position, and then carefully scribing around the edge. Mark in the frame and other pertinent locations on the plate.

Start plating at the keel and work either up or down, making sure that you work on alternate sides of the hull: that is, never plate up one side completely before plating the other. Keep the plating balanced so no undue stresses are placed on your hull framework by the plating pulling one way or the other. This can result in a twisted or otherwise deformed hull. The transom is best installed after the remainder of the plating is completed. The open transom will provide access inside the hull for the welders and let in light. Once you have marked the template outline onto the plate, you can cut it to shape. The method of cutting will depend on the hull material, and is covered in detail in Chapter 4, Tools and Safety Equipment.

Once you've cut the plate, you'll want to serve the panel up to the correct area. Using the alignment marks you've previously marked on the boat, pattern, and plate, clamp the piece in position. If there are any discrepancies in the fit, take the panel down and make the necessary adjustments before reinstalling the plate. It's worth noting that professional boatbuilders often find it necessary to "serve up" the plate several times before they achieve the desired fit. It's obviously easier to trim off excess than to put back areas that are over-trimmed. Keep this in mind when making patterns and cutting the plate.

On no account try the sloppy practice of installing an oversized plate and then trimming it by simply torching off the excess. If you plate your hull in this manner it will clearly show in the finished job. Buckles, hollows, and other large imperfections will tell all who care to look at your boat that you were indeed a sloppy builder. Always remember that one day you may want to sell your boat, and an unfair hull is one of the greatest factors in reducing the value of any used boat.

Before the plates are finally installed, make sure you have ground off any imperfections on the edges. Unless your plate is shotblasted and preprimed, which we recommend, make sure you clean up the face of the plate as well. It's easier to clean the plate before installation than when it's in place, especially in the case of interior surfaces partly obscured by the frames or stringers.

For steel, there are several ways to clean the faces of the plates before you install them. Grit-blasting or sandblasting is the easiest and best method, but in the case of steel, prime coating must follow immediately to protect the sand-blasted surface. You can use a disk grinder, a power-driven wire brush, or one of any number of similar methods. These techniques are very noisy, and are only for tidying up the plate, rather than preparing it for painting.

You should remove mill scale and any other foreign matter so that the panel of plate has no imperfections before you install it. Before you paint the hull, you must bring the surface back to bare white metal. You must paint this within a very short time, minutes rather than hours, to ensure a rust-free surface in the future. Finishing techniques are discussed in Chapter 10, Painting a Metal Boat.

The edges of the plate will need to be beveled before you install them. The amount of bevel will depend on the thickness of the plate and the metal you're using for plating. Note that aluminum and copper-nickel need to be prepared in a different manner to steel. Before hoisting the plate, you'll need to make provision for it to be supported while you're fitting it into position, and later welding it to the chines and stringers. One method is to tack-weld a few lengths of angle to a chine bar, frame, and stringer to support the bottom of the plate. Support the chine bar with another piece of angle that extends to the shop floor, thus transferring the load, so that the weight of the plate doesn't deform the fair line of the chine. The "plate holders" should be tilted inboard, so the plate will naturally slip into the correct location and not slip out of the holder as it's moved from side to side to get the exact alignment required.

You can use a selection of homemade C-clamps to draw the upper edge of the plate to the chine, the centerline bar, and the stem. As you tighten the clamps, you'll be drawing the steel plate into position in all planes. In a well-designed chine hull, you'll find that the plating will naturally conform to the shape provided by the framework of chine bars, frames, and stringers. Most plating is between ⅛ and 3⁄16 inch (3 and 5 mm) thick, so it will lie in place without your having to resort to extreme bending methods.

In cases where more pressure is required, several techniques will help you. A popular method is to tack-weld lengths of threaded rod in the area where you need assistance. You can judge the length of the pieces of rod needed for the job. Use ⅜-inch (8 mm) diameter rod that is tacked at a 90-degree angle to the inside of the plate, and use a prepared section of 2 by 2 by ¼ inch (50 by 50 by 6 mm) L-angle behind the stringers and chine bars to receive the inboard ends of the threaded rod. By tightening up on the rod, you'll be able to coax the plate into its correct location. Another method is to weld U-shaped eyes to the inside of the plate and then attach a "come-along" or other suitable device, such as a Spanish windlass, to pull the plate into position.

As you will have only tacked the stringers and chine bars into the slots, as we advised earlier, it's permissible and often desirable to "relieve" the stringers and even the chine bars by allowing them to come out of the slots to meet the plating. It takes some judgment to know when to let out the longitudinal, instead of pulling the plating in harder, to make the correct shape and fit. Do not hesitate to weld eyes, U-shaped round bar, and threaded rod to your plate, to help you get the result you want. You can knock off these temporary protrusions when you've fully welded the plate in position. Don't compromise on a good fit. Follow the welding guidelines given in Chapter 5.

Butt joints (where two sections of plate meet end to end) can be drawn together with bolts and large washers. The butt joints must be in near perfect alignment to achieve a smooth hull surface, otherwise they'll show as bulges or uneven patches. Drill several holes in the beveled seams between the plates, and insert bolts fitted with large washers and nuts. When you take up on the nuts, you'll be exerting great pressure up and down the vertical butt joint and you'll even out any bulges or other irregularities in the joint. After you tack-weld the plates along the bevels, you can take out the bolts and close the holes with weld.

Once again, as you install the various plates, be sure to work from one side to the other and keep the plating evenly balanced. Be certain to achieve a good fit. A little grinding here and there can make all the difference in making the plates fit as perfectly as possible. The plates may need to be slid back and forth to correctly position them. A "come-along," or a tap with a hammer (using a wooden block to protect the ends of the plate) can work wonders. The foregoing is another reason to ensure that you have the plate held securely, but with some freedom of movement, as you prepare to tack it into place.

Don't rush; you'll be looking at your hull for a long time. Don't fully weld any plate into position until you've installed all of the hull plating. Don't forget to work from side to side along your hull, never get more than one plate ahead on one side, and keep the plating balanced. Once you've tacked a few plates into position, you'll notice a considerable stiffening of the hull structure. Sight along the hull as each plate is installed to ensure that you are maintaining a fair curve and that no plate looks out of line. If you find you have incorrectly installed a plate, take it off and correct the problem before proceeding. The first plates will be the hardest to install, so make sure you get them right and you'll find that the plating process gets easier as you proceed. Most builders are able, after some practice, to pattern, fit, and install one or two plates a day. If you're achieving more than that, you may be working too fast at the expense of quality.

Any boat hull must look absolutely perfect *before* painting if it's to look reasonable *after* it's painted. If you're in doubt, splash some water on your hull to bring up a shine, and then judge how well you're doing. Another trick is to take a flashlight and examine your hull at night. When you shine the flashlight along the hull, all the imperfections become more apparent. Aim for perfection; you may not achieve it, but if you aim high, you should finish up with an attractive and fair hull.

RADIUS-CHINE HULLS

Here is what one builder had to say about plating a radius-chine section of the hull.

"Builders do not need to feel handicapped because they do not own several multi-ton rolling presses. Plate can be sent out for rolling to get the initial radius for $300 [$400] to $400 [$500] (£200 [£230] to £270 [£290]) plus the price of transport. After that, all that you need are about three 'come-alongs,' a cutting torch, and a few dogs and wedges. The actual process of oxy-fuel torch cutting shrinks the perimeter of the radius sections, and with the help of the 'come-alongs' and wedges, the sections will develop a compound curve. With patience, skill, and time it is not difficult to build a radius-chine boat.

"I have built a radius-chine Roberts 53. The actual radius sections (24 sections, 12 on each side) took approximately four hours each to cut and fit into place. You spend additional time welding one extra horizontal seam each side and three vertical seams each side, for a total weld time of about 30 hours. After welding (100 percent X-ray quality) I spent another 40 or so hours grinding the outside weld profile flush with the hull. Yes, it takes longer than multichine, *but if it is properly done, it is hard to tell the difference between radius-chine steel and fiberglass out of a mold*."

In the case of radius-chine hulls, we recommend that you plate the radius section first. Unless you have experience in rolling plate to an accurate radius, we suggest that you give this job to a local metal shop. Choose a metal shop that has the knowledge and the necessary equipment to undertake the work. A look in the telephone directory will provide many possibilities. Steel, aluminum, or copper-nickel are all easy to roll to a constant radius if you have the correct equipment and are used to this type of work. Perhaps the supplier of your metal plate will have these facilities; if not, he or she will certainly be able to point you in the right direction.

Radius-chine panels around the center of the hull need to be split lengthwise before being fitted.

a perfect fit. When the plates are split, the two halves are served up to the hull and allowed to overlap. The excess material is removed before tacking the radius panel into place. As with all plating, keep the ends of each plate exactly vertical, as this will assist in obtaining a good fit for the butt joints at the ends of each section of plate.

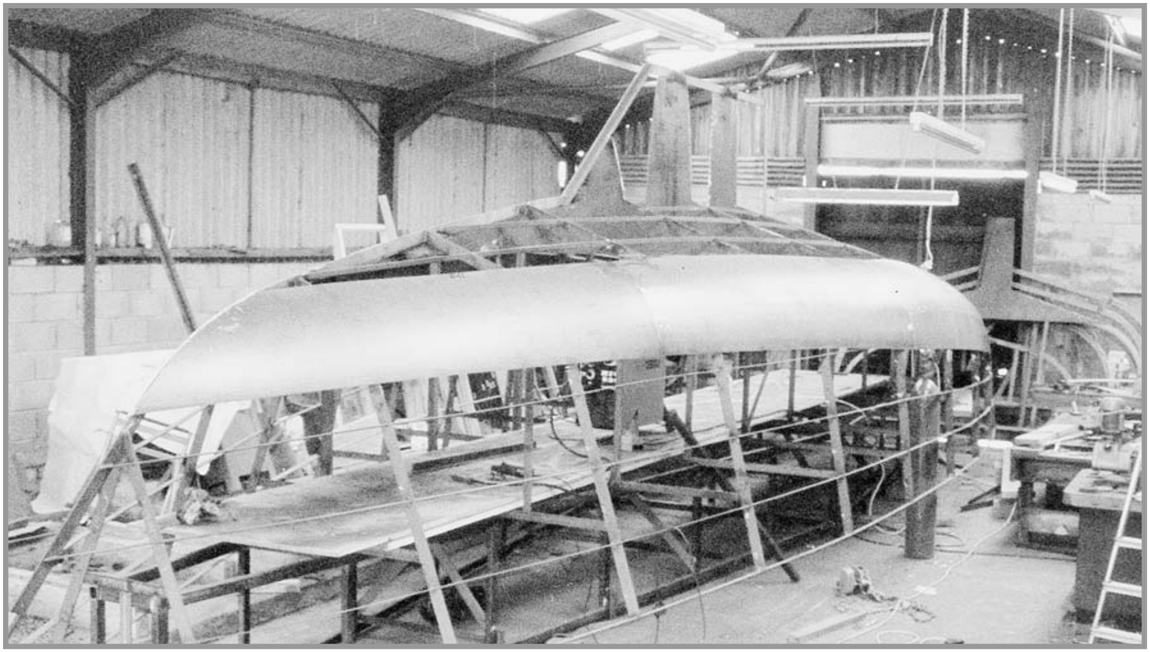
As we've already seen, you'll generally find that the largest arc of radius is at, or near, the stern of the vessel. When installing the radius plates, start at the aft end of the hull and keep the edges neat. Trim to a fair line, using a batten to strike a line where the radius panels meet the straight panels of the bottom and the topsides. You should previously have indicated clearly where the radius and straight sections meet on each frame.

Don't let the above explanation frighten you off the radius-chine technique. Hundreds of builders have used this method to build beautiful metal hulls. Many have taken the time to write, telephone, and seek me out at boat shows to

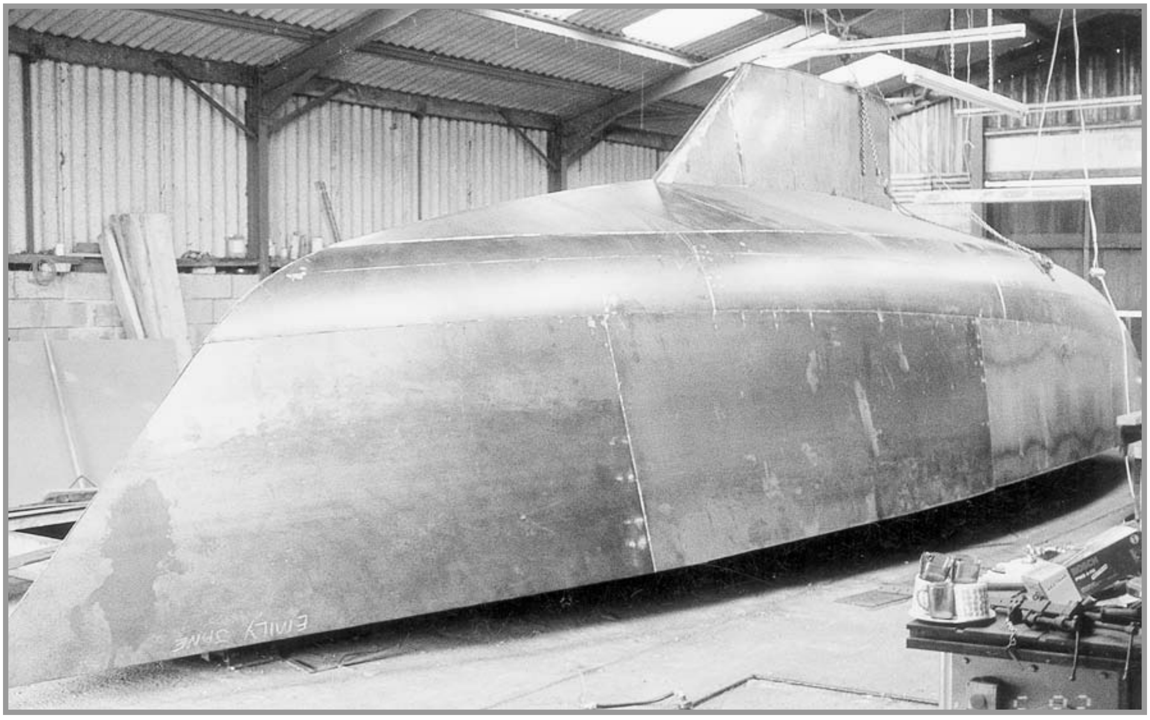
To ascertain the arc of radius you'll need for the largest (widest) plate, simply measure around this arc on your full-size patterns. Usually, the largest arc is at the stern or just ahead of the transom. It may be cheaper to have all the plates the same width, even though the arc (not the radius) will get smaller as the plating progresses toward the bow. You will simply trim off the excess and use the off-cuts for scrap. Needless to say, if you do measure each plate, make sure there's enough width to allow for trimming.

The radius plating should be ordered in about 10-foot (3 m) lengths. The center of the hull will almost always involve some compound curvature, and it will be necessary to split the center plate at least once, maybe twice, lengthwise. The plates on either side of the center one also may need splitting, but the plates near the bow and stern should fit in one piece. In a sailboat, with its greater beam-to-length ratio, you'll have more plates to split lengthwise to get

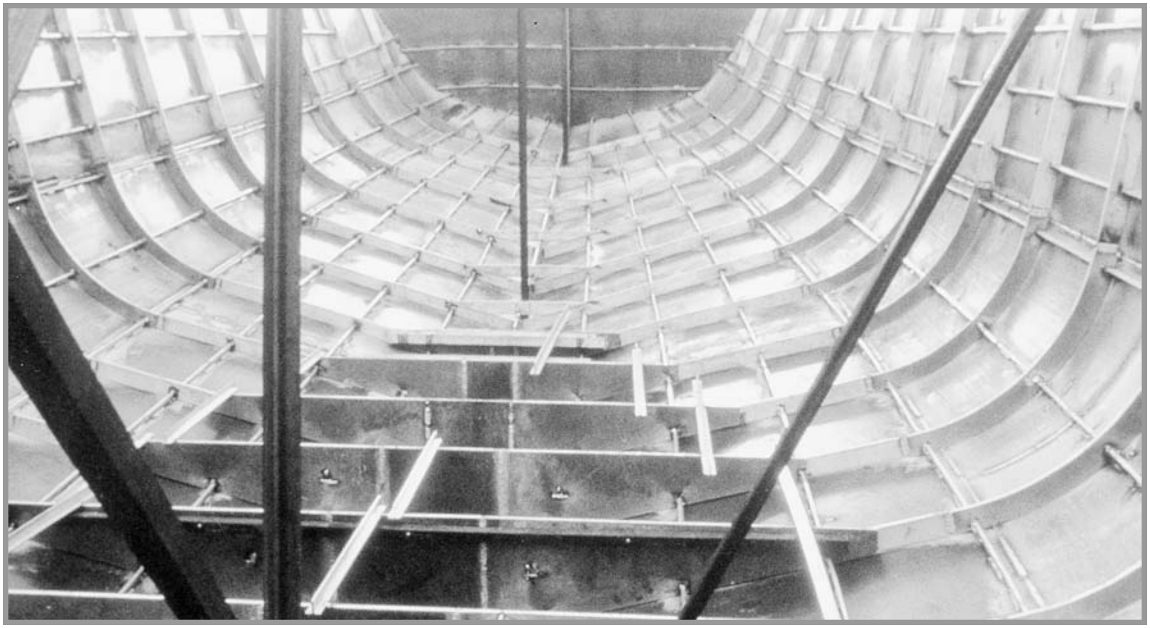
A rain shower shows up the fairness of this New York 65 radius-chine hull built by Howdy Bailey.



John Williams built this radius-chine Roberts 434. Note that he applied the radius panels first. We recommend that the radius panels be installed last.



The radius-chine hull form is one of the easiest to use if you want to achieve a professional-looking hull.



The interior of a Roberts 53 radius-chine hull, ready to receive bulkheads.

report their entire satisfaction with this metal-building technique. The flat, or nonradiused, areas of a radius-chine boat are usually simpler to install than those on a regular chine hull. Simply lift on the bottom and or side plate, mark the join from underneath, and trim the plate to shape. Of course, all of the plating, including the radiused and straight sections, is only tack-welded at this stage.

ROUND-BILGE HULLS

Building a round-bilge metal hull is the most difficult hull-building method, and should not be undertaken lightly. You must be certain that you can produce a fair hull; if you're not sure you can, you should use either the chine or the radius-chine techniques. If you find a professional who can plate your hull to your entire satisfaction, then that can be the solution.

Some round-bilge hulls have been plated lengthwise using strips of varying widths, but allowing the strips to overlap. This technique is similar to that used to build timber lapstrake hulls. Although the famous Joshua class is built in this way—and these are proven boats—it's our contention that corrosion must occur where the plates overlap. Our advice is to avoid overlapping plates of other metal sections wherever possible. This applies especially to steel hulls.

How you go about plating a round-bilge hull will depend on the shape of the hull. There are easy shapes, difficult shapes, and near-impossible shapes. Starting at the bottom of the keel, you'll find that the lower portion of the keel in a round-bilge hull will be similar in most, if not all, respects to one fitted to a similar style of multi-chine hull. If the hull features a "hollow heel," this will definitely be a job for a professional metal boat builder. If the hull and keel meet at right angles, or nearly, then plating the keel of the round-bilge hull won't present any undue problems.

Now you must examine the overall shape of the "canoe body." For instance, the traditional Spray design has a very full, golf-ball-shaped bow that makes it a difficult plating job even for an experienced metal boat builder. In our round-bilge versions of the Spray, and also in the chine hulls, we have drawn out the bow to make the hull easier to plate. In the case of the Spray, this also improves the performance and comfort of the vessel, as it cuts through short steep waves rather than pounding over them. Some metal hulls may have been designed with full-bodied, rounded sterns or other features that will make them difficult to plate. A careful study of the plans can give you some hints as to the "plate-ability" of the hull in question.

Once you're confident that your chosen design features a hull shape that's within your plating capabilities, consider the best technique for fitting the plate. There are three ways to lay plate on a round-bilge hull: longitudinally; in multi-shaped sections; and in diagonal strips. If the hull has a suitable shape, the diagonal method may suit the less experienced builder.

FINAL WELDING

Don't attempt any of the finish welding until all the hull plating is tack-welded into position. Before you start the final welding, give your hull a final check for irregularities. They will be easier to correct before the welding is completed. Bumps can be removed by any one of several metalworking techniques, including using a rubber mallet on one side while a helper holds a suitably shaped timber backing-piece on the other. Hollows on the hull are most unsightly, and must be removed. Small wrinkles along the chine can be removed from inside with the careful use of a large plastic-faced mallet and a person holding a suitable backing-piece from outside the hull.

Final welding consists of short welds laid down in the proper sequence for that particular plating. As mentioned in Chapter 5, Welding, different techniques are required to weld steel, aluminum, and copper-nickel. You must be fully conversant with the method best suited to the plating of your hull.

Much of the work, up until the running of the finish welds, can be handled by a person with a minimum of welding experience, but the final welding of the plating is another matter. If you're not a fully experienced welder, this may be the time to hire a professional. If you plan to take this route, we recommend that you seek help *before* you start the project. Discuss with the professional how much you can do yourself, and when and where you will need his or her assistance.

If you're going to seek outside assistance, make sure the person understands the problems of welding a pleasure boat. Welding a boat is quite different to commercial welding. In commercial welding, strength is important but laying down a considerable amount of weld per hour also has a high priority. A commercial welder might not consider a fine finish to be so important. Explain your expectations to the professional before you enter into a firm agreement. If you find that the person you've chosen doesn't come up to your expectations, make other arrangements before the job gets out of hand.

When the welding of the plating is completed, you'll need to grind off some of your welds from the outside of the hull. If you have laid good-quality welds with good penetration, you'll have the minimum of chipping and grinding before repairing or rewelding any unsatisfactory joins in the plate. It's normal practice to grind only those welds above the waterline. Most classification societies insist that the welds below the waterline are left unground so they retain all the strength of the original weld. Do not over-grind the welded seams above the waterline, otherwise you may weaken them to such an extent that you compromise the strength of the vessel.

KEEL PLATING

If you've built your hull upside down, now will be the time to plate the keel. The keel's leading edge (usually pipe or split pipe), the webs, and the aft end of the keel will already be in place. Your plans will instruct you about the order in which to plate the sides and the bottom. In the past, we've usually specified ¼-inch (6 mm) material for the sides, and ½-inch (12 mm) for the bottom plate. Today, we'd be happy to have the whole structure built of ¼-inch (6 mm) plate; this means that at the intersections of the sides and the bottom, you'll be welding material of the same thickness. Also, in the case of boats built inverted, you'll not have to struggle with the heavier ½-inch (12 mm) plate at the bottom of the keel.

FORMING AND PLATING THE TRANSOM

If you're lucky, your plans will include an expanded pattern for the transom. If you don't have this pattern, it's a simple matter to make up some transom formers to the correct camber and then, using inexpensive plywood or hardboard, simply make up a pattern to fill in the transom cavity. Make sure you don't create a "fish-tail" effect at the aft end of your hull. This is caused by making the transom too large (usually, too wide), and preventing the side and bottom plating from taking up its fair line. Don't forget to allow for the deck or transom camber when you're making the pattern and cutting the plate for the transom.

Chester Lemon fitting a rubbing strip to his Roberts 44.

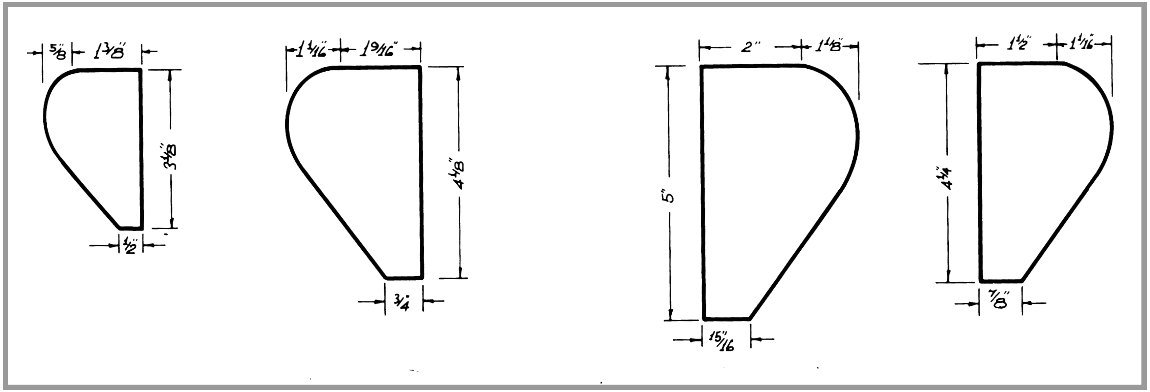
Once you're convinced that the transom plate is the right size and shape, you can install it. It's usual to have a centerline bar extending from the bottom of the hull to the top of the transom, and you can hang the transom plate on this bar while you're positioning the plate. The remainder of the transom stiffeners, usually vertical and transverse stringers, can be installed from inside once the transom plate is fully welded from the outside.

RUBRAILS

You can make rubrails, rubbing strips, or rubbing strakes from the same metal as the hull, or from one of a variety of other materials. The selection includes, but is not restricted to, D-section rubber mounted on a suitable metal structure; timber bolted in place; and rope mounted in a channel or other similar arrangement.

If you're using timber for the rubrail, it should be hardwood. Timbers similar to teak, or softer timbers, can be satisfactory when fitted with a stainless protective strip. For the ultimate timber rubbing strake, Australian spotted gum has the advantage of being durable, flexible, and long-lasting without the need for any additional metal protective strip. In general, timber is easily replaced, can be attractive, and is kind to other boats and structures.

A metal half-round split pipe of suitable dimensions makes an ideal rubrail on a metal boat. We show it on all our metal sailboat designs. You simply take the correct length of pipe, split it lengthwise, and use one half for each side. The aft end can be snaped and plugged with an appropriately shaped piece of hull material. It will finish either at the transom or about 6 inches (150 mm) ahead of it. The other end is tapered so that it will bend around the forward end of the hull, usually ending at or about station 0, or above the forward end of the waterline. Make sure that you give extra preparation and coating to the inside of the pipe and the hull where it will be installed.



Here we see the correct proportions for a traditional timber rubbing strake.

Placing underneath the rubrail a thicker hull plate that is 50 percent wider overall than the rubbing strip would provide extra insurance against corrosion and damage from contact with immovable objects.

The problem with this pipe rubrail is that you cannot repaint the inside. Even if you're very careful to give the inside a superior paint job before it's installed, the welding will undo at least part of your work. The pipe itself will have sufficient wall thickness to withstand many years of interior corrosion, but the plating underneath may not be so long-lasting. One solution would be to have a thicker base plate under the pipe, say three times wider than the pipe. It should be inserted into the hull plating, but not *over* the regular hull plating or you could have problems between the two plates. Skegs and other appendages are covered in Chapter 15. If there is a skeg involved in your hull design, you may prefer to install it after the turnover operation.

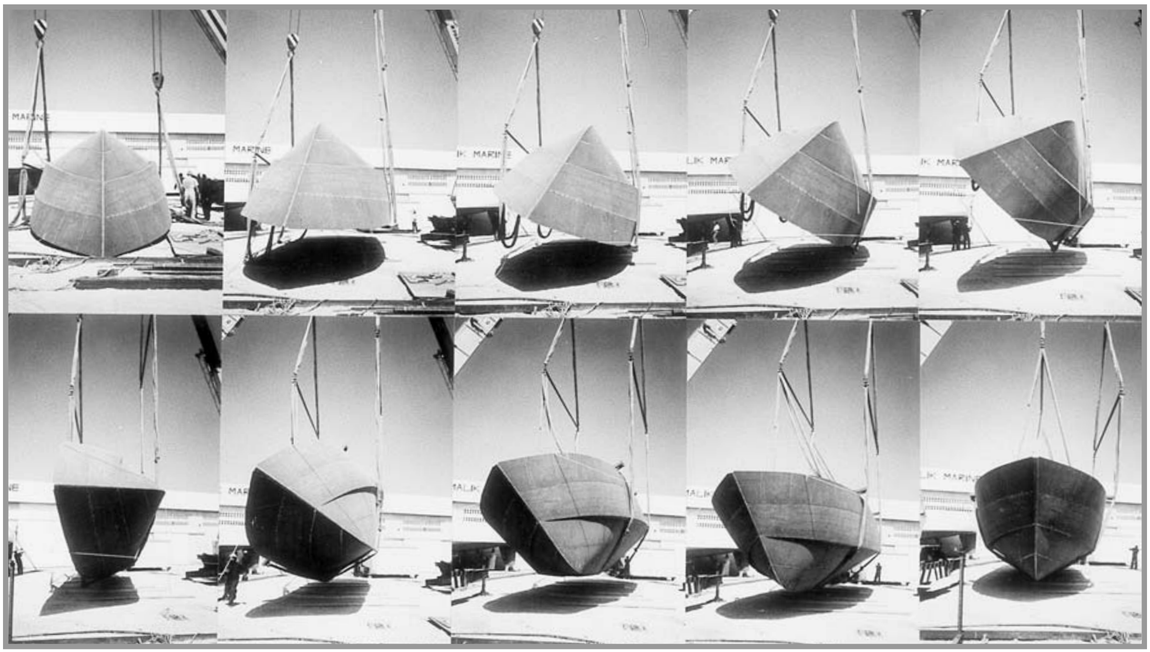
TURNING THE HULL

If you've built your hull upside down, now is the time to consider the turnover. When the plating is completed and all of the final outer welds have been run, you can decide on the best method for turning your hull and setting it in the upright

Many builders have fabricated various turning-over devices. These sophisticated turning wheels are ideal if you're building more than one boat.

position. No matter if yours is a large or small hull, give considerable thought to safety factors when considering how you will turn it over. Plan how to set up the hull and level it, ready for completion. The last thing you need at this stage is an injury to yourself, a friend, or hired assistant, so take care. Several methods have been used successfully to turn over large boat hulls. The method you choose will be in some part decided by the size of your boat, its location, and the accessibility of your building site. Boats up to about 25 feet (7.62 m) long can be rolled over without the use of mechanical assistance. For small hulls, you'll need no more than a few willing friends and a few bottles of cheer.

If you're building in a large, substantial commercial building then you may have overhead track fitted with chain blocks. It may be possible



This Waverunner 44 built in Oman was turned over using one crane fitted with two spreader bars and slings.

to set up strong points in the building that are capable of taking the load. You can arrange two overhead chain blocks for two endless slings capable of lifting the hull. Now the structure can be rolled over in its own width. The two slings are placed about 20 percent in from each end of the hull. You will need restraining lines to control the hull during the turning-over operation.

It may be preferable to remove the hull from the building and turn it over outside where there's more room. Or you may already have built hoops around your hull so that it can simply be rolled over. The hoops will later be used to tilt the hull to various angles, thus allowing easier access to the job at all times. Or you may wish to build a "turnover cradle," shaped something like a crate, around your hull and turn it over one side at a time.

Our choice would be to hire a crane fitted with a spreader bar and two endless slings. The slings are placed in about 20 percent from the bow and stern and the crane lifts the hull sufficiently to allow it to be rotated in the slings. Make sure you determine the balance fore and aft before the serious lifting begins. You will need restraining lines attached to a winch or other suitably strong device, to control the hull as it reaches the up and over stages.

When you have turned the hull, you'll need to set it up level in all directions. Use the waterline locations that you have previously marked on the outside of the hull as a guide. The simple type of water level with a clear tube will make it easy for you to set up the hull true and level in all planes.

MOVING THE HULL

You can move large, bulky, and heavy items such as boat hulls using the simplest of tools. You can use a few 2-inch (50 mm) diameter pipe rollers

Omani*, a radius-chine Roberts 434, was sailed around the world by Major Pat Garnett in only 218 days.*

about 9 inches (230 mm) long to roll your hull. Simply lay down planks for the rollers to run on, and keep taking the rollers from the back and reinstalling them at the front as the hull moves along the desired path. If you use either 4 by 2 inch (100 by 50 mm) timber, or 2-inch (50 mm) pipe levers, say 5 feet (1.50 m) long, you'll multiply your strength many times when it comes to lifting or shifting heavy weights. When you're lifting the hull or frame to insert the rollers, you'll find the levers are much quicker to use than a lifting jack.

You'll want to give some thought to the sequence of the various steps needed to finish the deck and superstructure. The building sequence includes gritblasting, insulating the hull, and may include installing the engine and fitting out the interior. You may want to undertake some of these steps before you build the decks and superstructure, so you'll need to plan your own work schedule. You must also be prepared to make minor changes as you proceed with the work. You may be considering building the decks, and/or the superstructure, in a different material from that of the hull (usually *not* recommended by this designer). As most of you will be building the entire boat in one metal, however, we'll leave detailed discussion on alternative deck and superstructure materials until nearer the end of this chapter.

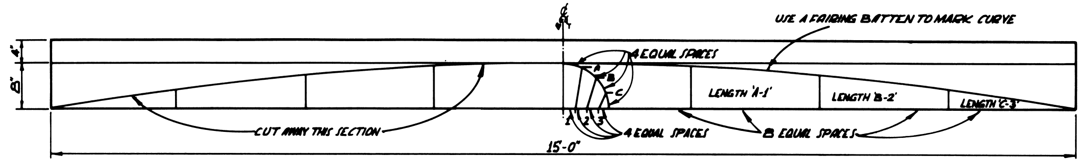
Before you start to build the decks and superstructure, you should consider installing all the bulky items that will need to be in the hull and which may be difficult, if not impossible, to install after the deck and cabin are in place. The engine, large tanks, bulkhead panels, the plywood sole, and similar items need to be in position before the hull is closed up by addition of the superstructure. You will have to balance this against the fact that you may need to gritblast the inside of the decks and superstructure, a practice that would not be recommended around your new engine! Again this is another reason why we recommend using all pregritblasted and pre-prime-coated steel.

If your hull is large enough, say over 35 feet (10.67 m), you may plan to set up a small workshop inside the hull where you can manufacture much of the joinery. This is worthwhile if you can fit in a small bench, a table saw, and a band saw, otherwise it may be better to consider one of the alternatives. For example, if your boat is smaller, or if you prefer to work outside the hull, then consider setting up a work area at the sheer or deck level, then you'll only have to climb a few steps to saw, plane, rout, sand, or temporarily assemble a piece of joinery. This can save a great deal of time and effort. Getting up and over and out of the boat to make each cut can soon become very tiring (and tiresome), so a better plan is needed.

You may find that some of the cabinets and joinery can be set up inside the hull and then taken out to a nearby bench for sanding, painting, and so forth, before being reinstalled in the hull. It's better to undertake as much preparation as possible before the deck goes on.

GRITBLASTING AND PRIMING

This brings us to the gritblasting that's necessary in steel boats. When is the best time to undertake this work? In our opinion, the best time is before the boat is started—yes, this means pregritblasting and priming all of the materials. If you opt to work with untreated steel, you'll have some problems with working out the sequence of fitting out. You can't install the insulation, the



MARKING OUT A CAMBER BOARD

Laying out a camber pattern for deck or cabintop beams will be one of your first tasks before you start work on the decks and superstructure.

engine, or other large items until after you've gritblasted and primed the inside of the hull. You certainly cannot gritblast the interior once these items are in place. You can see that if you work with untreated steel, you may create scheduling difficulties. Builders who choose steel as their building material should avoid these problems by either purchasing the steel already preblasted and primed, or by doing the job themselves before they start construction. (See Chapter 10, Painting a Metal Boat.)

CAMBER BOARDS

Your plans and patterns may include either the measurements or an actual full-size pattern for the deck and cabintop cambers. Using this pattern, it's a simple matter to cut a hard pattern from plywood or suitable timber. If you get the balance right, you can cut a male and female pattern from one plank. The pattern will be used to obtain the correct camber when you're bending the deck beams and cabin beams.

On sailboats, the cabin and the pilothouse tops will usually have more camber than the decks.. On powerboats, the opposite is sometimes the case, although quite often the same camber is used throughout. If your plans don't include full-size camber patterns, you can create patterns using the designer's recommended cambers, as shown below. For instance, in a powerboat that will be fitted with a flybridge, it is best to have a minimum (but still some) of camber in the cabin or pilothouse top as this will form the sole of your flybridge and too much camber is not desirable.

BULKHEADS

If you're building upright, you may have included some of the bulkheads as you were setting up the initial frames. It would also be possible to include bulkheads when you're setting up an inverted hull, but it may involve raising the whole struc-

The interior of John and Joan McDermott's Spray 33, Donegal Breeze.

ture so far off the floor that it would be impractical. Any setting-up method that makes you climb or walk more than is absolutely necessary is not recommended. In cases where the hull is built upside down, my preference is to wait until the hull is plated and upright before considering the installation of any bulkheads. That gives you an overview of the hull, so you can take stock of the available space before making firm decisions about placing bulkheads that will affect the layout of the accommodation.

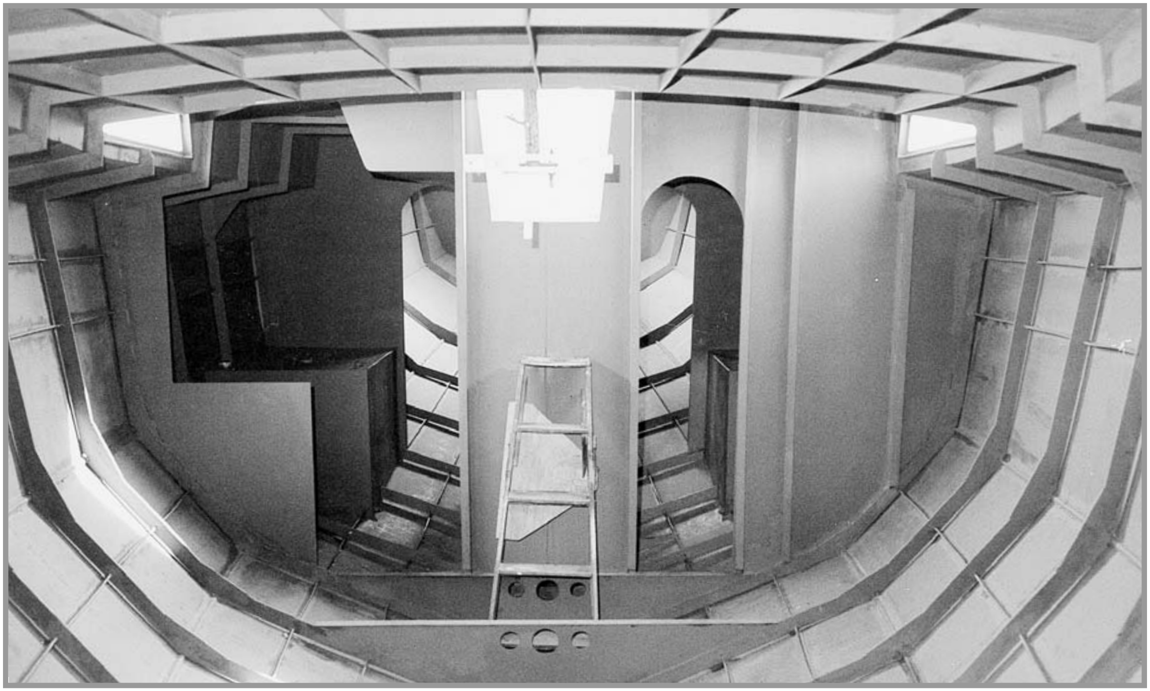
You'll need to decide which bulkheads will be metal and which will be plywood. The bulkheads that will be exposed to the elements should all be metal, including the aft bulkhead of the cabin and the bulkhead located at forward end of the aft cabin. If you have a pilothouse, the aft bulkhead should be metal. In Dutch powerboats, the aft end of the saloon or pilothouse is sometimes made partially of timber. This is acceptable if there is some awning or shelter over it to protect it from the elements. Bulkheads will usually be constructed from the same metal used for the decks. In boats under 40 feet (12.19 m), try to keep the number of metal bulkheads to a minimum, and use plywood where practical.

Metal Bulkheads

The bulkheads at the forward and aft ends of the engine room in both sailboats and powerboats should be constructed from the same metal as the decks but in some cases may be one measurement smaller in thickness. For instance where the decks are 3⁄16 inch (5 mm) you may use 5⁄32 inch (4 mm) steel for the bulkhead plate.

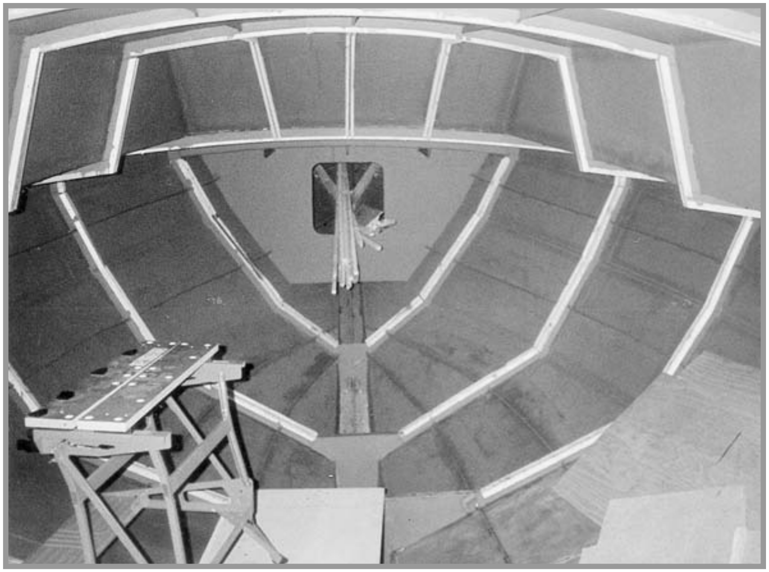
As was demonstrated in the Falklands War, aluminum can burn. For this reason, particular attention should be paid to insulating with fireproof material any aluminum bulkheads located where a fire may break out. The bulkheads that enclose the engine space, for example, will need special attention.

It's common practice to make the bulkhead



Steel bulkheads are usually placed each side of the engine room. In the case of a sailboat, they will often be at either end of the center cockpit, as shown here.

adjacent to station 0 from the same metal as the hull. This "crash" bulkhead is usually at the forward end of the waterline. Some classification societies and authorities, including boats built to U.S. Coast Guard survey and those built for sale and use in Europe, require this first bulkhead to be located 5 percent of the load waterline (LWL) aft of the forward end of the waterline. This is a sensible rule, but it sometimes takes up valuable space. Boats built to the Coast Guard survey will need the accommodation moved farther aft than would otherwise be necessary.



Timber "furring strips" for securing the lining material to the frames installed on Roberts 34 built in Sweden.

Some bulkheads may need stiffeners, depending on the size of the vessel, the metal used in the bulkheads, and the size of the particular bulkhead. These vertical L-angle or T-bar stiffeners are spaced about 12 to 18 inches (305 to 457 mm) apart and are installed with base of the L or T inward, thus making an excellent base for installing the cabin lining material. Some transverse stiffening also may be required. Check with the designer of your boat. The cavity formed by the L-angle can also be used to install the insulation.

Concerning those bulkheads that you're installing before the deck and superstructure are in place: make sure that the height above the sheer or deck will allow you to cut the correct cabintop camber later. We always recommend that you don't try to cut the shape for the cambered decks, cabin sides, and top camber at this stage; simply allow the top of the bulkhead to stand up square from the sheer. This advice applies to all metal and plywood bulkheads. Later, you can mark out the deck camber, the lay-in of the cabin sides, and the cambers for the cabintop and/or wheelhouse top. These cuts may be more difficult to make with the bulkhead in an upright position, but they'll be much easier to mark out with all of the bulkheads in place, rather than one at a time before the bulkheads are erected. More experienced builders may prefer to mark and cut the bulkhead tops as they install each one.

If you're building upright, and if many of the bulkheads are on a frame location, then it may be worth your while to include the basic bulkheads as part of the frame construction. Our advice is still to leave the tops square, as mentioned above. If you prefer, you may carefully work out the measurements and cabinside angles of each bulkhead, and cut them to shape before installation.

Plywood Bulkheads

Intermediate and partial bulkheads are best built from plywood. You can use any suitable grade that has a marine glue-line. One way to test the durability of plywood is to boil it. A widely used 8-hour boiling test will give you a clear indication of its quality. Plywood provides stiffening and strength in many directions and will keep the weight of the interior down. Plywood bulkheads should be installed with the tops left square, so the areas above the deck can be marked and shaped at the same time as the metal bulkheads. If your plans do not state the thickness for the plywood bulkheads,

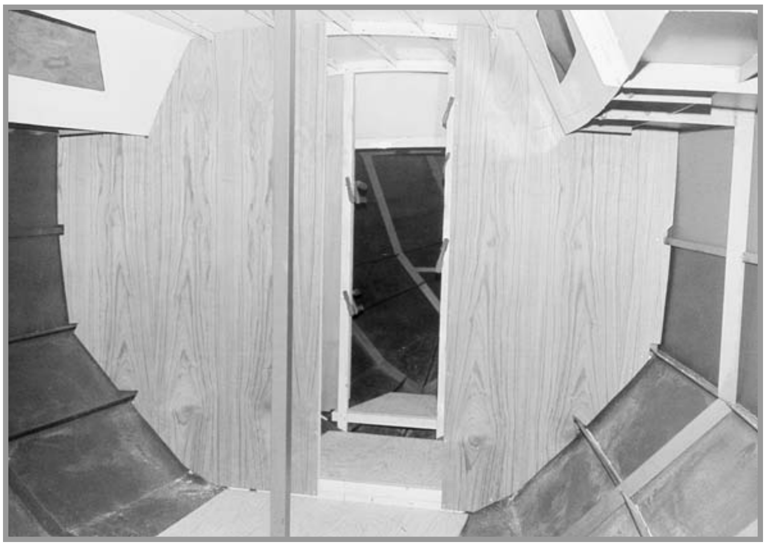
John McDermott varnishes the meranti tongue-and-groove bulkheads in his Spray 33, Donegal Breeze.

keep in mind that the adjacent furniture and joinery will add stiffness and strength.

The transverse plywood bulkheads will need to be bolted in place, either to existing metal frames or to short sections of framing material commonly known as *tags*. The tags are 6 to 12 inches (150 to 300 mm) long and they're spaced at the same intervals as their length. They're welded to the hull to accept the bulkhead. The tags become necessary if a transverse bulkhead is located between frames, or adjacent to a frame but not at its exact location. It may be possible to alter the bulkhead's location a small amount by bolting it to one side or other of the frame—but be careful not to create a space such as a berth that is too small or too long. You'd do better to install tags at a location between the frames. These tags provide more than adequate strength for bulkhead attachment. Don't forget to predrill the tags at 4 to 6 inch (100 to 150 mm) centers to accept the bolts that will attach them to the bulkheads.

As you're unlikely to be able to purchase plywood sheets large enough to make the bulkheads in one piece, you'll need to join or laminate the sheets somehow. The thickness of the plywood bulkheads will vary, depending on the size of the vessel as well as the purpose and location of the bulkhead. Transverse plywood bulkheads are generally thicker than longitudinal ones. The designer of your boat may have specified the thickness required.

To form one complete bulkhead, you can use plywood of the specified total thickness and have this scarfed to the correct sheet size, or you can scarf or half-lap the sheets yourself. Our preferred method is to divide the thickness into two or more parts and then laminate two or more sheets face to face. For maximum strength, the joins can be widely staggered by alternating the joins in each layer. Plywood bulkheads, with the exception of those in the area of the mast in a sailboat, will not be exposed to great strains. The



Plywood bulkheads can be attached to frames or to tags especially installed for the purpose.

bulkhead adjacent to the mast can be strengthened by the addition of framing as required.

Cored Bulkheads

If you are weight-conscious, you can consider one or more cored bulkheads. They can be used to divide the accommodation longitudinally, or to construct half-bulkheads such as those that form one end of a hanging locker or similar piece of joinery. The core material can be structural sheet foam, a light timber framing, or other suitable material that is both light and fire-resistant. The face plywood can be 3⁄16 inch (4 to 5 mm) and can be veneered with teak or a similar surface. The fiberglass bats used in house insulation are unsuitable for core material as they will soon shake down into a floppy mess when exposed to vibration and other marine operating conditions.

BENDING AND INSTALLING DECK BEAMS

The material for the deck beams can be flat bar, L-angle, or T-bar. It makes sense to use L-angle or T-bar, as either of these, when installed with the flange down, will provide an attachment point for the interior lining material. The insulation for the deck and cabin top will fit neatly in between the angle or T-beams.

The beams can be bent using the hydraulic-jack and steel-frame method, or you may prefer to have them bent by a professional metal shop. Your plan will at least give you a camber figure—for example, 6 inches in 13 feet (150 mm in 3.96 m). If you don't have a pattern, but you do have the numbers for the recommended camber, you'll have to make a pattern using the formula shown. If you have patterns for the various cambers, you should make a master pattern out of plywood or timber. You will use the pattern to check the beams as they're bent to the correct camber and also as a general pattern for cutting bulkhead tops.

In our designs, we recommend that you install the deck beams in one piece right across the hull. This method of installing the beams is much easier than trying to support short side deck beams while maintaining the correct sheer and curve of the deck/cabinside intersection. Later, you'll cut out the center of the beams and the section you remove will be rebent for cabintop beams.

You may need fore-and-aft intercostal deck stringers, depending on the spacing of the beams and the size of your boat. The intercostals are best cut from flat bar and should be snaped in at the ends and welded in between the deck beams, as required. You could use a lighter angle for the intercostal and have the flange level with the inside to provide a base for the lining material. The depth of the intercostal should be the same as that of the deck beams as you may need to weld the underside of the deck plating to the intercostal as well as to the deck beams themselves.

Once all the deck beams are in place right across the hull, then you can mark the position where the cabin sides intersect the deck, support the beams, and cut at the marked line on each beam. Next, install a carlin to accept the inner edge of the side deck plating. The carlin will be a vertical length of flat bar running around the inner edges of the cut inner ends of the deck beams.

You can, at this stage, make provision for hatches in the fore and aft decks or you can cut them out later and install any extra deck framing at that time. Once you're satisfied with the framing for your deck, you can go ahead and plate the foredeck, side decks, and the aft deck area. Remember at this stage you are still tacking everything together; no long, continuous welding should take place until the whole structure is tacked together. See also the welding recommendations that come with your plans; usually only the outside seams are fully welded while other areas have stitch or chain welds as the final welding.

FORMING THE CABIN

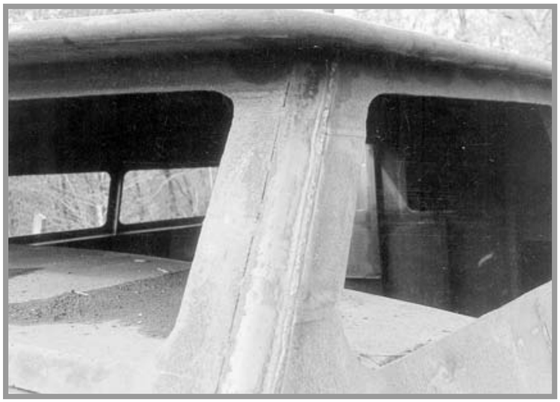
Cabinside Lay-In

At this stage, you'll need to consult your plans regarding the correct lay-in for the cabin and pilothouse sides. Lay-in of the cabin or pilothouse sides refers to the amount by which the sides are angled inwards toward the centerline. In other words, the base (where the sides meet the deck) is slightly wider than the top (where the sides meet the cabin or pilothouse top). Too much lay-in will be most unattractive and be an invitation for leaky windows and may also interfere with your interior accommodation. Too little lay-in will make the superstructure on your boat look boxy and, at worst, can make it look as though it's actually leaning outward at the top. How much lay-in is correct? Never less than 5 degrees and usually no more than 15 degrees is appropriate. When you cut the angle for the side lay-in, you may leave the tops square and cut the cabin or pilothouse top cambers after the cabin sides are installed.

Setting Up the Cabin Sides

Your plans should provide measurements for the cabin sides, so that you can make a pattern of the sides and then raise the pattern into position to check the accuracy before cutting metal and welding the sides in place. In boats supplied as steel kits or cutting files, the cabin sides are already precut to the exact shape. If your design includes a pilothouse, it may be part of the cabin sides or installed as a separate item.

It's often preferable to have the sides of the pilothouse set slightly inboard of the line of the cabinside-cabintop intersection. This step inward or knuckle will break up the large pilothouse-cabin inside area, and reduce the apparent height of the combined structure. You can also change the paint color at this intersection, which will further enhance the appearance by avoiding the slab-sided look. Until you've installed the other parts of the superstructure, and to ensure that the sides remain at the correct angle and position when they are first installed, you'll need to use bracing from one side to the other, and to the bulkheads and other areas. If the windows are closer than, say, 4 inches (100 mm) from the edge of the cabin sides or pilothouse plating we recommend that you don't make any cutouts for windows or portlights at this time. If there is insuffucient uncut metal between the cutout and edges of the plate you may have a problem and the cutout could cause the plate to buckle, and spoil the fair line of the sides. You may wish to mark out the windows and ports, as this will enable you to locate the correct position for any framing required in the sides.



Quarter of pipe used at corners of pilothouse. This boat would have been better built from preprimed materials that were not readily available at the time.

Cabinside Stiffeners

Depending on the size and type of boat, you may need some form of stiffeners installed in the sides of the cabin or pilothouse. If possible, always line up the cabinside stiffeners with deck and cabintop beams, so you have, in effect, a "ring frame" that will always be stronger than a discontinuous framing system. Wnen designing our kit boats we always try to have all frames, deck beams, cabin sides, and top beams line up as suggested above. You can use the same material for framing the sides of the cabin or pilothouse as you use for the deck and cabintop beams. Assuming you're using angle, the flange of the L or T will face inboard, and will assist in providing a ground to attach the lining. Don't forget to arrange some form of insulation in the cabin sides, otherwise you'll have condensation problems in the future.

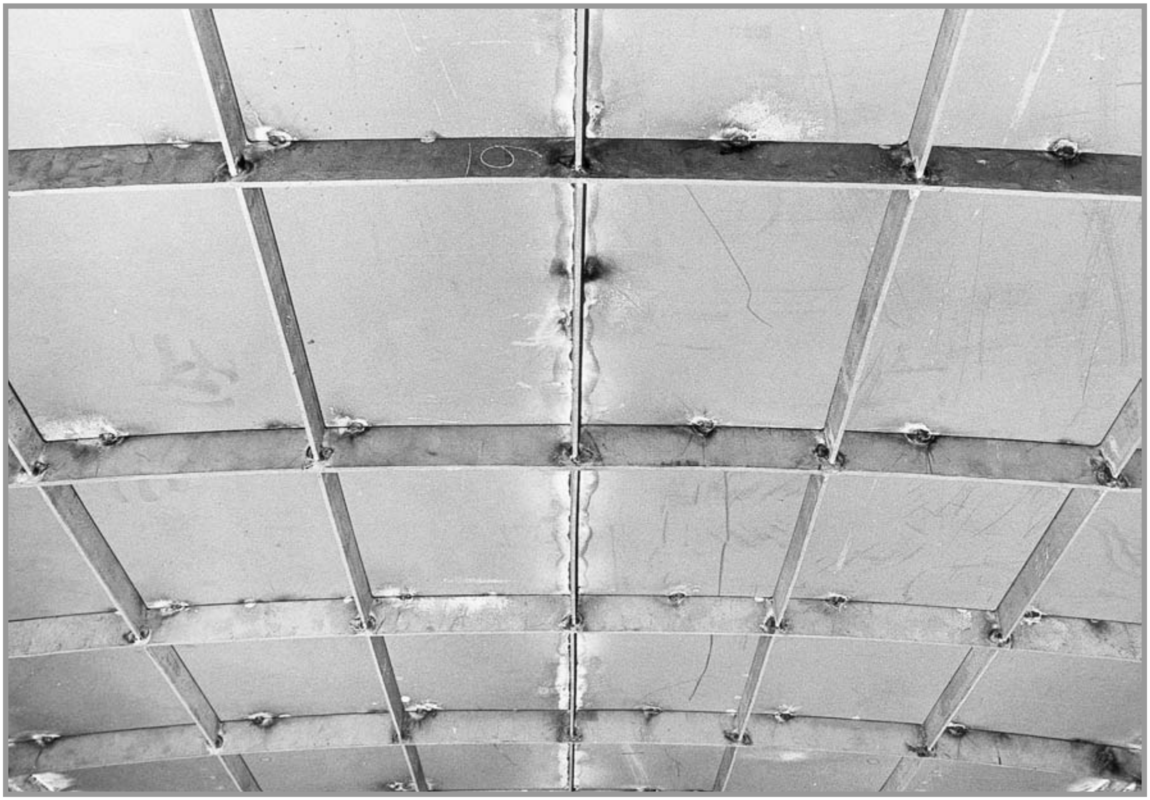
Rounded and Beveled Corners

Rounded corners where the cabin sides meet the top, and where the cabin front meets the top and sides, are a nice touch. You can use sections of suitably sized pipe, say 3 inch (75 mm), cut into quarters, or have some plate rolled to a suitable radius. We like beveled corners; they're easy to install and give an attractive appearance when used at the intersection of the cabintop and cabin sides, and in similar areas. The hull-sides-transom intersection may be fairly sharp without spoiling the appearance of the vessel. Sharp corners are hard to keep painted, though, so all corners should have at least a small radius.

Rounded corners can enhance the exterior appearance of any metal boat.

Installing Cabintop Beams

Installing the cabintop beams will follow much the same procedure as you have used for the deck beams. Hatches can be framed in now or cut out later and framed from underneath. We recommend that you frame up the main hatchway at this stage, as you'll need access to the interior when you plate the cabintop. As the surface area of the tops of the cabin and pilothouse will most cer-



Cabintop beams and fore-and-aft intercostals tack-welded in position; see text.

tainly be greater than that of the decks (except in a flush-deck boat), you'll need intercostal beams in the top. The intercostals can be installed before or after the top plating. If you install the intercostals from inside, after the plating is in place, you'll have more welding to do from underneath; however, installing the intercostals after the plating will ensure that you don't have any ridges in the cabintop caused by improperly aligned and installed intercostals. The intercostals can be installed in the same manner as those for the decks. Your cabintop may receive considerable traffic, so make sure the framing is adequate. A relatively light, closely framed cabintop will serve you better than a few, widely spaced, heavier beams. Follow your plans or consult the designer of your boat if you're unsure regarding the framing.

Installing the Cabin Front

The front of the cabin will most likely be curved; about the same master camber as was used for the deck-beam camber will be about right. You only take a portion of the deck pattern. For instance, if the deck camber pattern is 6 inches (150 mm) in 15 feet (4.572 m) and the cabin front is, say, 6 feet (1.83 m), then the actual amount of round in the front will be about 2 inches (50 mm) in the 6-foot (1.83 m) of width. Cabin fronts on traditional craft can be flat. The problem with flat cabin fronts—or any part of a boat that is flat—is that they tend to look convex. For that reason, you should always have a slight amount of curvature in any flat area on your boat.

The cabin front will always have some layback. If a truly vertical cabin front were installed, it would look as though it were leaning outward (forward) at the top. Don't forget to allow for the camber when installing the cabin front. You are dealing with many angles in this area, and overlooking sufficient camber allowance in the front is not an unheard-of occurrence.

Plating the Cabin Top

By now, you should have the cabin sides, cabin front, and cabintop beams and intercostals all installed and checked for accuracy and fairness in all planes. You'll need to decide if you're going to let the top overhang the sides or front of the cabin. These overhangs have many advantages and are commonly seen. While overhangs on a fiberglass or timber boat may present a potential weak point in the construction, this doesn't apply on a metal boat.

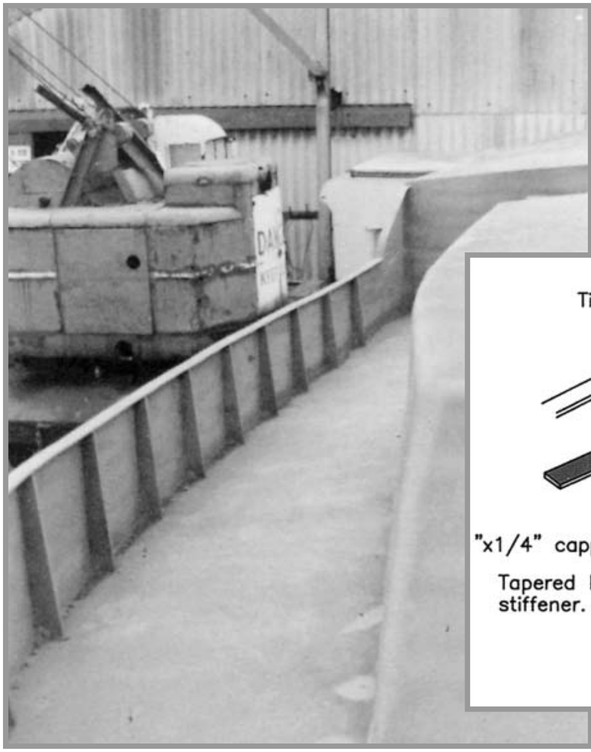
Check your plans regarding overhangs and "eyebrows," as the forward cabin and pilothouse overhangs are sometimes called. Overhangs must have a trim to complete the edge; you can use pipe, solid round bar, or flat bar depending on the design of your superstructure. Side overhangs, especially on powerboats, can carry the rainwater or spray from the top out past the windows. You can see that a careful balance of cabinside lay-in and top overhangs can improve the appearance and practicality of the design. Installing the deck plate will follow the same procedure as used for the decks. Plate flanges on overhangs can have about 5 degrees of outward angle at the bottom in relation to where the flange joins the top; this will tend to throw the water outboard away from the sides and windows and help avoiding dirty dust streaks on the cabin or pilothouse sides.

BULWARKS AND TOERAILS

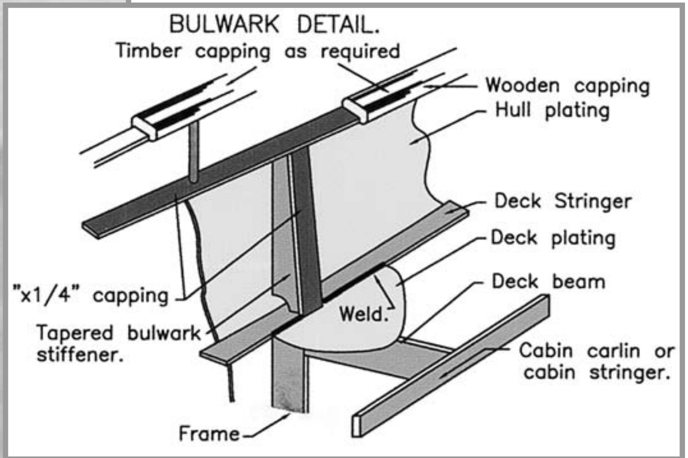
If you plan to have bulwarks, you'll have fitted a deck stringer at the appropriate height. The lines plan and/or the full-size frame patterns may show exactly where this stringer is to be installed on each frame.

If this information isn't on your plans, you can scale off the relevant measurements and use a batten to fair in the deckline on each frame from stem to stern. Before or after the hull is plated, you can taper the inside of the frame between the deckline and the sheer. Taper the frame so that it is the right width on top to accept a flat or round bar to be installed as a caprail.

If your bulwarks are less than say 8 inches (200 mm) at the highest point, and your hull is $^3/_{16}$-inch (5 mm) plate, then the frames may finish under the deckline and it will not be necessary to have the frames extend from the deck to the sheer. You should install a pipe or solid round of a



Steel decks and cabin on Roberts Spray*, built in England for Bruce Roberts UK, Ltd.*



Drawing of bulwark detail.

THE BEVEL

A beveled section makes an attractive intersection between the cabin or pilothouse sides and the top. There are other areas of the superstructure where a bevel can be an attractive alternative to a round edge or a plain right angle. The bevel is one of our favorite architectural features and we note that a few boat manufacturers are incorporating a bevel between the cabin sides and the top. The bevel can be of any size, but it's usually set at about 45 degrees to the vertical and could measure 3 to 6 inches (75 mm to 150 mm) depending on the size of the boat. The use of the bevel is also a good way to disguise cabin height. If your design calls for a high cabin structure, then consider the bevel. For the record, the bevel, when used in timber work, is often referred to as an arras, or small bevel taken off the corner of a post or other feature. The arras, or bevel, does soften the appearance of any area where it is used, and it's a great way to remove sharp edges from any object in your boat.

The beveled cockpit coaming adds to the attractive appearance of this Roberts 53 built in Canada by A. Skodt.

minimum of ¾-inch (20 mm) diameter or flat bar, to complete the top edge of the bulwark plate and this may also be used to accept a wooden caprail on the top of the bulwark plating. In any case, you should stiffen up the cutouts; see below regarding reinforcing the edges of the apertures.

WATERWAYS AND FAIRLEADS

If your hull has bulwarks, you'll need to install waterways on the frames and freeing ports to allow water to flow between the frames as well as through the bulwarks and off the decks. The bulk of the freeing ports must be situated at the lowest point of the deck-bulwark intersection, and the apertures must be large enough to let the water out without delay. Usually, several freeing ports spread over the lowest area are better than one large hole. All openings made in the hull plating for freeing ports, fairleads, or any similar purpose must be reinforced with suitably sized solid round bar. If docking lines are used with fairleads, the reinforcing bar in a steel hull should be stainless steel. The movement of docking lines and the anchor rode would soon wear away any paint applied to mild steel reinforcing.

BUILDING OR ADDING A PILOTHOUSE

Consider a pilothouse if you want to improve the livability and comfort of your existing or future sailboat or powerboat. Pilothouses have gained in popularity over the past 30-odd years that we've been recommending these structures. Almost all of our sailboat designs feature at least one version that includes a pilothouse.

If you think your boat is a candidate for one, you'll need to consider the style and design carefully before starting the actual installation. We strongly recommend that you contact the original designers of your boat and request that they check the effect on stability and prepare plans for the structure. The addition of a pilothouse can not only provide more comfort aboard your boat, but it also can enhance its appearance and value.

The low cabin on this Roberts 39 will receive adequate light and ventilation from the opening hatches and dorade vents.

The pilothouse on the 28-foot Spray K*I*S*S *has reverse-sloping windows up forward, and while they may not be to everyone's taste, they do have many advantages, two of which are lack of glare and reflection and absence of moisture in light rain conditions.*

Conversely, a poorly designed appendage can totally destroy what you have set out to achieve.

One decision you'll need to make is whether you prefer forward- or reverse-sloping windows. Most fishing boats and workboats have reverse-sloping windows up forward; there is a good reason for this. When steering into the sun and under other difficult conditions, reverse-facing windows give you the best view. When the rain is light, the overhang at the top of the reverse-sloping windows will keep the windows clear. Reverse windows are practical, but their appearance is not to everyone's taste. Regular forward-sloping windows have a racier appearance and do enhance

ADDING A FLYBRIDGE

The main thing to consider when building a flybridge on any vessel is weight: keep it light. This structure is always high above the waterline, where weight is most undesirable. If you plan one of these items on your boat, be sure that the cabin top doesn't have excessive camber—usually the same camber as the decks is acceptable. No matter what material you used to build your hull, deck, and superstructure, you can use aluminum or fiberglass for the construction of the flybridge. Don't make the flybridge so large as to attract too many passengers. Keep in mind the stability of the vessel under all conditions. Some restriction on the number of seats available will help in this regard.

Flybridge decks need less camber than regular cabintops. Note our favorite trim angle, the beveled edge of the overhang.

the appearance of your boat. For the best vision where you need it most, keep the slope of these windows to a reasonable angle; an extreme angle will cause vision problems.

Building a pilothouse follows a procedure similar to that used to build your regular cabin structure. You must make sure that supports of adequate proportions are placed between the generous-sized windows often associated with this structure. Additional strength by way of side framing may be required, and the windows should be divided up into reasonably sized areas. If your boat is capable of offshore work, then you should make provision for shuttering that could be fitted in the event of one or more of the windows being broken. In order to keep the weight of these rarely used storm covers to manageable proportions, you could consider building them of fiberglass sandwich, fiberglass-covered plywood, or aluminum.

Hatches, Companionways, Portlights, and Doors

If your vessel was designed for offshore use, your plans should indicate the size and location of the various hatches. If you're the builder, the details of strength and suitability will lie in your hands. In the interests of safety, all hatches and companionways are best located on the centerline of the vessel. This is especially important for passage-making vessels. In the event of a knockdown, an open hatch on or off the centerline can admit tons of water before it can be closed.

You should take some time in deciding where and when to fit hatches. Before you start making holes in your decks, you need to have a firm idea as to the exact layout of your accommodation. You can simply plate the entire decks and superstructure, leaving the main hatchway available for access, and lay out your hatches at a later stage. Always keep in mind, however, that these areas need to be carefully planned and strongly constructed, especially in long-distance sailboats and power cruisers. The hatches that cover the openings in your boat may be called upon to withstand tons of water being dumped on the deck. Don't treat them lightly; they need to be as strong as the hull.

About the only places in which a steel boat can leak are around the hatches and other openings. It's important to construct and fit these hatches so that they are absolutely watertight. Strong hinges and closing devices are a must. There are many cases where boats have been seriously damaged and lost through the fitting of inferior hatches. Combining safety with livability, it's best to fit hatches with hinges on both the forward and the after edges.

Ready-made hatches can add a professional touch to any deck arrangement.

Commercially Made Hatches

Deciding whether you will make your own hatches or use commercially made ones may be a matter of economics. Careful shopping can often reduce the prices to an acceptable level. Professionally manufactured hatches may add a nice finishing touch to your otherwise self-built boat. Most commercially made hatches will be manufactured from marine-grade aluminum.

Unless you have your decks and superstructure built out of the same material as the hatches, you'll need to isolate the hatches from the metal decks. A good commercially made hatch will have a precision-cast body of high-tensile alloy that will not corrode in the harsh marine environment. Tinted glazing is preferred, and it must be capable of taking the weight of more than one person and able to withstand the force of a breaking wave without deforming or breaking. Larger hatches should have three hinges that have been cast as part of the body of the hatch. To ensure watertightness under adverse conditions, a hatch that uses a neoprene O-ring seal is preferable to one that uses soft rubber strips. The neoprene is far superior to the spongy type of rubber seal and it will not deteriorate as quickly; also the O-ring neoprene seals are more resistant to sunlight.

Making Your Own Hatches

If you decide to build your own hatches, you can save a some money. It may be possible to construct them from materials you would otherwise throw away. We recommend that you build your hatches of steel, aluminum, or fiberglass. Timber and plywood hatches require considerable maintenance and, if of insufficient strength, offer a weak link in the security of your boat, so if you choose timber, make them strong. On the other hand, timber hatches and skylights can give a metal boat a touch of warmth, so if you're prepared for additional work, both during and after installation, then timber hatches may be worth considering.

Metal deck hatches can be built easily with inner and outer coamings. You can weld the coamings directly to the deck, making sure you've installed either deck beams or intercostals (or both) to reinforce the deck plating from below. You can install the reinforcing beams from underneath after you've cut the aperture for the hatchway.

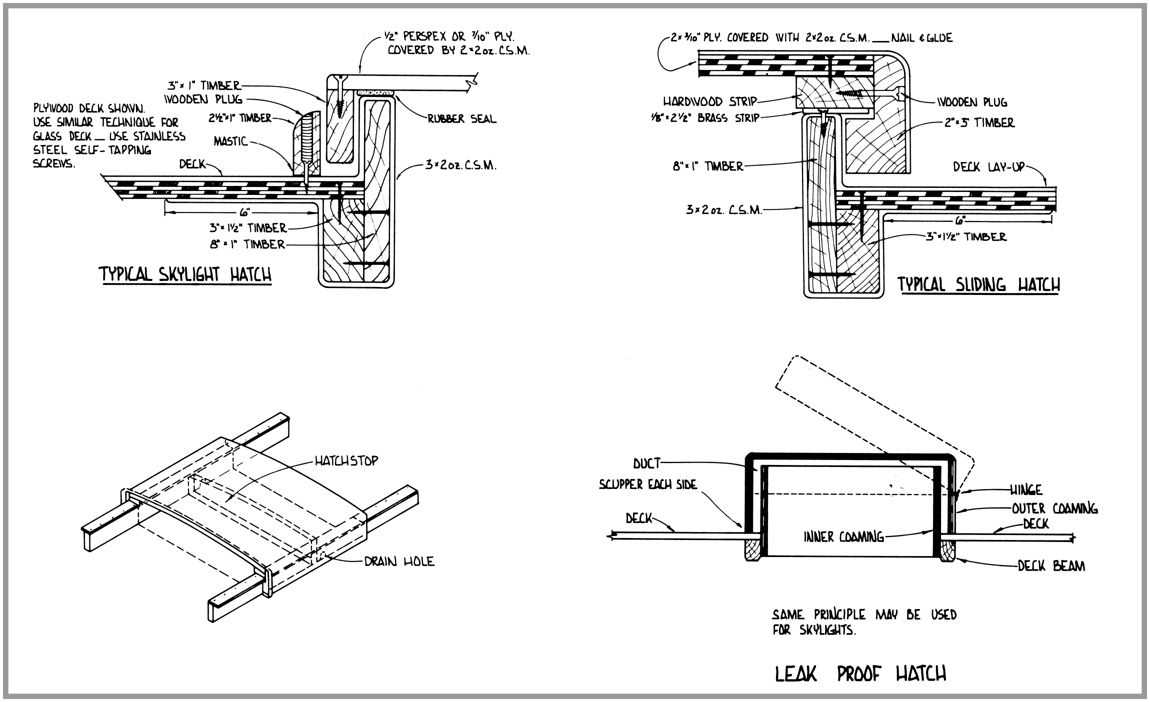
Metal Hatches

Obviously, it's best to construct the hatches from the same material as the decks and superstructure. You're more likely to have these materials on hand, and there will be no additional corrosion problems caused by mismatched materials. Arranging rounded corners on your hatches shouldn't present you with any problems as all metals are capable of being formed into, say, a 3-inch (75 mm) radius. If you build your own hatches, some of the money you save can be invested in extra-thick acrylic-sheet glazing. Make sure it's set in a suitable sealant and bolted in place with an adequate number of fastenings.

Metal hatches can be built with inner and outer coamings; this arrangement is like a box made with a fitted lid. The inner box that acts as the coaming can be welded directly to the deck around the cutout you've created in the deck or cabintop. The height of the inner coaming can be from 2 to 6 inches (50 to 150 mm), and higher in larger vessels. The hatch top can have sides of 2 to 3 inches (50 to 75 mm). The top will look best if it's cambered similar to the line of the deck. This will look more professional, but it's harder to build, especially if you plan to have acrylic, Lexan, or similar material included in the top of the hatch.

Hinges for metal hatches are simple and easy to construct. They are basically one set of square tangs welded on the hatch cover to face a set of lugs welded at a 90-degree angle from the deck. A suitably sized rod, usually ⅜- to ¾-inch (10 to 20 mm), depending on the size of the vessel and the hatch in question, is inserted through the tangs and lugs and the hatch cover will pivot on the rod. The rod will need a right-angle bend, a nut, or some similar stopper at one end, and a removable retaining device at the other end. If you install hinges on both the forward and after edges of the hatch, it will open either way. At sea, you should always have the hinges on the forward side, but in port or sheltered waters it may be useful to be able to open the hatch in more than one direction. On our current powerboat we have a hatch in the pilothouse top that can open straight up or in any one of four directions—a wonderful arrangement when one is seeking relief from the heat and needs to catch some breeze.

Any one of a variety of locking devices can be arranged to work with a metal hatch. In serious offshore cruisers, both sail and power, it's im-



These plywood hatches can be used on timber or plywood decks and cabins, or adapted for use with a metal superstructure.

portant that the hatch can be screwed down tight to prevent pressurized seawater from forcing its way into the interior of the vessel.

The top of the inner coaming will need to be fitted with a sealing strip, as with other types of hatches. The round neoprene O-shaped material is the most long lasting and, properly installed, gives a superior seal. A proper hatch should have a separate raised coaming of sufficient height placed ahead of it and on the two sides of it, to deflect the spray and rainwater streaming across the decks and/or cabintop. Don't underestimate the power of water and its ability to force its way into any weak areas of your deck openings.

Wooden Hatches

Wooden hatches are relatively easy to construct but a perfect fit will take some woodworking skills. The best way to build these hatches is to build two boxes, one being the inner coaming and the other, the hatch itself. Obviously, one box will fit neatly over the other. The inner box should be made of 2-inch (50 mm) thick hardwood, and should be 4 to 9 inches (100 to 230 mm) in height. Usually, the larger the vessel, the higher the coaming. This box will be equal in size to the inner dimensions of the hatch opening. The minimum size to allow access by the average person is 20 inches (508 mm) square; however, you should decide what size hatches are most appropriate for you and likely crew members.

It's important the upper edge of this inner box (coaming) is perfectly square and level, as this is the edge that will contact the sealing material of the hatch itself. When you have constructed this basic square box for the inner coaming, you can cut a hole in the deck or cabintop to match the inner dimensions of the box. Next, add reinforcing intercostal and other beams underneath, around the perimeter of the hatchway.

Next, build the box that will be the hatch that will fit over the coaming. The hatch can be built out of 1½-inch (35 mm) timber, and 3 inches

(75 mm) high is about right. This hatch will fit snugly around the coaming but will have sufficient clearance to allow the completed hinged hatch to be opened and closed. So far, you have no top to your hatch. You can use ¾-inch (20 mm) marine-grade plywood for the top, and screw and glue it to the frame. For a fancy finish you can glue and temporarily staple ⅛-inch (3 mm) mahogany or teak-faced plywood to the top of the hatch. In any case, the edges of the plywood top will need to have an outer timber strip to protect them.

You can have a Lexan or Plexiglas top instead of plywood, and you can have a combination of glazing and plywood for the top simply by fitting the ply top first, and then cutting out for the required amount of glazing. The glazed area should be of ½-inch Lexan or Plexiglas. When buying your glazing material, check the telephone directory and try to buy scrap material rather than specifying cut-to-size, for which you will pay a premium price.

You will need to take some special precautions when working with the plastic glazing fitted to your hatch tops and portlights. The holes you drill in the plastic must be slightly oversized. You must allow for the different expansion and contraction rate, as opposed to the timber framing. You will most likely use tinted plastic, and this will expand in hot weather; if the bolt holes or screw holes are too snug, the plastic will crack and need to be replaced. Usually, the next size up from the screw size is about right for the hole. The safest type of screw is round headed with a flat surface on the bottom of the head where it meets the plastic; self-tapping stainless steel screws are ideal. Fancy screws, such as hex-headed, sheet-metal, stainless steel screws will give you a good looking and strong fastener. Sheet-metal screws have larger threads than woodworking screws and therefore provide additional fastening surface.

The plastic should be bedded against the timber with as good a grade of silicone sealant as you can find. A small amount of the silicone sealant in each hole prior to screwing the glazing in place will ensure that the oversized holes remain watertight.

Hinges are fitted to the forward area of the outer coaming so that the hatch is aft-opening. The hinges should be heavy-duty and made of stainless steel or other noncorrosive metal. To secure the hatch from below, a number of catches and locking devices are available. One of the best is the type with screw-down devices, so you can dog the hatch down firmly onto its gaskets.

When fitting the wooden hatch, assemble it completely with gaskets and then lower it into position. The best way to make the fit between the coaming and the deck or cabintop is to first make sure the whole assembly is set up level. Next trace the shape of the cut required, allowing the coaming to make a good fit with the deck or cabintop. Now you can bolt or screw the coaming in place through the metal deck, working from underneath the deck. Make sure you bed the coaming in a suitable sealant.

Custom hatches can be made even more suitable for the rigors of cruising with a few simple additions. You can add an extra coaming on the deck or cabintop immediately adjacent to the hatch. This coaming should surround the forward edge and sides of the hatchway. It will be slightly lower than the entire hatch assembly and fit so as not to interfere with the operation of the hatch. The extra coaming will help keep water away from the hatch. The top of this extra coaming could be timber or metal. If you make it of timber, round off the top to give it the best appearance. In all cases, the sides can have holes in their bottom edges to allow for drainage.

Another improvement to any hatch is to install eyebolts close to either side of the hatch assembly. You can use them in extreme weather conditions to lash the hatch down even more securely. The eyes need to be close to the hatch so you don't stub your toes. Wood slats running fore and aft across the top of the hatch will strengthen Plexiglas tops and can improve the look of the hatch at the same time. These 1 by 1 inch (25 by 25 mm) timber slats can be screwed into the outer frame and then screwed to the acrylic from underneath. The slats will take some of the force and distribute the weight of persons standing on the hatch, or the weight of a heavy breaking wave. You can also make canvas covers for all of the hatches. Not only will you need these in hot climates, but they can also be a safety factor when included as part of the lashing-down arrangement.

Access Hatches

Access hatches, as opposed to hatches used only for ventilation, must be of a size sufficient to allow even a large person to enter and exit the boat in an emergency. The minimum size for an average person, as we've already seen, is 20 inches (508 mm) square, but don't make hatches unnecessarily large. They must be able to withstand all that the sea can offer. You should be able to open all your hatches from both outside and inside the vessel, and you should be able to lock them to deter unauthorized intruders. Hatches in accommodation areas should be built with some form of glazing to admit light and add a spacious feeling to the interior.

Companionway Hatches

The main access hatchway can be in the form of a sliding hatch, a hinged hatch, or a quadrant companionway type hatch, as illustrated. Sliding hatches should not be simply a sheet of plastic running in the simplest of aluminum tracks, even though this is sometimes seen on production powerboats. Build, or buy and install, a proper seagoing hatch as your main entry and exit point.

The companionway hatch consists of two main elements: the runners, which fit on the cabintop, and the hatch, which slides on or in the runners. The runners and the hatch may be constructed of timber or metal. If timber runners are used, you'll need 3-inch-high by 2-inch-wide (75 by 50 mm) timber. The timber runners could be deeper, and could be bolted directly to a set of intercostal beams situated around the perimeter of the hatchway. The runners will need to extend beyond the opening; the length is twice the hatch length plus 3 inches (75 mm). Where they extend over the cabintop, they'll need to be screwed from inside, through to the timber.

The tops of the runners are faced with heavy (say, ¼ by 2 inch, or 6 by 50 mm) brass strips that act as runners for the hatch top. The brass strips are set in silicone and screwed to the runners with flathead screws set flush with the surface. When it's properly set up, the hatch must run smoothly on the brass slider.

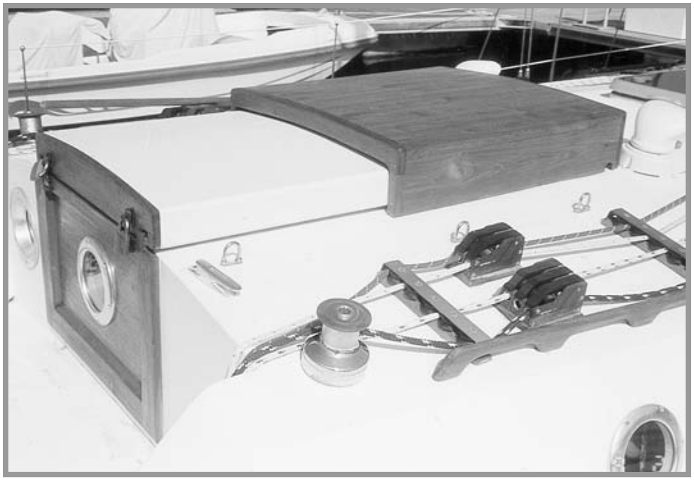
The sliding hatch is another box, with the frame built of 1½ by 2 inch (35 by 50 mm) hardwood. The corners can be half-jointed. Considerable care is needed to ensure that the frame is a true rectangle and sits perfectly flat on the runners. Around this inner frame, an outer frame is constructed from 1½ by 4 inch (35 by 100 mm) hardwood. The outer frame is glued and screwed to the inner frame, with the tops of both frames flush and the outer 4-inch-deep (100 mm) frame acting as a guide to allow the inner frame to slide on the runners. The whole arrangement must slide smoothly. A hatch that jams is in no way desirable aboard any boat. Now you need an arrangement to keep the hatch on the runners, and you can do this by gluing and screwing a ½ by ½ inch (12 by 12 mm) cleat inside the outer frame ⅛ inch (3 mm) underneath the brass runner. Now the hatch has to be slid onto the runners from the front.

The forward and after ends of the hatch are finished off with hardwood plates. The companionway end can have a handle or grip built into the top. The bottom of this facing board will need to be shaped to clear the cambered cabintop as it glides (we hope) forward to its fully open location.

If you have the recommended garage, then the front should be large enough to cover the aft end of this arrangement. Incidentally, the garage houses the hatch when it's open. The garage is particularly important in forward-facing sliding hatches, as it helps to divert water away from the open companionway. It also partly provides a neat cover for the runners and the open hatch, eliminating one area where lines can snag and toes can be stubbed.

The front facing of the hatch, with the handgrip built into the top, will also need to accommodate the hasp part of your hasp-and-staple locking arrangement. The top of the hatch can be finished with ⅛-inch (3 mm) teak plywood and the whole structure coated with epoxy and light fiberglass cloth for a long life.

The top of the hatch can be three layers of ¼-inch (6 mm) plywood, and if you've taken our advice and made the top match the cabintop camber, you'll find that the plywood will laminate into a strong and durable top. A trim strip will be required for the outer edges of the plywood top to seal them from the elements.



To soften the steel exterior, John McDermott added this timber "garage" and companionway door to his Spray 33.

When you're building a timber or plywood sliding hatch above a metal cabin, the hatch opening can be finished off inside with a timber trim strip of suitable width. You'll also need washboards (vertical hatchboards or dropboards) that will fit in preinstalled metal channels to complete the closure of the main-access companionway.

It's worth noting here that any timber you attach to your steel hull or superstructure should be given at least three coats of epoxy resin, which will go a long way toward stabilizing and protecting the timber. All timber runners, hatch coamings, and the like must be set in silicone before they are either screwed or bolted in position. Space the screws or bolts at 3-inch (75 mm) intervals.

Deck Prisms

Another form of underused light-admitting device is the deck prism. These wonderful devices admit much more light than their size would indicate, and they can be installed to be absolutely watertight and secure from the ravages of man and the sea. Check with your local hatch manufacturer and other equipment suppliers to see what they have to offer in this area. If you fit prisms, make sure your crew is well protected from contact with the sharp inside edges—but do not let this last statement put you off; deck prisms are great for admittiting the most light with the minimum of hassle.

Portlights and Windows

Portlights and windows can be opening or fixed, but it's a fact that the opening variety, no matter how well constructed and maintained, will always be a source of leaks and worry for the crew. It's often desirable to have one or more windows or ports that can be opened; however, it's wise to keep their number to an absolute minimum. The plans for your boat will no doubt give you some indication of the size and location of the ports and windows. Our advice is use only fixed portlights and rely on opening hatches to provide adequate ventilation.

If you're planning to use opening ports, they should be professionally made and of the highest quality you can afford. Most commercial ports are made from marine-grade aluminum, so if your boat is built of steel or copper-nickel you'll need to isolate the aluminum from the other metal. Neoprene is commonly used for this purpose. Don't forget to use sleeves in the boltholes where the ports are bolted to the hull or superstructure. Occasionally, you'll find steel-framed professionally made ports, but they're generally made for very large vessels so they may not be suitable for your boat.

There are many ways in which the windows can be fitted. One popular way is to set the win-

Recessed ports and windows always add a professional finish to any metal hull; these are fitted to a Roberts 64 built in Canada.

dows back into the cabin sides or into the hull. To achieve the latter result, the window aperture is framed with an inward-facing, L-angle, shaped flange. The bottom of the L is where the window or fixed portlight will be set in sealant and bolted in place.

As you will realize, this is a more complicated procedure than simply bolting the window into a hull or cabinside cutout; however, the results are worth the extra effort. Set-in ports and windows give a vessel that extra touch of quality that not only enhances pride of ownership, but one day will return dividends in a better resale value. Forward-facing wheelhouse windows that will be fitted with windshield wipers will need to be glazed with toughened glass instead of the usual acrylic favored for many other boat windows and ports.

If it's well made, the simplest portlight or window can have an appearance that belies its low cost. The design and method of installation is simple. You cut a hole 1 to $1\frac{1}{2}$ inches (25 to 35 mm) smaller than the overall size of your port or window and fit and bolt a larger piece of Plexiglas or similar plastic over the aperture. The glazing is set in silicone, the holes for the bolts are drilled slightly oversized, and the corners of the hole for the portlight, and the covering Plexiglas, are all radiuses.

You can use clear silicone, but it's preferable to use silicone that matches the color of the area of the boat into which the port or window is being installed. If the bolts have hexagonal heads, and you line up the slots in the heads, you'll improve the appearance of the glazed area. If the ports or windows are located in a high-traffic area, such as adjacent to the side decks, then you should have bolt heads that fit flush with the glazing and thus avoid scratching crew members who brush by the window. Be careful when making countersunk holes to allow bolts to fit flush. Acrylic can be induced to crack if it's handled too roughly during the shaping and assembly stage.

Make sure the windows don't have an overly large area without sufficient support in the underlying cabin or wheelhouse side. Plexiglas and similar acrylic materials come with a paper protective covering; never remove the bulk of this until the boat is completed and ready for launching. You'll need to remove a strip of the paper, of course, after you've drilled for the bolts but before you install the window or portlight. The thickness of the glazing will be between $\frac{3}{8}$ and $\frac{3}{4}$ inch (10 and 20 mm), depending on the size and area of the aperture.

For most windows and ports, you can use Plexiglas or the harder and more scratch-resistant Lexan. You can dress up the outer edges of these bolt-on windows by using timber, stainless steel, or other suitable metal frames that can be cut to, say, 1 or 2 inches (25 to 50 mm) wide and bolted in place at the same time as the window is installed. If you use metal, it can act as an outer washer for the fastenings and will generally enhance the appearance of the windows and ports on your boat.

With powerboats, where the boat is more or less always in an upright position, and where the boat is not designed or built for extended ocean voyaging, you can be more liberal with the expanse of glazed area. Most powerboats have at least one forward-facing opening window adjacent to the inside helm position. This opening window can admit copious quantities of fresh air, and when it's open it gives you better vision ahead in fog or poor visibility.

Even in powerboats, we find that opening windows, usually of the sliding variety, are a source of problems. Sooner, rather than later, the rubber or other material used in the bottom track for the glass will perish and allow water to enter. In some steel powerboats, it's common practice to have the large side windows fitted without any provision for insulation. Perhaps the designers and builders feel that the expanse of glass takes up so much of the available area that it is not worth insulating the remainder. The problem is that when plywood lining is attached directly to the steel cabin side, the resulting condensation can cause problems. In one case, it was natural (though wrong) to blame a leaky window for causing discoloration of the teak plywood lining. It took some time before the culprit was diagnosed as lack of insulation in the cabin side, which caused condensation. It would have been too expensive to remedy the situation, but luckily it was discovered that a dehumidifier would solve the problem. Lesson: Always insulate all areas of your accommodation.

Outer Doors

As a rule, outer doors are seen in powerboats, especially trawlers. If you wish to have a door opening in the side of the accommodation, usually near the helm location, make sure it's properly designed, fitted, and suitable for marine use. Marine doors are usually of a more robust construction than sliding windows and are therefore easier to maintain and keep watertight.

Side doors in a trawler yacht's cabin can be built of timber and may be arranged to slide; or, if you have a very large yacht and wide side decks, then it may be possible to have the door hinged at the forward edge, or perhaps open inward. On smaller boats, a half-height, side-access door adjacent to the inside helm position may be found useful. All doors, especially sliders that are either outside or inside the accommodation, should have a means to secure them in the open position, as well as when closed.

A recent report told of a boatowner receiving severe injuries to his neck from an unsecured aluminum sliding door. Patio-style aluminum doors at the aft end of a powerboat's main saloon? *Ugh!* The sliding variety, especially, are famous for lopping off fingers. And the large glass area is vulnerable to being broken in a variety of ways.

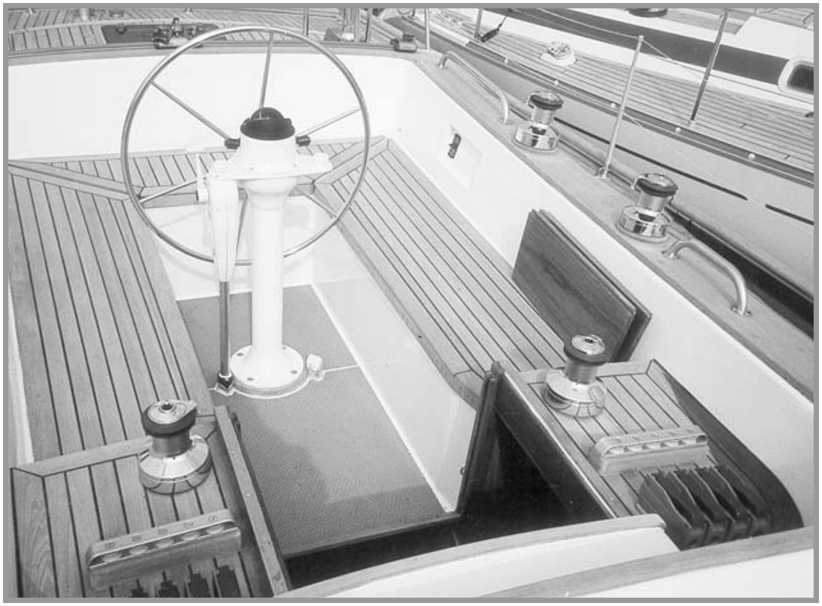
If your powerboat is of the aft-cockpit variety, then you'll most likely have a metal aft bulkhead in which you can fit a pair of timber doors. The top one-third of the doors can be glazed, and you'll have all the light you need. As the cockpit and after deck is usually well protected, the timber doors will need little maintenance.

On a similar subject, you may wish to lock some of the interior doors; this may slow down an intruder.

COCKPITS

Not all boats have cockpits but most sailboats have, or should have this feature. Most of us prefer the security, real or perceived, offered by a well-designed, self-draining cockpit. They work particularly well when combined with protective coamings and comfortable seating.

This neat Roberts 34 cockpit was built in Sweden about 30 years ago.



This teak-trimmed cockpit is installed in a radius-chine Roberts 432 that sold in the UK for a handsome price.

back should lean backward about 5 degrees to be comfortable when sitting in a level cockit. All cockpits should be self-draining, with two separate outlets of generous size, a minimum of 2 inches (50 mm) in diameter. The cockpit drains should be fitted with seacocks that can be closed when required. Finally, you should have a reasonable view forward when you're seated in the cockpit. This is easier said than achieved, especially if there is a pilothouse ahead of your cockpit.

The choice between center cockpit and aft cockpit is usually governed by your choice of interior layout. This choice has become blurred with the advent of staterooms fitted beneath and around an aft cockpit.

The dimensions of this arrangement are most important and can influence the safety and comfort of the boat in many ways. It's desirable, but not always possible, to have the cockpit seats measure 6 feet 6 inches (2 m) in length to allow a person to lie full-length. The width of the cockpit is best arranged so a person can rest one or both feet on the seat opposite; this usually results in a well that is 2 feet 3 inches (686 mm) wide. The depth is best at 1 foot 6 inches (457 mm). Seats should be between 1 foot 3 inches (381 mm) and 1 foot 6 inches (457 mm) wide. For comfort behind your knees, the inboard edge—the intersection of cockpit side and the forward edge of seat—of the cockpit seat should be rounded, radiused, or beveled.

The height of the seat back (usually part of the coaming) will vary depending on the design; however, about 2 feet (610 mm) seems to work out well for most people; the

This attractive cockpit is devoid of timber trim, but it can be dressed up with cushions and still retain its maintenance-free concept.

The steel deck on this Roberts 64 is now ready to receive a laid wooden deck or one of many other alternative treatments.

Metal cockpits can be framed up using L-angle or flat bar, depending on the size of the vessel. Boats under, say, 30 feet (9.14 m) can use flat bar, and larger boats can use L-angle placed flange-down. Provided the transverse framing is spaced the same as the hull's, a minimum of fore-and-aft reinforcing should be required. Most boats today have cockpit cushions, so these need to be considered when laying out the area. Self-draining arrangements for the well are obvious, but don't forget to drain the seats. Wet seats and continuously wet cushions make for very uncomfortable sitting, so consider how you can best drain these areas. A teak grating in the well adds a nice finishing touch to any cockpit.

DECK COVERINGS

Your metal deck will need some form of treatment to provide a nonslip footing as you move about the boat. The least expensive treatment is to apply a special paint that contains grit. Many metal boats use this paint-grit combination, and provided it's installed in a proper manner it can look attractive and it does work well in practice. When you're installing a painted nonskid surface, you should leave small borders around various fittings and alongside the cabin and inside the bulwark and so forth—places that do not have grit added. Be careful how you lay out these ungritted areas, though, as you don't want to leave skid-inducing shiny spaces in high-traffic areas. If the ungritted areas are no more than 1¼ inches (320 mm) wide around any feature, you shouldn't have a problem. You can always fill in any problem spaces with gritted paint.

The next step up in cost and appearance is to use a deck covering like Treadmaster or a similar product. These coverings are composite materials formed in patterned sheets suitable for gluing to your deck. When laying out this covering, you should use a similar pattern as suggested for painting decks with gritted material. Available in a range of attractive colors, these products are bonded to your deck with special glue.

The diamond pattern on some of these sheet products can be hard on your bottom and other

Reinforced chainplates and deck fittings. Note that the Treadmaster deck covering is kept clear of the fittings to allow the free flow of water off the decks.

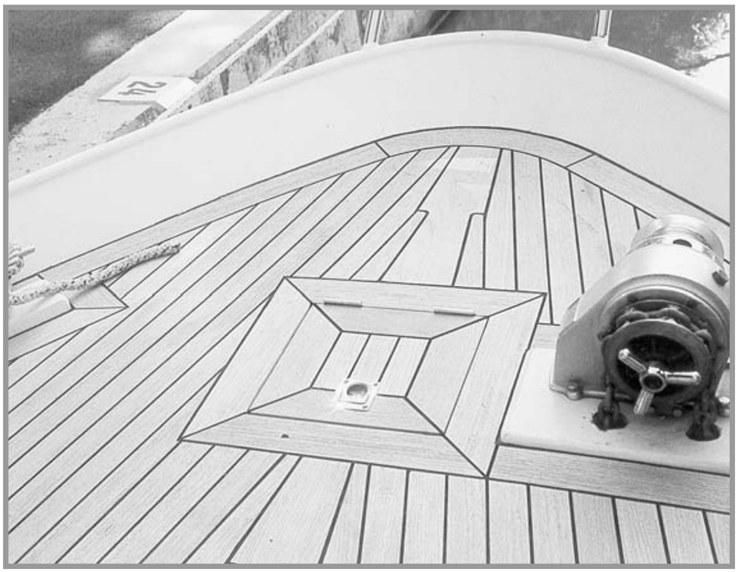
areas that may come into contact with the deck. So don't use it on cockpit seats or similar locations. There are alternative, less harsh patterns that can be used where a user-friendly, nonslip surface is required.

Personally I do not favor timber-laid decks on metal boats. If you plan to keep your boat longer than, say, 10 years, then you can expect have some problems if you install a laid timber deck on a steel boat. Problems with laid timber decks are not restricted to metal boats; many fiberglass boats that are manufactured by the most reputable companies also have problems with the laid timber decks once the boat has reached a certain age. The main problems are caused by the breakdown in the caulking materials. The caulking will develop hairline cracks after a few years and this allows water to seep through to the metal decks below. If you are installing or renovating a teak deck, under no circumstances stint on the quality of this caulking material.

Recently a simulated teak deck material has become available and this plastic-based (for want of a better description) material will be worth your investigation. It closely resembles teak and is laid in a similar manner, so check out this material before you consider a wooden deck.

However, some of you will settle for nothing but a laid wood deck. You may be surprised to learn that there are species of timber other than teak that are suitable for laid-plank decks. In Australia, beech is widely used, and in the United States quarter-sawn Douglas fir has been used for the same purpose. Nonetheless, teak is the premier material and the one you are most likely to be using to finish the decks of your metal boat in style.

After you decide that a laid deck is for you,



This 1-inch (25 mm) teak deck has been in place for 15 years; some recaulking has probably been necessary. Note the low bulwark, ably supported by a pipe caprail.

the next step is to determine if you're going to have a "wannabe" teak deck or the real thing. The "wannabe" type is usually ½ inch (12 mm) or less thick, and in most cases it will not do justice to your boat or to the craftsmanship needed to install any laid deck. A "proper" laid deck should have planks of at least ⅝ inch (15 mm) and preferably ¾ inch (20 mm) minimum thickness.

There are many ways to install this deck on a metal boat but all will involve setting the planks in some form of bedding compound. Again, we can take a lead from Dutch builders who have been successfully installing laid decks on steel and other metal boats for a long time. The outer planks will need to be fastened to the steel deck itself. The inner planks may simply be set in the bedding compound and caulked.

The regular planks should be about 1¾ inches (42 mm) in width. The outer and inner covering boards, king plank, and other featured planks around hatches and vents will be wider, usually 4 to 6 inches (100 to 150 mm), depending on the size of the boat and the way the deck is installed. The outer covering board is a misnomer in this case, as there should be a space between the edge of the teak covering board and the edge of the deck to create a channel for water to run alongside the outer teak plank and on out through the scuppers.

The bulk of the fore-and-aft planking can be laid in several ways. It can follow the outer shape of the hull, generally known as the "swept" style of fore-and-aft planking, or it can follow the line of the cabin sides, or it can split the difference. The main effect of these various methods is the way the planks need to be "nibbed" into the outer and inner covering boards and king plank. It's also possible to lay the deck in a herringbone pattern; this has been done on more than one of our designs, but we prefer longitudinal planking that splits the difference. (Naturally, this is the most expensive form of planking!)

The deck and cabin of a very attractively finished Roberts 434 built in the UK. Note the recessed ports.

ALTERNATIVE DECKS AND SUPERSTRUCTURES

Although there are arguments for building a boat using all steel, all aluminum, and perhaps all copper-nickel, there are many reasons why some of you may prefer to take a different approach. In the case of copper-nickel, as this material is much more expensive than either steel or aluminum, it would make sense to have the hull built from copper-nickel; the hull is where the material is most beneficial; the decks and superstructure could then be built from an alternative, less-expensive material. If your metalworking skills are limited, and you have more experience with working in timber, you may consider a timber deck and superstructure. As you can see, there are a considerable number of options and you have to weigh up the benefits and disadvantages for yourself.

Plywood and Timber Decks and Superstructure

A good reason to install a plywood deck and superstructure on a small steel boat is to keep weight down. If you take the timber-and-plywood deck option, you'll need to select a point

Teak decks require a lot of maintenance; with any luck, your partner will be as willing to assist with the more onerous tasks as mine is.

where you make the transition from metal to timber. The choices are to have the hull built in metal and install a *margin plate* welded to the inside or sheerline of the hull, where the deck will join the hull. The margin plate will take the place of, and be installed in the same location as, the deck stringer in an all-metal boat. Another alternative is to have the hull and complete decks built from metal and include an up-stand in metal to accept the timber superstructure, located all around the inner edge where the cabin sides will be installed. In both cases, the timber and/or plywood would overlap the metal so that surface water or other moisture would be less likely to get between the metal and timber to cause corrosion.

If you're planning a laid teak deck, it may influence your decision. A teak deck is much easier to install over a timber and plywood deck than it is over a metal one. There's no doubt that a timber deck and superstructure is a beautiful sight from both without and within. You pay a price, though, at least for the beauty of the exterior. The maintenance requirements of external timber and plywood will be far greater than if the items were constructed from metal. This applies not only to large items, as in a pilothouse or cabin structure, but extends to timber hatches, handrails, caprails, and rubbing strips. These items, when built in timber and finished "natural," do improve the appearance of any boat, but the maintenance requirements can be horrific.

After you've installed either the metal margin plate to the hull, or the metal up-stand to the inner edge of the metal decks, then you should install a timber carlin to allow you to carry on the remainder of the construction in timber. You should rebate this timber in such a way as to discourage any water from becoming trapped in the joint and later causing rot in the timber. It's imperative that you make a watertight join between the timber and the metal.

Deck beams may be of timber or metal. In the case of a metal deck, then L- or T-metal deck beams will be used; however, in the case of an all-timber-and-plywood deck and superstructure, you may choose either metal or timber beams. If you use metal beams with a plywood deck, make sure you place the flange upwards. This is opposite to what you would do for metal decks. The flange will provide a ground and will allow you to screw the plywood to the beams from underneath. Timber beams can be laminated or sawn, but laminated beams are recommended.

This is a good time to mention that you should use epoxy-based adhesives throughout the construction of any plywood decks and/or superstructure. Where the plywood is attached to the metal margin plate or up-stand, a suitable bedding compound will be used rather than an epoxy adhesive. An epoxy system such as the West System should be used to saturate all of the timber and plywood parts used to build your decks and superstructure, but not on teak decks.

It's usually preferable to laminate the decks and cabintops from more than one layer of plywood. If your deck calls for ½-inch (12 mm) plywood, then use two layers of ¼-inch (6 mm) each. If the recommended thickness is ¾-inch (20 mm) plywood, then use two layers of ⅜-inch (10 mm) or, better still, three layers of ¼-inch (6 mm). Use either bronze nails or staples to apply pressure to the glue lines until the adhesive has cured.

If you're installing plywood decks, one labor-saving tip is to paint the underside of the first sheet before you install it. Make sure you don't paint the strips where the plywood will be glued to the beams. Fit the panels first, and, from underneath, mark where the beams will fall and where the plywood rests on the other timber supports. Now mask off those areas on the plywood and paint the rest.

There are several methods of finishing off your plywood decks and cabin structure but no matter how you do it, we recommend that you give the entire area a coat of fiberglass cloth in epoxy resin. Don't use polyester resin for fiberglassing over plywood or timber, always use epoxy resins. The only place for polyester resins is in the building of an all-fiberglass boat.

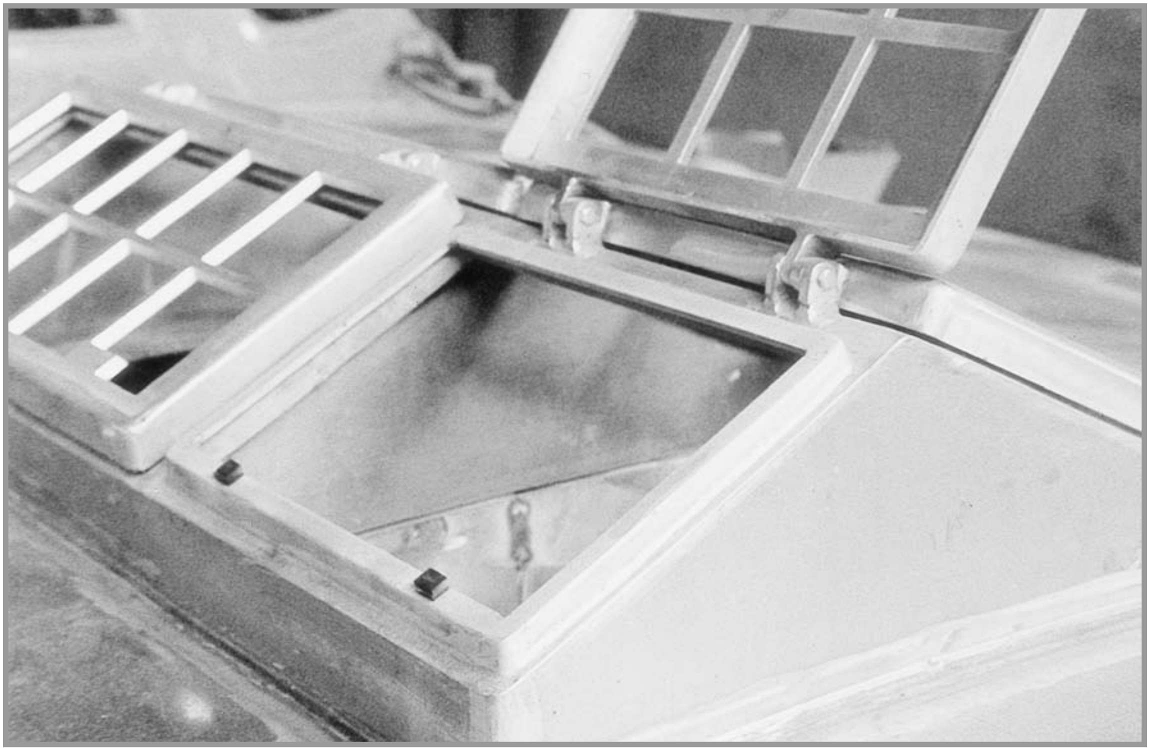
When you're using epoxy resins and adhesives, make sure that you follow all of the safety precautions recommended by the manufacturers. When handling these materials, always wear protective gloves and use protective skin creams. Keep in mind that epoxy stays toxic for several days while it's curing. When you're building timber and plywood decks and superstructures, you'll find the Gougeon brothers' West System book a good source of information. See Appendix 1 for more details.

Aluminum Decks and Superstructure

When you build an aluminum hull, you'll almost certainly install decks and superstructure of the same material. The benefits of installing an aluminum deck and superstructure on any metal boat include less weight up high, where it's detrimental. Aluminum is easier to form into small-radius sections such as those used on the corners of cabins, pilothouse fronts, coamings, and similar areas. A little forethought and a considerable amount of welding can be saved by combining seats to backs and so forth.

The aluminum decks and superstructure are somewhat more removed from the seawater elements than the hull is, and it's easier to avoid some of the electrolytic problems suffered by boats built completely from this material. The practice of installing aluminum decks and superstructures on steel hulls has been well proven over the past 30 to 40 years, so you can consider it an acceptable boatbuilding practice.

Aluminum decks and superstructures fitted to steel or copper-nickel hulls will need to have the different metals isolated from one another to prevent electrolysis. There are a number of methods you can use to achieve this isolation.



This attractive skylight is an example of what can be achieved by a dedicated metalworker.

Transoms can be customized to suit the owner's needs. Boarding from the dinghy was a major concern for the owner of this Voyager 495, which we overcame with transom steps.

The first that comes to mind is to insert a neoprene strip between the two different metals and bolt them together with bolts housed in nylon sleeves and nuts that are isolated with nylon washers.

The superior way to join aluminum and steel is to use the specially manufactured strip that has aluminum on one side and steel on the other. The two metals on this strip are explosively fused together so that when you weld the steel to the steel side and the aluminum to the aluminum side, no contact occurs between the two metals, and the possibility of electrolysis is eliminated, or at least reduced. Careful planning will be required so that the intersection of the two dissimilar metals is located in such an area as to reduce the chance of prolonged contact through salt water.

PAINTING A METAL BOAT

COLOR

This subject will probably be the first thing that comes to mind when you, or at least the family, are considering the paint job for your new or used metal boat. Even a simple matter like choosing the colors has its technical side. In my opinion darker hulls look better than white hulls. This may be especially true in powerboats. To my eye a dark blue hull adds “class” to any boat. That’s just my opinion, but it’s something to consider as you look at various other boats to help you decide on a color scheme for your metal boat.

In metal boats, a darker color for the hull also makes good sense. The darker color will absorb sunlight and drive off both the dew and some internal condensation. If the decks are painted, then you may choose a two-tone scheme of light beige for the larger areas and cream for the trim or unsanded areas. This arrangement will look smart and it will be easy on the eyes. You should never paint decks white, as the reflected light will cause too much glare. Except in the coolest climate, dark-colored decks will be too hot for bare feet and will also make the interior of the cabin unbearably hot.

This Roberts 370 built in Finland shows one reason good protective coatings are essential.

GRITBLASTING AND PRIMING STEEL

If your boat was constructed from raw steel straight from the mill you will need to gritblast the metal before attempting to apply any paint coating. This process is variously referred to as sandblasting and gritblasting. It's the only way you can provide a satisfactory base on which to apply your prime coating andsubsequent layers of protective paint. Blasting is necessary to remove all contaminants and corrosion from the surface of the metal; and as this process slightly roughens the surface, it also provides an excellent "tooth" for the paint. For reasons that will become clear, we believe the best way to build a steel boat is to use preshotblasted and primed material, and to build under some form of cover. Nonetheless, some builders do blast their own steel.

The exact roughness of the surface will depend, for the most part, on the particular metal, the type and grade of grit used, and the force with which it's applied during the blasting process. The result is commonly referred to as the anchor pattern, and will vary between 1.5 mils (thousandths of one inch) and 4 mils (0.038 mm and 0.1 mm) in depth. Four thousandths (0.1 mm) is considered a heavy and deep blast, and may be satisfactory for tar-epoxy finishes. For most paints, however, you should aim for a 1½-mil to 3-mil (0.038 to 0.076 mm) anchor pattern. Your paint manufacturer may have special recommendations in this area. Make sure you choose a warm and dry day with low humidity when you are blasting your boat.

For blasting, you'll need a powerful compressor; for instance, one that can deliver something over 350 feet (107 m) per minute would be perfect. You need manpower: two or three people plus yourself would be adequate. There are various specifications for the blasting of steel. For our purposes, near white blast-cleaning will deliver a successful, corrosion-free, and long-lasting paint job. Near white blast-cleaning produces a surface in steel that, when viewed without magnification, is free of all visible oil, grease, dirt, dust, mill scale, rust, and paint. Generally, evenly dispersed, very light shadows, streaks, and discoloration caused by stain of rust, stains of mill scale, and stains of previously applied paints may remain on no more than 5 percent of the surface.

Sand is the least expensive abrasive, but because of its high silica content and the health hazard presented by silica, you may find that your local contractor is not willing to use this material. If you're doing the job yourself, and you wear the correct protective face mask, then blasting one boat with this material should not represent an undue health hazard. It's your responsibility to decide on using sand as opposed to the more expensive alternatives. Sand can't be reused, so you'd need more sand than slag or grit.

Grit is a little more expensive than sand but contains none of the silica that, when used over a period, can cause respiratory and lung problems, among other things. In the United States, these products are marketed as Copper Blast, Copper Slag, Green Diamond and Garnet. Similar products are available in Britain, Australia, and elsewhere.

Crushed-steel shot is more expensive than either sand or grit, but as it can be reused many times you may consider it to be worth the additional expense. It's formed from crushed iron or steel, and has irregular shapes with very sharp edges. It's one of the better blasting materials.

You'll need to consider matching the type and roughness of the blasted surface with the paint you plan to apply. A surface that's too rough will show through your paint finish, and a surface that's too smooth won't provide a good grip for that most important element in your paint job, the primer.

Many builders have found that it takes a lot of effort to undertake this job, and it saves very little in cost. By the time you hire the equipment, purchase the grit, and arrange for the help needed, it can cost nearly as much as a professional job. You need three people for this operation; one to operate the blasting gun, one to feed the material, and one to apply the primer. If you don't have three people, the job will take much longer. For instance, if the blaster has to feed his own abrasive, he has to remove and replace his bulky helmet each time more grit is needed: a time-wasting exercise.

In the case of steel hulls, the prime coating must be applied immediately after the blasting. This means that the painter has to follow the

Careful masking of the various parts of the boat will play an important part in ending up with a professional-looking paint job.

blaster as closely as is practical. Rust can form in a surprisingly short time; the actual time depends on the weather and humidity prevailing when the blasting takes place. It's usual for the owner or his employee, as opposed to one of the contractor's employees, to undertake the painting. If you control this critical job yourself, you'll be assured of its success. Make sure the paint is being applied to a perfectly clean and dry surface at a minimum temperature of 50°F (10°C). The paint is best applied within 30 minutes of the blasting. That way, as well as avoiding rust, you'll have the extra advantage that the steel should still be warm from the blasting. Finally, 3 to 4 hours is the absolute maximum time lag between blasting and prime coating. This is definitely not a one-person operation.

Estimating the time it takes to blast and prime coat is difficult, given all of the variables involved. However, about 50 square feet (4.65 square meters) per hour seems about average. No grit operator or painter can operate flat-out for extended periods. It's wise to divide the hull, deck, and superstructure into reasonably sized segments; say, quarters on a small- to medium-sized hull, and smaller proportions on larger craft. Keeping the blasting and the painting apart will take some organizing, but you will need to do it to ensure a clean and long-lasting priming job.

When you purchase preblasted and primed steel from a specialist supplier, then these materials have most likely been blasted by a wheel rather than blasted in the regular way. This process is most effective in plate of ⅛-inch (3 mm), or 10-gauge, and larger thicknesses, but lighter plates may distort when exposed to wheel "blasting."

Wet blasting involves using water mixed with the grit or sand. This process keeps down dust, but afterward it leaves a great deal of heavy, wet grit or sand to be cleaned up. A rust inhibitor is used in the water, but you have to blow the hull dry and apply the paint before the effects of the inhibitor disappear.

The interior of the hull, under the decks, and inside the superstructure will all need to be gritblasted: a difficult and messy job. Don't forget to have all of the cutouts and openings for windows, ports, and hatches already completed before you gritblast and apply the prime coat. It will probably be best to blast the outside first; that

SPRAYING HOT METAL

This method of applying a protective coating is included here because we're still occasionally asked about its merits for a steel hull. Metal spraying was at one time popular with some steel builders. During the 1970s, when it was most popular, there were many who decried its use on the grounds that if it chipped or otherwise failed, water would creep underneath and cause considerable invisible corrosion problems. Time has proven these critics correct, in fact, and the method is infrequently used today. Another drawback was that the materials used for these coatings were notoriously averse to holding paints as intended. The development of modern epoxy and urethane protective coatings has allowed flame spraying (or metalizing, as it was popularly known) to fade from the scene. In the interests of thoroughness, however, here are the details.

Hot-metal spraying is accomplished by melting either zinc or aluminum metal wire in a special gun that drives it at high speed onto the bare steel in the form of molten droplets. Like a surface prepared for painting, the steel surface must be prepared by gritblasting down to white metal. Without this etched surface, the hot metal spray will either roll off or flake off after cooling.

Many advocates of this method claim a chemical bond forms between the aluminum or zinc and the steel; they claim that the metals are fused together. Actually, the hot metal spray forms a mechanical bond only. It depends on the correct spraying techniques, as well as a gritblasted surface, to maintain its grip on the steel. If you plan to metal-spray your hull, don't use sand as the blasting agent. Commercially manufactured grit is necessary to give the correct key for the metalization process.

If you use a hot spray involving aluminum or zinc, then you should apply a special wash to the aluminum coating before applying any paints. An example of such a wash is Interlux Viny-Lux Primewash, which is specially formulated to adhere to bare aluminum and is a good primer for the other coats that will follow. If you are considering one of the hot metal spays for your boat, you should seek out the latest information on the subject. My advice is stick to the well-proven regular painting procedures for metal hulls.

way, you won't have any worry about grit coming through openings into an already prime-coated hull interior.

We have now come full circle. We've considered the alternatives and you can see that my advice to use preshotblasted and primed material makes sense. Even if you are building in the open, depending on the climate and the amount of care you take in covering the hull, you may find that the preblasted and primed materials are worth the extra cost and effort. Even so, covering your hull during nonwork periods will pay off.

If you use pre-prime-coated steel, then you'll need to clean up only in the area of the welds. You'll recoat these areas before proceeding with another prime coat of the entire hull, deck, and superstructure. The welds can be cleaned with a grinder, a wire brush, or a similar device to expose a clean surface that's ready to be touched up with matching prime coat.

Be careful when you're using solvents and other liquids to clean metal; be aware of the deposits they leave behind, so that you're not faced with a never-ending circle of cleaning and recleaning a particular area. Acids can sometimes be used to advantage to remove surface contaminates, including rust. Acids tend to etch the surface and thus improve the adhesion of the paints you apply afterward. Generally, acids are only used as cleaning agents in smaller areas such as those where welding has spoilt an otherwise prepared and primed hull.

FILLING AND FAIRING

For a perfect or near-perfect finish, almost all metal boats need some filling and fairing, but it's important that you do not rely on the filling compound to cover sloppy workmanship. The following advice will probably be ignored by the sloppy builder and resented as unnecessary by the perfectionist. It's to the greater proportion of you occupying the middle ground that we address this advice. Your aim should be to make every step of the building process produce a fair and smooth hull, deck, and superstructure. You should strive to build a boat that will require the minimum of filler. If you are building from a precut kit you will find that very little filler is required. Precut kits do make for a fairer hull than can ever be achieved by building from scratch. If your hull is truly fair you will only need to apply filler in the areas where the plate is joined or where welding and grinding has taken place. Often just a smear of filler will do the job.

Now, having established that all hulls and most superstructures need at least some filler to produce the near-perfect appearance, it's simply a matter of choosing and correctly applying the right material. Automotive body putty is not the correct filler for your boat. It won't withstand the rigors of marine use.

Incidentally, please let the recommendations of your paint manufacturer overrule any advice we give here. You must choose one manufacturer and use its products exclusively. If you mix brands, you'll have no protection if the product fails. Each manufacturer will blame the competitor's product as the cause of the problem.

The correct filler for your metal boat should be epoxy, not polyester based (as is usual)with automotive fillers. Your fairing compound should contain inert fillers such as microballoons. Many paint manufacturers have their own fairing compounds as part of the overall paint system. Make sure you choose a manufacturer who will give you local advice and technical assistance. This is not just a case of visiting your local marine store and taking what's on offer. You'll need to undertake considerable research to ensure you end up with a long-lasting and attractive paint finish on your metal boat. To quote our own experience, our 38-foot (11.58 m) steel powerboat was originally painted in 1991, and today the superstructure looks as good as new. Due to mishandling and neglect by the previous owner, the hull recently needed a blow-coat to cover scuff marks.

PAINTING

In the process of selecting the paint, you'll have to consider how it will be applied. Certain fin-

This Roberts 434 shows that a stripe can enhance the appearance of most hulls.

ishes lend themselves better to one application method than another. Some paints can be applied in many ways, so this may influence your choice of paint as well as what equipment you either purchase or hire for the job. No matter what method you choose for applying the various paints, you'll need a selection of brushes, rollers, paint trays, scrapers, sandpaper, and all the usual tools one associates with painting any structure. We've seen many fine metal hulls painted with hand tools, including a combination of rolled and brushed finishes.

Airless, or air-assisted spray equipment is favored by those experienced in painting hulls, and it's possible to lay on high-build paints in a way that could not be achieved by hand. If you elect to blast your boat, it's well worth considering using a professional team to at least apply the prime coating on your hull immediately after blasting. A team of, say, three or four professionals can blast and prime your boat in just a few hours and thereby ensure that you get the best cover for the blasted steel before it starts to rust.

The success of your paint job will depend on the care and attention you lavish on the preparation of your vessel before the first finish coat is applied. You must identify individual items that will be more prone to rust, and then give them additional attention. One way to identify potential problem areas is by studying other older steel boats. If you've followed our advice on layout and construction, then you will already have avoided most of these potential problems. Now, all you have to do is carefully check your own boat before you start to paint.

Usually, rust doesn't form on smooth areas of the hull. Irregular and sharp surfaces are often the culprits. For instance, we have always recommended that you avoid sharp corners on your hull or superstructure. To avoid creating rust traps and areas where paint is easily damaged, liberal use should be made of split pipe and/or rolled plate. When you eliminate the potential problem areas, you will also eliminate the corrosion problems that, at best, ruin the appearance of any metal boat, and at worst endanger its security. Therefore, no sharp edges, sharp corners, water traps, overlapping plates, or other bad practices that we have already covered in earlier chapters.

Don't attempt to paint areas of high wear, such as anchor fairleads, cleats, and similar fittings. They must have a stainless steel liner welded in place to accept the wear, and thus avoid any corrosion problems. All welds in areas above the waterline must be ground smooth and filled. This will ensure that no jagged edges or high spots are present. Sharp corners and jagged welds prevent the layers of paint from covering evenly, and thereby diminish protection.

As we've said already, we don't recommend that you grind smooth the welds below the waterline. This is a safety factor, and it means that these welds should be most carefully executed to give maximum strength and maximum smoothness, to enable them to accept a full quota of paint.

Aluminum

Many aluminum workboats are left unpainted and this is not a problem when the correct grade of marine aluminum has been used to build the vessel. The metal forms an oxide on the surface and further protection is unnecessary. But even these unpainted aluminum vessels need some protection below the waterline, so the underwater hull must be coated with a suitable antifouling paint. In France, we've seen many aluminum-hulled sailboats and powerboats with unpainted topsides, and quite frankly, they look unfinished. Unless you want your boat to look like an untidy workboat, you should accept the fact that you will be painting your aluminum vessel.

You'll need to abrade the surface of your aluminum hull by sanding it, or by using abrasive pads to roughen the surface of the metal. Next, thoroughly clean the surface with the chemical preparation recommended by your particular paint manufacturer. Now etch the surface. This is usually done with a phosphoric acid solution that changes the chemical properties of the surface of the aluminum, allowing better adhesion for the first coat of paint. Your paint manufacturer will recommend an etch primer or a wash. A primer coat will follow this. Needless to say, this primer coat is one of the most important of the whole system; if it fails, then the whole system will break down.

After you have applied the primer coat, follow it with two or more high-build barrier undercoats above the waterline. The finish coats will be applied above the waterline. A special tin-based antifouling is normally applied below the waterline. In some areas, a license is required to purchase and use toxic tin-based antifouling. Check locally to see if you require a permit to use this material. Because of galvanic corrosion problems, you must never use copper-based antifouling paint on an aluminum boat.

Copper-Nickel

Preparation for painting copper-nickel should include good-quality gritblasting or sandblasting followed by a high-build epoxy filler/primer or epoxy mastic. For final coatings, polyurethane-based coatings are recommended. As with the painting of all metal boats, advice and assistance should be sought from a local paint manufacturer, or at least one who has a readily accessible and knowledgeable technical department.

Finish Painting All Metals

Most paint manufacturers have their own specifications for painting the various metals. Many of the procedures are similar, and consist of roughening the hull surface, and/or using chemical preparations to thoroughly clean off any impurities. Next comes the application of prime coats, and more than one barrier coat. The process is completed with several finish coats to the hull topsides as well as to the decks and superstructure.

The bottom paint requires a thicker application. Paint located on and below the waterline must not only protect against corrosion, but also

This beautifully painted radius-chine steel Roberts 434 shows the excellent finish that can be achieved on a well-built steel boat. This hull has no filler.

must prevent excessive marine growth. Nature helps out; the area under the water has less exposure to oxygen, which is one of the agents needed to promote rust, and other corrosive elements. Your metal boat should be hauled at least once a year and the bottom should be given a thorough scrub.

The bottom paint must be checked for flaws and a new coat of antifouling applied. Make sure it's applied according to the paint manufacturer's specifications. Even if your boat is continuously moored in freshwater, you'll still need to antifoul the hull regularly. Details on the installation and replacement of anodes, together with other actions you should take to protect the underwater areas of your hull, are covered in Chapter 12, Preventing Corrosion.

Decks and Superstructure

In general terms, you'll use the same paint on the decks and superstructure as you have used on the hull topsides. The cabin sides and ends will almost certainly be painted in the same way as the hull. With a few exceptions, the preparation methods for the decks, cockpit and cabintops will follow a similar routine. Don't have too many colored strips, and don't chop up the area into many small sections or you may end up with a pattern that looks fussy. It takes careful thought and some experience to lay out a successful two-color paint scheme for the decks and cabintops. The designer of your boat may give you some advice and assistance in this area.

If you're planning to install one of the composite patterned deck-covering materials such as Treadmaster, then obtain it in advance and carefully study the installation instructions. You must ensure that the adhesive used to install the decking will be compatible with the paint used on the deck. Having the decking material on hand will also allow you to make a better choice of color for the painted areas of the deck, that is, those areas that will remain exposed after the patterned material is in place. If you're planning a timber-laid deck, you'll need to make sure that the preparation is in keeping with the materials you'll be using.

No matter what arrangement you decide on for your decks and superstructure, make sure you give the area adequate coats of paint. Our steel power cruiser has five hand-applied finish coats; a perfect finish after many years of constant exposure to the elements proves the worth of a good paint job. Always carry a supply of primer, undercoat, and finish paints to touch up the dings and scratches that one gets from time to time.

Antifouling

The technology behind antifouling paints is constantly changing. On boats with copper-nickel hulls you won't have to worry; they don't need antifouling. The natural action of the metal keeps most marine growth at bay. But steel and aluminum boats need a preventive coating for the areas below the waterline.

Just when we believe we've found the answer to the antifouling problem, along comes an environmentalist to point out the toxic problems caused by the use of certain protective bottom paints. For this reason, it's hard to make specific recommendations. As is the case with the entire paint job, my advice is to select one manufacturer and use their system from the first etch primer through to the final coat of antifouling. When you're applying antifouling, you will need to estimate the load waterline and make sure your antifouling is carried to about 2 ½ inches (60 mm) above this line. The reason for painting the antifouling above the true waterline is that the water is never static, and if you finish the antifouling right at the waterline, you'll soon have an ugly growth of weed at, and just above, the true waterline.

Boottops

You shouldn't paint the boottop until after the boat has been launched and trimmed. After you've conducted trials, loaded stores and water, and determined the exact load waterline, only then should you consider painting the boottop. Incidentally, they're not just a straight, parallel line; they need to be applied so the line, when

Fine signwriting puts the finishing touches to any well-painted metal boat; Sea Pea II *is a Spray 38 built in the UK.*

viewed from the side, appears parallel, or appears to have slightly more width at the ends. These lines are difficult to get right, especially on sailboats where the aft sections sweep underneath the hull and require quite a wide line to give the correct appearance. Avoid excessive upward sweeps of boottop at the bow.

If you start with a level line parallel to the load waterline, it can represent the bottom of your boottop; next, using a level, strike a second line above and parallel to the first, you will see how this line widens out at the stern. Study other boats that are out of the water, and you'll get the idea. Don't copy the ones that don't look right. Powerboats will not present the same problems, because the hull sides are more-or-less parallel. A boottop made of a tape of constant width can work with a powerboat, but it would look totally wrong on a sailboat hull.

In our opinion, engines powered by gasoline (petrol) have no place in any metal boat—or in any other cruising boat, for that matter. Those who build or buy metal boats are usually thoughtful individuals, and safety is one of the reasons they choose metal. Petrol or gasoline engines do not fit this profile. We recommend diesel engines.

ENGINE COMPARTMENT

When you're choosing your engine, make sure that there's sufficient room to install (or retrofit) it. It isn't just a matter of shoehorning the engine into a given space; you'll also need room for insulation and servicing. The engine must be accessible. If access is difficult, then there is always the chance you'll neglect essential maintenance work. Make accessibility one of your primary concerns when installing the engine(s) and arranging your engine room space.

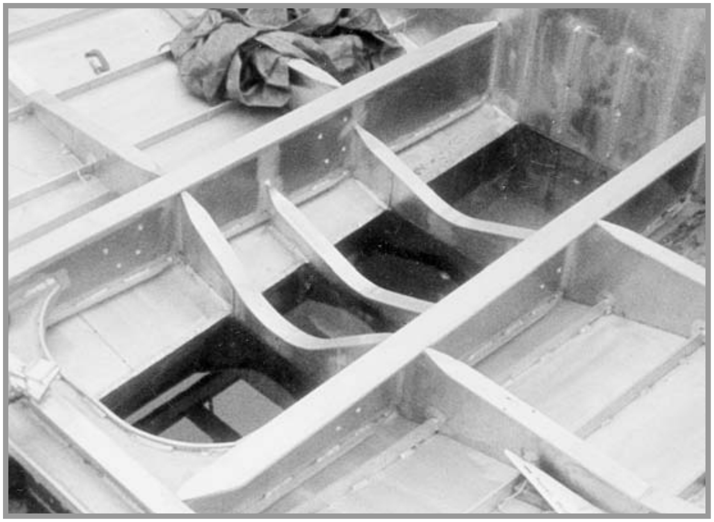
Out of the several boats we've owned, we have never been totally satisfied with the accessibility of all the items that need servicing on a regular basis. Unfortunately, total accessibility, although aimed for, is seldom achieved. For example, batteries need regular inspection, testing with a multimeter and/or hydrometer, and topping up with distilled water. These inspections are likely to be far less frequent if the batteries are in some difficult-to-reach location. The oil dipstick and the water filters should be inspected every day that the boat is in service. Primary fuel filters fitted with water traps need to be drained on a regular basis. Water impellers need to be changed occasionally, sometimes in a hurry. Main fuel taps should be easily accessible; and the list goes on. Can you easily reach the injectors, stuffing box, and fuel-tank inspection hatches?

Some single-engine, semidisplacement powerboats have insulated engine boxes in addition to an insulated engine room. This makes for very quiet running but it does restrict accessibility to some items on and around the engine. In sailboats, the engine often intrudes into the accommodation, where it is inaccessible and almost impossible to service. If you're building a new custom-designed boat, or rebuilding an older one, here's your chance to do yourself a huge favor: consider accessibility a number-one priority.

Engine room insulation in one form or another is essential if you want to keep noise down. In a sailboat, the engine box is usually a fairly close-fitting affair and the problem is also one of accessibility.

You can use several combinations of materials to insulate and quiet your engine, but however you do it, make sure the insulation won't give off toxic gases in the event of fire.

Here are some suggestions: aluminum-covered Styrofoam; fiberglass insulation with a lead insert; fiberglass and foam; and layers of lead, foam, and aluminum (or vinyl foam) sheeting. Most boatowners have found that a material that incorporates a layer of lead is usually the most effective in reducing noise. The classified pages of



These engine beds embody many of the features described in the text.

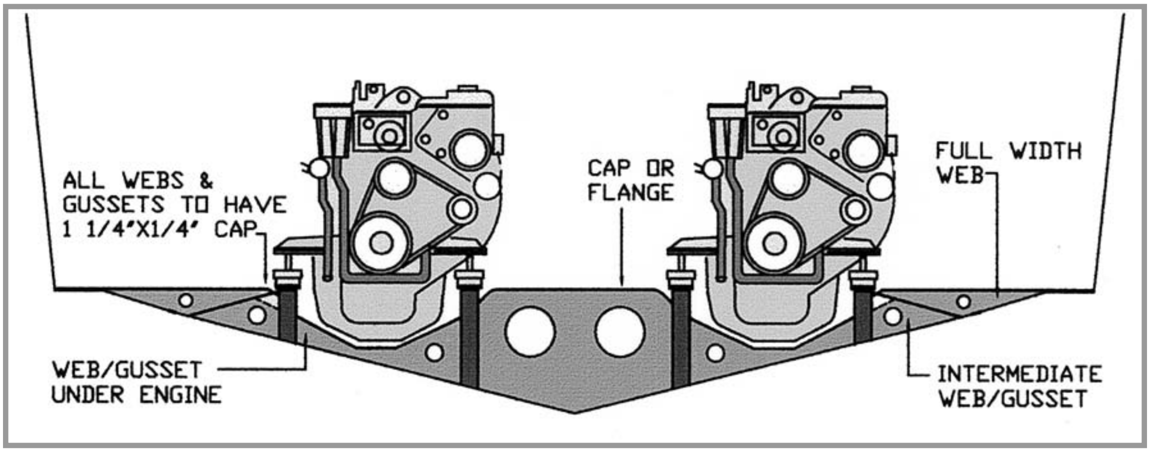
your local boating magazine or the advertising pages of your telephone directory will reveal many sources for these products.

Insulating the engine room in powerboats is relatively easy, as there is usually more room to lay out the insulation without interfering with access to the engine's vital organs. In some powerboats with relatively cavernous engine compartments, it's necessary to insulate the engine separately by having a separate, insulated box around the motor. In a single-engine powerboat, while an insulated sound box reduces the noise to almost a whisper, it does make access to the engine more difficult and it certainly earns its share of rude comments, especially during service checks.

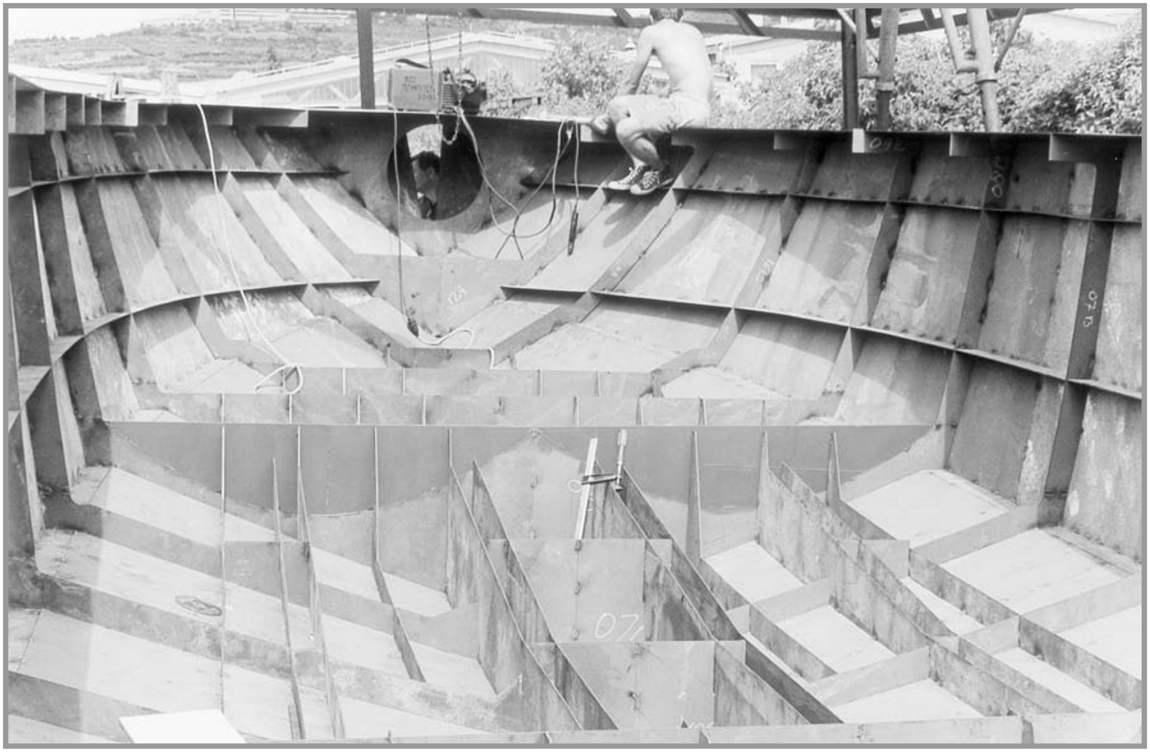
ENGINE BEARERS

The engine bearers, or beds, should be made as long as possible to spread adequately the various loads imposed by the engine. We recommend beds that are two or more times the length of the engine. Space restrictions may defeat this ideal, but make them as long as possible. In our powerboat designs, we always try to mate up the engine bearers with fore-and-aft webs that run almost the full length of the boat. These webs also add strength throughout the hull and have the secondary use of helping to support the sole.

The engine bearers should be made of plate that is two to two-and-a-half times the thickness of the hull plating. Naturally, the exact thickness should be specified in your plans. The size and horsepower of the engine, and its size compared with the hull, will also have to be considered when designing the beds and their supports.



This twin engine-bed arrangement will fit most powerboats over 35 feet (10.67 m) and leave room for fuel tanks outboard of each engine.



The engine bearers in the Almarine-built powerboat kit are precut and only need the tops added to complete the beds.

The transverse web supports in our designs are part of the regular frame web construction sequence, with additional webs added as required by the spacing of the frames. For example, if the frames of the hull are spaced at ten frames to the waterline length, then additional webs will be required between the stations.

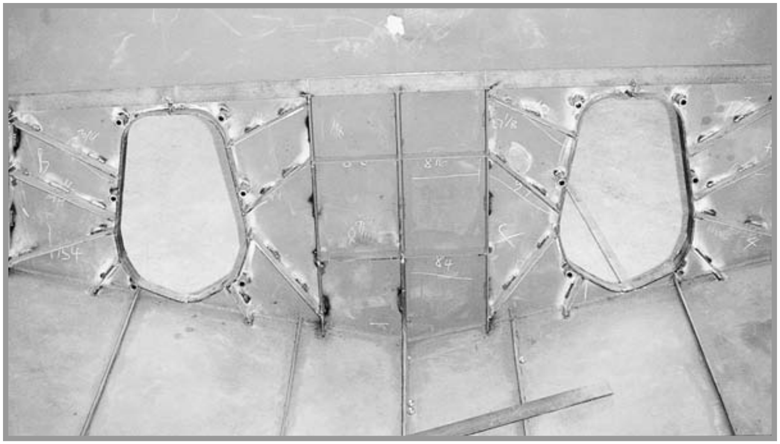
It's difficult to match the height of the beds with the line of the shaft and the stern bearing. If you don't already have the engine on-site, then using a three-dimensional plywood mock-up of the engine can help.

THE DRIVE TRAIN

You must consider the drive train of your engine, from transmission to propeller, to be a single, integrated unit. Most engines have flexible mountings and feature a suitable coupling, such as an Aqua Drive unit to complete the vibration-free installation. The Aqua Drive and similar units allow for slight misalignment between the shaft and the engine transmission. This is a necessary feature because when the engine is mounted on flexible mountings, there will be some movement between the engine coupling and the propeller shaft. Several marine engine manufacturers now have preangled transmission arrangements to allow the engine to be installed in a relatively level way; the shaft angle is allowed for in this arrangement.

Stuffing Box

You'll need some form of gland to prevent the water entering your boat where the propeller shaft passes through the hull. Your main choices will be between a traditional stuffing box and one of the newer devices, such as a Deep Sea Seal. If you choose a stuffing box, it may have an external grease-lubrication system or depend on the natural oils of the stuffing and the water for



This stiffener arrangement was used to beef up the transom when fitting a pair of diesel Volvo sterndrives to a steel Waverunner 342 built in Europe.

lubrication. Grease-fed stuffing boxes usually employ a remote cylinder that you have to pack with waterproof grease. One or two turns on the plunger each day forces enough grease through the line to the bearing; this helps to keep the water at bay. All stuffing boxes (also known as packing glands) will drip twice or so per minute and produce about a cupful of water per day. If they're overtightened, and don't drip, then the bearing and the shaft will probably suffer from excessive wear.

Patented Stern Bearings

Stern bearings, such as the unit marketed as the Deep Sea Seal, have long been used on large ships, but only in the past few years have they been installed in pleasure boats and workboats of all types. The Deep Sea Seal has an excellent reputation and has been fitted to many thousands of boats around the world. The basic DSS has been improved with the addition of an additional red clamp that allows the unit to be serviced while the boat is still afloat The basis of the Deep Sea Seal is a rubber bellows that is fitted with a bearing steel ring that runs on a bearing surface in such a way as to prevent water from entering the hull through the stern tube. The rubber bellows is adjusted to maintain constant pressure on the bearing surface. The unit is lubricated by some of the engine-cooling water being introduced through a spigot on the bearing surface.

The main advantage of installing a Deep Sea Seal–type stern bearing is that it doesn't drip, hence there's one less way for salt water to enter the hull and promote corrosion. Another advantage is that the unit needs only an occasional check to ensure that it's doing its job, as opposed to the constant attention required by the conventional stuffing box bearing.

There are other manufacturers of these devices, and you should investigate the various types, before making your choice.

If your boat has twin engines, it's a sure thing that on many occasions you will want to run on one engine. If your engines are equipped with Deep Sea Seals or similar water-lubricated stern bearings, you should consider the need to supplying water to the bearing of the shutdown engine. The Pedro 41 *Van Hoff*, a custom-built, steel trawler yacht with aluminum decks and superstructure, owned by our friends Mike and Caroline Hofman, is fitted with a cross-over water supply to both Deep Sea Seals. We confess we showed only moderate interest when Mike explained this system. The twin water supply was necessary, because, as with most twin-engine vessels, *Van Hoff* is often operated on one engine for the sake of fuel economy. In light of subsequent events not fully detailed here, we should have taken more notice! There follows a clue!

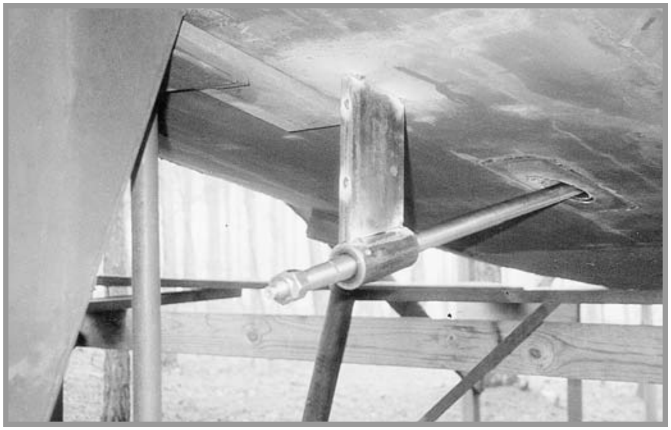
Even if you have only one engine, consider the possibility of engine failure. Then, when your vessel is towed, do you let the shaft rotate? If so, how do you provide water to the bearing? If the situation persists for more than a short time, unlubricated stern bearings can be damaged. It may even be wise to consider installing shaft-locking devices that are available to suit most size engine-shaft combinations.

Aft Shaft Bearings

Your boat will require a bearing where the propeller shaft leaves the outer end of the tube. The choice is between a fiber bearing, a Tufnol bearing, and a Cutless rubber bearing. Cutless bearings are well proven and when properly set up with two small water scoops at the fore end of the tube to introduce lubricating water, they will give long and trouble-free service.

If the distance between the inboard stuffing box (or seal) and the outboard end of the tube is over say 6 feet 6 inches (2 m), you may require an intermediate bearing generally known as a plummer block. This may be another Cutless bearing that has been slid down the tube to the midpoint location.

If your shaft protrudes from the tube by more than a few inches, you may need a Y-bracket bearing to support the outer end immediately ahead of the propeller. Decisions as to whether you need an intermediate bearing and similar questions are best addressed to the designer of your boat or a qualified marine engineer.



Either a Y- or P-bracket is required to support the shaft between the hull and the propeller.

EXHAUST SYSTEMS

Most diesel engines do not come completely equipped with a suitable exhaust system. In the past, one exception was the range of diesel auxiliaries supplied by Vetus den Ouden. Unfortunately, the engines and equipment are now sold separately. Vetus does have a good range of exhaust systems that are available all over the world.

Diesel engines fitted to sailboats and powerboats will need a properly engineered exhaust system. Engines mounted below the waterline—and most are—will need special antisiphon devices. There are two basic ways to cool an engine and both have a bearing on the type of exhaust system required. Most air-cooled (noisy) engines have a dry-exhaust system, which means that no water is added to the necessarily heavily insulated (lagged) exhaust. In the confines of a sailboat, dry exhausts are hot and noisy but this type of exhaust can be used to good effect in some types of traditional powerboats. Dry exhausts, combined with a vertical stack, are often seen on fishing boats and workboats.

A wet-exhaust system cools the exhaust gases with water soon after they leave the engine. The water and gases are expelled together. This system is necessarily interrelated with the cooling system of your engine. A stainless steel water-lift muffler is a nice addition to any exhaust system and will dampen noise.

Sterndrive engines and outboards have the exhaust systems built in. Outboard engines are beyond the scope of this book, but you may be considering a diesel powered sterndrive for your metal powerboat. Sterndrive exhausts usually exit via the center of the propeller, no doubt adding a minuscule amount of thrust in the process.

COOLING SYSTEMS

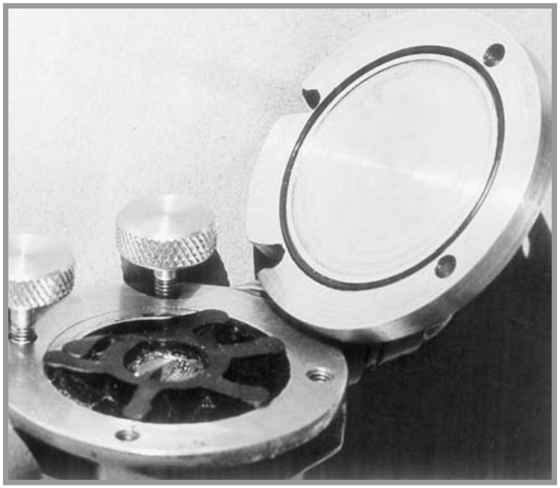
Heat Exchanger Cooling

Most modern diesel engines feature freshwater, heat exchanger cooling. This method uses a special tank of fresh water that runs through the engine's cooling system. The freshwater tank contains internal piping and is, in turn, cooled by seawater pumped through the pipes. This method prevents the internal cooling system of the engine coming into contact with salt water. Most modern diesel engines are cooled in this manner. One problem with this method is that if the outside intake for the cooling water becomes clogged, then the whole system overheats. A sensor in the system can warn you about this condition, before your engine overheats. Make sure each engine is equipped with this warning device.

Raw-water cooling is usually found on older diesels. The method is to pump outside water (seawater or fresh water) through the engine casing and then out through the exhaust, thus cooling the engine in the process.

Engine Water Pump

Most cooling systems include a water pump that draws water from outside the hull and forces it through the cooling system. The pump will include an impeller that will need replacing from time to time. Most water pumps, unfortunately, are located in inaccessible places. Make sure you know where yours is, and check that you have a spare impeller. Also, check the difficulty of removing the impeller and its cover plate. You can buy a special Speedseal cover plate that's attached with only two knurled screws. Because it can be removed and replaced quickly with one hand, you might want to replace your regular water pump cover with one.



This Speedseal cover plate makes changing the impeller a little easier and much faster; it's a handy addition to any engine installation.

Engine Water Filter

If your engine uses water drawn from outside, either directly as raw-water cooling or by way of a heat exchanger, you'll require a water filter to remove any foreign matter that could damage the water-pump impeller or otherwise clog the cooling system, and, in turn, cause the engine to overheat. The usual arrangement is to place the water filter immediately after the seacock where the outside water enters the system.

The filter should be easily accessible, as it should be checked daily—even more often if you're motoring in weed-infested waters. It's often made of clear plastic so you can see what's going on inside, but don't let this discourage you from removing the top for regular inspections. Plastic bags are one of the most common foreign bodies lurking in our waterways and they're not always visible without removing the top of the filter. Most filters have a rubber sealing ring, and you may find that a light coating of Vaseline will prevent the unit from sucking air. In any case, the rings will need replacement every two years or so. If you have a diesel-powered generating set, you should have a separate water filter for it. If possible, place the two filters close together so you can check both at the same time.

Keel Cooling and Similar Methods

There is a third method of cooling that requires no external water to be drawn into the boat. The most common of the self-contained cooling systems involves outside pipes that are usually tucked into the keel-hull intersection. Hot engine water flowing through them is cooled by the surrounding seawater. The most interesting version of this method is only possible with boats that have a hollow metal keel. It involves boxing off a section of the keel to store a 50-50 mixture of antifreeze coolant and fresh water. This mixture is run through the engines' cooling system, and provided that the surface area of the selected portion of the keel is adequate, the system works extremely well. This arrangement employs two header tanks, and works in a manner similar to the way your car's engine cooling system works.

There's another advantage to these engine cooling systems. You can incorporate an insulated hot-water tank, or calorifier. This tank has an internal pipe coil through which hot water from the engine cooling system is circulated. This pipe, in turn, heats the domestic hot water. In the sailboat we owned previously, *K*I*S*S*, we found that running the engine for about 20 minutes every other day was sufficient to provide hot water for two days of showers, plus other daily hot-water requirements.

Any internal cooling system that doesn't import raw water requires a lagged, dry exhaust. Considerable care is required in routing any exhaust line, especially the dry variety, which can get hot despite the lagging. If you have a dry exhaust, pay particular attention to the ventilation of your engine space and the surrounding area. The main negative feature of this arrangement is that dry exhausts are usually noisier than the water-cooled systems.

Mufflers

Many exhaust systems involve the use of a water-lift muffler. The engine cooling water is fed into the exhaust pipe just aft of where it leaves the engine, and then into the muffler, where the pressure of the incoming exhaust gases forces the water out of the boat. This system can be one of the quietest, and quietness in your exhaust system is a very desirable feature.

If you are purchasing a ready-built new or used metal boat, the engine cooling and exhaust systems will already be in place, and usually it's an expensive proposition to change from one system to another. If you're building your own boat, however, you should choose carefully. Check other boats; weigh up the advantages and disadvantages of each system before you make your final decision.

Raw-water cooling (no heat exchanger) is the least desirable because the innards of your engine are constantly exposed to the ravages of salt water or outside water containing all sorts of pollutants. Your choice should be between a system with a regular heat exchanger (using outside water to cool it) and a system that has outside piping to allow keel cooling. Alternatively, you can choose the fully internal system. The fully internal system is similar to keel cooling using external pipes, the difference being that a reservoir of coolant is arranged in a section of the keel instead of outside pipes. This system is not recommended for engines over about 120 hp or for the tropics, where the ousted water temperature would not have enough cooling effect.

No matter which system you choose, remember the advantages of having your hot-water tank (calorifier) as part of the engine cooling system.

SAILBOAT AUXILIARY POWER

You'll want to know whether your cruising boat has sufficient power to do the job. The auxiliary is often undervalued until you need it most. There are many formulas used to ensure it is up to the

ALTERNATIVE POWER

Hydraulic drives, electric drives, jet drives, and the like have no place in a sailboat. Over the past 30-odd years, we've been asked to design every imaginable type of "alternative" power arrangement. After completing many, sometimes long-winded, investigations, we've reached the conclusion that diesel power is the way to go. If you have a particular hobby, such as steam engineering, and you wish to combine this with your boating activity, then there may be an argument for installing an engine that allows you to indulge in your pet interest. But it's worth noting that you'll probably need to remove this unique installation before you sell the boat.

UNDERSTANDING HORSEPOWER

When you're considering horsepower, be aware that there are several terms used to describe the power generated by the engine at certain revolutions. One term you'll encounter is brake horsepower (bhp). This is the power produced by the engine without regard to the power loss caused by the transmission gearbox, or other losses from such items as the alternator, water pump, and general friction in the transmission system. Shaft horsepower (shp), on the other hand, represents the power available at the propeller.

Usually, more than one rating is shown. For instance, there's maximum power. This is the power you could get for a very short time before you burn up the engine. Then there's intermittent power, which is the power the engine can deliver for a limited period—usually 30 to 60 minutes—without problems. Continuous power is the rating at which the engine can operate for long periods without damage. This is the rating that will be of primary interest when you decide what horsepower you need to move your boat at the desired speed. Increasingly, you will find that the power ratings are given in kilowatts (kW). The Système International d'Unités, the overseeing body of the official metric system, gives the conversion as 1 kW = 1.341 hp and the reciprocal = 0.746; 746 watts = 1 hp.

task; for preliminary calculations, we use a power-versus-weight ratio. This calculation will reveal if your sailboat has enough power to propel it in the direction you want to go when, for one reason or another, the sails can't do the job.

We can start with a ballpark calculation and estimate that for any sailboat, 2 hp per 1,000 pounds (454 kg) displacement is a reasonable requirement. The addition or reduction of horsepower from the above calculation will depend on your philosophy. In general, American sailors prefer more power than their European counterparts.

Most inboard engines fitted to sailboats require gearing down by way of a transmission gearbox to produce the power required to drive the vessel in anything but a flat calm. We usually recommend a 2:1 reduction, thus halving the rotation rate of the propeller versus the engine revolutions. You'll find that most manufacturers have a range of reduction options between 1.9:1 and 2.15:1; any one of these can be considered to fall within the 2:1 recommendation. Generally speaking, the larger the reduction, the larger the propeller diameter required. For this reason, it's not practical to install a very small engine that is geared down to say 3:1 or 4:1. The large propeller required would destroy the sailing performance.

Single or twin engines? Unless your sailboat is over 55 feet (16.76 m) long, this is hardly worth discussing. And by over 55 feet, we mean considerably over!

METAL POWERBOAT ENGINES

Because of the variables involved, this is a much more complex subject than powering a sailboat. For want of space, we can only give a brief overview of this subject, but if you're interested in learning more, check out the recommended reading in Appendix 1.

Powering a Displacement Hull

Powering a displacement-hull motor vessel follows much the same rules as those used to calculate the requirements for sailboats. The exception is that while the sailboat has its sails to use in an emergency, the displacement powerboat relies totally on its engine. Most displacement powerboats are fitted with only one main powerplant, so you should select yours with care. To estimate the horsepower requirements, start with an estimate of 2 hp per 1,000 pounds (454 kg) of displacement. This should be taken as the minimum requirement.

You can gear down your engine to give max-

Table 11-1.
Brake horsepower for sailboat auxiliary engines.

This chart reflects data collected by the John Thornycroft Company (UK). The figures represent the various brake horsepower (bhp) requirements for auxiliary engines installed in sailboats. The calculations assume a three-bladed propeller. The bhp quoted is at the engine and allows 15 percent for engine and shaft losses.

Waterline Length	Tons Displ.	5 Knots	6 Knots	7 Knots	8 Knots	9 Knots
25 ft. (7.62 m)	2	5.0	5.0			
	3	6.5	6.5			
	4	8.7	8.7			
	5	12.0	12.0			
30 ft. (9.14 m)	2	1.9	3.6	6.4		
	3	2.5	5.0	9.7		
	4	2.9	6.4	13.0		
	5	3.3	7.7	16.0		
	6	3.5	8.8	19.0		
	8	4.0	11.0	26.0		
40 ft. (12.2 m)	4	2.8	5.2	8.5	13.0	
	6	3.5	7.0	12.0	25.0	
	8	4.0	8.4	15.0	26.0	
	10	4.4	9.9	18.0	33.0	
	12	4.6	11.0	21.0	40.0	
	14	5.0	12.0	24.0	46.0	
	16	5.2	13.0	27.0	53.0	
	18	5.6	14.0	30.0	59.0	
	20	5.9	15.0	33.0	66.0	
50 ft. (15.2 m)	8	4.1	7.2	13.0	19.0	28.0
	10	4.6	7.9	15.0	23.0	35.0
	12	5	8.8	17.0	27.0	42.0
	14	5.3	9.6	20.0	30.0	49.0
	16	5.6	10.0	11.0	34.0	56.0
	18	5.8	11.0	23.0	38.0	63.0
	20	6.0	12.0	25.0	41.0	70.0
	25	6.5	13.0	30.0	50.0	87.0
	30	7.0	14.0	34.0	57.0	105.0

imum performance at lower speeds and reduce the amount of power required to drive your vessel. This option results in a larger-diameter propeller, and there may not be room for it. There are also other disadvantages to taking this minimum-power route; one day you may need extra power to get out of a sticky situation, or tow another vessel. Conversely, a diesel engine likes to be worked moderately hard, so it's not advisable to have an installation where only 50 percent or less of the power can be used without driving the stern down to an unacceptable level. If you want more power, you may wish to consider a semidisplacement hull that can make better use of it.

Powering a Semidisplacement Hull

A fact you must consider is that it takes excessive power to drive a semidisplacement hull faster than 1.5 times the square root of its waterline length. For example, a semidisplacement hull measuring 36 feet (10.97 m) on the waterline would have a square root of 6. So 6 times 1.5 equals 9 knots. A broad definition of planing is when a boat reaches a speed in knots of twice the square root of the waterline length in feet.

Taking the 36 foot (10.97 m) example shown above, the square root of 36, times 2, gives us a 12-knot planing speed; at this speed, the necessary horsepower and fuel requirements will turn a comfortable, economical cruising boat into an expensive proposition. Please note that the formula given is only for the *start* of planing, and to make a semidisplacement hull reach a full (near-level) planing attitude will take considerably more power, and use more fuel than consumed by a similar-sized true planing hull. The point is that it makes no sense to grossly overpower any semidisplacement hull—you'll be just spinning your wheels or, in this case, your propellers. This whole subject will be fully covered in our e-book, *Choosing a Cruising Powerboat*. Go to bruceroberts.com for for details.

Next, we have to consider the weight of our vessel. Weight in this instance means *loaded* displacement. This includes not only the weight of the finished boat but also fuel, water, stores, and crew. In addition, there are all of those items that are brought aboard for a particular use or occasion and then never leave the boat.

Now, there are many kinds of semidisplacement hulls, ranging from a full displacement vessel through to almost a full planing hull. The degree of rise in the chine or buttock lines aft will determine how fast the hull may be driven. Simply put, the more stern there is in the water at rest, the faster the hull may be driven. Overpowering a hull will cause the stern to drop and create a large stern wave. In certain instances, this wave can overwhelm the vessel.

Powering a Planing Hull

Only a few years ago, it was thought impossible to build a successful small-to-medium-sized steel planing hull. Fortunately, modern building techniques and technical advances in design have not only made this possible, but practical as well. As mentioned above, planing occurs when the boat reaches a speed in knots equal to twice the square root of the waterline length in feet. A planing hull will then make the transition from "just about planing" to "full planing" with less fuss, less extra horsepower and less extra fuel than a similarly sized and equipped semidisplacement hull or semiplaning hull.

Aluminum has been used to build hundreds of thousands of small, medium, and large planing hulls. Although at first glance this material may appear to be the ideal metal for a fast hull, we have reservations about this material when used in any type of hull, preferring to recommend it for decks and superstructures. You'll find our thoughts on this material scattered through this book, so it's not necessary to repeat them here.

Now, for those who prefer aluminum: you'll find that the performance of planing hulls relates to *weight* and *power*. Unlike displacement hulls and (to a lesser extent) semidisplacement boats, waterline length plays a smaller part in the performance of a planing hull.

So, in simple terms, the more power and the less weight you have in your planing hull, the faster it will go. Fortunately for designers like us, however, it's not that simple. A well-designed planing hull with modest power will outperform an overpowered, poorly designed vessel.

"Get-You-Home" Engines

Before we consider the subject of single or twin engines, we should touch on the possibility of installing a "wing" engine, or using the diesel that powers the generating set as an emergency arrangement to get you home. Most owners prefer a separate wing engine consisting of a smaller diesel engine set off to one side and equipped with its own shaft and propeller. This engine is generally only required in the case of failure of the main engine, but of course it will need to be run from time to time for maintenance and testing purposes. For obvious reasons, the wing engine is only needed in boats with a single main engine. The wing engine and similar arrangements are often referred to as take-home engines. Some owners have installed an electric drive powered by the gen-set, and have used this as emergency propulsion.

Circumstances have caused us to give this matter considerable thought, and we have recently designed a range of long-distance power cruisers. These vessels are generally referred to as passagemakers and, to be successful, they need a minimum range of 3,000 miles. Some vessels in the 50-foot plus range (more than 15.25 m) can be built to cover up to 6,000 miles without refueling. For various reasons, most of these long-distance vessels are fitted with a single engine, hence the interest in alternative propulsion methods. As a safety factor, both for medium-distance and local cruising, my choice would be for a wing engine.

One or Two Engines?

As mentioned earlier, most displacement-hull vessels are traditionally fitted with a single engine. But many owners have twin installations, and the bulk of them quote safety as the prime reason for taking this route.

We've always maintained that when you install twin engines, as opposed to a single engine of the same total horsepower, you'll lose 20 percent in total output. More recently, we've decided that the effective loss of power may be even higher. Other examples show that the additional fuel consumption of the second engine is not justified by the small increase in performance when the two engines are used.

If you're considering a new boat, and you're considering twin engines in the interests of safety, you should be aware that in the interests of economy you might be operating only one engine for much of the time. You would be well advised to lay out your engines and systems with the above facts in mind. Owners who regularly take this course use each engine alternately on a four-hourly or daily basis.

PROPELLERS

It would be convenient if we could buy a propeller to match our hull material. Builders using copper-nickel are fortunate; the bronze propellers that are readily available are a close relative to the hull material, so the interaction between different metals that causes corrosion is at least reduced. Steel, or cast-steel, propellers are very difficult to obtain, so steel boat owners are forced to use the bronze versions, or to join their aluminum-boat-owning friends and opt for an expensive stainless steel "wheel." So there you have it: steel boat, bronze propeller; copper-nickel boat, nickel-aluminum-bronze propeller (must be more noble than the copper-nickel hull); aluminum boat, stainless steel propeller.

Propeller nomenclature is simple, but choosing the correct size and pitch of the wheel is somewhat more difficult. The *diameter* refers to the size of the circle scribed by the tips of the propeller blades. The *pitch* is the distance the propeller would travel in one full revolution if it were rotating in a solid. *RPM* refers to the revolutions that the shaft achieves in one minute; this figure is usually a factor of the engine rpm, but due to the transmission reduction (1.5:1, 2:1 and so forth) the shaft rpm will be different from the engine rpm. When calculating propeller sizes, it's the shaft rpm that is important. The *slip* refers to the loss of forward motion due to the fact that the propeller is rotating in a liquid, not a solid. Slip is the theoretical difference between what a propeller of a given pitch would travel, and what it actually is expected to achieve, usually expressed as a percentage. The *pitch ratio* is figured by dividing the pitch by the diameter. Fast powerboats sometimes have a diameter and pitch of the same number; this is referred to as a "square wheel."

Propellers for Powerboats

In powerboats, you'll want to install the most efficient propellers that will allow the engine to reach its operating and top rpm when required. In some designs, the propeller aperture is not sufficiently large enough to allow the correct propeller to be installed, and in this case a change from a three-bladed to a four-bladed wheel may prove successful. If you're experiencing cavitation because the tip clearance is too small, or because of the shape of your particular hull, then a change to four blades or even five blades may remedy the situation. You may need to discuss your particular problems with both the designer of your boat and the propeller manufacturer or supplier.

The design and matching of a propeller to the hull, engine, and reduction ratio is something of an occult art. As designers, we do our best, but even the most detailed calculations can result in a propeller match that can be improved during trials conducted over a variety of conditions. You can also contact one of the many well-known propeller manufacturers in the United States, Australia, the UK, and elsewhere. They will usually be most helpful. If you have a propeller problem, don't disregard it; seek assistance as required.

Propellers for Sailboats

The most efficient propeller from a sailing point of view is the two-bladed folding variety. Two blades mean a larger diameter, and this can cause problems where space is restricted. These may be considered if you're building a high-performance metal sailboat. Some of these two-bladed folding propellers are inefficient and others have a reputation for not always opening on demand, which could be disastrous. If you do decide to choose a two-bladed type, make sure you are able to get a first-hand recommendation from another person who has already had experience with the brand you favor.

The elimination of drag is the aim of every sailboat owner. One way around the problem is to use a *feathering* propeller. These units are complex and expensive. Finely engineered feathering propellers may be suitable for larger yachts, where the owners have the resources to cover the initial expense and possible high maintenance costs. Unless you have very deep pockets, you're best advised to accept a small loss of speed under sail and select a *fixed* three-bladed wheel.

Rope Cutters

These devices are mentioned here because they may require a slightly longer shaft to be fitted. Suitable for both sailboats and powerboats, rope cutters are designed to be clamped on your shaft just ahead of the propeller. They can be very effective in cutting rope or a similar obstruction that would otherwise foul your propeller.

FUEL FILTERS

Does your engine have a separate primary fuel filter? Not all boatbuilders or manufacturers supply or fit these essential items as standard. The fuel filter that comes with the engine is basically a secondary filter, so at least one good primary fuel filter that incorporates a water trap is needed between the fuel tank and the engine. The filter should have the capacity to handle a considerable amount of dirt and water. Twin primary filters can be arranged so one can continue while the other is unclogged or changed. The installation of twin primary fuel filters should be a serious consideration even in single-engine craft.

Filters with glass bowls have pros and cons. The sealed-filter units have expensive cartridges that need to be replaced completely, rather than simply replacing the internal filter. A major advantage of glass is that one can quickly observe if water is present. However, the glass-bowl filters are now outlawed in Europe for all boats and in the United States in gas-powered vessels, the argument being that in case of fire they present an additional danger.

Recently, we met the owner of a motor cruiser, a Dutch-built steel vessel of 34 feet (10.36 m), who got into trouble because of the glass bowl. This fellow, an experienced boater, was alone off the Spanish coast, near Barcelona, motoring along in heavy seas, when his single engine stopped. Upon investigation, he found that the glass bowl on the primary fuel filter had shattered. This had allowed diesel fuel to spray in all directions—and of course the engine stopped for lack of fuel. Fortunately, there was no fire. No replacement bowl was available and the engine was too hot, and the motion too violent, to allow the owner to deal with the situation. He was forced to swallow his pride and call out the Spanish Coast Guard, who responded promptly. Within an hour, the disabled vessel was safely in port. The owner believes he overtightened the glass bowl on the filter and when it expanded, due to the heat from the engine, it shattered. There are two lessons here: reconsider the use of glass-bowl filters, and don't overtighten them.

You'll need to change the filters at regular intervals. In the case of a fuel blockage, you'll need to change them as required. This is a very messy job and is one area of boat maintenance that you must understand. You should practice preventive maintenance wherever possible. When you're reassembling filter units, make sure you have the sealing O-rings in the correct order and position; sometimes the top and bottom rings look similar but are different enough to allow fuel or oil to leak out when the engine is fired up. Start the engine with caution after servicing these items.

VENTILATION

In all boats, ventilation of the engine space is an important feature. Your engine needs a considerable amount of fresh air. Install two vents of adequate size, one ducted below the engine to bring the fresh air in, and the other ducted high up in the engine space to take the hot air out. Generally, a blower is not required in northern latitudes. In hot climates, however, you may need one to turn the air over at the correct rate. An engine-space blower is simply a ducted fan that is designed to either import or export larger quantities of air than would circulate naturally.

INSTRUMENT PANELS

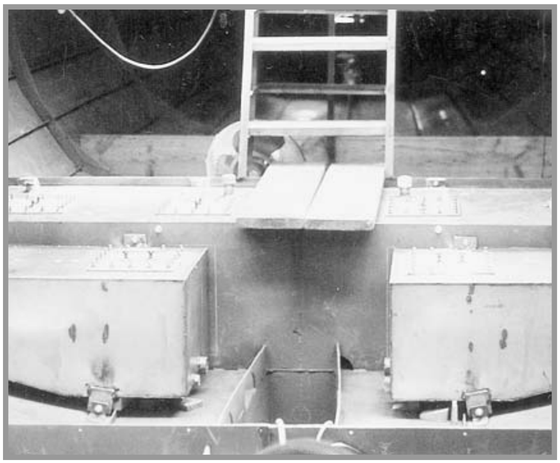
Your engine will usually be equipped with an instrument panel, but you may want to add to the instruments supplied in the standard package. The minimum engine instrumentation should include a tachometer (revolution counter), an engine-hour meter, a fuel gauge (notoriously inaccurate in boat installations; have a dipstick handy), and a volt/ampere meter. Regarding fuel gauges, we have always preferred a sight-glass gauge that is attached to the fuel tank and allows the level of fuel to be seen at a glance. For two reasons this feature may not be available to you; in some areas they are illegal (fire hazard) and if your tank in hidden from view then a sight gauge would be impractical. You'll require an instrument light switch, including a dimmer control for night use, an audible alarm to indicate if you fail to switch off the ignition after the engine has been stopped, an engine stop control, and a water-temperature gauge. Warning lights and or buzzers may indicate some potential problems; in our opinion, warning lights are not as effective as proper gauges. Audible alarms are recommended for water temperature, alternator output, and the other vital life signs. Your electrical panel, complete with fuses, is usually located in a separate box; however, in some boats with inside steering, it may be incorporated in the main panel.

BILGE PUMPS

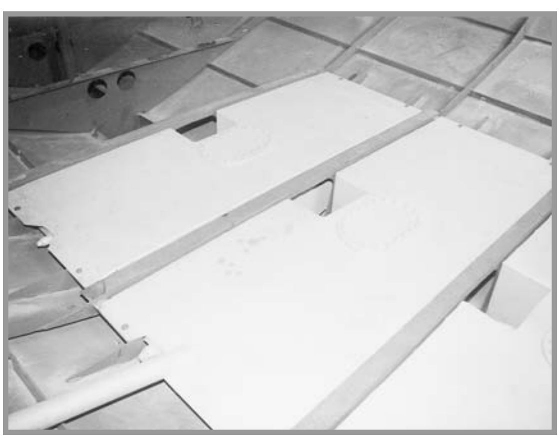
Take some time planning and laying out your bilge-pumping systems. Bilge pumps can be driven manually, electrically, or mechanically. Usually, the first line of defense is the automatic, electrically powered unit situated in the lowest point of the bilge. This bilge pump should be fitted with a strum box. This is a special perforated box, or strainer, fitted over the end of the bilge pump hose that is installed low in the bilge. If you have an automatic shower pumpout system, this can double as another bilge pump. The shower and toilet pumps will often be located in a different compartment to the main unit.

You'll need at least one, preferably two, hand-operated bilge pumps and one of these should be a large-capacity, portable unit mounted on a board, thus allowing it to be operated in any part of the vessel. The Edson 18 and the Whale Titan are both excellent hand-operated pumps.

You'll also need to arrange a sump or suitable collection point for bilge water. This sump is usually under, or nearly under, the engine so that any spilt diesel fuel and other unwanted liquids can be pumped or sponged out. A hand-operated bilge pump with a hose attached is useful in this area so that you can pump any contaminated water into a separate container for proper disposal ashore. U.S. federal law prohibits the pumping of oily bilge water directly into the surrounding water. For instance, in Florida a heavy fine can be the result of pumping even the smallest amounts of polluted water into the local canals. Any bilge pumps located in the sump or elsewhere should be fitted with a strainer. In the event of any large particles being present, you need to ensure that they will not find their way into, and totally block, the pump.



These tanks were fabricated and tested outside the hull and then installed as shown. As it is usually impossible to remove tanks without destroying interior joinery, you must make sure that your tanks are thoroughly tested before installation.



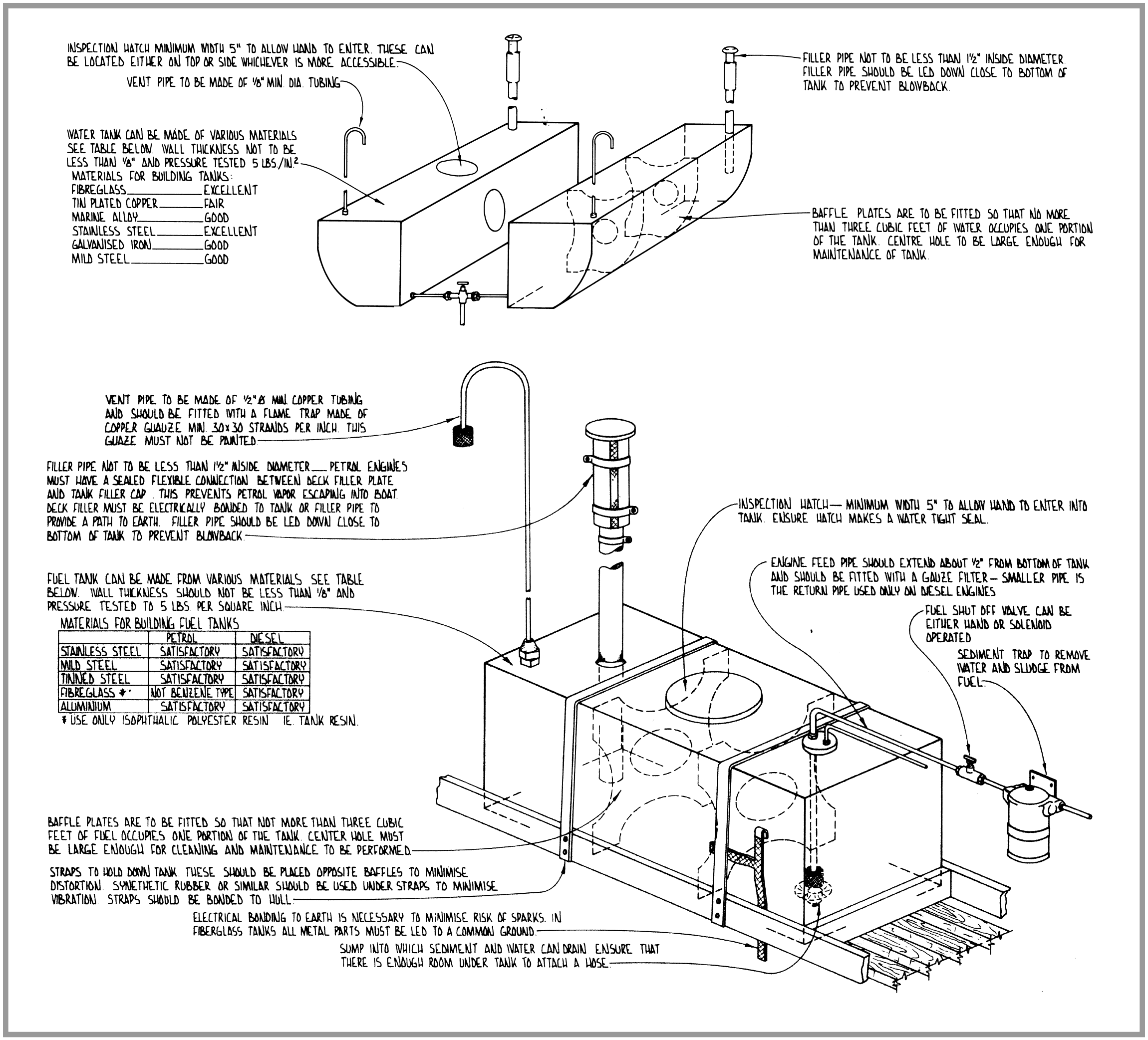
Tanks can be neatly arranged under the sole. Note the inspection and cleaning hatches in the tank tops.

FUEL TANKS

Aluminum is often used for fuel tanks, but there have been many problems. Aluminum tanks are susceptible to vibration and can fracture along the weld lines where baffles are attached inside. If you do use aluminum for tanks, make sure they are made from a high-magnesium alloy such as 5083 or 5086 specification. It may be better to consider tanks made of, or molded from, polypropylene.

Aluminum and steel tanks are sometimes built with the hull acting as one side of the tank. It's preferable to have the tanks built as a separate unit and tested before installation in the boat, because this will ensure that there are no leaks. Air pressure of about 3 pounds per square inch (psi) can be used to test the tanks. *On no account simply connect the tanks to a high-pressure air hose.* You may cause the tank to explode. Because of the risk of explosion, some experts recommend hydrostatic testing rather than the air test mentioned above.

Diesel fuel tanks may be built from a variety of materials, including high-density polyethylene, stainless steel, aluminum, or mild steel. Most builders choose regular mild steel. This material has the advantage of low cost, ease of fabrication, and low maintenance. The diesel fuel inside the tank prevents interior corrosion, and provided you keep the outside well painted, your steel fuel tanks should give you long service.



Your tanks should embody all of the features in these sketches. See the text.

Tank capacity is a contentious subject. Most designers specify small, easy-to-remove tanks. The builder wants large tanks so he can offer a cruising range greater than the competition. The owner often requests an *enormous* cruising range under power. Keep your tanks to a reasonable size; remember that diesel fuel gets stale; and it is subject to attack by various bugs when not changed on a regular basis.

All tanks should be fitted with inspection hatches and be capable of being cleaned through these openings. Fuel is drawn off by way of a pipe that enters the tank from the top and extends to within 1 inch (25 mm) of the bottom. Arrange the tank and fuel line so that any sludge will collect below the drawing-off line. A drain cock from the bottom of the tanks will allow you to flush out the tank. In the United States, these drains are not legal. Outside the United States, check local regulations before fitting the bottom drain. All tanks will need breather pipes—see the illustration on page XXX for these and other details. If you are purchasing a used or new production boat, your tanks may not meet all the criteria outlined in this chapter, and they may need attention in one or more areas that we have already mentioned.

If you're installing new tanks, or replacing old ones, choose tanks that give you a sensible cruising range. If you plan to have a diesel-powered generating set, a diesel cooking stove, and/or a diesel-powered heating system, take the usage of these items into your calculations. Remember that to avoid condensation and to minimize the chance of bugs infecting your fuel, you should keep your fuel tanks topped up whenever possible. In any case, it doesn't make sense to be carrying excessive weight in the form of too much diesel fuel. So the size of your fuel tanks is important. Large is not always the answer.

Sailboat owners should make careful calculations of their requirements. Armed with the knowledge that you will need to use the engine for a percentage of the time, allow for this and then add the other uses, such as diesel heating. Now decide on the size of your fuel tanks.

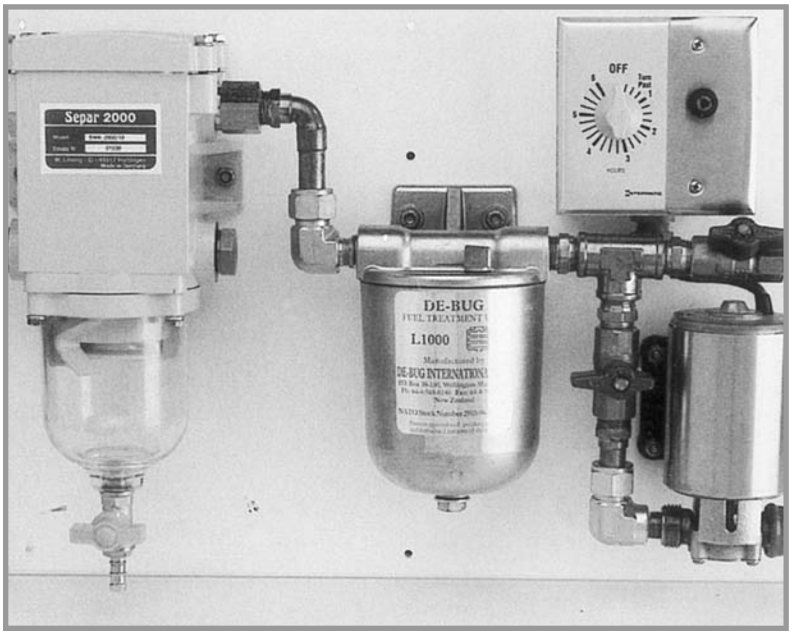
No matter what type of material you choose for the fuel tanks (or any other tanks), make sure they're firmly anchored in place. The thought of a loose tank, full or otherwise, charging about the boat in a rough seaway, should be enough to make you check all tank supports and containment arrangements very carefully.

MICROORGANISM CONTAMINATION

All diesel fuel systems can be contaminated by microorganisms. Neglected or unprepared fuel systems will continue to provide life support to these pests once they are introduced into the system. Problems show up in shortened fuel life, clogged fuel lines, and increasingly corroded fuel system components, including the tanks.

The degree to which microorganisms grow and prosper in the fuel system is relative to how fast the fuel is used up. Boats with small fuel tanks or with high-horsepower engines are less likely to have this problem. For several reasons already covered, cruising sailboats tend to have larger tanks and keep the fuel longer.

If you leave your boat for extended periods without making sure that the fuel tanks are totally full, then you run the risk of allowing microorganisms, or "fuel bugs," to breed in the tank. Partially empty tanks allow water to condense there, and the least effect of this is that your water trap and fuel filter will be working overtime. These bugs—in the form of algae, bacteria, yeast, mold, and fungi—all thrive when water is present. All owners and operators of diesel engines face this problem, no matter where the engines are located or what type of transport the engines are installed in. Boats used and laid up in warmer climates are most susceptible to the bug but



A fuel recirculation system is an effective solution to maintaining onboard fuel. The unit pictured is the ESI-Clean Fuel System.

many cases have occurred in the UK and colder parts of the United States, so this problem is not confined to tropical areas.

To eliminate bugs from your fuel, you need to understand how they breed. The various microorganisms need water to survive, since they live at the interface between the water and the diesel fuel, and they use the fuel as a food source. Diesel contains carbon, hydrogen, and dissolved oxygen, so it's a good source of nutrition for the bugs.

Once you've removed water from the system, you still need to take preventive measures against microbial growth. In a marine environment moisture is always present, and diesel bugs can grow quite rapidly. They can be present in the air, or in fuel taken aboard after you thought you had cured the problem. Some bacteria can grow into a mass many times their original size in just 24 hours. Other types can corrode fuel systems without being so obvious. They may show up as black grit, resembling coffee grounds, either in the filter, or, if you still have one, in the water-separator sight bowl.

Biocides

If you purchase a boat that hasn't been used for some time, you'd be wise to remove all the existing fuel from the tanks and have them flushed out and filled with fresh fuel. If you're in doubt about the cleanliness of the existing fuel, or if you're refilling after flushing out the tanks, you should add a biocide to your fuel. This will ensure that any remaining bugs are destroyed before they multiply and clog your fuel system at some inappropriate moment.

There are many brands of biocides available and they have one major factor in common. They are all expensive, usually costing around $25 (£15) for an amount sufficient to treat a 150-gallon (680 L) fuel tank. Another shared feature is that they are all composed of highly toxic chemicals; so highly concentrated, in fact, that they need to be handled with utmost care. It's as well to keep in mind that over time biocides lose their effectiveness and have to be replenished. If you have a bad case of the bug, don't be afraid to give your fuel tank a double dose of biocides. Select a safe storage method and wear disposable rubber gloves when handling biocides. Needless to say, keep these chemicals well away from children.

Water Dispersants

These additives are only successful when you use them as a preventive, rather than as a cure. The biocides should be used if your tank is already infected with the bug. Water dispersants are designed to absorb water into the fuel and in this way remove it before the fuel reaches the filters. Before using these additives, you must first drain as much water as possible. There are other benefits claimed for these products, including the fact that they inhibit separation of the waxes and gums that are present in diesel fuels. Only use dispersants if you have minor water problems or as a preventive method.

Enzyme Treatments

Having tried several methods to cure the chronic attack of "diesel bug" that attacked the diesel fuel in one of my own steel boats, I finally tried an additive called Soltron. This product was developed in Japan, but my supplies came from the UK. After three treatments, my diesel fuel system was finally free of the bug that had clogged my filters on several occasions. Soltron is a clear, enzyme-based liquid, and about half a pint treats 660 gallons. An Internet searchshould locate a source near you (www.soltron.co.uk in the UK and www.solpower.com in the U.S.).

Microorganism Fuel Filters

The system as described here is best used as part of your overall fuel-scrubbing system. Since not all diesel fuel sold at the various waterside filling stations is equal, it's possible to introduce unwanted additives to your fuel tanks just by filling up at an unknown fuel dock. This can be especially troublesome overseas. The best solution to this problem is to have a system in which all the fuel is cleaned before it reaches the main engine filters.

The De-Bug filter is part of an overall fuel-filtering and scrubbing system marketed by the manufacturer. The De-Bug filter doesn't only kill the diesel bug, it also gets rid of the bodies. Those of you who plan to operate your boats under conditions where the fuel bug is likely to be an ongoing problem may want to consider a more positive solution to microorganism growth. Developed over 10 years ago in New Zealand, the De-Bug Fuel Decontamination unit uses patented and unique "multi magnet" technology to kill microorganisms. When it's correctly sized to the fuel flow of the particular engine installation, this unit kills 97 percent of the bugs in a single pass.

The De-Bug filter produces magnetic fields from ceramic-coated magnets. They destroy the microorganisms as they flow through the filter. This unit is a one-time installation; it has no moving parts and no electrical power is required. Replacement filters are not necessary and the only maintenance required is an occasional cleaning. Unlike the chemical biocides, the dead bacteria cells are destroyed in a way that does not result in a messy residue that will clog filters.

The De-Bug filter comes in various sizes and has been used in all types of diesel-powered applications, both ashore and afloat. The smaller unit is capable of handling up to 35 gallons (160 L) per hour. Larger sizes of this unit can handle amounts ranging from 265 gallons (1 kL) to 5,000 gallons (18.925 kL) per hour, and remembering that a 97 percent bug kill is claimed, this is one of the most efficient pieces of equipment you could add to your boat. Do you need it? We do, after the experience of losing engine power in a rather embarrassing situation—and all due to "the bug." Our boat is now fitted with this device.

SPARE PARTS, TOOLS, AND MATERIALS

The field of spares alone covers a multitude of possible items. Add some construction materials, and you can see that a large number of items could be assembled under this heading. Perhaps this is a good time to review those items that you have already decided to install, and to decide if you really need them. Now consider how likely they are to need spare parts in order to remain in service.

You'll need to carry an adequate number of spares for your engine, of course. For instance, you must have at least two replacement sets for each filter installed on your boat. If you have more than one type of filter, then you need two spare filters for each one. Filters clog up at the most inopportune moments. Usually, one set of spares is just not enough. Don't forget the spare oil filters. While they're not needed as often as fuel filters are, they're required at regular intervals.

Hoses, cooling fan belts, alternator belts, impellers; the list goes on. Ask your engine supplier to suggest a complete list covering your expected requirements. Most manufacturers have recommended lists for local, coastal, and offshore cruising. Look over these lists and choose the one most appropriate for your needs.

On the subject of marine engine manufacturers, the word "manufacturer" is misleading. Most marine engines are assembled or "marinized" from another manufacturers' basic engines. Many of the filters, fan belts, and other consumable spare parts are available at less cost when some other manufacturer supplies them. The engine manufacturers naturally discourage you from obtaining these outside-sourced spares. You'll need to decide for yourself whether to buy and use these less expensive, unofficial spare parts.

You'll find various references to corrosion throughout this book, but I feel the subject is sufficiently important to warrant a chapter of its own. In seawater, corrosion is electrochemical in nature, and it's important that every boatbuilder who works with metal is familiar with the causes and effects of the more common types of corrosion. You should know how to avoid corrosion problems.

Corrosion is not confined to metal boats, nor to modern boats. Corrosion can damage every type of vessel, including those built of timber, fiberglass, and ferrocement. It is because of corrosion that keels and rudders fall off, that stainless steel tangs break, and that rigging fails. Corrosion is often the cause of fastening disease, an age-old problem with wooden boats. The results of corrosion can be severe, to the point of failure for rudderstocks, through-hull fittings, propellers, and seacocks. There have been instances where the seacocks have been caught in the final stages of disintegration just before they crumbled away and let in the outside water.

When a metal is immersed in seawater, it will achieve a certain electrochemical potential. Different metals have different potentials. Different potentials can also occur locally—from area to area in a single metal surface, for example, or near a weld area, or between areas exposed to different levels of oxygen. It's the potential difference between metals in contact with each other, or areas on the same metal surface, that acts as the driving force for corrosion under certain circumstances.

GALVANIC CORROSION

When two different metals are immersed in such a good electrolyte as seawater and connected through a metal path, an electric current will flow, causing corrosion of the metal with the lower potential. The metal that corrodes is called the anode and the metal that has the higher potential (the nobler metal) is called the cathode. When this type of corrosion occurs it is termed galvanic or bimetallic corrosion.

Although the less noble metal in the galvanic couple will corrode at a higher rate than it might otherwise have done, the more noble metal will corrode at a lower rate. You can use this to your own advantage; in fact, it's the basis for cathodic protection. The accompanying table shows the galvanic series, and will help you predict which alloy in a metallic couple is more likely to corrode.

The metals and alloys lower in the galvanic series have lower potentials and will be corroded by those higher in the list. The degree of corrosion that occurs depends not only on how far apart they are in the galvanic series (and thus the size of the potential difference), but also on the relative surface areas of the cathode and anode. Alloys close together in the series, such as copper and bronze, will be less prone to galvanic corrosion than those further apart, like copper and steel. Corrosion can be expected to be greater if the exposed surface area of the more noble metal is large compared to that of the less noble alloy. An example of this is that steel bolts in a Monel

Table 12-1.
Galvanic series of metals in seawater.

The position of the metals on the scale may vary slightly depending on the exact composition of the particular metal.

Cathodic or most noble
Platinum
Gold
Graphite
Silver
Titanium
Hastelloy C
Stainless steel (304 and 316 passive)
Nickel
Monel (400, K-500)
Silicon bronze
Copper
Red brass
Aluminum bronze
Admiralty brass
Yellow brass
Nickel (active)
Naval brass
Manganese bronze
Muntz metal
Tin
Lead
Stainless steel (types 304 and 316 active)
50/50 lead tin solder
Cast iron
Wrought iron
Mild steel
Cadmium
Aluminum alloys
Galvanized steel
Zinc
Magnesium
Anodic or least noble

Source: Copper-Nickel Association, 1998.

structure will corrode very quickly, whereas Monel bolts would corrode insignificantly in a steel structure, unit for unit.

There are various ways of controlling galvanic corrosion. Choosing metals close together in the galvanic series can be a good way of reducing galvanic problems. If possible, you should use only similar metals throughout the vessel. In this way, no galvanic current will flow.

It's not always possible or desirable, of course, to use one metal throughout the hull, deck, and superstructure. Luckily, galvanic current can be avoided by electrically insulating the two metals from each other. Insulating washers and sleeves can be used on bolts; nonconductive gaskets can be used on flanges.

Paint coatings can also be used as protection against galvanic corrosion. In this case, the temptation is just to coat the alloy that is likely to corrode in the metal couple. But coatings may have imperfections or "holidays" in them, or can be damaged, so the current can pass through in very localized areas. The large area of the uncoated cathode produces high rates of corrosion in the small areas exposed through the coating. Always apply coatings to the more noble metal, or to both metals, rather than to the anode alone.

Nonmetal fittings are another possibility; however, some classification authorities are reluctant to accept this solution. They suggest that fire and degradation from sunlight could be a problem. We have seen examples of the latter, where plastic (presumably nylon) skin fittings were wiped off when the vessel rubbed against a piling. This vessel had spent a considerable time in a sunny climate and the sun had affected the fittings to such an extent that they had very little strength. There are some plastic seacocks, skin fittings, and the like, that are said to be unaffected by the sun and ultraviolet rays. You should check these out for yourself before purchasing them and fitting them to your boat.

Again, the best overall protection is to stay with one metal, especially in the hull, where you have a good chance of maintaining all-steel or an all-aluminum structure. In practice, the solution is to use a combination of the above methods to minimize chances of galvanic corrosion.

In the interior of your metal boat, you can choose the closest compatible metal to attach the interior joinery to the metal hull. There is no point in using regular steel screws, as they would soon rust in the marine environment. You can use stainless steel screws or Monel screws and bolts (expensive), or you can plan your interior to avoid as much contact of dissimilar metals as is possible.

Galvanic corrosion can also occur in the same metal. For example, type 303 free-machining grades of stainless steel suffer extraordinarily severe corrosion in salt water. These metals contain high densities of manganese sulfide, or selenium inclusions, which create many, built-in metal-to-inclusion galvanic cells. These grades should never be used in salt water.

SELECTIVE CORROSION

Selective corrosion can occur in certain alloys when one component of the alloy corrodes away more quickly than another. We've seen this with brass seacocks, which contain copper and zinc. The zinc dissolves in seawater and leaves behind a weak and spongy mass of copper. This is called dezincification. Bronze seacocks prevent this.

Cast iron also can exhibit a form of selective corrosion called graphitization. The matrix of cast iron contains flakes or spheroids of graphite. The iron can corrode, leaving a weak, brittle network shell of graphite. The external appearance remains unchanged, which can make the condition difficult to detect. A further consequence is that the graphite shell is galvanically very noble and can then cause galvanic corrosion of adjacent parts.

Stainless steels can undergo selective attack in heat-affected weld zones. You can avoid this completely if you weld with carbon-L grades, or titanium- or niobium-stabilized grades, of stainless steel.

CREVICE CORROSION

In seawater, stainless steels have very low general corrosion rates. If they corrode, it's normally in localized areas under hard fouling or tight, manmade crevices such as gaskets. When the oxygen in the crevice is used up, an oxygen-concentration cell forms with the oxygenated metal outside the crevice. This can lead to corrosion reactions within the crevice. The 316 alloy has better resistance to this than the 302 or 304 alloys. Cathodic protection by anodes or galvanic contact with other less noble alloys can also help.

STRAY-CURRENT CORROSION

This is another type of corrosion that can be prevented. Unlike galvanic corrosion, which is caused by two different metals in water, stray-current corrosion results from an outside electrical source, such as direct current from the ship itself or alternating current from a shore electrical hookup. You will find additional information on the cause and remedy for this situation elsewhere, including Del Kahan's essay in Chapter 14.

In most cases, the villain is one of these sources: a current leak in the wiring from frayed or broken wires; improper or crossed grounds; electrical leaks from loose, broken, or poorly insulated terminal connections; or bad marina shore-power equipment.

When you're connected to shore power, you should always use heavy-duty extension cords. The length should be sufficient only to transfer the current from the power source to your boat. Power tools often generate stray currents and onboard radios can also cause problems in this area.

Unfortunately, while galvanic corrosion occurs relatively slowly and over a period of time, electrolytic corrosion can occur rapidly, depending on the strength of the stray current. The stray current can be a mere trickle of direct current from an area that is damp, to a blue-sparking short circuit on board from a marina's 220/110-volt system. Stray current can also give shocks to the crew and can cause fire or explosion.

Warning signs can range from blue sparks and a crackling noise from a shorted-out power cable to heavy static on radio speakers because of voltage drop. If you have electrical equipment that doesn't function up to expectations, suspect a stray-current flow that ends up somewhere other than where you want it. Voltage can be traced with a multimeter. Metal damage in the grounded area, resulting from electrical leakage, shows up as massive rusting and scaling on steel parts, abnormal brightness on bronze, and the total disintegration of aluminum parts.

Stray currents, like galvanic corrosion, can be eliminated when electronic devices are installed on the vessel. A custom builder should take the approach that both types of corrosion are predictable problems that not only can be built in, but can equally be "built out" of the boat and totally eliminated.

You should use high-quality wiring, fittings, and switches designed for the marine environment by a reputable marine manufacturer to protect yourself against most of the potential problems described in this chapter and elsewhere. Shore power needs particular attention since it has the greatest potential for danger. You'll want to use heavy-duty cord that is moisture resistant and specifically made for marine use. Use watertight marine connectors at both ends and, if possible, use a "molded-cord set," which is the last word in connecting shore power to your vessel.

Install a ground-fault circuit interrupter in the vessel's panel or fuse box. It will help prevent electrical accidents, especially those that result from current flowing from a hot wire to a ground. It will also reduce your chances of getting a shock.

CATHODIC PROTECTION

Many people are under the false impression that boats that cruise exclusively in fresh water do not require any special form of cathodic protection. The most commonly used method of protection is to install anodes to various underwater locations on the outside of the hull. M. G. Duff, the British experts on this subject, have produced two excellent pamphlets. One is for boats operating mostly in salt water and the other covers the freshwater environment. These publications explain the special requirements needed to protect your stern gear, rudder, and associated underwater equipment from the ravages of mysterious gremlins that can damage them and even the hull itself.

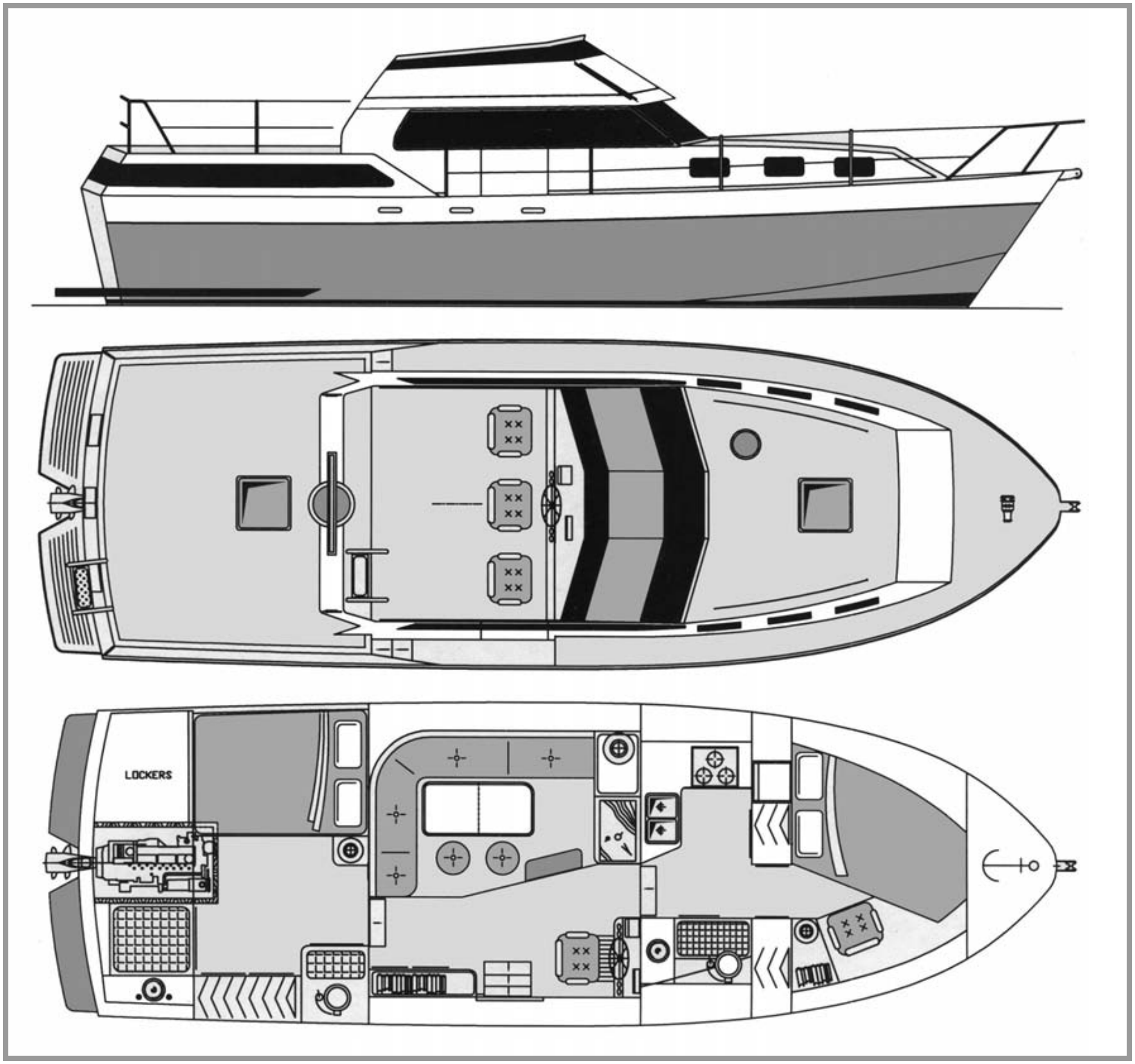
Most metals are extracted from ores by various processes, and they are prone to return to their natural state under the action of oxygen and water. We have all seen unprotected metals react in this way. Marine aluminum is one exception, it can be left unpainted and still not deteriorate even in a saltwater environment. The French build aluminum sailboats and leave them totally unpainted above the waterline; the Canadians do the same with fishing boats built in British Columbia. Pity about the appearance of the unpainted boats!

Cathodic protection is a means of transferring the corrosion electrochemically to another less noble metal. The concept is not new. For instance, Samuel Pepys, back in 1681, noted in one of his diaries that the removal of lead sheathing on ships of the line reduced the corrosion on the iron rudderposts. Over 100 years ago, the Italian physicist Luigi Galvini conducted experiments in this field and proved that when two metals were electrically connected and immersed in water, the resulting corrosion of one of the metals was speeded up, while the other received some level of protection. Once we understand this concept, the method of controlling hull corrosion and protecting immersed fittings becomes relatively simple. Sacrificial anodes of reactive metals can be applied to a metal to protect it.

A word of caution: cathodic protection of a copper-nickel hull is unnecessary because the alloy already possesses good resistance to corrosion by seawater. The use of cathodic protection will also reduce the effectiveness of the antifouling of the material. Hull attachments below the waterline should, if possible, be copper-nickel, or if not, the fittings should be made of a slightly more noble metal.

SACRIFICIAL ANODES

Sacrificial anodes are usually made of magnesium, aluminum, or zinc. For metal boats, anodes are either zinc or magnesium, and come in various shapes and sizes. These protective devices are relatively inexpensive and a complete spare set



Powerboats like this Waverunner 342 will require special attention when considering anodes. Most boats of this type have a considerable amount of electrical equipment that can give rise to all types of corrosion problems if not correctly wired and suitably protected.

should be carried at all times. An unexpected haulout could reveal the necessity to replace the anodes, so a set should always be on hand. For fresh water, use magnesium anodes and for salt water or heavily polluted water, use zinc anodes.

If you're building a new boat, the designer will be able to recommend the type, number, and placement of the anodes, and they can be either welded or bolted to the hull. We recommend the bolt-on method, as the replacement of this type will not cause the paintwork or inside foam to be damaged by additional welding. Bolting on replacement anodes is a much simpler process than removing and replacing old spent ones that have been welded in place.

When you're setting up your anodes for the first time, simply use the anode attachment straps and bolt holes to mark the position of the

When laying out your anodes, don't forget the rudder.

threaded studs to be welded to the hull skin. The fact that you're going to reuse the same locations and bolting arrangements, is another good reason to have more than one spare set on hand. On one occasion, we had to redrill several anode straps to match existing studs when we were unable to buy the same brand with matching holes. The studs and surrounding area should be painted after the studs are installed. Under no circumstances paint the anodes: this stops them from working.

The position and placement of the anodes depends on the size and displacement of your boat. The anode manufacturers have special charts showing the relationship between the size of boat, the number of anodes required, and where they should be located. It's common practice to have one anode on each side of metal boats up to 25 feet (7.62 m) long; they're placed below the waterline about 25 percent forward of the stern. Boats up to 35 feet (10.67 m) long require four anodes, two per side, one 25 percent and one 50 percent forward of the transom. Boats up to 44 feet (13.41 m) in length can use the same numbers and positions, but larger anodes. For larger boats, it's normal to have three anodes per side.

In addition to anodes already mentioned, every boat should have a small anode placed around the propeller shaft, another on the rudder, and a third in the area of the bow thruster, if fitted. When placing the anodes, either make sure that they're adjacent to the seacocks (if they're made of dissimilar metal) or fit additional anodes as required. For a foil-shaped rudder, the anode can be fitted with threaded studs about 25 percent below the waterline. On a powerboat's single-plate rudder, the anode can be through-bolted in position, using a bolt of the same metal as the rudder.

If you fit a bronze seacock on a steel or aluminum hull, make sure you insert a heavier metal section in the hull skin in the area where the metal standpipe is located. We recommended that the standpipe be carried inboard until the bronze seacock can be fitted clear of the waterline. The seacock will be isolated from the standpipe by liberal bedding compound installed between these two items.

Please note that the installation of anodes for a metal hull differs from that of a wooden or fiberglass boat in that the metal hull and metal fittings inside conduct galvanic current to the anodes. You don't have to run wires from the engine, engine shaft, or other similar items to the anodes. The reason is that the engine and other fittings are already grounded to the metal hull and carry the galvanic current to the anodes.

If you keep the hull of your steel or aluminum boat well painted, especially the area below the waterline, this alone will contribute to your maintenance of the boat and reduce the demand on the anodes. Anodes will need replacing before they are totally used up. Deterioration of the anodes shows that they are working. As mentioned elsewhere, the underwater sections of a copper-nickel hull will not need any painting or antifouling protection.

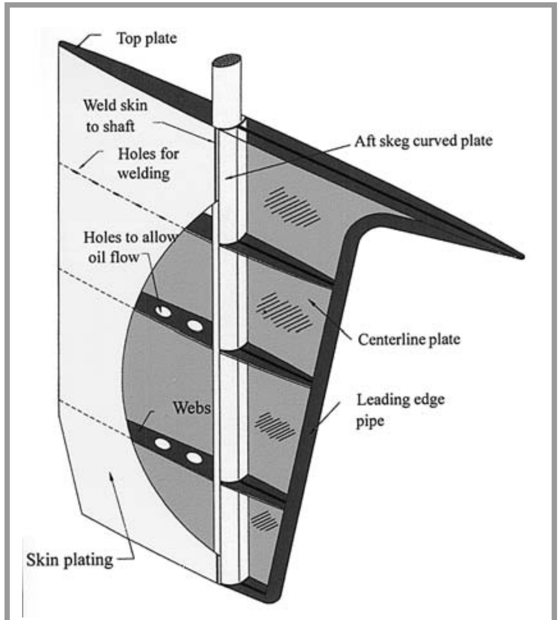
Skegs are usually fitted to sailboats with fin keels, and sometimes to powerboats. On fin-keel sailboats, we consider skegs to be preferable to unsupported spade rudders. On powerboats, skegs can often improve the directional stability. You may want to add a skeg, even if your metal boat was not designed with one.

If your sailboat plans call for a skeg and rudder combination, you'll need to assure yourself that the arrangement will stay with the boat at all times. Skegs are vulnerable and are more easily damaged than a boat that has a longer keel combined with a heel-supported rudder.

With many older sailboats now available on the used market, you should pay close attention to the construction and current state of the skeg on any boat you are either considering purchasing or for that matter sailing on at any time. It has become apparent over past few years that skegs represent a very vulnerable area of the underwater section of any boat. These problems are not restricted to steel or other metal boats; fiberglass and wooden boats can and do have the same problems with skegs becoming detached from the hull. The skegs on powerboats are usually much smaller, less vulnerable, and are designed and built so less stress is placed on these appendages.

In our own case we have become aware of the potential problems such as cracking around the root of the skeg, damage through past groundings, or contact with underwater obstructions not only in our own designs but in many others as well. We have designed a work-around fix for any skeg, and details of these modifications and advice on "beefing up" existing or new skegs are available at www.bruceroberts.com . Because of potential and known problems with skegs we are concentrating our design efforts on our well-proven contemporary long keel systems, which make the use of a skeg unnecessary.

For those who are determined to have a skeg fitted to their sailboat, please read for the best design and fitting of these appendages. On sailboats where a skeg is fitted, it usually occupies about

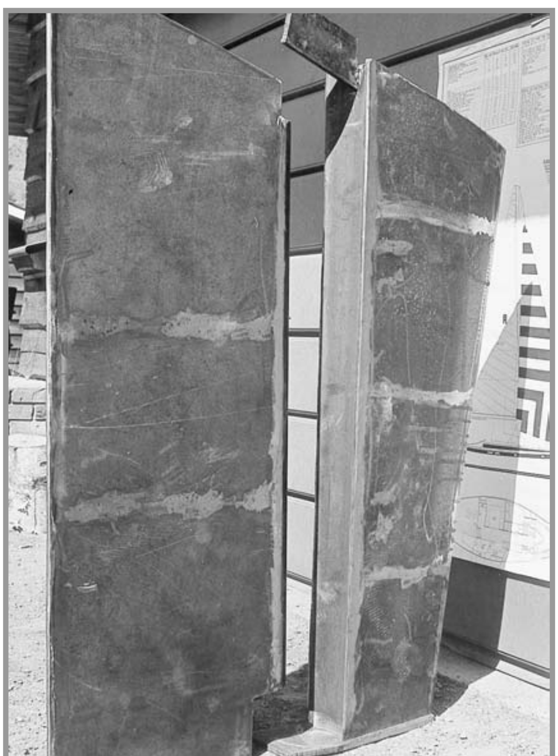


One of several ways to build a metal skeg and rudder.

one-third of the total area of the rudder-skeg combination. Even though we have been guilty of designing single-plate skegs and rudders on sailboats, we've learned that this arrangement is far inferior to an airfoil-shaped appendage. Fortunately, if you have a single-plate skeg and/or rudder, it's a simple matter to add some support fins and outer plating.

Assuming your boat is designed to be fitted with a skeg, it's important that it be built strongly enough to withstand a reasonable amount of rough treatment. It would be possible to design and build a skeg so strong that it would tear the bottom out of the hull before the skeg was severely damaged. This type of overkill may cause you to lose the boat. How strong is strong enough, but not too strong?

First, we consider it important that the skeg be built onto the hull after the plating is completed. The skeg should not be a hollow appendage that is open at the top, similar to the keel. A keel structure has to be strong enough to withstand anything that the elements can offer. Most keels on metal boats will survive grounding but, unfortunately, a skeg is not large enough to have the same strength.



The skeg and rudder shown here were built using the methods shown in the illustration on page 207. [pd]x-ref to drawing on 2nd ed p. 179

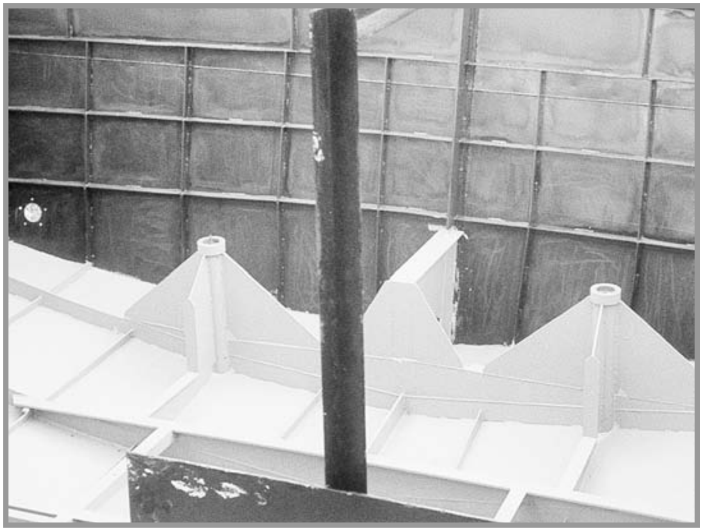
Most metal hulls have a substantial centerline bar on which to weld the centerplate for the skeg. The centerplate can be the same shape in profile as the skeg and can be welded directly to the bar. You could have the plate continue up through the hull and then have a number of web floors to reinforce the plate. This latter arrangement may be too strong and likely to take some of the hull plating with it if ever you have the ultimate skeg-damaging collision.

You can see by the foregoing that designing and building a skeg is no simple matter. If you make it too weak, you may lose the skeg; if you make it too strong, you may sustain hull and rudder damage in the event of a serious collision. This is one reason why, in most of our latest cruising sailboat designs, we're now leaning toward a contemporary version of the long keel, with a heel supporting the bottom of the rudder. Generally speaking, powerboats do not have so many of these problems.

The drawing on page 207 represents our idea of sensible skeg construction. We would follow the elements shown in this sketch. In some of our earlier designs, we allowed the skegs to have propeller apertures. Our current thinking is that the security for the propeller comes at too high a price. It's almost impossible to include the cutout without seriously weakening the skeg.

The leading edge of the skeg can be whole pipe, split pipe, or rolled plate. Your plans may incorporate a *fence*, which is like a fin that runs parallel to the DWL and usually extends from the front of the skeg to the aft end of the keel. The skeg can have the leading-edge pipe continued around and forward to form the bottom of the fence. The aft edge of the skeg is best constructed using an open-faced, large-diameter split pipe or rolled plate. The after end needs to be open enough to allow the rudder to swing at least 40 degrees in each direction. The centerline plate will support the airfoil-shaped half webs that are arranged on each side of the plate. If the centerline plate is omitted, you can have full-width webs attached to the leading and trailing edges of the skeg. The bottom airfoil web is usually ½-inch (12 mm) plate and can support the rudder-bearing cup.

To install the plating on the skeg, you'll need to make slots in the plate so you can weld through them and attach the plate to the webs. After fully plating the skeg, you may wish to install a fillet at the top on both sides where the skeg joins the hull. The fillet should measure, say, 4 to 6 inches (100 mm to 150 mm) and be installed at 45 degrees between the hull and the root of the skeg. Fair off the forward end of the fillet that will be welded to both the skeg and the hull plating.



Note the stiffeners on the transom and webs that support the rudder tubes on this steel Waverunner 44.

SAILBOAT RUDDERS

Build the rudder in a manner similar to that used to make the skeg. The leading edge of the rudder will be either solid round material or a hollow tube of suitable strength. Your plans will indicate the size and type of material recommended for the rudderstock. Take care not to introduce stress into the stock when welding the webs and the plate to it. Some builders fit drain plugs to their rudders and skegs and fill them with oil. The idea is to prevent corrosion inside. In some publications, we've seen concrete recommended as a fill for rudders and skegs. Don't follow this recommendation. Our experience with concrete in boats, including metal hulls, is that it can cause corrosion from inside the hull, so don't include this material anywhere in your metal boat. A fill with foam, similar to that used as insulation inside the hull, may be of some benefit.

You may wish to have an arrangement that allows you to remove the rudder without removing the skeg bearing or lifting the entire boat. You can arrange flanges bolted together to make the removal of the rudder a simple matter. If you use flanges in the system, make sure they are of a metal compatible with the remainder of the hull and have sufficient strength. You will need to have at least five bolts per set of flanges and they need to equal or exceed the cross-sectional area of the rudder shaft. If you have flanges and bolts, then you must wire the nuts together usually will stainless steel wire, so there is no risk of the bolts coming loose and allowing the rudder to part company with the boat.

In the bottom cup bearing you may insert one or more metal balls as a bearing surface for the bottom of the rudderstock. If you use this system, make sure that the hanging arrangement for the rudder is such that it cannot part company with the boat if the balls fail.

POWERBOAT RUDDERS AND STEERING SYSTEMS

Hydraulic steering systems can more easily be interfaced with autopilot systems, and for this and other reasons they're generally preferred for most powerboats. This whole question of steering systems and choosing the right system for your boat is covered in our book *Choosing for Cruising* (sailboats) and the e-book *Choosing a Cruising Powerboat* (for details, go to bruceroberts.com).

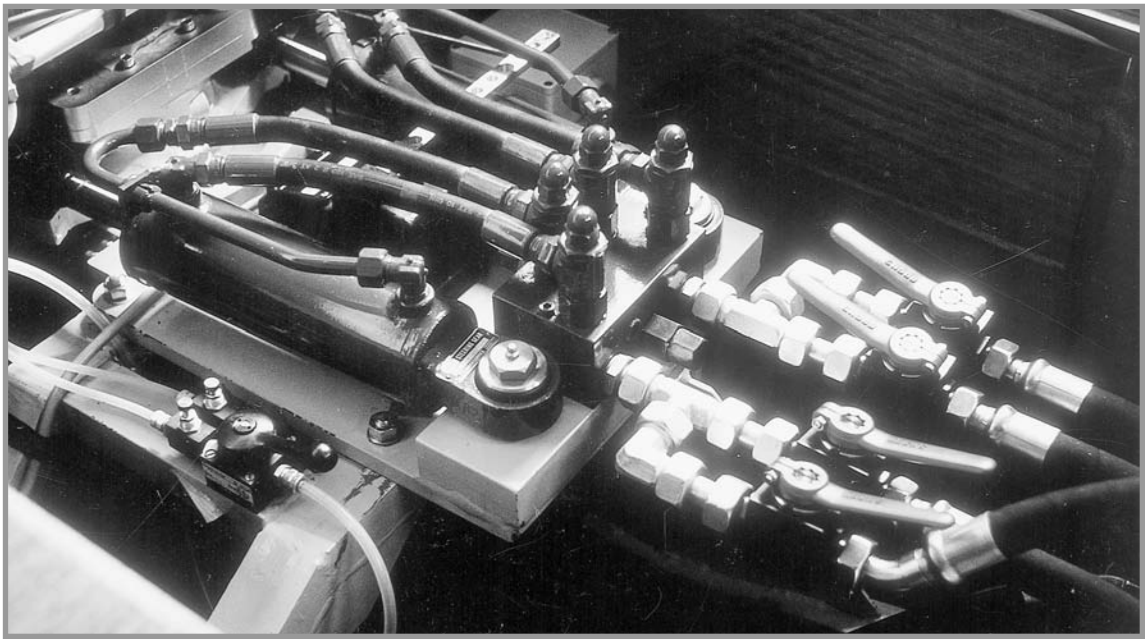
Powerboat rudders are usually cast from alloys, and the size of the blade and shaft has to be carefully calculated to allow your boat to be steered within a range of speeds. The problem is that the larger rudders that would be ideal for handling the boat at slow speeds are not suitable for a boat operating on a plane. It's essential that you have the correct rudder size to suit the type of hull and expected performance characteristics of your particular boat. Consultation with the designer of your boat, or better still with a rudder specialist, is essential if you're to have a successful match.

SAILBOAT TRANSOM STEPS AND SWIM PLATFORMS

Most sailboats can be improved with one of these features. The platform will need to be designed so it's still clear of the water when the boat heels to its maximum sailing angle. On sailboats, the swim platform and boarding steps are usually incorporated into the construction of a reverse or sugar-scoop transom. If you're building from new, then the whole arrangement can be designed into the stern. If you are planning to add these features to an existing metal boat, then careful thought will be required before you start to alter the transom.

If the after end of the transom is too high from the water, say more than 1 foot 6 inches (457 mm), then you'll need to include a boarding ladder in the arrangement. If you're having a boat designed, or altering an existing design to suit your particular requirements, it's worthwhile noting the height of the bottom of the transom above the water. It may be possible to modify the design so a separate boarding ladder isn't required.

The sugar-scoop stern is one feature that has proved its worth; combined with transom steps, it makes a fine addition to any boat. Be careful if you're planning to have one of these added to the stern of your sailboat; we've seen some poorly de-



Hydraulic steering coupled to a self-steering arrangement will require some substantial pipe work, as seen here in a steel Roberts 53 sailboat.

signed additions that have spoilt an otherwise attractive design.

POWERBOAT SWIM PLATFORMS AND BOARDING LADDERS

In some places the swim platform is referred to as a duck board. We confess to not having given this matter much thought until we finally owned a powerboat fitted with one of these appendages and then noticed how the ducks find them ideal for roosting. This isn't a problem if you are using your boat regularly, as the birds seem to know which boats are unused, and concentrate their unwelcome attentions (and gifts) on those vessels.

The transom arrangement on this Roberts 53 makes boarding and unloading a dinghy just that much easier.

A large percentage of powerboats feature some form of swim platform and most are fitted with a boarding ladder at the stern. Anyone familiar with boating will be aware of the usefulness of these features, and if you're building a new boat or refitting an existing metal craft, the design and construction of this part of the hull should receive your serious consideration. We've also seen a set of steps incorporated into the bow of a powerboat. These simple, U-shaped stainless steel steps enabled a crew member to step from the boat to the shore more easily. This arrangement is worthwhile considering if you're planning extensive cruising in canals.

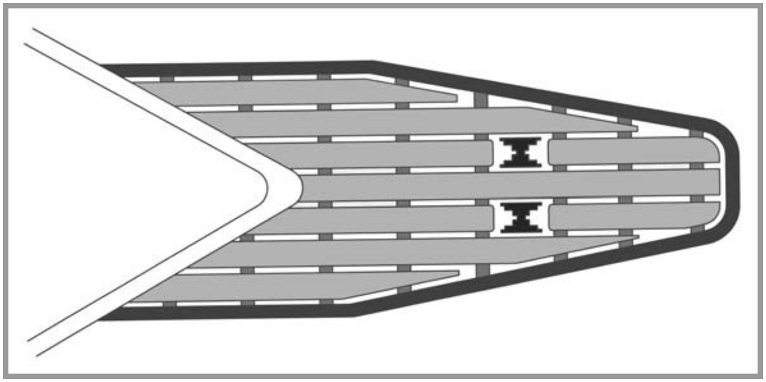
Recently, there has been a trend to carry the hull underwater sections past the regular transom and thus provide a base for the swim platform. This additional underwater volume will need to be considered with the rest of the hull if the boat is to retain its designed fore-and-aft trim. One way to ensure that there are minimum trim problems is to use this extended hull volume as liquid storage, either as a holding tank or as a way to increase water or fuel capacity. The holding tank option is the most popular solution—and dare we say you'll have more control as to when and how this form of ballast is discharged?

Another option when considering a swim platform is to have the structure built with a pipe frame that may be permanently left in position, or designed to fold upward when not in use. The fixed version is easier to build and maintain, and unless you have some reason that forbids its use (such as marina costs or space restrictions) then this is the type I recommend. A pipe swim platform can be built out of 2-inch-diameter (50 mm) heavy-wall pipe, and can be an attractive addition to your boat. Suitably spaced 2 by 2 by ¼ inch (50 by 50 by 6 mm) angle can be used to support a system of teak planking.

The top of the swim platform will need to afford easy access from the water. In some cases, this may involve a calculated guess as to where the final waterline will be located. In any case, transom steps or, more likely, a boarding ladder will be needed from the swim platform to the main deck.

BOWSPRITS

Although they're usually confined to sailboats, short bowsprits can often be usefully incorporated into a powerboat hull. Construction would be similar in either case but the sailboat version



A pipe bowsprit is easily fabricated from the same metal as your hull; this is one place where you can avoid the use of dissimilar metals.

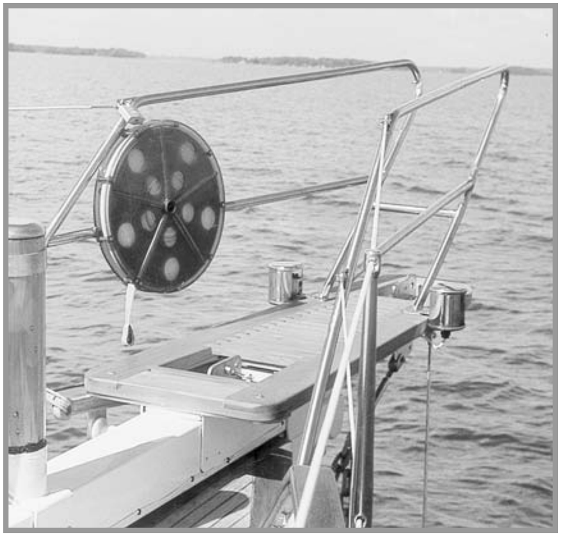
will need extra strengthening to take the loads imposed by the sailing rig.

The simplest and most effective form of bowsprit on a metal boat is one built of heavy-walled pipe to form a U-shaped or similar structure. The ends of the U are anchored to a suitably reinforced section of the plating near the bow. The illustration gives you a reasonable idea of what we consider to be the basis for a sturdy bowsprit. The structure may incorporate rollers to accept the anchor chain. Your bowsprit should provide an ideal place on which to stow the anchor. The anchor should be stowed far enough ahead of the bow so as to be out of the way, while remaining ready for immediate use.

In the sailboat version, tangs will be needed to accept the lower end of the forestay. The ideal material from which to build the main pipe structure is 316 stainless steel. The high cost of this material in the sizes and weight required means that you'll probably be using mild steel, aluminum, or copper-nickel, depending on the metal used to build you boat. It's preferable to use stainless steel for the tangs and other areas of the bowsprit where normal usage would soon wear away the paint and cause future maintenance problems.

The working platform of the pipe bowsprit can have L-angle installed as supports for the teak decking. Some form of bobstay may be required, depending on the strains imposed by your particular sail plan. In some cases where the bowsprit is no more than an extension of the bow/foredeck area, and intended to make the handling of anchors and ground tackle as simple as possible, then a bobstay may not be required. If the U is

This bowsprit was installed on a beautiful Centennial Spray 34 launched in the UK.



This arrangement combines a bowsprit, a sturdy pulpit, a jib boom, and an anchor-line reel for the second an-

wide enough where it's attached to the hull, then side stays may not be required.

DAVITS

These dinghy-stowage devices are sometimes seen on sailboats. Davits on sailboats can be a mixed blessing because all too often they're of crude design and construction. Davits can increase the available deck area by moving the dinghy out of the way, but they may impede the operation of a self-steering windvane and can cause problems when you're sailing in a following sea. As davits may sooner or later require some repairs, you may consider it preferable to bolt them in place rather then weld them directly to the deck. There is one type of davit that may be suitable for all types of boats and that is one where the dinghy is lifted from the water in the normal manner and then flipped over to lie upside down on top of the davits.

We'd like to mention the fittings known as snap davits. They're generally bolted to a swim platform, and matching fittings are glued or otherwise attached to the dinghy. The dinghy is positioned so the attachment points match up. The dinghy is now in a position to be pulled upward and sits parallel to the vertical transom. The dinghy actually hangs on these snap hinges outside or aft of the swim platform, thus allowing reasonable access to the platform. This arrangement is an alternative to fitting regular davits. You should decide if the disadvantages of restricted access to the swim platform and some restriction of aft vision by the dinghy outweigh its advantages.

Regular davits can be built of mild steel, stainless steel, or aluminum and can be constructed of pipe, rectangular tube, or sheet metal. If you have a generous budget, then it may be simpler to purchase ready-made davits. The rest of us will need to decide which design and construction method would best suit our needs. For other reasons, your dinghy should be as light as practical, so it shouldn't be necessary to build the davits of such heavy construction as to add unnecessary top hamper to your vessel. Try to match the style of the davits to the style of your boat. This is one of the many areas where it is possible to spoil the overall appearance of a boat by adding an ugly item that is there for all to see.

Because of the variety of dinghies likely to be carried, it is impossible to give detailed advice on constructing davits. If you study other boats with off-the-shelf or custom-built davits, you should be able to gain sufficient information to enable you to build a set for your boat.

The sturdy tabernacle on this Roberts 53 is in keeping with the rest of this beautifully built boat. It's built to go anywhere.

MAST STEPS

No matter whether your mast is deck-stepped or keel-stepped, it will need some kind of device to secure its lower end (heel) of the mast tube. Many commercially manufactured masts come complete with a cast-aluminum step. It's fastened to the deck and the mast simply sits in this cup-like arrangement. Make sure that your deck-mounted step has the ability to drain the water that lodges around the bottom of the mast.

Examine the mast-support post—it may be 2- to 3-inch-diameter (50 to 75 mm) metal round or rectangular pipe—you need to ensure that it is up to the job. Your mast's under-deck support may be in the form of a beefed-up bulkhead.

Check your plans for details. If your mast is stepped on the keel, check if you have an arrangement that will allow you to alter the rake of the mast (this will change the fore and aft location of the foot and may cause problems with the through-deck sleeve and collar).

You may also consider a tabernacle mast step, a vertical trunk that accepts a deck-stepped mast and often allows it to pivot fore and aft. It can be manufactured of cast aluminum or fabricated from stainless or mild steel. Naturally the design of the tabernacle will need to match that of the mast and gear it's expected to support. When we say that it can be built from ¼-inch (6 mm) plate, you'll have to determine if that's suitable for your particular situation.

CHAINPLATES AND TANGS

Because of the wear and tear imposed on chainplates and tangs, they should be fabricated from 316 stainless steel. If you build chainplates or tangs out of mild steel that is subsequently painted, you'll find that the paint will wear away and corrosion will soon appear. Most metals, other than stainless steel, are also unsuitable for making these parts. When you paint the boat, make sure you extend the paint up 2 inches (50 mm) on to the stainless fittings; this will prevent any corrosion caused by the proximity of two dissimilar metals. Most chainplates and tangs will be made from plate of a minimum thickness of ¼ inch (6 mm), but consult your plans for exact sizes. Some designs call for the chainplates to be made from solid round stainless steel bar. Watch for crevice corrosion. Reread the section on stainless steel in Chapter 3. Its strengths and weaknesses should be kept in mind when using this material.

Avoid chainplates that are simply welded to the outside of the hull; they look crude. They're also corrosion traps because they're welded on top of another section of metal. In our opinion, welding even similar metals one on top of the other is bad practice. For instance, if you're welding a cleat to the deck, either reinforce the plate with a section of heavier metal *let into* the deck or use a cleat where you weld the legs of the cleat to the deck. The same advice applies for parts, such as standpipes, that you weld to the hull deck and superstructure. If the area needs reinforcing, then let a section of heavier plate *into the area* rather than weld another piece over the first. Failing to follow this advice will allow corrosion to form between the two layers of plate. Make sure the chainplate angle is in line with the load of the shroud or stay. Check fore-and-aft angles and loads, as well as the obvious athwartship ones. All loads of this type should be in sheer, avoiding all twisting or bending loads.

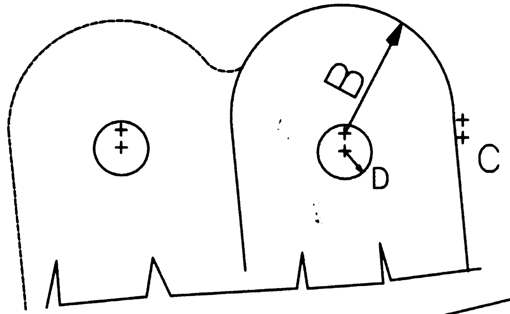
CLEATS

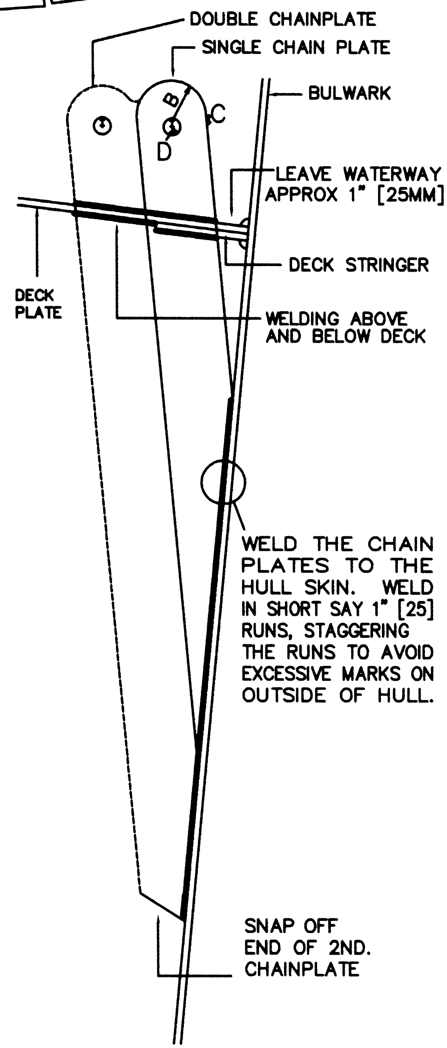
Make sure your cleats are adequately sized to handle your lines. Cleats may be made of aluminum or stainless steel. Painted mild-steel cleats would corrode due to the paint being worn off when the cleats are in use. Try to position them in such a way as to minimize the chances of stubbing your toes. In many cases, cleats have to be in a certain location, but you can usually manage to avoid placing them in the most dangerous places. Fastening the cleats to decks, coamings, and cabintops should be a simple matter of welding them in place.

Always use 316 stainless steel when making these items. It's worth taking the fabricated cleats to a metal shop and having them polished, as the finish will be long-lasting. One of the many advantages of building a metal boat is the fact that you can weld most cleats and fittings directly to the deck or other surface. Your plans may include the exact locations of the sail-handling cleats or you may confer with your rigger and/or sailmaker for suggestions in this area. In a sailboat, you'll have a variety of cleats including ones to accept the various sheets and halyards.

Both sailboats and powerboats require mooring cleats and they should include one each side in the following locations: one near the bow, one amidships, and one near the stern. The midship pair are sometimes omitted, which is a pity

CHAINPLATE DETAIL:





WIRE SIZE	'A' PIN SIZE	'B' RADIUS	'C' OFFSET	PLATE THICKNESS
1/4" 6MM	1/2" 12MM	11/16" 18MM	1/8" 3MM	1/4" 6MM
5/16" 8MM	1/2" 12MM	13/16" 20MM	3/16" 4MM	5/16" 8MM
3/8" 9MM	5/8" 16MM	7/8" 22MM	3/16" 4MM	7/16" 11MM
7/16" 11MM	3/4" 20MM	1" 25MM	3/16" 4MM	1/2" 12MM
1/2" 12MM	7/8" 22MM	13/16" 20MM	1/4" 6MM	1/2" 12MM

WHEN WORKING OUT THE SIZE MATERIAL NEEDED FOR YOUR CHAINPLATES, FIRSTLY ESTABLISH THE SIZE OF THE RIGGING WIRE REQUIRED AND THE ALL OF THE DIMENTIONS FOR THE ACTUAL CHAIN PLATES WILL BE SHOWN ON THE ABOVE CHART.

FOR CHAIN PLATES THAT TAKE TWO STAYS OR SHROUDS, MAKE WIDTH AS FOR TWO PLATES.

FOR FORESTAYS AND BACKSTAYS ADD 1/16" [1.5MM] TO THICKNESS.

THE WIDTH OF THE PLATE IS TWO TIMES THE RADIUS 'B' MEASUREMENT.

ANY REINFORCING OF DECK PLATES ARE BEST UNDER DECK WHERE IT CAN NOT TRAP SURFACE WATER.

IN GENERAL FACE EDGE OF CHAINPLATE ALONG LINE OF STAY, BACKSTAYS RUN FORE AND AFT, SIDE STAYS OR SHROUDS RUN ACROSS VESSEL.

The chainplate detail shown here can be adapted to suit most metal sailboats.

Stainless steel bollards are sensible and attractive on any metal boat.

This bollard and fairlead combination works well; it would be improved if built from stainless steel.

because they're often the most useful. If your boat is over 40 feet (12.19 m) long, you may require additional mooring cleats. It's always advisable to install a substantial cleat on the foredeck; it can be used for towing and other purposes. Even if you have a substantial anchor winch, the centerline cleat can be used when setting additional anchors. Always make sure that any cleats, bitts, or other fittings welded directly to the deck or superstructure are fully welded to the surface. Don't leave gaps where moisture can creep underneath and start corrosion. That advice applies to all fittings welded to a deck, coaming, or cabintop. A thickened section of plate under the cleat or other fitting may be required; in any case, this is just good metal boat building practice.

BITTS AND BOLLARDS

On our boat, we prefer mooring bitts to cleats. Cleats are fine for handling sails, but when you have the weight of the entire boat plus a surging action wanting to separate a mooring line from your boat, a set of bitts is preferred. Six of these fittings should suffice on boats up to 55 feet (16.76 m) in length: one pair up near the bow, one pair amidships, and another near the stern. These bitts make the best termination for your mooring lines and will provide a perfect arrangement should you decide to take your sailboat through some of the canals and waterways of Europe, the United States, and elsewhere. As with all stainless fittings that you can weld directly to the boat, don't forget to paint an inch or two (25 mm to 50 mm) up the sides of the stainless fitting to ensure no corrosive action will take place between dissimilar metals.

Bollards are deck fittings featuring a tubular base with a solid pin set at right angles—a sort of cross between a cleat and a set of bitts. One advantage of bollards is that they're popular on powerboats, so they're easy to obtain ready-made in marine-quality stainless steel. Of course you can make your own from tube and solid rod. As with many fittings, you may decide to purchase one as a pattern and then make as many as you require, thus saving yourself a great deal of cash.

STANCHIONS AND GUARDRAILS

Stanchions and guardrails as well as pulpits and pushpits, are best fabricated from stainless steel. However, if the cost is too daunting, then galvanized and painted ones will be the next best thing. Some builders construct stanchions and chainplates as a combination fitting. In our opinion, it's better to separate them as they need strength in different areas. There's much discussion as to whether you should weld the stanchion directly to the deck or mount it on a plate that is, in turn, bolted in place. Some experts suggest that an oversized pipe socket to accept the stanchion be welded to the deck. Our opinion is that provided the stainless variety, as mentioned earlier, are painted at the attachment point, then these and mild-steel stanchions are best welded directly to the deck.

If you want the ultimate connection, you could have 2½-inch (35 mm) square plate, or a disk of ¼-inch (6 mm) plate, beveled on the edges so the thicker portion stands proud of the deck and then welded in place. The stanchion is simply welded to this thicker, reinforced, and raised plate. The water will naturally run off the area of the stanchion-deck join and minimize the chance of corrosion.

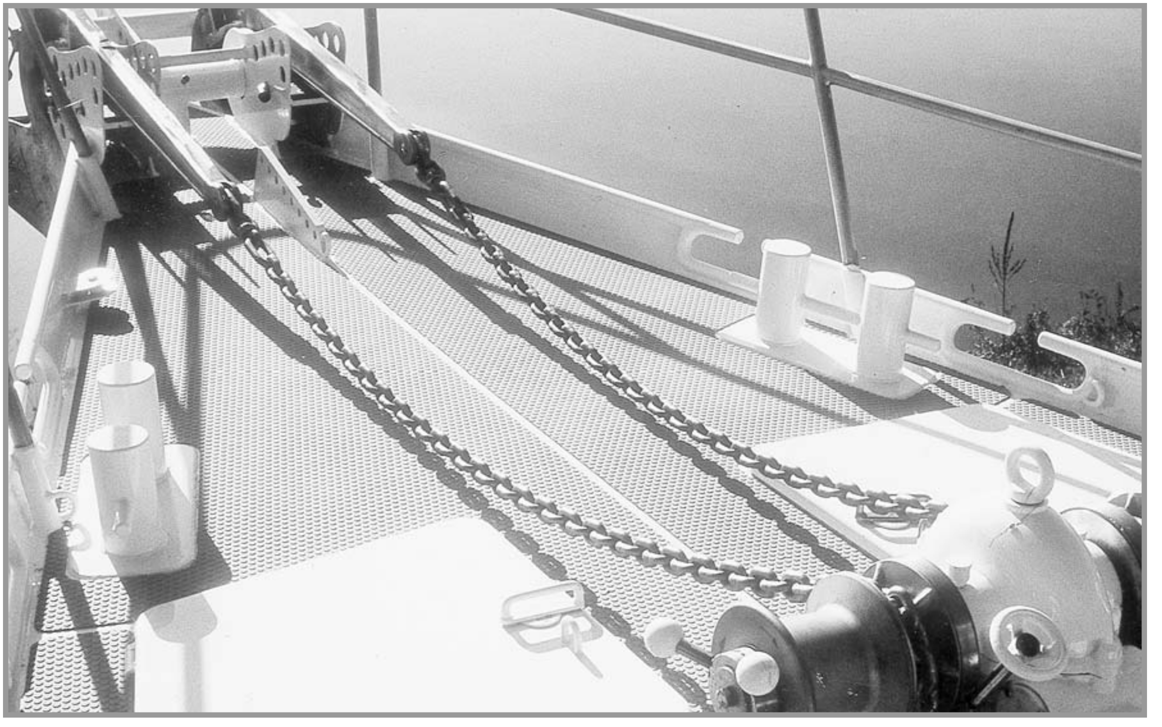
If your boat is large enough, you may wish to consider installing guardrails as opposed to stanchions and wire lifelines. Any sailboat over 40 feet (12.19 m) should be able to carry them. Any powerboat, even of smaller size, seems to look right when fitted with guardrails. To look right, the rails should be of smaller diameter than the stanchions. Rails about 75 percent of the stanchion size seem about right. The diameter of the stanchions will depend on the size of boat. Any "security fence" around the perimeter of your decks that is less than 28 inches (711 mm) high is dangerous. You need stanchions that are 36 inches (914) mm high. This is perfect for security, but would look too high on some boats. If possible, combine your stanchions with at least a low bulwark, and this will keep the apparent overall height of the stanchion/bulwark within reasonable limits. Don't forget access in your stanchion arrangements. You should have a "gate" each side, near the most obvious exits from your side decks. If you opt for stanchions and wire lifelines, make sure you have either small-diameter pipe fitted through the stanchions to carry the wire, or use some method to avoid water getting into the stanchion and causing corrosion at the base. Use flexible stainless steel wire for lifelines; galvanized wire will not last long. The use of the off-the-shelf, plastic-coated variety is dangerous as corrosion is not always apparent and the line could fail at a most inopportune moment.

PULPIT AND PUSHPIT

The pulpit and pushpit can be built of the same metal as the stanchions but use pipe of a slightly larger diameter. You can study other boats as to the latest trends and designs of these items. The pulpit is best arranged with an opening in the most forward area so you can exit and enter the bow when moored bow-to, as is necessary in some areas. This arrangement will combine well with a short bowsprit or platform. The pulpit can be a little higher than the guardrails without spoiling the overall line of the hull.

The pushpit, or stern pulpit, needs a gate for

Stainless steel pipe rails, pulpits, and pushpits are recommended on all metal powerboats and can be a great asset on larger sailboats.



If you need a break from the main project, then make a few fittings. These were made by Herbert Fritz for his steel Roberts 53. Fritz must have done a good job; this boat has now successfully completed a circumnavigation.

This is one way to make a strong and inexpensive forestay fitting; again, stainless steel would improve its durability.

aft access to the boarding ladder or swim platform. Before designing and fabricating this safety feature, study other boats similar in size and style to your own.

BOW FITTING

Your bow fitting is best constructed from 316-grade stainless steel. Your plans may include specific details on how to construct this item. On a sailboat, the bow fitting will most likely include tangs for the forestay and an attachment for the furler or tack of the jib.

Depending on the arrangement for your boat, you may also incorporate rollers, one for the anchor chain and another for the anchor line. If you wish to stow the anchor on the bow roller, then a Bruce or CQR anchor may be arranged in that manner.

ANCHOR LOCKER

You will want to decide if you want a self-draining anchor locker, which has drains at the bottom of the locker and which is sealed off from the rest of the boat. Water can drain out; it can also flush in through the drain holes. I prefer a locker that drains through a pipe to the bilge where the bilge pump is located.

Many cruising boats carry two anchors in the forward anchor locker; however, very few are divided as they should be so that the anchor lines and/or chains do not become mixed. Generally the main anchor, a CQR (plow type) or Bruce style (no relation!), is kept stowed on bow rollers or a small bowsprit, ready for use. The secondary anchor, usually a Danforth type, is stowed in the locker along with its rode. Some anchor lockers are arranged so that the chain runs through a tube down toward the center of the boat. This puts the weight where it can contribute to the stability of the vessel. If you decide to arrange your anchor chain in this manner, make sure that you can reach into the locker to assist the chain to stow neatly. Also ensure that it can't get loose in the event of a knockdown. You may want to consider carrying a third anchor at or near the stern, where it can be useful when you wish to anchor fore and aft.

Most powerboat hulls need some form of spray rails to prevent water climbing up the bow or throwing excessive spray back over the crew. You will be surprised just how effective a rail such as the one shown here can be in keeping spray off the decks.

HAWSE PIPES

Formerly the preserve of larger vessels, hawse pipes are now often seen on powerboats as small as 30 feet (9.14 m). If you carry only one bow anchor, and your hawse pipe is only on one side, it can be a problem when you're anchoring in certain wind and sea conditions, as the chain can chafe the bow. In a smaller boat, the hawse pipe should be located in the bow itself and placed on the centerline. Where you are able, have an anchor locker with a bulkhead down the centerline, and then carry two bow anchors, each in their own hawse pipe. This arrangement is worth considering, especially on a larger powerboat. Make sure the actual hawse pipe is large enough for the chain, about three to four times the diameter of the chain should be about right. Don't install a hawse pipe so that the chain has to make difficult bends before it stows itself in the chain locker.

When your boat is fitted with one or more hawse pipes, you'll need to prevent the anchor from damaging the hull paintwork or even scoring the hull. A light stainless steel plate is usually placed around the area where the anchor will reside. In addition, you should fit a floating ring that stows permanently over the chain and lies between the anchor and the hull.

Especially in a sailboat, we'd favor a small bow platform or bowsprit, and then the anchor and chain would be more accessible at all times.

LENGTHENING A METAL BOAT

We should at least mention the possibility of your altering a boat you already own, or one you can acquire at the right price. By "altering" we mean shortening or lengthening an existing boat. (In our opinion, widening a boat is almost impossible, so unless you have some information that has eluded us all these years, then you had best put that idea aside.) It's simpler to make these alterations to a boat built of metal than it is to make similar modifications to one built of fiberglass or timber.

It's uncommon to consider shortening an existing powerboat, so we will confine our remarks to the possibility of lengthening a sailboat or powerboat. Steel, and aluminum present about the same amount of difficulty, so they can be considered at the same time. There is one exception to the above statement. This concerns the shortening of barges and similar vessels. Many Dutch, French, and other European working barges are shortened when they are converted from commercial to pleasure usage.

Thousands of large metal powerboats have been lengthened. This usually occurred when the owners decided that it was less expensive, or in some way more desirable, to increase the size of the boat than to buy or build a new vessel. There are many factors to be considered before you commit to changing the dimensions of your metal powerboat. First, where to make the addition. Many owners often mistakenly believe that to increase the length is just a matter of adding a few feet to the stern. Although many boats are lengthened in this manner, it's worth exploring all the options before making the final decision on how you'll tackle the project.

It is possible but expensive to add sections into the center or other than the aft end of a metal vessel. People who have the means to buy large boats and then totally gut the interior sometimes take the opportunity to lengthen the boat at the same time. Remember, any vessel that's lengthened should have a new, complete set of stability and other relevant calculations prepared for the altered vessel.

If you opt for extending the stern, here are a few items you will need to consider. Will the engine room need to be moved? How about the rudder(s)? How will they be affected? And the steering location: will the new longer hull be harder to steer from the current steering station? How will the hull lines be continued and how will this affect the handling? Will the fore-and-aft trim of the vessel be affected, and how can we overcome any problems in any of these areas? Many of these factors will need to be discussed, preferably with the original designer, or, if that's not possible, then you should seek the help of a suitably qualified naval architect.

The reason that extending a powerboat by lengthening the stern is such a popular option is that usually it means that the interior accommodation, electrics, and plumbing can be similarly extended without disturbing the existing arrangements.

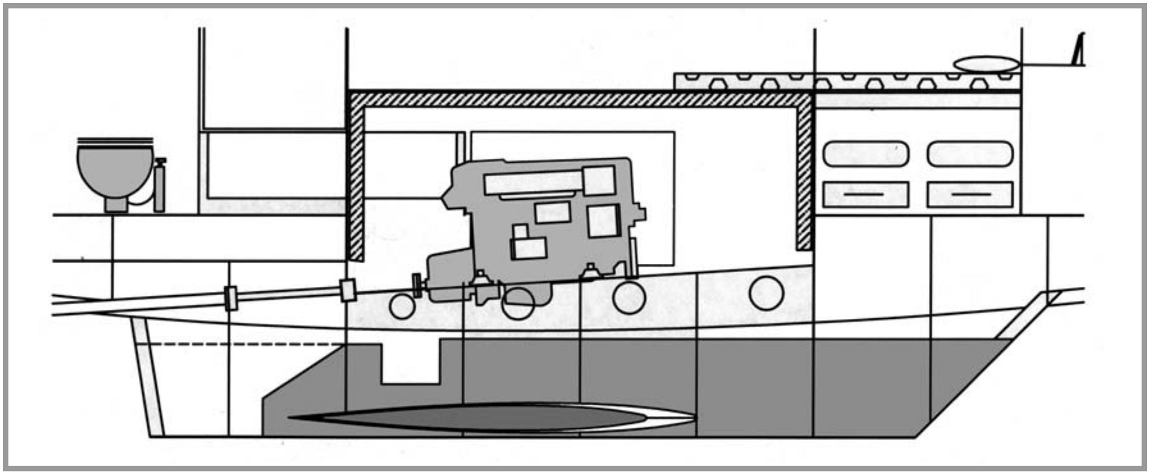
It's harder to lengthen a sailboat. Here we have a whole new set of factors to consider. The position and length of the keel, the amount and location of the ballast, the location of the auxiliary engine and the possible increase in the size of the rig are all factors that need consideration when increasing the size of a metal sailboat. If you plan changes in these areas, you'll need the services of the original designer. It's our opinion that lengthening a sailboat is probably not worth the trouble.

ALTERING CABIN STRUCTURES

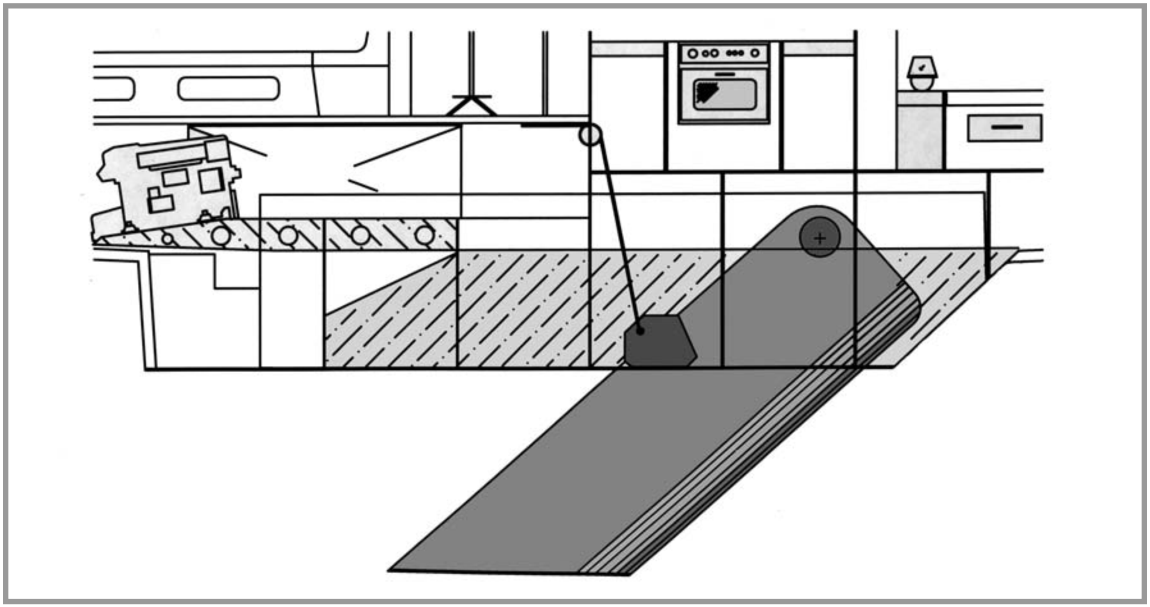
The cabin is one area where you may be able to improve your existing boat. First, on no account raise the overall height of the cabin structure without seeking professional advice. You may totally destroy the stability, handling, and performance of your vessel if you raise the cabintop beyond sensible limits. The most common change made to cabins is the addition of a pilothouse. While this can be a worthwhile addition for many boats, it's one that needs to be carefully designed before changes are made. Keep it light and keep it low. See Building or Adding a Pilothouse, Chapter 9.

BALLAST AND TRIMMING

It's impossible for the designer to know how the builder keeps track of the materials used to build the boat. Only the builder knows what has been



Wing keels are relatively easy to fabricate on a steel boat.



The ballasted drop keel is one way to obtain minimum draft; however, the complexities of these keels are obvious even in the simplest form, as shown here.

added to the basic construction materials and gear specified in the plans.

If you want your ballasting to be correct, and as efficient as possible, keep accurate records and generally follow the designer's recommendations as closely as possible. It may be worth having the hull weighed before installing the ballast. The crane that is used during the moving of the boat from the building location to the launching site can often undertake this weighing operation. Perhaps a small side trip to a weighbridge could achieve the desired result. With the minimum of planning, it should be possible to add the ballast just prior to launching the boat.

When you do install the ballast, make sure that you install it by weight not by volume.

Weigh each portion as it's installed in the keel. This is a time-consuming and thankless task, but you may be well rewarded if you need to trim the boat, add tankage, or otherwise change the ballast arrangements.

In a metal sailboat or trawler yacht, the keel sides, the bottom of keel, and the web floors all form part of the ballast. In some cases, such as in ultra-shallow-draft boats, the bottom plating is considered to be part of the ballast. Back in the early 1970s, we didn't make this sufficiently clear, and this caused some builders of our designs to install more ballast than was intended. Some removed some of the ballast, an even more thankless task! Fortunately for those who chose to retain the extra ballast, this didn't materially harm the handling of the boats in question. But there's no doubt that in many cases carrying too much ballast can detract from performance.

No matter who designed your metal boat, make sure you know how much ballast has to be added in addition to that already created by the keel and supporting structure. Of course, this advice mainly applies to steel and copper-nickel hulls; aluminum hulls require the full amount of ballast quoted by the designer. Especially in the case of steel boats and during the construction stage of any boat, it's wise to only install between 70 and 80 percent of the total ballast required. The remainder can be added for trim ballast, as and when required.

Another point to remember is that there may be some confusion over the quoted displacement/ballast ratio. Total the amount of the "naturally acquired" ballast and the added ballast before making any judgmental comparisons in this area.

Over the years, many different materials have been used as ballast. Today the choice lies between lead, cast iron, and scrap steel. A cast-iron keel would now costs about the same as a lead keel. You cannot, unless you own a foundry, pour your own cast-iron keel. You may be able to pour a lead one; however most metal boats have envelope keels, so the ballast is installed in pigs or precast portions. In the case of cast-iron ballast it's mostly used as bolt-on ballast, and consequently it's less suitable for metal boats. The designer may have already chosen your ballast material after taking its relative center of gravity into account when figuring the stability of the vessel. Always consult the designer before making any changes to the amount, type, and location of ballast.

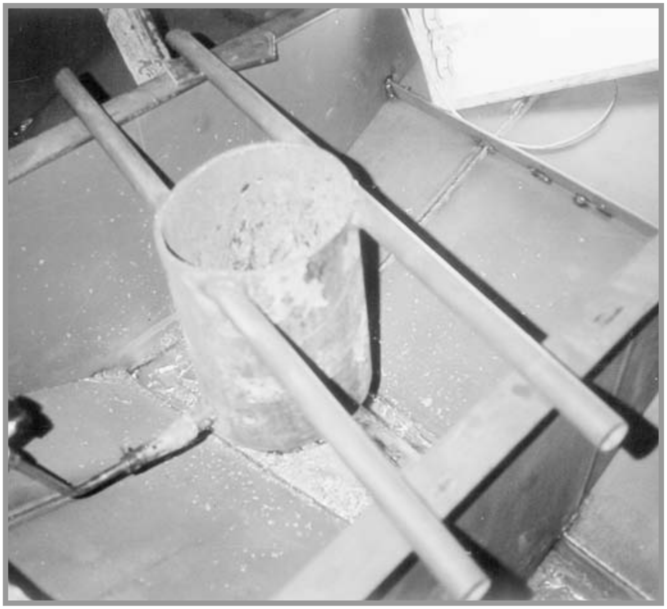
Some builders have found it convenient to install the ballast at an early stage. If you're building upright, it may be a good idea to install the bulk of the ballast before the final bottom plate is installed. This means you don't have to carry the ballast material up and over the sides of the hull. Some builders have constructed the keel separately and, after setting it in position, have installed most of the ballast before even setting up the frames. All these factors should be taken into consideration before you decide to build your hull upright or upside down.

Lead Ballast

Lead weighs 710 pounds per cubic foot (3,466 kg per cubic meter), and this, combined with its low melting point of 621°F (327°C), makes it the superior ballast material. If you're building on a tight budget, then all of the advantages may be purely academic. The price for lead will vary from one dealer to another, so it's worth shopping around. You may collect scrap lead from a variety of places, including garages and tire outlets where those small lead weights are used to balance the wheels on your car.

When considering the ballast material, the boat design will be a factor: shoal draft favors lead ballast, while a deeper draft may accommodate the scrap-steel option. No matter which draft option you choose, lead is best and will greatly contribute to the stability of your vessel. These advantages of lead ballast may also apply to your trawler or similar powerboat as well as the more obvious use in a sailboat keel. Lead ballast is more expensive than steel, but it can be installed in a smaller space, which, in turn, will leave more room for the stowage of stores and perhaps the installation of additional fuel and water tanks. As mentioned elsewhere, the storage of canned goods and other relatively heavy stores under the sole is a very practical idea. The weight is located where it will provide some benefit as ballast. The stores are much less likely to be thrown about in rough weather than are similar stores located above the waterline.

Another reason to choose lead ballast is that it will definitely add to the resale value of your boat. It should be remembered that almost every boat is sold sooner or later. By installing lead ballast, you're helping to protect your investment.



This homemade lead-melting device is fine for installing the final, relatively small amounts of molten lead used to bind the lead pigs into one mass.

The lead may be installed in standard pigs, or melted and recast into shapes of a suitable size and weight and then installed into the keel. Melting lead can be a hazardous operation, and you should take the utmost care when handling it. Wear gloves and other protective clothing including a breathing mask. Masks used for avoiding paint fumes are not suitable, and special respirators are available that will filter out the lead particles and gases given off during the melting process. Totally avoid the fumes that lead gives off; needless to say, you should stay upwind of the melting operation at all times.

To melt lead, you'll need some form of vessel to hold the chunks while heat is applied. The type, size, and complexity of the melting pot will depend on the amount of lead you plan to melt. Less is better, so try to choose one of the installation methods that requires the least melting before the lead is installed in the keel. For example, lay large chunks or pigs in the keel and then use small amounts of molten lead, poured over and around these larger pieces, to solidify the whole mass. For large melting jobs, an old cast-iron bath is ideal. They used to be available from the wreckers. These days, however, many of these older items are prized as artifacts and are no longer available for other uses.

If you have to construct a melting pot, it should be about 2 feet 6 inches (762 mm) in diameter, or 2 feet (610 mm) square. Make it about 3 feet (914 mm) high and raise it about 2 feet 6 inches (762 mm) from the ground. Either use strong pipe legs or a similar very strong structure to support your melting pot. The melting pot will need to have plate walls at least ¼ inch (6 mm) thick. Don't use oil drums or similar containers; they'll be far too light for this purpose. At the bottom of your melting pot, you'll need to install a tap or valve to allow the molten lead to be drawn off as required. A pouring bucket or ladle will be needed to transfer the lead to your mold or directly to the keel for pouring over the large solid pieces that you have already installed.

If you require only a relatively small amount of molten lead, then the melt-and-pour-in-place arrangement may suit you better than a melting pot situated some way from the keel. As lead solidifies rather quickly, and as you need to eliminate voids between your large pieces and the molten filler lead, make sure you install the lead in small amounts and in a sequence that will achieve the desired result. There should be no voids, and using this method the lead can be "welded" together.

Many builders have made patterns of the keel areas between the webs where ballast is to be installed. Heavy pine planking, say 1 ¼ inches (35 mm) thick, can be used to build a mold for these blocks of ballast. Using a well-constructed melting pot and an adequate ladling or pouring bucket, pour and mold each section. A lifting eye or wire loop can be installed in the top of each lead block and the completed ballast section is then installed in the keel. The keel will still need to be lined to avoid the lead's interacting with the steel, aluminum, or copper-nickel. (See below).

Never melt the bulk of the lead directly into any keel, not even a steel one. The heat of the molten lead will surely buckle the sides of the keel. The heat could ruin the shape and structure of the keel. Lead can be cut, but with some difficulty; it tends to clog up the teeth of a saw. Some boatyards have used chainsaws to cut lead; this seems to add one hazardous operation to another. An oxyacetylene torch can be used to burn off chunks of the material. You can weld angle or plate over the ballast so that in the event of a 'knock-down' you can be sure that it stays in place. Another method of securing the ballast is to cut holes in the web floors and allow the ballast to extend from one keel compartment to the next. There are many simple and ingenious ways to ensure that the ballast is effectively one unit and will stay in place under all conditions.

It's desirable to make some provision to separate the lead ballast from the interior of the keel plating. This applies to all metals. One method is to coat the inside of the keel with tar epoxy, but watch out for the fumes as you install the molten lead ballast. Another method is to line the inside of the keel with sheet zinc before installing the ballast. The zinc will melt when the molten lead touches it, and will float up the insides of the keel, giving the inner surfaces a coating and protecting them from any interaction with the lead. Bitumastic is another material that has been successfully used to line the steel keel before the lead ballast is installed.

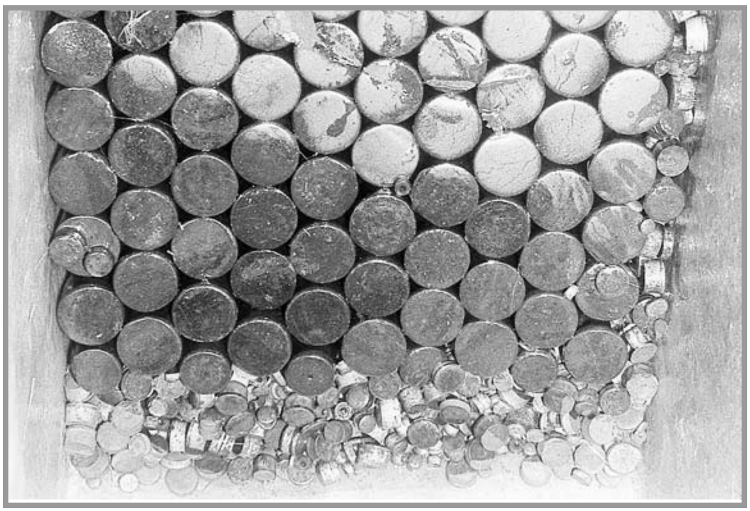
Ballast Mixes

It's possible to purchase ready-mixed ballast, usually in granular form. This ballast is very easy to install but, because it has been "processed" for your convenience, it's relatively expensive. A check of the classified advertisements in your local boating magazines should reveal the suppliers of this type of ballast.

Scrap-Steel Ballast

If you're installing scrap-steel ballast, you should obtain the largest possible pieces of material that you can conveniently place between the webs in the keel of your boat. One scrap-steel material that's particularly suitable for installing in keels consists of the pins used in the tracks of crawler tractors and other earth-moving equipment. These track pins are usually about 12 inches (305 mm) long by 2 to 3 inches (50 to 75 mm) in diameter, and have proven in the past to be ideal as ballast material. The pins may be set either on end or on their sides. You'll need to insert small steel rods in between the round pins to achieve as solid a mass as is possible.

When using scrap-steel ballast,



The pins from crawler tractors make excellent ballast in boats able to accept the lesser density of steel ballast.

Most Spray designs will accept scrap-steel ballast, thus considerably reducing the cost of the hull. This round-bilge steel Centennial Spray 38 was built in Sweden.

it's most desirable that you obtain a ballast density of 350 pounds per cubic foot (1,708 kg per cubic meter). This is a minimum figure, and it may be useful to make a test "brick" of the materials you have available. Weigh the brick to make certain it reaches the proper density. If you use scrap-steel punchings, you may have a problem in reaching the desired density, so larger pieces of metal are preferred. Railroad track, combined with other steel materials, may be suitable.

After the scrap-steel ballast has been installed, and small pieces of steel have been added to ensure a minimum of voids, it will be necessary to bond the whole mass together. You must be sure not to trap air in the ballast mix, otherwise you'll have corrosion problems with the ballast. If you have voids in the ballast, bilge water will find its way to the lowest point and it can set up a corrosion process that may remain undetected until serious damage is done, either to the ballast itself or, more importantly, to the keel. Hot pitch or similar material can be poured over and into the ballast and it will effectively find its way into the same voids that would harbor bilge water. The pitch will fill and seal off the voids and prevent corrosion problems. Tar epoxies, or other suitable epoxy materials that have been thickened with suitable fillers, can be used in place of the hot pitch. This would give a superior, but more costly result.

Securing the Ballast

In the past, some builders have used cement (or concrete) for bonding the lead or steel ballast and locking it in position. We have often warned against this practice, and recently have been made aware of two examples where the cement caused the steel to rust out from the inside. In one case, this caused the loss of the boat and, in the other, all the bottom plating had to be replaced. Never use cement or concrete in your ballast mix. Try and avoid letting the ballast to overflow the keel and thus onto the bottom hull plating. Some designs with shallow keels are best served with lead ballast so there is not the temptation to allow the ballast to lie on the thinner bottom hull plates. You may want to consult your designer if you find the required amount of ballast will not fit in the suggested location in the keel.

After the ballast is installed (except the trim ballast) you may consider welding L-angle or other reinforcing across the top of it. Some builders have plated over the ballast. The timing of this operation is difficult as you need to have the trim ballast installed, and by this stage you have all of the exterior paintwork completed. The welding of the plate over the ballast will disturb your paint job. Careful planning is necessary to overcome this and other scheduling problems.

When you've completed the installation of the primary and trim ballast, you can seal off the top of the ballast with epoxy filler troweled to a smooth finish. A thin plywood liner could be used to complete the finish of this area above the ballast, making an ideal storage compartment. You'll need to make provision for the flow of bilge water. In modern, well-maintained metal boats, the amount of bilge water will be small and mostly caused by preventable condensation.

Before buying or building your metal boat you should pause and ask yourself why you want a boat and what you will do with it. For what it's worth, during 35 years in the marine industry we've found that most women would prefer a powerboat, while most men prefer sail. Be sure to discuss the decision thoroughly with your partner or family before writing any big checks. (The sizes of the boats I refer to here are between 35 and 65 feet [10.66 and 16.76 m]. My opionion as stated above is the result of discussing the preferences of power versus sail with literally hundreds of couples. The fact is that many women only *go along* with their partners when they want to have a sailboat. In many cases, eventually the lady gets her way or the male partner cruises alone.)

SIZE

When it comes to choices, size is an obvious place to begin. If you're building in aluminum, then you can build as small as you wish. If you choose steel or copper-nickel as your basic building material, then we feel that 24 feet (7.31 m) length on deck (LOD) is the practical minimum for both power and sail designs. On the other hand, you should only build as large a boat as you need. A well-equipped sailboat of 55 feet (16.76 m) LOD, can be handled by a reasonably fit couple without outside assistance. There are many examples of sailboats of this size sailing the world with two persons thoroughly enjoying the cruising experience. In our opinion, this is the upper size limit that any couple or small family should consider. Our advice is that if you are considering long-distance cruising then a boat between 40 feet (12.19 m) and 46 feet (14.02 m) is the perfect size, if you can afford it; if not, then remember many enjoyable voyages have been sucessfully completed in smaller boats.

STABILITY

There are three primary kinds of stability: initial or form, positive, and ultimate.

Initial or *form stability* refers to the shape of the hull and the amount of effort it takes to heel the boat to the point of capsize. This factor ignores the ballast and other factors, which contribute to other forms of stability. A wide-beam boat with a boxlike hull would be expected to have the most form statility. *Positive stability* or *range of positive stability* is calculated by the designer and reveals at what point the hull would lose its natural tendency to remain or return to the upright position. This type of stability is measured in degrees, and an acceptable range for most vessels is between 115 and 140 degrees. *Ultimate stability* is the factor that measures whether the hull will return to its upright position from a complete capsize. This factor is more related to positive stability than to form stability.

First, let's make it clear that a high range of stability doesn't necessarily make a great cruising boat. Conversely, neither does a lower range of stability make a bad cruising vessel. Positive stability does play an important part in the success or otherwise of any cruising sailboat, but a high number is not the be-all and end-all that some would have us believe. It's important, yes. But the most important design feature? Not necessarily. There are many other equally important factors that go into making a good cruising boat. These include general hull shape, sea-keeping ability, initial stability, the number of openings in the hull and their placement, the integrity of the deck and superstructure, and many other design features.

The most important thing about stability calculations is that they must be accurate. Often, the numbers quoted in magazines and sales brochures are not correct. Many, if not most, are based on "light ship" conditions and most fail to take into account all the weight that accumulates in the real world of offshore cruising. If you feel that these calculations are important to you, be prepared to pay around \$2,500 to \$4,000 (£1,600 to £2,700) for a complete "Stability Book." When properly calculated by a qualified person, this document can tell you a lot about your boat. In our own custom designs that are prepared for cutting as kits all these calculations are made and supplied as part of the design package. The EU Recreational Marine Directive and other national rules on the building and operating of marine craft have made it desirable to have all these calculations available to the owner/builder of any new pleasure craft. If the boat already exists, you'll need to take certain measurements and supply a considerable amount of information to the person making the stability calculations, and incling experiments—to determine stability by using known weights placed at known distances from the centerline of the vessel—are usually required if you do not have the necessary design calculations available for a particular boat. In the course of writing the above text, I checked one of our own set of calculations made on an existing vessel; considering the complexity of the steps needed to asertain the stability of any boat and covering loading conditions, etc., you can expect to pay the larger cost figure quoted above if you want a accurate and reliable set of calculations, graphs, and written report, all of which is part of the is process of establishing the stability factors of any existing vessel.

How much stability should a cruising boat have? What is the right number? First, smaller boats need a higher number. For those who rely on this calculation, the farther you sail south or north, the higher the number should be. Taking a cross-section of available sailboats, you'll fine that the range of positive stability is between 110 and 140 degrees from the vertical. In our own case, the Voyager 495 has a positive stability range of 136 plus, depending on the keel configuration, rig, tank sizes, and several other options. We feel that this is very satisfactory considering the size the boat and other factors.

SAFETY

In our opinion there is no place in a cruising sailboat for such modern developments as canting keels, water ballast, and other quirky ideas promoted and experimented with by the designers of the ultimate racing machines you see in the Bermuda race, Sydney–Hobart, and other long-distance, offshore, crewed and single-handed events. Keels have fallen off, boats have broken in half; just read a few of the race reports and you will find a catalog of near or real disasters.

PRISMATIC COEFFICIENT

This important hull calculation is often quoted, so we'll include some explanation here. If you wish to expand your knowledge of hull characteristics, performance prediction, fuel economy, etc., then refer to Appendix 1, Recommended Reading, which lists books on both powerboats and sailboats. These books contain formulas, detailed hull analyses of various hull types, and other information.

The prismatic coefficient is usually indicated as PC or CP. It's a figure that represents the underwater portion of the hull. If you take a block of wood that has the maximum length, width, and depth of the hull, with the shape of the midsection carved throughout its length, and then carve the underwater shape of the hull from this block, the PC is the relationship of the volume of the finished block as opposed to the block originally carved to the midsection shape throughout. Thus, the number represents the fullness or fineness of the ends of the hull. The more you carve away the ends, the smaller the PC number becomes. In sailboats, PCs can range from just below 0.50 for a fine racing hull to 0.60 for a motorsailer. Most cruising sailboats will have PCs that fall between 0.53 and 0.59. In powerboats, the figure will range from 0.60 to 0.75.

HULL TYPE

Developed Hull Surface

In chine hulls, some "round" will naturally be incorporated when the hull is built. In the days before computer-aided design it was necessary to develop the hull by triangulation or conic development. These processes were needed to ensure that the flat plating would indeed conform to any compound curves in the hull. This involved considerable calculation on the part of the designer or loftsman. The alternative was a very boxy hull without any compound curves. Computer design and lofting has changed all that. Now it takes just a few minutes to transform a set of straight sections into a beautifully faired, "developed" hull that will accept the plating with ease. My favorite expression is: the plating simply drapes over the structure that is formed by the frames and stringers. This assumes that you are building the hull upside down.

Single Chine

This hull form is best for planing or semidisplacement powerboats. It's also recommended for some displacement-hulled trawler types, where it can be used to advantage. Trawler-type motor sailers can sometimes benefit from using this hull form.

Double Chine

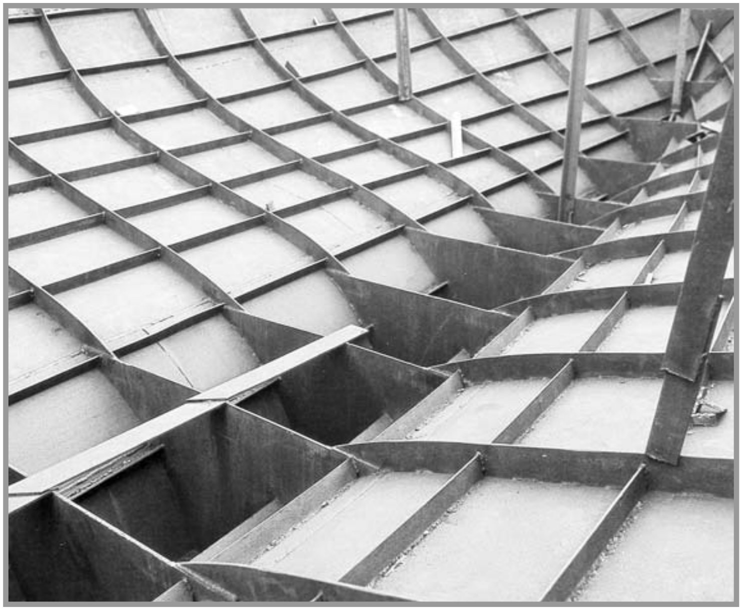
This configuration is often used as the basic shape for sailboats. One of the main attractions of this hull form is that, compared to single chine, it allows superior hull shapes to be built in metal without resorting to rolling the plate. Generally, these double-chine hulls take on a "developed" hull form and have considerable round in the sections up towards the bow. Double-chine hulls have their own beauty; but you either love or hate this hull form.

Radius Chine

Metal boat building, especially of sailboats, changed forever when designers switched to computer-aided yacht design. One of the first benefits was the development of the radius-chine technique. This construction method could not be practically achieved without the aid of computer software and special training. We are forever in the debt of those who developed the various computer yacht-design programs that made this technique possible. While radius-chine methods can be used to build fiberglass or wood epoxy hulls, their biggest impact is in the ease with which they allow beautiful, rounded, metal sailboat hulls to be constructed. These hulls are usually impossible to distinguish from their fiberglass counterparts.

The secret lies in the computer fairing that provides a constant radius from the stern through to the bow. This allows plate that has been prerolled to a predetermined radius to be installed without fuss or the degree of difficulty associated with round-bilge hulls. The secret of radius chine is that it fairs the radius through the bow. Previous attempts at this type of hull form have tried to fade out the chine before it reaches the bow. This can result in an unfair or flat spot in the forward area of the hull.

The radius chine, as developed by Grahame Shannon and was included as part of Grahame's Auto Yacht software, is the perfect metal boat hull-building technique, particularly suited to (but not restricted to) sailboats. As we have seen, excellent results can be achieved by any person



This round-bilge steel hull was built from the fiberglass lines, which feature a hollow "heel." This is difficult to build in metal and this type of hull/keel intersection should be avoided by all but the most experienced builders.

with minimal metalworking experience. Full details on building hulls using this and other hull building methods appear in Chapters 6, 7, and 8.

Other Chine Configurations

Before the advent of the radius chine, builders had sought to "soften" the double-chine hull by the addition of mini-chine panels, or by introducing rounded sections of split pipe at the chine. These softening techniques required a considerable increase in the amount of welding. Not to be confused with the foregoing is the alternative to use solid round bar of 1 inch (25 mm) diameter in place of the flat-bar chine stringer. The solid round can soften the chine, but it makes it more difficult to obtain a perfectly fair chine line. The round bar also needs special attention to prevent water lying on top of the chine bar inside the hull.

Some designers have designed multichine hulls that try to approximate a round-bilge form. We don't favor these many-chined hulls. They are expensive to build and usually, at least to our eye, give a fussy appearance. The popularity of double-chine hulls has been somewhat eroded by the development and ease of construction of the radius-chine hull form.

Round-Bilge Hulls

This method is best suited to sailboats and full-displacement, long-range powerboat hulls. This hull building method requires some previous metalworking experience. It's possible for a competent metalworker with little or no boatbuilding experience to produce a fair and attractive round-bilge metal hull.

There are relatively easy round-bilge hull shapes, there are virtually impossible shapes, and there's everything in between. Unless you're an experienced metal boat builder, avoid the difficult shapes, such as rounded "golf-ball" sterns, hollow-heel garboards, and the like.

This large round-bilge steel sailboat clearly illustrates how a conical bow can be formed.

There are simpler shapes that will provide you with an easy-to-build, seaworthy, and attractive round-bilge metal hull.

Selecting the Hull Form

So, among these alternatives, which is the best hull form? There are several factors to consider, including the use you have in mind, ease and cost of construction, and estimated resale value. We would choose radius-chine because it has many advantages and no major points against it—in other words, a near-perfect sailboat hull configuration.

Many hull types, especially the modern computer-designed variety, can be matched with either long or short keels. To be effective, a sailboat with a short or medium-length keel needs a skeg/rudder combination. As mentioned elsewhere, because of the problems with skegs and their general vulnerability we are less inclined to design sailboats with short keel/skeg combination. We prefer to design and use the well-proven contemporary long-keel arrangements in all our cruising sailboats.

Note the rigging arrangement used on the cutter Spray of Del Quay*, a steel Spray 40.*

Make sure you are selecting a design that is not only proven, but also proven to be a satisfactory all-round performer. The smaller the crew in relation to the size of the boat, the more important it is to have a well-balanced hull, keel, and rig combination.

With our own cruising-sailboat designs, we have updated some; for example, the Roberts 53 was first designed in 1969, and now the updated version known as the Roberts 532 (scratch-build version) and the Voyager 542 (kit version) is more popular than ever. We doubt the owners of the original boats would recognize the boat as it is today but it does retain the best elements of the original design. Other updated designs include the Roberts 43, the Mauritius 43, and others of the same family. The above-mentioned designs were updated to become the popular Roberts 432 (scratch-build version) and the Voyager 432 (kit version). Other designs have been left out of some catalogs and lists simply because they just were not popular enough to warrant their inclusion. We give you these examples because you must be careful not to build or buy a metal boat (or any boat for that matter) until you're sure of its design history and the designer's current opinions. Most naval architects and yacht designers

This German-built Spray 40 has been cruising for many years and is a fine example of the durability of steel as a boatbuilding material.

are very frank about the merits and shortcomings of their boats. The more well-established designers can afford to be frank; they have many great boats to balance any less-than-successful designs.

STERNS AND TRANSOMS

Each of the many types of sterns has its benefits and drawbacks. Although not strictly accurate in nautical terminology, *stern* and *transom* are often used to describe the after end of the hull. Not all sterns have transoms. In fact, not all transoms are at the stern. You will hear terms such as canoe stern, transom stern, rounded stern, poop stern, cruiser stern, chevron stern and, more recently, sugar-scoop stern. The shapes and names of the after end of the hull have changed over the past years. Some changes are caused by racing rules, others through fashion. Many sterns have been developed through experience, and these are the ones that concern us here.

Most sailboats today have either a traditional transom or reverse-transom stern. One relatively recent development is the advent of the sugar-scoop stern, which incorporates a vertical transom within a reverse-angled ending to the sides of the hull. This arrangement usually features steps for boarding from the water, or boarding when the boat is moored stern-to. The reverse transom is also often fitted with steps built into the transom itself. In fact, steps are one of the most important benefits of the reverse transom.

Ulrich Kronberg, editor and publisher of the German yachting magazine Der Palstek*, at the helm of his owner-built Spray 40,* Mirounga.

On powerboats, the underwater section of the hull may be carried aft to form a boarding or swim platform. The underwater area is sometimes used for holding tanks, or for storing other liquids. If you wish to extend the underwater section of a powerboat hull in this way, consult the designer first. You may upset the fore-and-aft trim of the hull. The tankage may only partially offset the extra buoyancy provided by the extended underwater section.

Rounded or ball-shaped sterns are difficult to build in metal, so this feature is best left to the professional builder. If you're planning to build your own metal boat, make sure you select a design that has a "buildable" stern or transom. Fortunately there are not many (I can not think of any) advantages to this type of stern so the difficulty of construction is no loss to the less experienced builder.

BOW SHAPES

Before the advent of hulls faired and developed by computers, we often designed bows on metal powerboat hulls that were somewhat difficult to build. During the 1960s and 1970s, flared bows were the norm on fiberglass hulls, so that is what our clients wanted. Some of these flared bows were so extreme as to give the boat an "aircraft carrier" appearance; fortunately tastes have changed in a favorable direction. Today, most builders are more enlightened, and appreciate the beauty of a hull with properly developed forward sections. These bows, when combined with spray chines, have the effect of keeping the boat dry. They are also much easier to build than the flared bows of the past.

Conical bows used to be considered less suitable for sailboat hulls than for powerboat hulls. This has changed; the more attractive appearance plus additional foredeck room make the conical bow a desirable feature on many current sail- and powerboats designs. In the powerboat, the cone starts with little or nothing at the forward end of the chine and ends at the deck. This gives an attractive, rounded shape to the bow, especially when seen in plan view. The resulting shape plays a part in keeping the foredeck dry, adds some buoyancy, and increases the deck space up forward. This extra space is often most appreciated when handling anchors and ground tackle in adverse conditions. Not strictly part of the bow, a short, "anchor-handling," U-shaped, pipe bowsprit is an asset on any sailboat or powerboat.

Sailboat bows come in all varieties; fortunately the few sailboat designs (not ours) that featured flared bows have long since disappeared. Overhangs come and go out of fashion, and bow profiles vary from clipper, through straight—sometimes almost at right angles to the forward end of the waterline, to convex. The bow on the design you decide to buy or build will already have been carefully calculated and not just simply styled by the designers, and our advice is not to try to improve on their efforts.

From station 2 *(generally two-tenths of the waterline overall measurement)* forward be very wary of sailboats that are too full, or have large flats; they may pound excessively. Some fullness is required in the bow sections, but it must be moderate. This is a good time to say that if you're considering a wholesome, and perhaps fast, cruising boat, then you should avoid the excesses, fashions, and rule bending of the racing fraternity. Please note that nothing looks more dated, or is harder to sell, than a boat that was built to a racing rule that has long since passed into obscurity.

MOTOR SAILERS

What is a motor sailer? This term has been used to describe a variety of vessels, from a regular sailboat that happens to be fitted with an oversized engine to a powerboat that has a small steadying sail. The term motor sailer used to mean a boat best described as a 50-50, that is 50 percent motor and 50 percent sail. Occasionally, one would hear boats referred to as 60-40, or by some similar definition. We have even seen boats referred to as 100-100; goodness knows what that is supposed to mean; we suspect it is an advertising slogan used to try and convince the uninformed that

The PCF 40 is based on a trawler hull and is a true motor sailer. Many of these boats have been built and one sailed from Australia to Ireland—not a recommended use for this type of vessel.

The pilothouse can be reduced in height by lowering it into the main deck, if you're looking for a lower profile—there's adequate height in the engine compartment to accept any power plant you're likely to install (50–100 hp).

LOD	*40' 0"/12.19 m*
LWL	*35' 0"/10.67 m*
Beam	*13' 0"/3.97 m*
Draft	*4' 3"/1.3 m*
Displ.	*31,000 lb/13,950 kg*

the boat can give 100 percent performance under both power and sail!

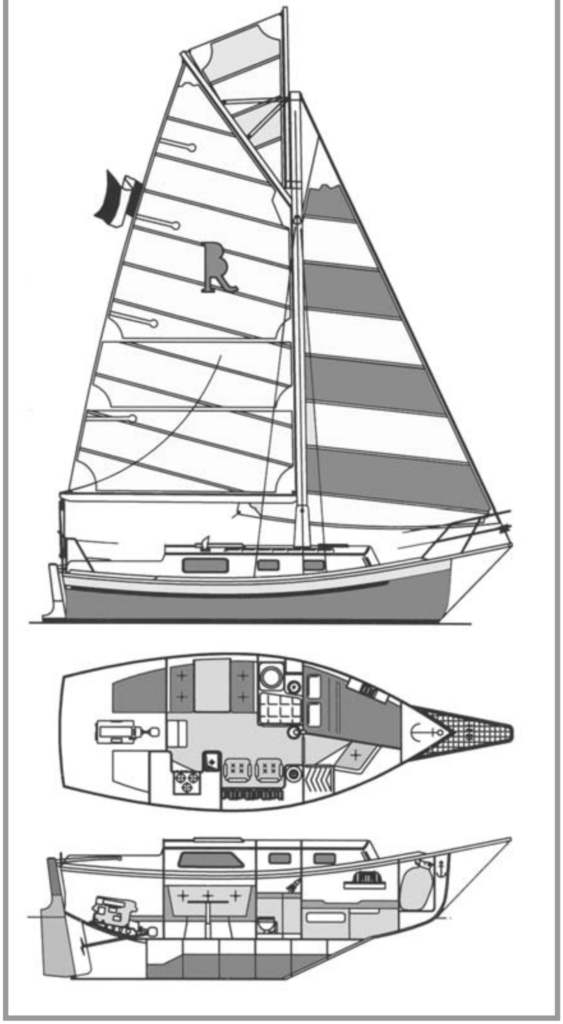
The Pacific Coast Fisherman 40 best expresses my interpretation of the term motor sailer. The PCF 40 is a single-chine, displacement trawler, a fishing-boat hull that has been fitted with a modest but effective sailplan—one recently sailed from Australia to Ireland. The *Spray*-type hulls,

The Roberts 58 can be powered to qualify as a motor sailer. This radius-chine aluminum version was built in Belgium.

while being good performers under sail, also make excellent motor sailers and are noted for their precise handling under power.

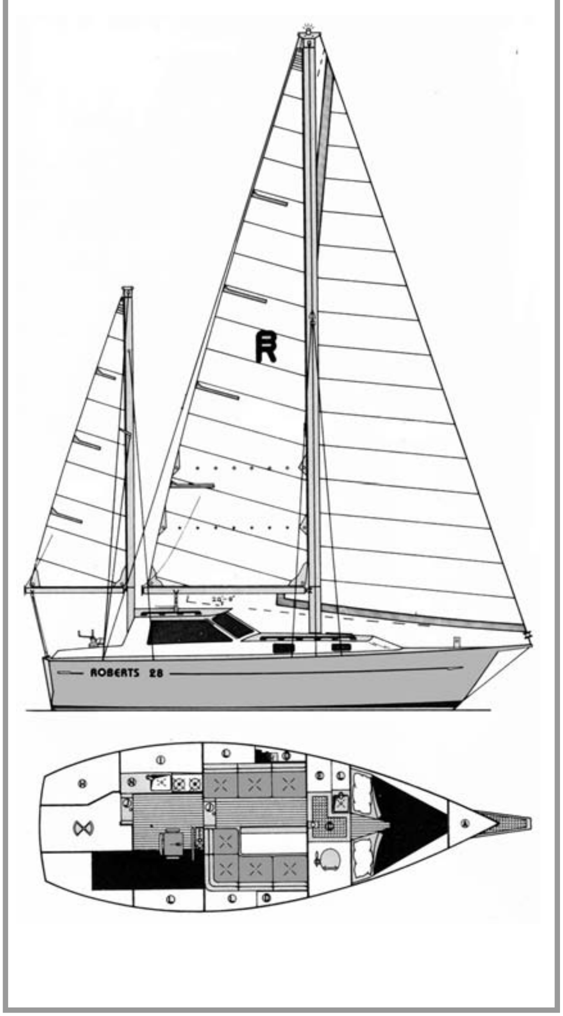
More recently, you're likely to hear the term motor sailer applied to a variety of sailboats equipped with varying sizes of auxiliary power. Considering the term motor sailer in its more recent usage, we'd say that a boat fitted with an engine with more than 3 hp per 1,000 pounds displacement (2.23 kW per 454 kg), might be termed a motor sailer.

You should consider the hull form, rather than the general terminology, when you're making your decision as to which hull is most suitable for your type of cruising. If you're considering cruising in the canals of Europe, with the odd foray into the Mediterranean, then a motor sailer in its true context could be the right choice.



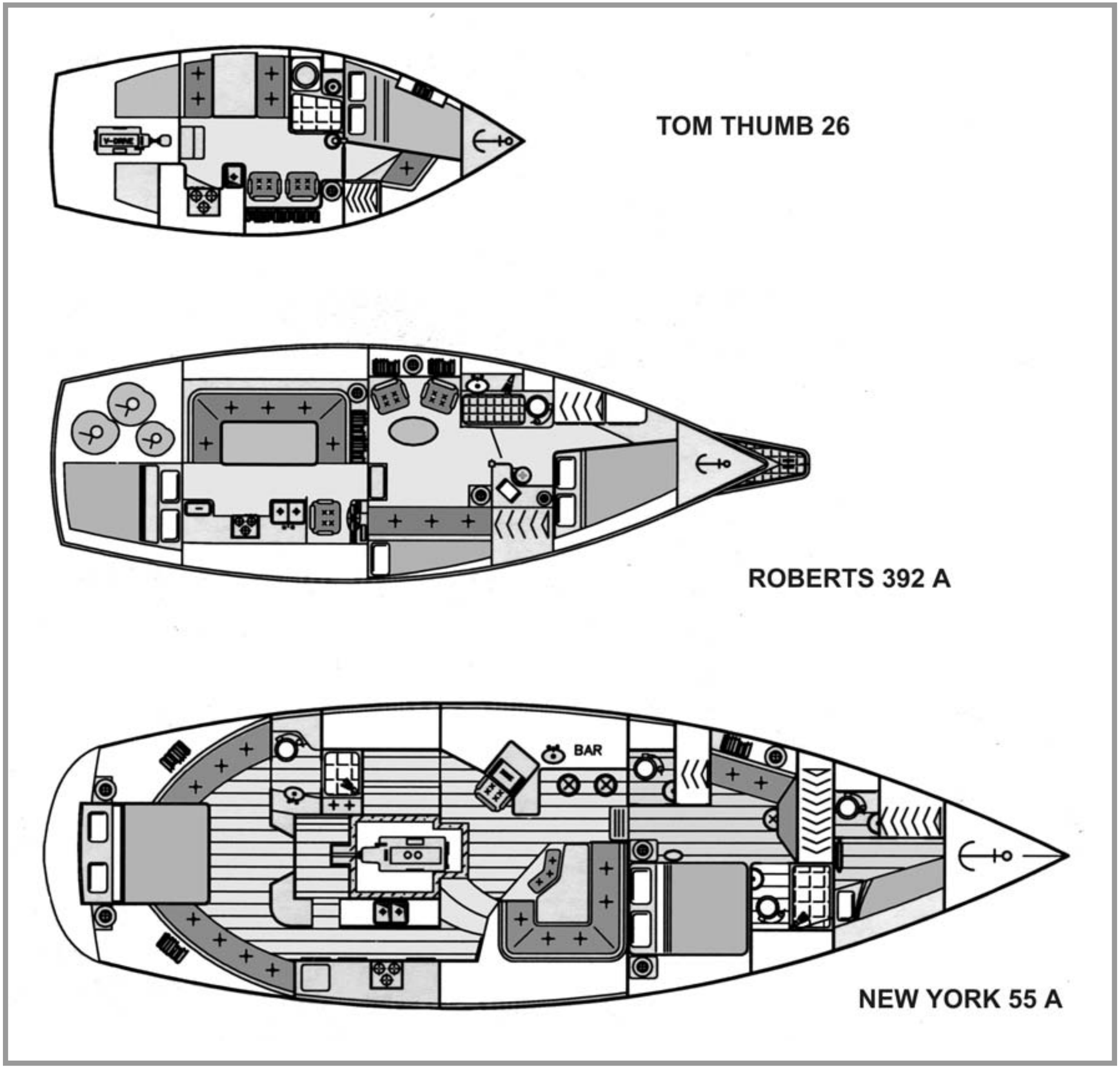
The Tom Thumb 26 uses frameless construction techniques in either steel, aluminum, copper-nickel, or a combination of any of these metals and is an ideal first project for a go-anywhere boat. This design has been built in several different configurations, and the plans include alternate accommodation plans and a choice of rigs, including Bermuda sloop, gaff cutter, and a cat rig.

LOA	*25' 11"/7.92 m*
LWL	*23' 9"/7.24 m*
Beam	*10' 4"/3.15 m*
Draft	*4' 0"/1.22 m*

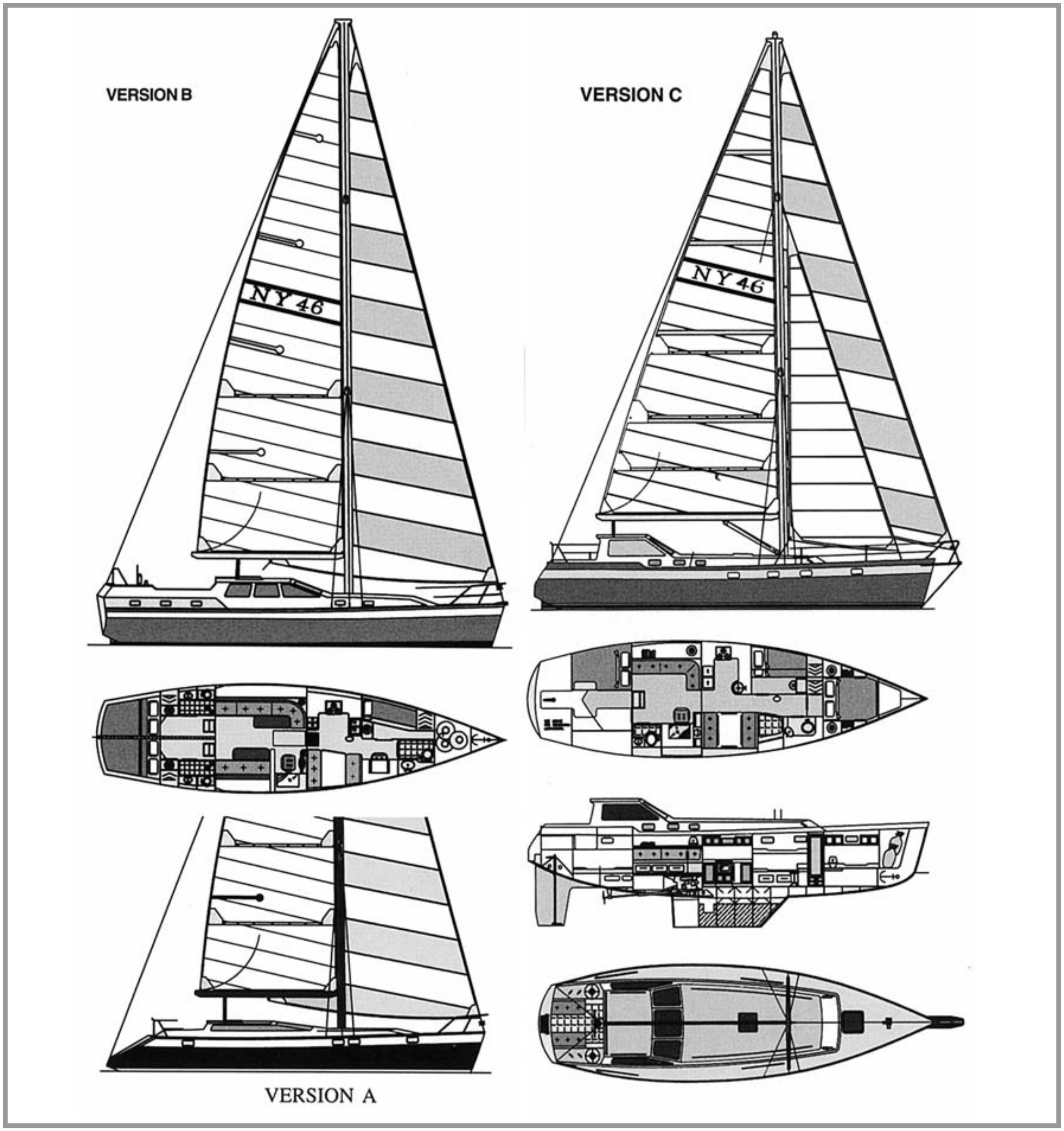


This Roberts 28 can be built in steel or aluminum and makes a comfortable small pilothouse cruiser.

LOD	*27' 8"/8.43 m*
LWL	*24' 2"/7.37 m*
Beam	*10' 2"/3.10 m*
Draft	*4' 9"/1.45 m*



Accommodation plans for three different boats. The Tom Thumb 26 (top) is fine for two people, with room for the occasional guest or child. The Roberts 392 (middle) has a pilothouse that determines how much space is available for other areas. The New York 55 (bottom) has plenty of room for all the elements of a comfortable, liveaboard cruising boat.



Three versions of the New York 46. Note the additional living space offered by a traditional transom; it accommodates twin double cabins in the stern. The smallest of the New York series, this design combines a fast hull with the ability to carry sufficient stores to qualify her as a proper cruising boat. There are several accommodation and deck layouts to choose from, and a variety of sail plans have been designed for this boat. It can be built in aluminum, copper-nickel, or steel.

LOA	*46' 10"/14.28 m*
LWL	*43' 5"/13.24 m*
Beam	*I3' 1"/3.99 m*
Draft	*7' 6"/2.29 m*
Displ.	*42,972 lb/19,492 kg*
Ballast	*12,750 lb/5,783 kg*
Sail area	*1,200 sq. ft./111 sq. m*
Aux. power	*85 hp*
D/L ratio	*235*
S/A displ. ratio	*16.5*

A multichine Roberts 43 surfing in moderate weather in the Pacific.

An owner-built steel Roberts 432 cruising in the Mediterranean.

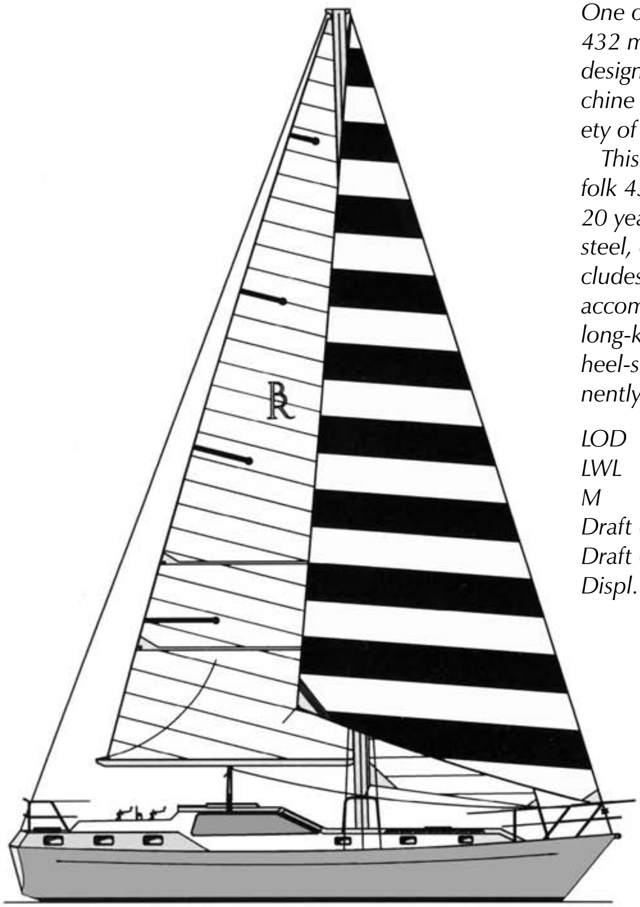
This beautiful Roberts 434 radius-chine hull was built in the UK.

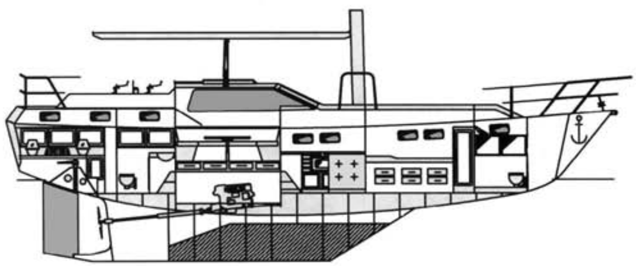
Sequana*, a steel Roberts 43, was built in Germany by Willi Jansen and sailed to the United States before cruising in the Caribbean.*

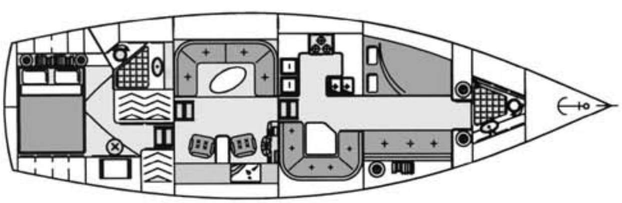
One of our most popular designs, the Roberts 432 makes an ideal family cruising boat. This design can be built in radius-chine or multi-chine steel or aluminum and comes in a variety of versions and accommodation layouts.

This design replaced the Mauritius and Norfolk 43, which were in production for over 20 years. This design is ideal for building in steel, copper-nickel, or aluminum and includes several versions featuring different accommodation and sail plans. The 432's long-keel configuration combined with a heel-supported rudder makes this boat eminently suitable for serious offshore cruising.

LOD	*43' 11"/13.4 m*
LWL	*38' 0"/11.6 m*
M	*13' 6"/4.10 m*
Draft (shoal)	*5' 3"/1.60 m*
Draft (regular)	*6' 0"/1.80 m*
Displ.	*29,850 lb/13,539 kg*





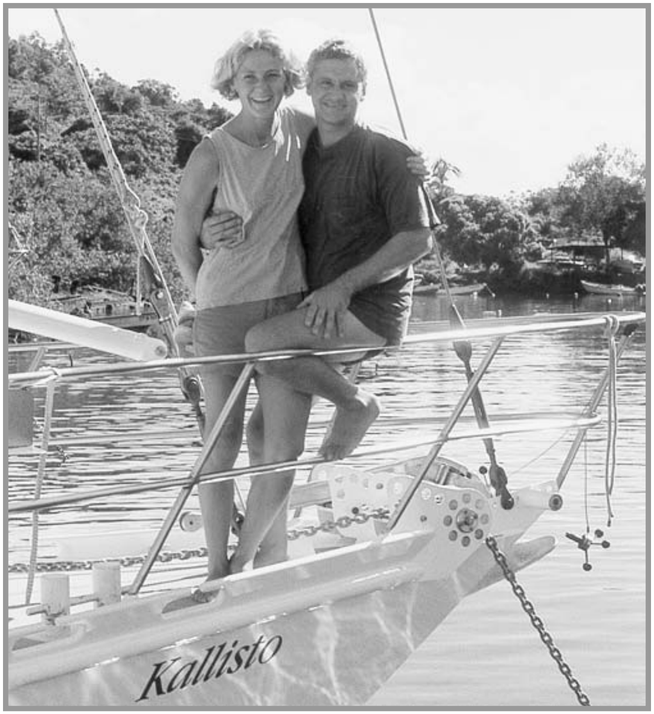


The Roberts 434 Baltic Rose *is one of many steel boats built by Put Veini in Riga, Latvia.*

This steel Roberts 44, Sifu, *was built in California, sailed to Florida, then crossed the Atlantic to Bristol, England, where it was refitted by its present owner John Clark.* Sifu *now has several Atlantic crossings to its credit, plus thousands of miles of island cruising.*

This steel, cutter-rigged, radius-chine Roberts 434 is another fine example of what can be achieved when building in metal.

Herbert and Petra Fritz, seen here during their successful circumnavigation. The happy smiles tell it all.



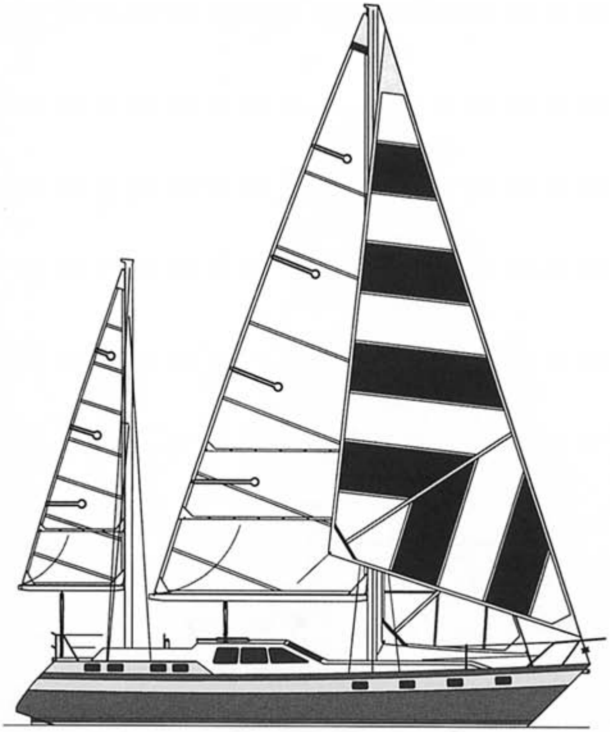
Any reasonably fit couple can handle this well-equipped Roberts 53 sailboat. Kallisto *was built by Herbert and Petra Fritz, who sailed her around the world without assistance.*

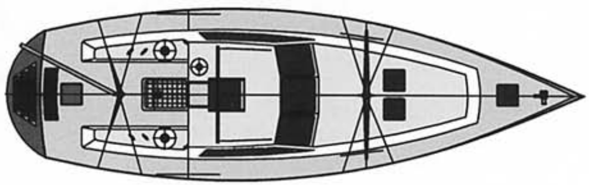
The steel Roberts 53 Henrike *was built as a training ship for the Sea Scouts of Finland, who were more than satisfied with its 9-knot performance.*

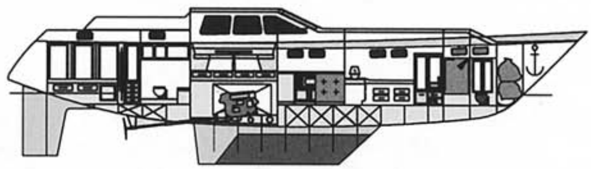
Another Roberts 53 radius-chine sailboat, built by Terry Erskine in Malta.

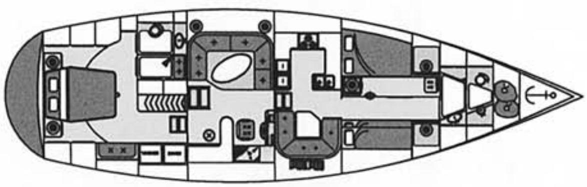
The Roberts 532 was the first of the Mark 2 versions of the ever-popular Roberts 53. It is available with a long cruising keel as well as the original long fin and separate skeg-and-rudder combination shown here. Both keel arrangements work well. You can build the 532 in steel, aluminum, or copper-nickel or a combination of these metals.

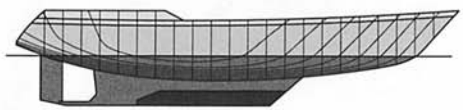
LOA	*53' 6"/16.3 m*
LWL	*44' 5"/13.50 m*
Beam	*16' 0"/4.90 m*
Draft (shoal)	*5' 6"/1.68 m*
Draft (medium)	*6' 0"/1.83 m*
Draft (deep)	*7' 0"/2.13 m*
Displ.	*55,000 lb/24,950 kg*

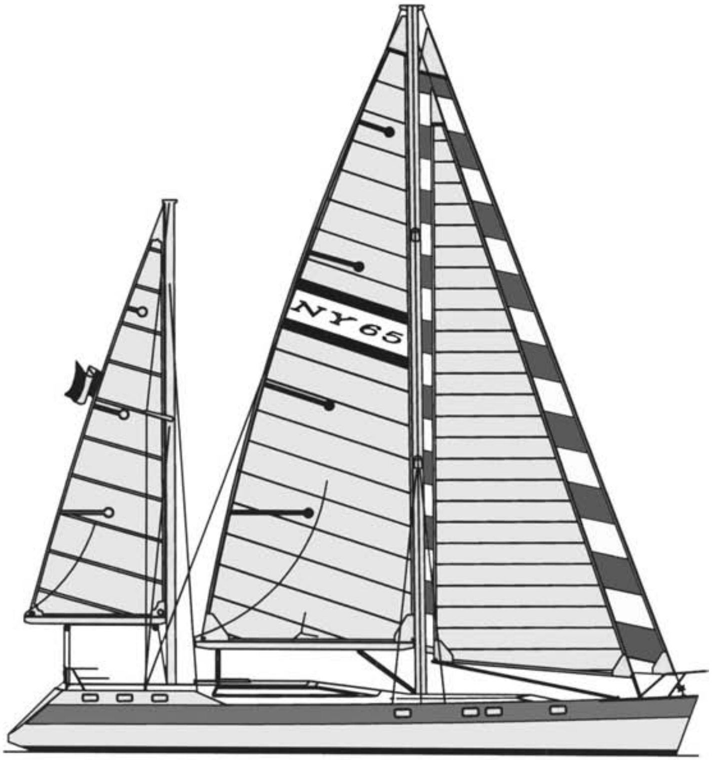


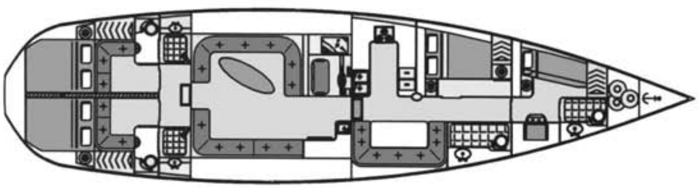


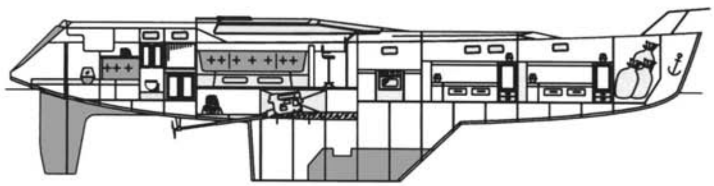


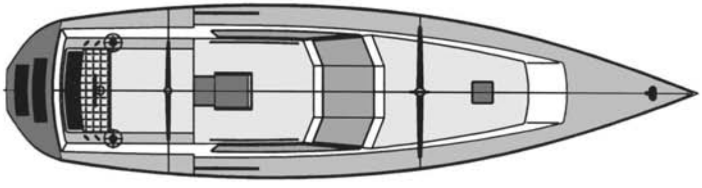












The radius-chine New York 65 has proved very popular, both as a liveaboard and a charter boat. Many have been built in radius-chine steel and aluminum. A kit version, known as the Voyager 655, is also available. This sailboat can be modified to suit a variety of sailing lifestyles. Both slimline and wide-body versions are available.

The prototype is the Omani 65. For fast family sailing, the New York 65 offers a variety of accommodation options and layouts.

LOA	*65' 0"/19.81 m*
LWL	*60' 8"/18.53 m*
Beam (slimline)	*12' 6"/3.81 m*
Beam (wide-body)	*16' 0"/4.88 m*
Draft	*various*

Most of the files on this CD-ROM are PDF (portable document format) files that can be viewed using Adobe Reader version 5 or 6. The Adobe Reader software is free and can be downloaded from the Internet (www.adobe.com). We have included a copy for you to install if this program is not already in your computer.

Once you have AdobeRreader installed, double-click on the PDF file or the icon of the file that you want to view and the program will open the file.

Once it's open, you will see some tabs on the left. Double-click on the PAGES tab and all the pages contained in the file will appear. You can scroll through these pages and view the drawings or photos by clicking on the small page on the left that represents the page that you want to view.

If you look at the tabs on the top of the screen you will see one called VIEW; this is a very versatile tab. Open the drop-down Menu list and try out the FIT PAGE, FIT WIDTH, or FIT VISIBLE options to see which setting gives you the best viewing results. Also in the VIEW drop-down menu you can try out the AUTOMATICALLY SCROLL feature, which scrolls through the pages in the file to give you an overview of the content. This is great for looking at photos or "leafing through" an e-book.

You can print any of the plan or photo pages on your printer or send the files out to a commercial copy or print shop if you want larger-scale drawings than your printer can provide.

Remember toadjust the VIEW to the best setting to see the photos at a resolution that shows the best results.

Enjoy!
Bruce Roberts-Goodson

BUILD-FROM-SCRATCH BOAT PLANS

Many potential builders have asked what the difference is between a "boat plan" and a "set of cutting files and plans." Below I'll explain what is included in a regular build-from-scratch set of boat plans. Then I'll explain what is included with the more expensive cutting files and assembly plans and engineering drawings.

To build a boat from scratch you need a set of suitable boat plans. Your plans will include a set of full-size patterns for the frames and the stem. Below is listed what our own design office supplies in this regard. With the advent of modern computer yacht design we have been able to offer the complete plans on CD. The benefit of receiving your plans and full-size patterns in this way is that you can have as many prints made of each sheet as you may need. For instance, if you are looking for quotes on either having the hull built or to purchase some piece of equipment or quotes for mast, sails, and rigging, then these suppliers will want to see the plans. You will find that having the ability to have the plans printed locally will offer many advantages during the building program. Also on the CD the designer can supply photos of similar boats under construction and other printed material that will assist you to better understand the plans and the boatbuilding process in hand. As most printed plans cover many large sheets of paper and it costs a considerable amount in postage (usually about \$/ 50 or £35) to deliver the plans and patterns from the designer to you. CDs can be mailed for only \$/ 10 or £7.

Using the boat plans shown below and a collection of appropriate materials you build a boat from scratch. You make the frames from the patterns supplied and then you make patterns for each subsequent part as you proceed to build the boat.

As mentioned earlier, your plans can arrive either printed on paper or as printing files on a CD. You should receive the latest updated version of your selected boat plan, remember, which is only possible when you order your plans direct from the designer. You will receive many construction sheets, which include copious written notes as well as the detailed drawings necessary to build all parts of your boat.

The following list is what we consider to be a complete set of plans and full-size patterns to enable you to build your boat with the minimum time spent in doubt as to how and what to do next!

- Sheet 1A (there may be several sheets covering various versions of the same design). These sheets cover the boat's general arrangement drawings, profile and plan views of the hull, deck, and superstructure, plus the deck plan. In the case of sailboats, the sail plan and measurements are usually included on these sheets.
- Sheet 1AA (there may be several sheets covering various versions of the same design). These sheets show the boat accommodation laid out and shown in plan and profile views. In the case of sailboats, various available rigs will be shown in detail. The several versions of the design are shown on separate sheets. Also included is a list of all the materials needed to build the hull, deck, and superstructure. In the case where the boat can be constructed of a variety of materials, these materials are all listed to allow you to cost out the boat in each specified material.
- Sheet 2. The boat lines plan shows hull sections, profile including all water and buttock lines, and plan view including all water lines and buttock lines. The frame spacing, stern or transom detail, keel measurements, and rudder and skeg should all be included and all dimensions clearly shown.
- Sheet 3. This sheet will be a reduced drawing, representing what you can expect to see when you lay out the full-size boat hull patterns. We call this sheet the key to full-size patterns; it acts as a key when arranging the hull patterns and will enable you to readily understand just what the patterns contain. This sheet will help you resist the temptation of trying to lay out the patterns on your living room floor before you are actually ready to start construction.
- Sheet 4. This sheet shows you how to manufacture and assemble the frames, plus form up the stem and other parts of the basic framework. It also shows how to set up all these items on a strong back or a system of bedlogs, which forms the shape of your hull.
- Sheet 5. This sheet shows the installation of the stringers and deck shelf plus the installation of the plating in metal boats. In the case of radius-chine boats, additional information is supplied on installing these plates. Assuming you are building upside down, this sheet will show the turning-over process.
- Sheet 6. Now the boat is upright and this sheet covers the inside of the hull, and shows the installation of the floor webs, bulkheads, engine beds, and all interior stiffeners for your boat.
- Sheet 7. This sheet may show detail of the various items not covered in sheet 6. Often it takes two or more sheets to cover webs and bulkheads.
- Sheet 8. This is the engineering sheet that covers the engine installation, locating and building the fuel and water tanks, and making the rudder. Also included are details on making the stern and rudder tubes plus propeller shaft detail. Stanchions, swim platforms, and similar items may also be on this sheet.
- You may note that much of the above work

can be completed before the deck and superstructure are in place. It is far easier to install the heavier items such as the engine and fuel tanks before the "top" goes on. Individual builders will have a preference in this regard.

- Sheet 9. This sheet shows details of the forming and installation of deck beams, side decks, foredeck, aft deck, cockpit construction and all deck framing detail for your boat design.
- Sheet 10. This shows the patterning and making of the cabin sides, cabin front, etc. In the case of the cabin sides the measurements should be adequate to enable you to make up a plywood pattern and trial fit before cutting the actual cabinside plates.
- Sheet 11. This sheet covers such items as deck fittings, additional rudder construction, etc.
- A detail folio showing how to build some boat fittings and tools plus other valuable boat construction tips is included with all plans. When the plans are ordered on CD it is often possible to include numerous photos showing a sample boat under construction and examples of completed versions.
- Sheets A, B, C, D, E, F, G, and H are the full-size boat hull frame pattern sheets that are laid together like wallpaper. The full-size patterns contain details of all frame shapes, stem, deck and cabintop cambers, and the pattern for the expanded transom. Patterns are either paper or computer files (if you have plans supplied on CD), which can be printed by your local print shop.

The price of the boat plans includes as much consultation with the designer as YOU feel necessary to help you successfully complete the project; my offer to "CALL BRUCE ANYTIME" is not made lightly. You *can* call me anytime for advice on your boatbuilding project.

CUTTING FILES AND ASSEMBLY BOAT PLANS

Preparation of Cutting Files

Many of you may be surprised that it's not possible to take a regular boat plan—even one that is already prepared using the latest computer-aided design techniques—and use it for automatic computer-controlled cutting. There are many steps between creating the original design and having the boat cut out on a computerized plasma-oxygen cutter. If a particular design is to be sold as a precut steel or aluminum hull, deck, and superstructure package, then this should be decided at an early design stage. Some designs can be converted, but it is preferable to start with automatic cutting in mind.

The main steps in preparing a new design for a boat that is destined to be cut out by a computerized plasma-oxygen cutter is as follows. It is usually the customer who gets the process started by contacting the designer with a brief outline of what they have in mind. Further correspondence quickly establishes the client's wish list, which usually includes things such as type and style of boat, intended usage, and overall length and beam. Draft limitations should be specified at this stage.

Accommodation requirements, including the number of regular crew versus occasional guests should be defined. Speed requirements are important, as is the client's attitude to fuel costs. This list may need refining since some elements may conflict with one another. The communication ensures the client ends up with a boat that meets most if not all their desires and overall requirements. So far the process is very similar to what would be followed no matter from which material or building method was used to construct the vessel.

The client and designer then enter into what can be a simple agreement where the designer agrees to prepare preliminary plans for the proposed vessel for a reasonable (a relative term!) fee. In our office the preliminary plan includes the lines plan, general arrangement drawings (consisting of exterior profile, deck plan, accommodation profile, and plan views), plus sufficient calculations to ensure that the final design can meet the client's requirements.

Before a preliminary plan can be produced, the designer produces a 3-D computer-generated model of at least the hull of the vessel. Once the preliminary plans are completed and both the designer and the client are satisfied with the overall concept and layout of the vessel, complete plans for the vessel are prepared.

Next, the 3-D computer model is completed that includes all parts of the hull (including transom, keel, and rudder), all decks, cockpits, a complete superstructure, main interior bulkheads, and any other features such as a flybridge, radar arch, and exhaust stack. Special items such as transom steps and other similar features are included in this model. Depending on the complexity of the design, this process can take between 500 and 600 design man-hours.

From this model, all the salient hydrostatics—such as detailed weight calculations to enable material requirements and final displacement—are calculated. Stability calculations are also made at this time. During this process, fine-tuning of the model can be undertaken to make sure that the finished vessel will meet all the design requirements.

When the comprehensive 3-D model is completed and checked, copies are provided to a team of specialized designers who prepare the final model, which includes all the scantlings (such as transverse and longitudinal framing, sole bearers, deck beams, and engine beds). This team separates out all the parts for the frames, stringers, engine beds, bulkheads, hull, deck, and superstructure plating, etc., and adds notches to the frames and bulkheads before nesting the parts on plates.

The design team numbers each item and draws reference lines on each part to represent frame locations, etc. (the numbers help builders identify each part, and the lines are used during the assembly process to locate frames and other structural members).

Then the designer works out a *path* for the computerized plasma-oxygen cutting machine. The path is the point at which the cutter enters the plate and starts to cut the parts. It must make sure the parts are cut in the correct order. For instance, if a window has to be cut from a cabin side, then the window aperture must be cut before the larger cabinside part is cut; otherwise any movement in the cabin side after cutting could cause the window to be cut in an incorrect location.

Assembly Plans

The assembly plans we supply with the cutting files or kits cover several sheets of drawings and include all the information you will need to assemble your kit. Also included are several sheets of engineering drawings showing the layout of your engine room, exhaust system, steering system, fuel and water tanks, etc.

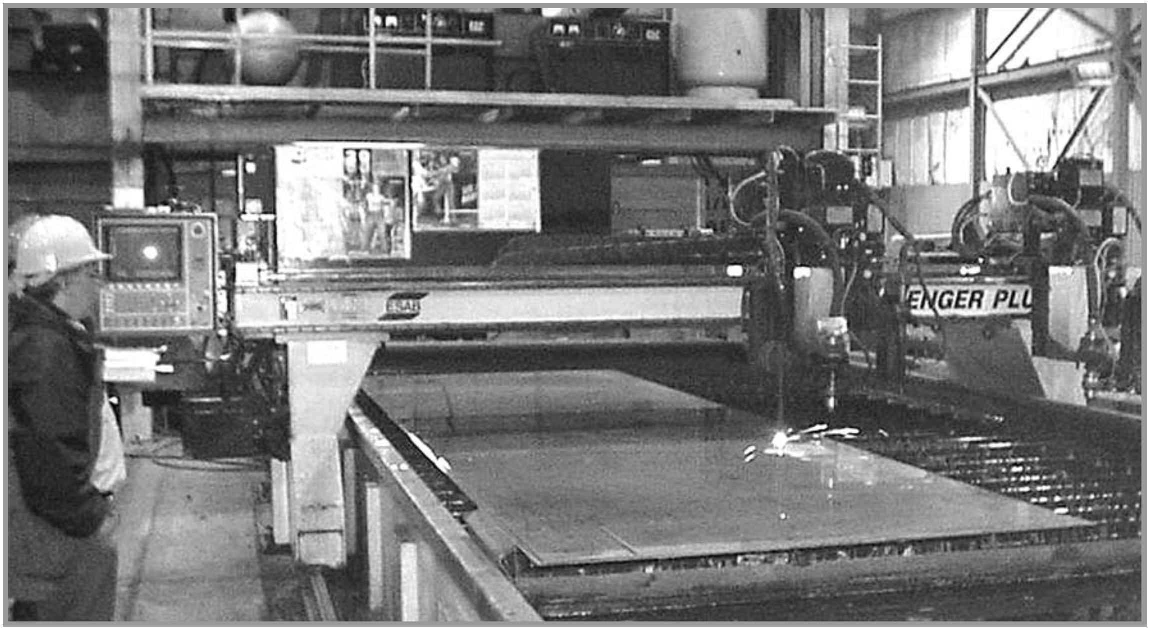
CUTTING FILES LIST OF DRAWINGS

Cutting files can be nested to a variety of sheet sizes. We are prepared to re-nest the parts on smaller, larger, or different-size plates but the following should be kept in mind.

Kits should be cut from plates that are 6 feet (2 m) wide. Due to the enormous amount of extra welding involved, the chances of having a perfectly fair hull, deck, and superstructure will be greatly reduced if your kit is cut from narrow plates. The larger the sheet sizes used to cut the kits, the smaller the number of hull and deck plates, and the fairer the hull.

We have cut over 200 kits for sail- and powerboats ranging in size from 34 feet (10.4 m) to 85 feet (26 m) and in every case the resulting plates avoided excessive welding and were easily handled using the minimum equipment.

The plating size we use in our cutting shops are 19 feet 6 inches, by 6 feet 6 inches (6 by 2 m); occasionally we use the size that is 26 feet 3 inches, by 6 feet 6 inches (8 by 2 m). We can of course re-nest these parts to shorter plates (more cutting and welding) but we feel that the width



This is the type of machine your local cutting shop will use to cut your kit.

of the plates is even more important. Any plate less than 6 feet 6 inches (2 m) in width means some hull plates will have to be cut lengthwise. This is not recommended because of the excessive welding needed, which will adversely affect the final appearance of the hull.

If the larger plates cost more, the extra expense is justified when considering the reasons outlined above.

If in doubt, let us know what plate sizes are available locally, try more than one supplier for quotes, and most importantly, DO try and obtain preshotblasted and preprimed plates and profiles.

Finally, make sure you get competitive quotations from both Bruce Roberts and more than one local cutting shop. The local cutting shop may need “cutting and marking lengths” as these govern the cutting machine times for cutting a particular kit. Bruce Roberts can supply this information.

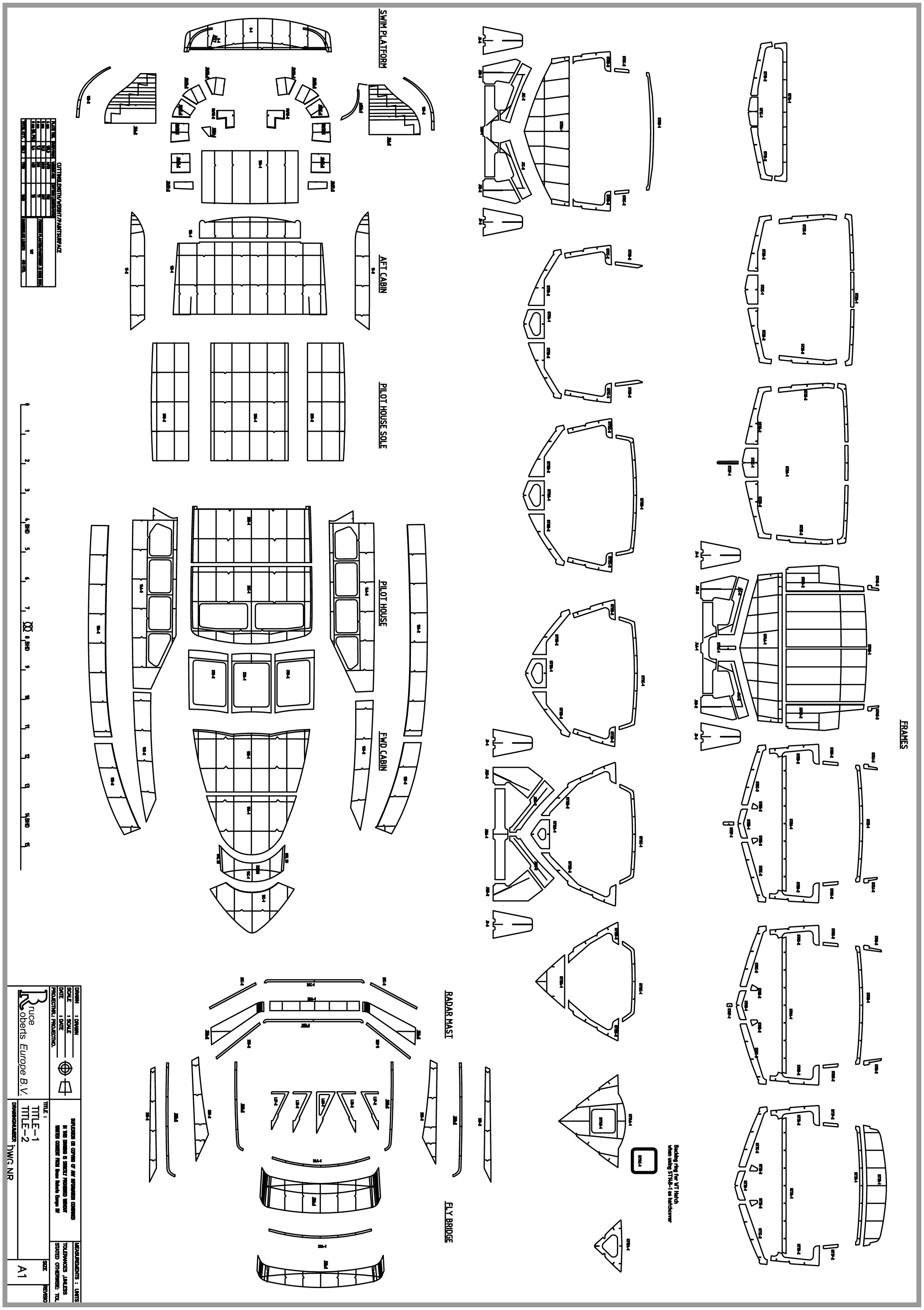
The drawings in the cutting files are Autocad drawings. If you want to view the Autocad files and do not have a recent version of Autocad you will need to have the drawings printed out by us or your local print center.

When we supply the cutting files or the kit study plans on CD we include all the drawings in DWF (design web format) or PDF. We also include a reader so you can view all the drawings on your computer plus you can print them on your printer.

The various calculations are made using Excel so you need access to that software to read these files or if necessary have prints made by ourselves or your local print center.

The following lists what is supplied for the Voyager 495-2 A cutting file set, but it is also typical of what is included in ALL of the sets of cutting files for other kits.

- Sheet 1A. Sail plan. including sail measurements, deck plan, fittings layout, and rigging plan with rigging sizes, etc.
- Sheet 1AA. Accommodation profile and accommodation plan with notes on arrangements.
- Sheet 1BB. Alternative accommodation plan with accommodation profile and accommodation plan with notes on arrangements.



This drawing shows a set of parts cut and laid out as they will be assembled into your hull deck and superstructure. See Chapter 6 for more information on cutting files and kits.

- Sheet 1AAA. Additional detail on deck layout with details of deck equipment, fittings required, and suggested layout.
- Sheet 1AAAA. Detailed accommodation plan in both plan and profile with measurements for the interior joinery, etc.
- Sheet 1 BBB. Alternative accommodation plan with detailed accommodation in both plan and profile with measurements for the interior joinery, etc.
- Sheet 2. Lines plan with sections, profile with buttock lines and waterlines, plan view with waterlines and hydrostatic calculations shown.
- Sheet 3. Engine installation details including installation of fuel tanks, all shown in plan, profile, and sectional view. Many explanatory notes included on this sheet.
- Sheet 3A. Engine room showing details of the exhaust and fuel systems and the battery placement. Many explanatory notes included on this sheet.
- Sheet 4. Details of fuel tank construction including venting arrangements, inspection hatches, details of the propeller tube and shaft, plus the rudder shaft and bearing, etc.
- Sheet 5. Details of chainplate construction, sizes, hole sizes for attaching correct size rigging screws, and instructions for cutting to correct dimensions, etc., plus suggested method of installing the chainplates.
- Sheet 6. Instruction on how to build the bowsprit, assembly of rudder, and construction of rudder bearings, etc.
- Nest plot sheets. These are the actual cutting files that are given to the cutting shop.
- Sheet 2A-03. Bulkhead detail showing stiffeners, cutouts, and extra frame details.
- Sheet 2A-05, nest plot. Expanded and forming information for the radius plates.
- Sheet 2A-02 (1). Shows the layout of the various parts of the kit in exploded form; each part is numbered and shown in its correct location on the boat, all in plan view.
- Sheet 2A-02 (2). Shows the layout of the various parts of the kit in exploded form; each part is numbered and shown in its correct location on the boat, all in profile view.
- Sheet 2A-02 (3). Shows each frame separately with measurements and layout of the numbered parts for assembling each frame.
- Sheet 2A-02 (6). Complete welding schedule for all parts of the boat. Each weld is shown in graphic form so all can understand the exact weld required.
- BJPG or PDF

Building a metal Spray.

Aluminum, Multi-chine steel, Round bilge steel, Radius chine steel.

ALUMINIUM - ALUMINUM

Widely accepted as a boatbuilding material, aluminum has the advantage of being about one-third the weight of steel, (this is partly offset by the fact that for boatbuilding, a thicker material is necessary). Aluminum is easy to work and hand tools, including some woodworking ones, can be used with this material. Aluminum is ideal for decks and superstructures where its lightweight and easy forming characteristics can be used to advantage. In some areas of the world, aluminum has become extremely popular for building commercial craft and fishing boats. The popularity with some commercial fishermen is due to the fact, that when the correct marine grades are used, the entire boat can be left unpainted.

The disadvantages include greater cost and relatively greater susceptibility to corrosion. Aluminum requires expert fabricators and experienced welders who are used to handling this material. It has less impact strength than other metals (on a dark and stormy night, think about those containers floating around in the ocean). When and if repairs are required, then aluminum also needs welders who are used to handling this material...not a problem if you have 'built your own'.

The only Sprays where it makes sense to use aluminum as the building material are the trailerable Spray 22 (Shown above) or Spray 27. The lighter weight of the finished hull would be an advantage in these boats. In the case of the larger Sprays, these are all designed to be moderate displacement cruising boats and there is no point in using the more expensive and less robust aluminum as a construction material. There are cases where we will recommend aluminum for superstructures but this is only in a few cases and this is noted in information about the particular Spray design. Spray 52 and Spray TY 475 are two examples of the foregoing.

If you are building a smaller steel Spray (22 ft - 33 ft) you may want to consider frameless construction. This technique involves building a temporary mold - former in either steel or timber as shown here.

Next step is to fit the plating by making a pattern for each plate and then cut plate to shape after checking pattern against framework..

Inside of Spray 22 frameless steel hull. Note tags are in place to allow attachment of plywood bulkheads to hull.

When the hull is fully plated then you simply roll over the hull and mold former, remove the mold and weld in'tags' for the bulkheads and webs to support the sole etc.

MULTI CHINE STEEL

My first and later intense interest in metal boats came about almost by accident. By 1973, I was already established as a designer of custom fiberglass sail and powerboats and fiberglass materials were inexpensive and readily available. Our building techniques were proven and widely accepted around the world so who needed any other building material? The oil embargo of the early seventies changed all that.

As our clients still wanted to build boats, we were forced to consider the options. Ferro cement was already thoroughly discredited as a boatbuilding material; wood/epoxy was well established, but the materials were relatively expensive and did not have a wide enough appeal. By this process of elimination we turned our attention to metal.

In 1973, excluding Europe and especially The Netherlands, there were relatively few designers and builders of metal pleasure boats, so we felt free to develop our own techniques, but where to start? That was easy; the Dutch had been building metal boats, particularly steel, for a century so I spent several weeks visiting many boatbuilding yards in Holland. The Dutch are very friendly people and I was able to study the building techniques and discuss construction methods with several established builders.

Steel is the most commonly used boatbuilding metal and it has many advantages including great strength, low cost and ease of fabrication. There are great numbers of experienced welders available in all parts of the world. Add to

Top: We recommend that you build under cover.
Mid: This Spray was built by in Oman so building outside was OK.
Bottom: Frames erected and first plating in place on Spray Donnegal Breeze

this, the ease of repair and the availability of a wide selection of suitable plans designed especially for building in steel. It is easy to see why steel has become so popular with the cruising fraternity. Successful steel cruising boats can, and have been, built from as small as 22ft / 6.70 m.

Steel is the least expensive of the metals suitable for boatbuilding and is considerably cheaper than either fiberglass or the materials used in wood/epoxy construction. Steel is definitely today's bargain boatbuilding material. Aluminum costs a few percentage points more than fiberglass or wood/epoxy construction.

The hull costs (meaning hull, deck and superstructure) represent 25 to 33 per cent of the overall cost of the vessel. A good argument can be made for ignoring the cost factor of the hull. If your budget allows this, then choose the material that is most suitable for your needs. After you have examined the building techniques explained in later chapters, then you will be in a better position to make an informed decision.

Building a Spray in steel has proved the most popular method since we designed the first steel version over 30 years ago. Any one who can weld can build a multi-chine steel boat without any previous boatbuilding experience

Top: Donnegal Breeze *hull ready for turn-over.*
Mid: Donnegal Breeze *exterior completed and off to fitting out yard.*
Bottom: Some larger Sprays like this Spray 52 are fitted with bow thrusters.

BUILDING A MULTI-CHINE SPRAY HULL FROM SCRATCH

The following sequence of photographs was kindly sent to me by Robert Millikin who is doing a wonderful job building this aluminum Spray 28-31.

Each photo is accompanied by text and shows how simple it to build one of these boats providing you follow the plans.

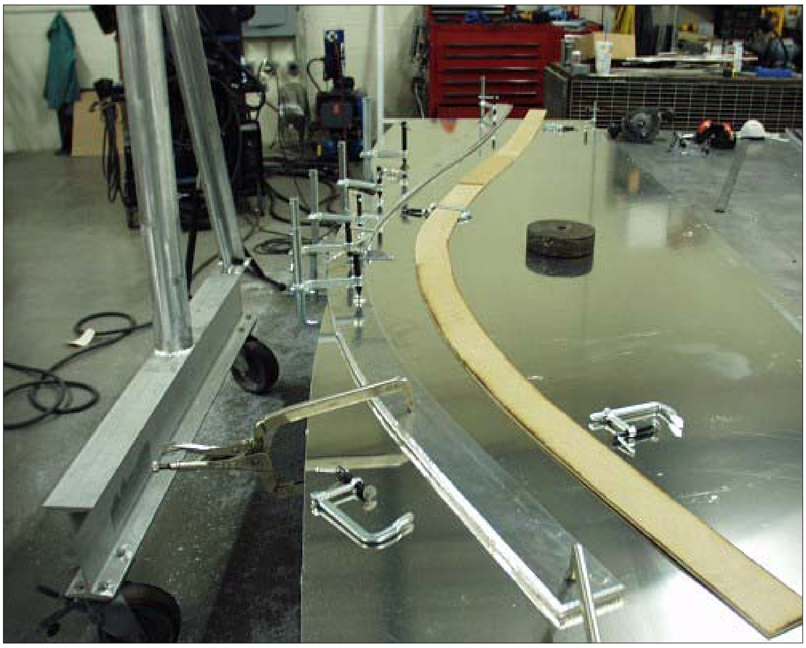
It is important to have the support of your partner and or family; not just physical support but active encouragement will be a great help during those periods when you wonder if you will ever get to complete to some particular part of the project !

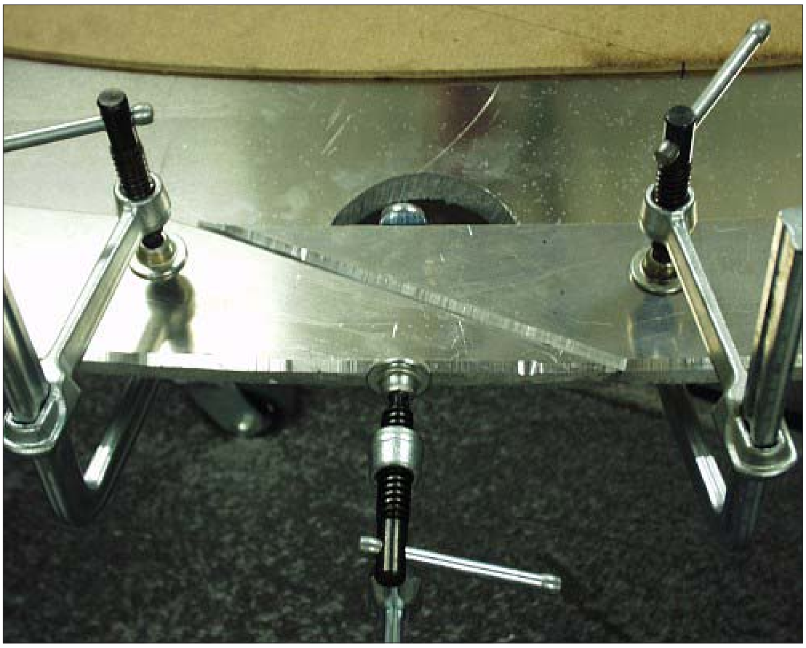
Please remember that you can always contact a member of the Bruce Roberts Design team for advice.

Robert Millikin photos.

LEFT:
Assembling the frames and building the strong back that supports the frames is clearly shown in the plans and here we see the frames set up on the strongback.

RIGHT:
Making patterns for various parts of the hull deck and superstructure is an important part of building the boat; here we see the pattern for the stem.





LEFT:
Preraring joins for welding will make the job go more smoothly; note the treatment of join is the side of the stem.

LEFT:
In this case the steel frames are only being used as a jig and will not remain in this aluminum Spray 28 / 3. Note the aluminum webs bolted to the frames so that they will remain with the hull when it is removed from the framework jig.

RIGHT:
The forward part of the stem and the bottom of the keel on the Spray series are one long piece. Note the web floors in this photo.

LEFT:
Here is an overview of the frames, webs and stem.


EXIT

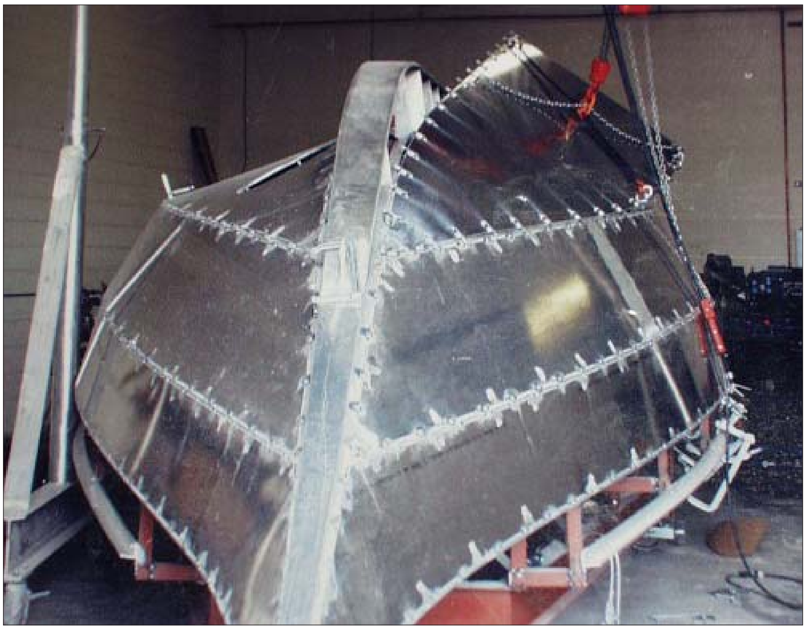
LEFT:
A wiew of the hull freame-work looking from aft to-wards the bow. Note the aluminum webs bolted to the frames.

RIGHT:
Note the way that the tran-som is formed up on thiis Spray 28 / 31

LEFT:
Making patterns; here we see the pattern for one of thehull plates..

LEFT:
Making patterns; here we see the plate cut and being installed on the hull.

RIGHT:
Here we see the bottom plate cut and being installed on the hull.



LEFT:
Now the plating is all installed on the hull; note he bow thruster tube already in place.

LEFT:
Here we see a close up opf the welding at the intersection of the transom and hull sides at one on the chines. A very small amount of filler, just a smear will complete this job.

LEFT:
The interior is shown here and you can see the rudder tube complete with flange on the inside the the hull in the area of the transom..

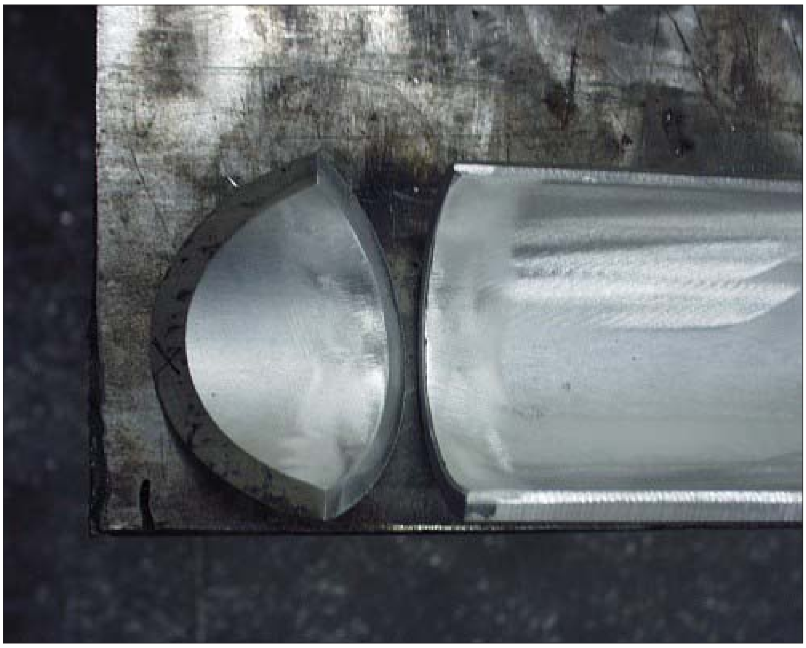
LEFT:
Here we see the interior of the hull around the transom area. Note the reinforcing bracket; useful in an aluminum boat but not essential in the steel version.

LEFT:
Here is the propellor shaft tube and some of the steel framing that will later be removed from the hull.

RGHT:
The builder is now preparing the split pipe tube that will form the rubbing stip on the hull.

LEFT:
Installing the rubbing strip on the hull; note the builder developed clamps to make the job go faster and easier.

LEFT:
Close up pf the nstalling the rubbing strip on the hull; note the builder developed clamps to make the job go faster and easier.



RIGHT:
Close up of the aft end of the rubbing strip and the end capping shaped from the same section.

LEFT:
Close up of the aft end of the rubbing strip and the end capping shaped from the same section.

LEFT:
Close up of the preparation of the bottom of the hull where the keel cooler will be installed.

RIGHT:
Another close up of the preparation of the bottom of the hull where the keel cooler will be installed. The bow thruster tube is in the foreground

LEFT:
Note how levers can be used to hold parts in place so they can firstly be tack welded and later finally welded into position.

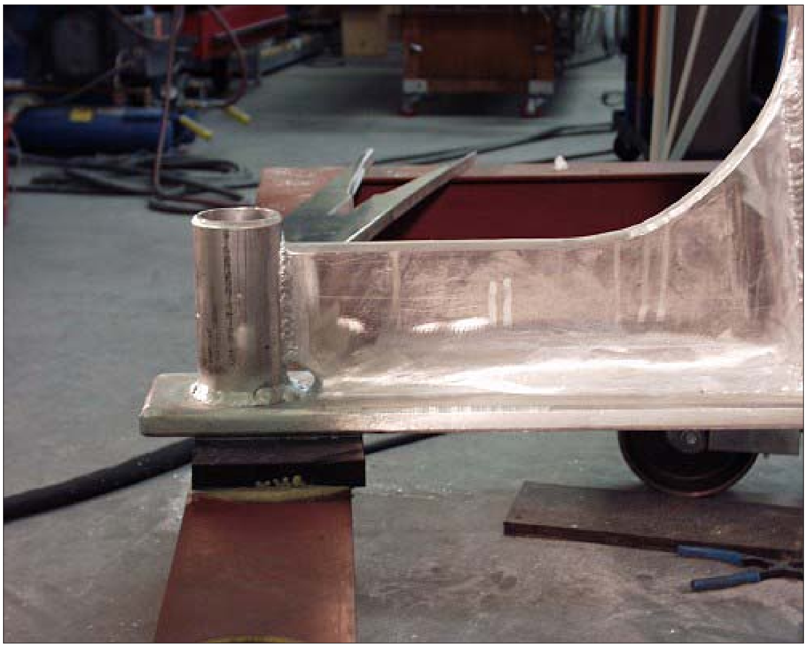
LEFT:
Preparation of the turn over operation; the boat is suspended in two endless slings.

LEFT:
Over she goes; only a small amount of man-power is required and in some cases a restraining line is also necessary.

LEFT:
First look at the hull as she will remain for ever more !

LEFT:
Note the pre-prepared cradle that will support the hull until the entire boat is completed.

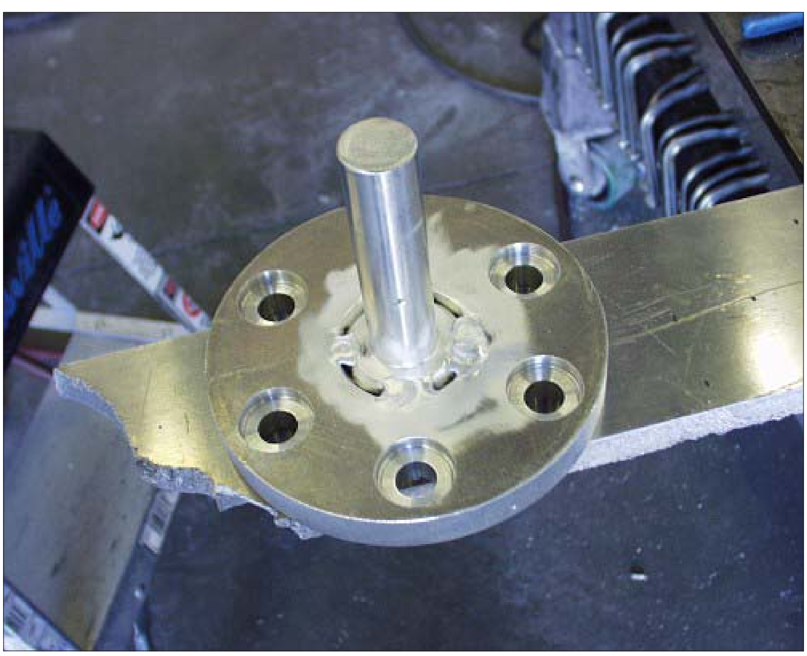
RIGHT:
Close up of the heel and tube that will accept the bottom end of the rudder shaft.



LEFT:
Close up of the outer end of the completed propellor tube, heel and rudder bottom bearing; a very strong, neat job.

LEFT:
Another view of the close up of the heel and tube that will accept the bottom end of the rudder shaft.

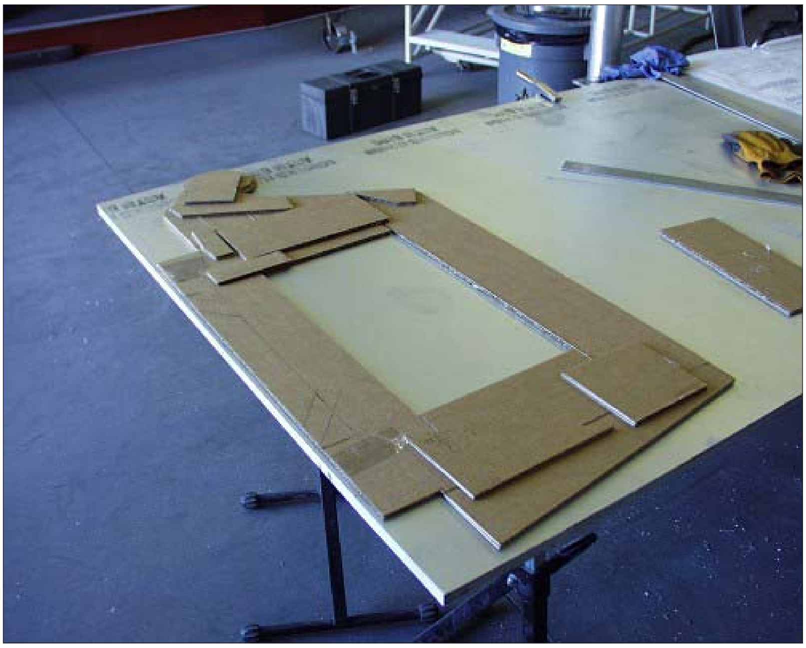
RIGHT:
Close up of the heel and tube that will accept the bottom end of the rudder shaft.



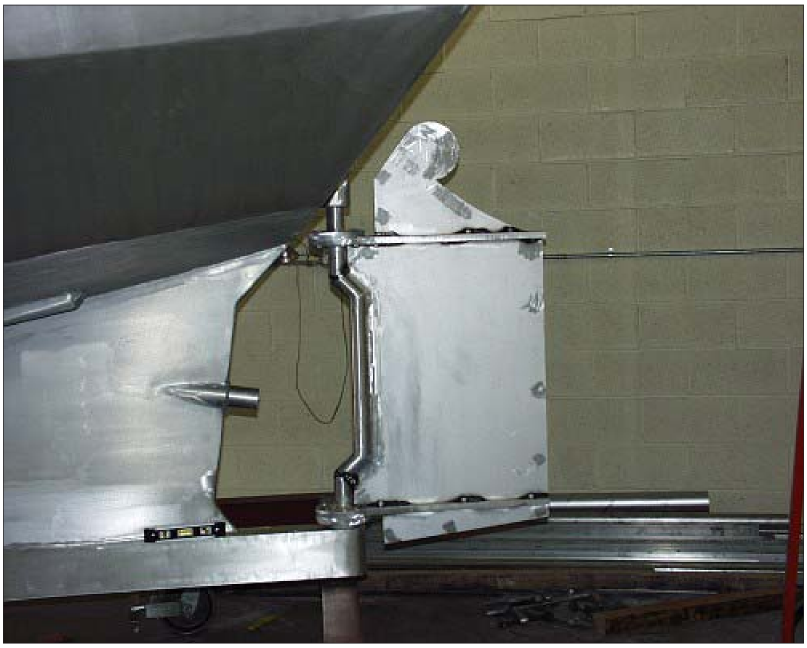
LEFT:
Close up of the flange that will form part of the rudder installation.

LEFT:
Here we see the rudder flange and the nylon bearing.

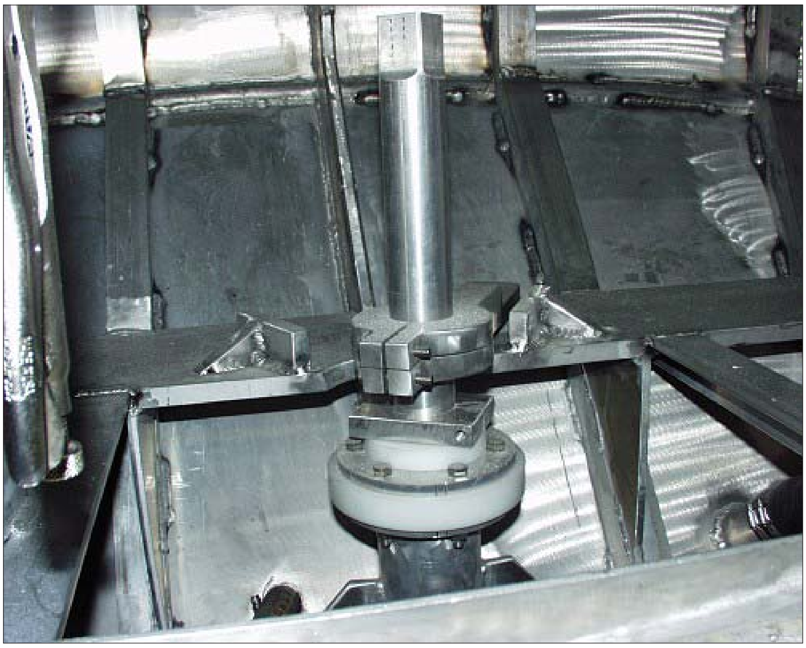
RIGHT:
Another case for a pattern; this one for the rudder. It is essential you make an accurate pattern for the rudder when building any boat in any material.



LEFT:
Close up of the pattern for the rudder in position ans ready to transfer the shape on to the plate.



LEFT:
Rudder in position.



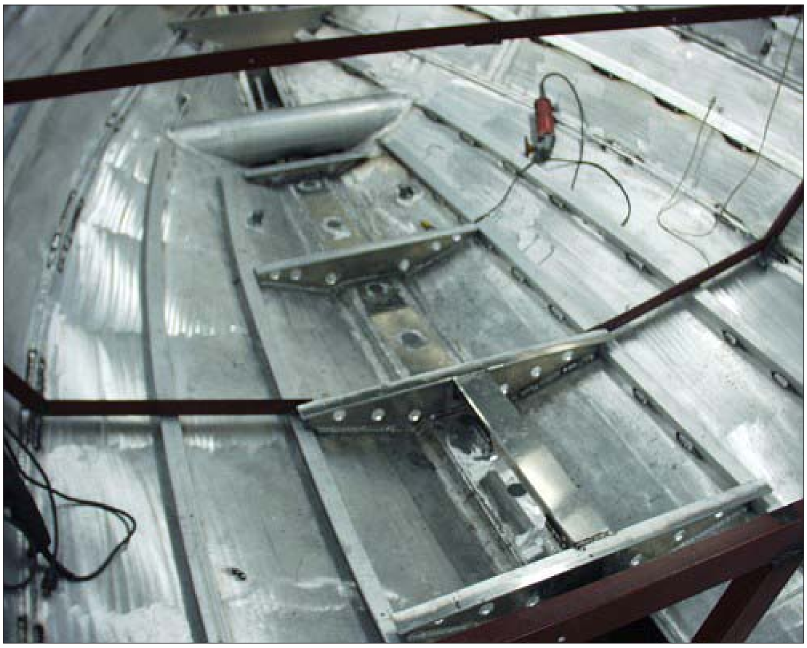
RIGHT:
Inside the hull showing the set-up for rudder bearing, connecting flanges, steering arm and emergency tiller connection squared off at the top of the shaft.

LEFT:
Here is some lead scrap that will be melted down to form the cement between the larger pieces of ballast.

LEFT:
The weight of the pre-cast lead has been calculated so that the correct amount of ballast can be installed. In an STEEL boat and preferably in ANY boat NEVER install more than 75% of the ballast at this stage; save the rest for trim ballast to be locacted where and if required.

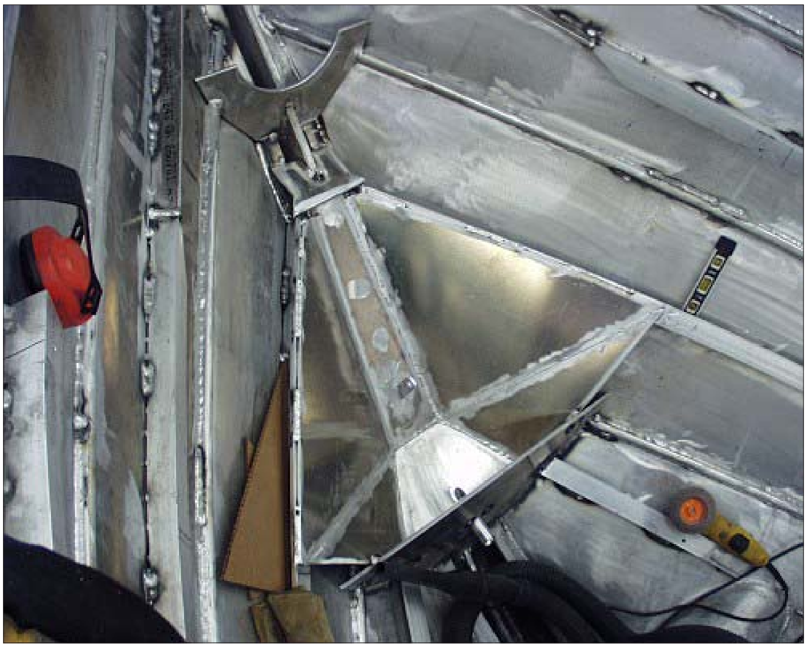
RIGHT:
Close up of the heel and tube that will accept the bottom end of the rudder shaft.

LEFT:
Close up of the heel and tube that will accept the bottom end of the rudder shaft.

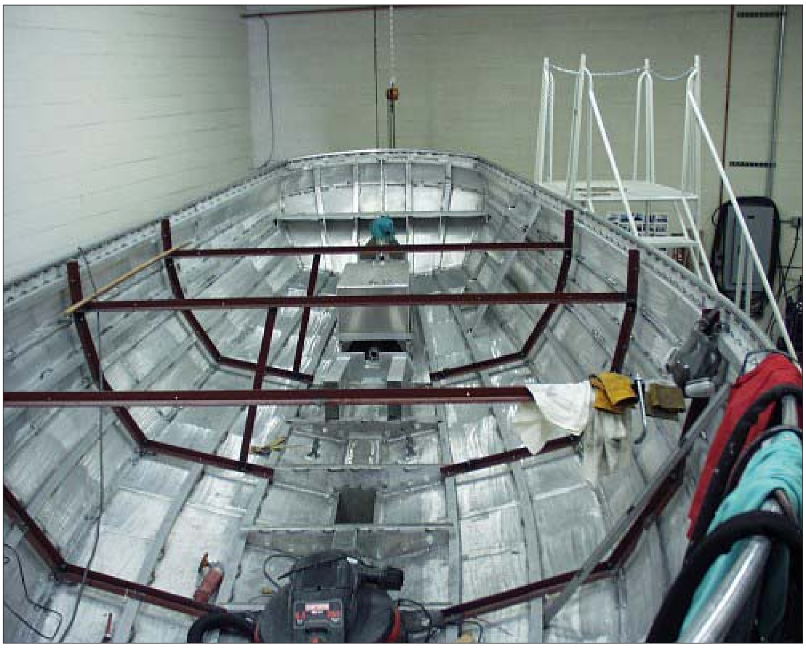


LEFT:
Here you can see the webs that are bolted to the temporary frames and the tube for the bow thruster.

RIGHT:
Many parts can be pre-made and installed into the hull at the correct time..



LEFT:
Close up of the bow area were the achor chain will be located when not in use.



LEFT:
Looking aft; General view of the hull looking aft. Later the steel frames that are bolted to the webs will be removed.

RIGHT:
Looking forward; General view of the hull looking aft. Later the steel frames that are bolted to the webs will be removed.

LEFT:
This is a tool that was developed at our boat yard in the early 1960's. This simple 'tool' is vital for bending deck and cabin top beams to the correct camber.

LEFT:
Here is a close up view of a tool that was developed at our boat yard in the early 1960's. This simple 'tool' is vital for bending deck and cabin top beams to the correct camber.

LEFT:
Here we see the pre-bent beams that have been bent to the correct camber and are now being installed in the hull. We often recommend installing the beams full width and then later cutting out the center section of the beams where the superstructure will be installed and save the center sections for re-bending and re-use as cabin top beams.

LEFT:
Here are the beams looking from bow aft.

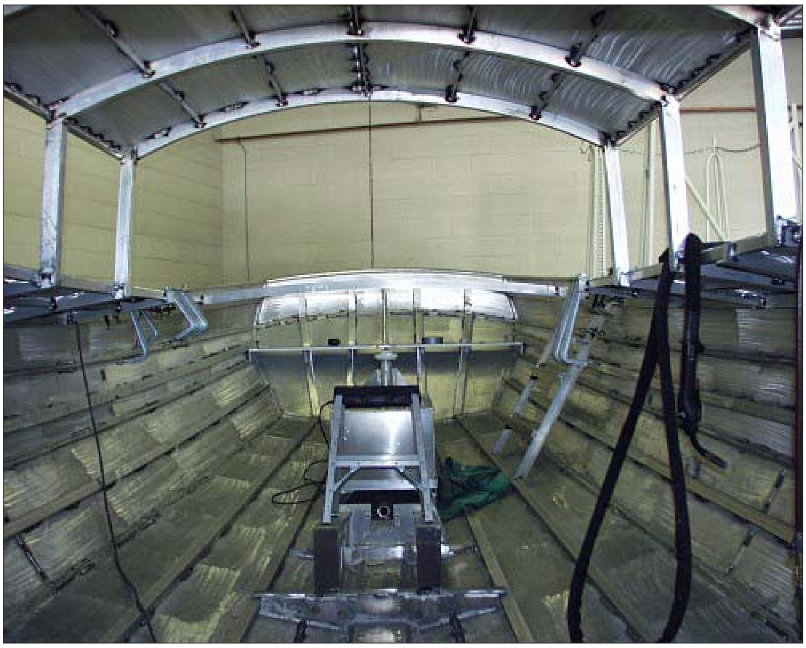
LEFT:
Here is an example of installing the beams full width and then later cutting out the center section of the beams where the superstructure will be installed and save the center sections for rebending and re-use as cabin top beams.

RIGHT:
This pilot house and fore cabin combinatioin is the builders own design. You should take care when customizing a boat to suit your needs and wishes; one day when you want to sell, will others like what you have created ?

LEFT:
View of the side of the hull with the start of the framing for the owner designed superstructure.

LEFT:
This sequence of photographs shows the building of the superstructure on the Spray 28 - 31

RIGHT:
This sequence of photographs shows the building of the superstructure on the Spray 28 - 31



LEFT:
The builder chose to use patterned aluminum plate for the deck and cabin top surfaces; I assume he had non-slip in mind; I will be interested to hear how this works out. As a matter of interest; this type of plate makes excellent sole plating in an engine room.

LEFT:
View of the side decks and part of the cabin structure. Note the chain plates are already in place.

RIGHT:
View of the side of the hull with the start of the framing for the owner designed superstructure.

LEFT:
View of the hull with some more of the fore-cabin and pilot house structure in place.

LEFT:
This sequence of photographs shows the building of various additions including cleats, gas bottle container etc., to the hull and deck on the Spray 28 - 31

RIGHT:
Here we see the self draining sealed gas bottle container on the Spray 28 - 31

LEFT:
Another view of the self draining sealed gas bottle container on the Spray 28 - 31

LEFT:
Chain plate installed at the predetermined angle of the shrouds it is meant to serve.

RIGHT:
Here we see the reinforcing by way of webs that will spread the load of the rig transmittede through the chain plates.

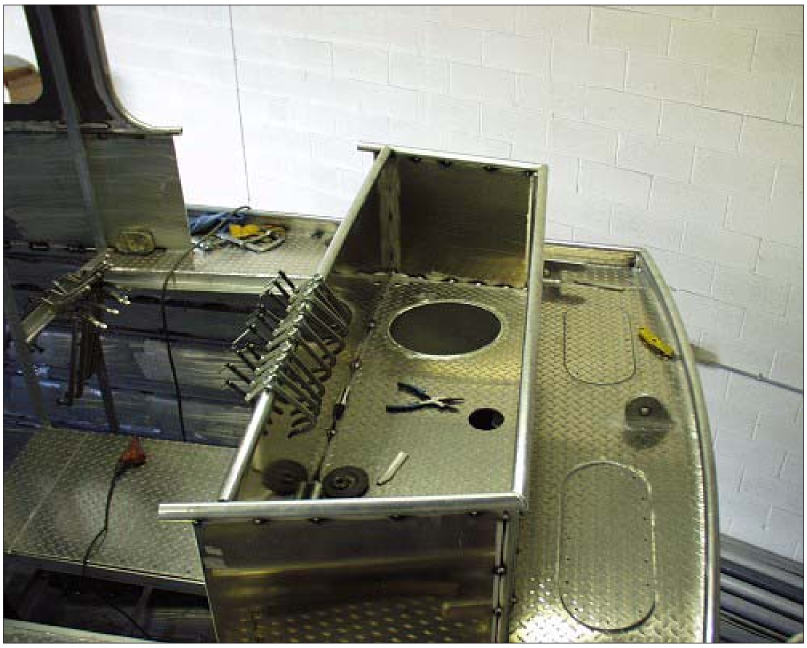
LEFT:
Another view of the superstructure progressing to completion on the Spray 28 - 31

LEFT:
Another view of the superstructure progressing to completion on the Spray 28 - 31

RIGHT:
Note the builders attention to detail where parts that will be exposed are lined. This type of finishing is appropieate in an aluminum boat where the weight savings of the material can be put to good use.

LEFT:
Another example where the prepartion of patterns before cutting the plate makes good sense and also saves time and materials in the long haul !

LEFT:
Wiew of the deck locker being built on the aft deck of the Spray 28 - 31



RIGHT:
Another view of the deck locker being built on the aft deck of the Spray 28 - 31; look at those clamps ready for use !

LEFT:
Another view of preparing patterns for the superstructure on the Spray 28 - 31

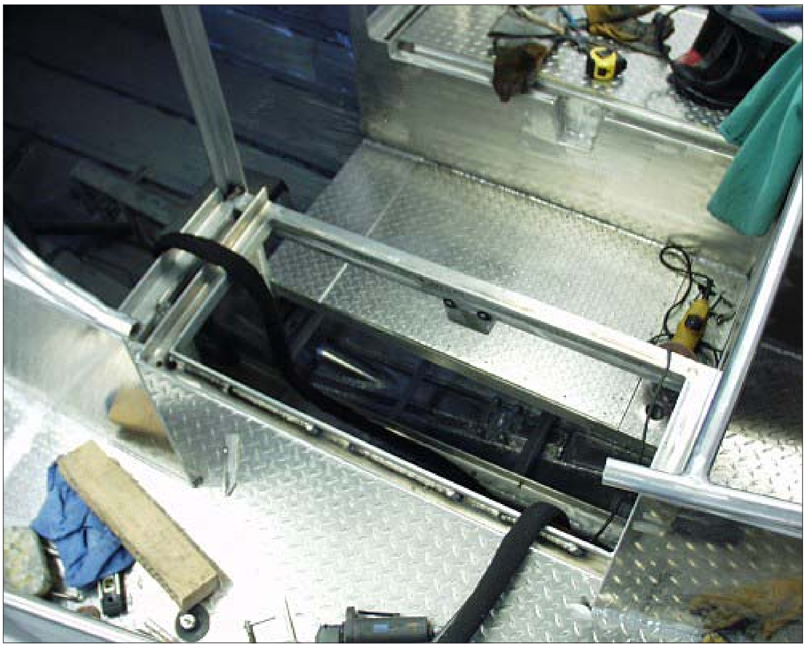
LEFT:
Here is the sequence showing the construction and installation of the 'duck board' or 'swim platform' on this Spray 28-31

RIGHT:
Here we see the part assembled above is now being installed as the 'duck board' or 'swim platform' on this Spray 28-31

LEFT:
Another view of the part assembled above being installed as the 'duck board' or 'swim platform' on this Spray 28-31

LEFT:
Here we see some of the aluminum framing in the cockpit area of the Spray 28 - 31

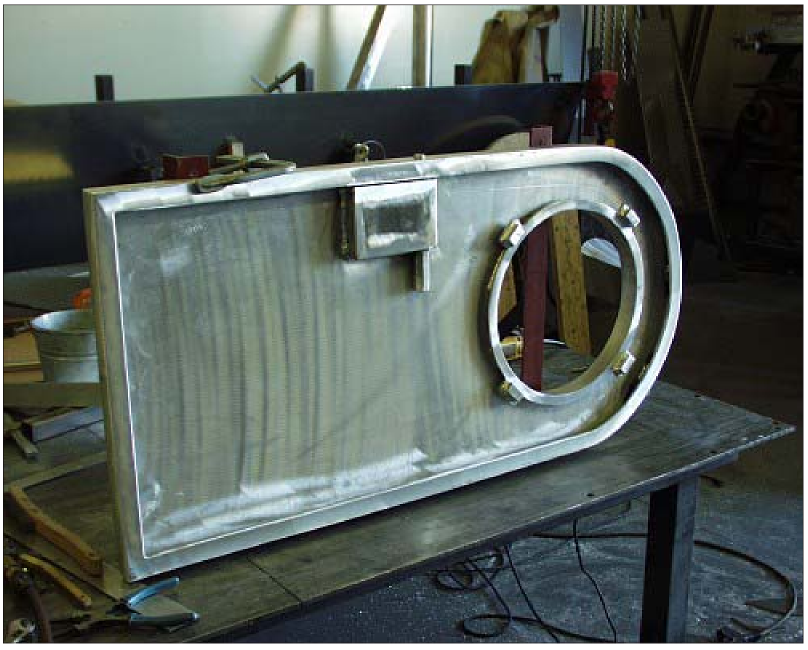
RIGHT:
This sequence of photographs shows the attention to detail that Robert Millikin *has paid to the building of his aluminum Spray 28 - 31*



LEFT:
More detail of the interior aluminum framing in the Spray 28 - 31

LEFT:
General view of the progress being made in the building of the aluminum Spray 28 - 31

RIGHT:
This sequence of photographs shows the construction of the pilot house door.



LEFT:
This shows the insulation being installed with care to allow for the interior locking device etc.

LEFT:
Insulation complete in the pilot house door, note the other skin of the door is prepared and ready for instlation.

RIGHT:
Here we see the completed door a true masterpiece.

LEFT:
This handle has provision for locking and looks up to the job!

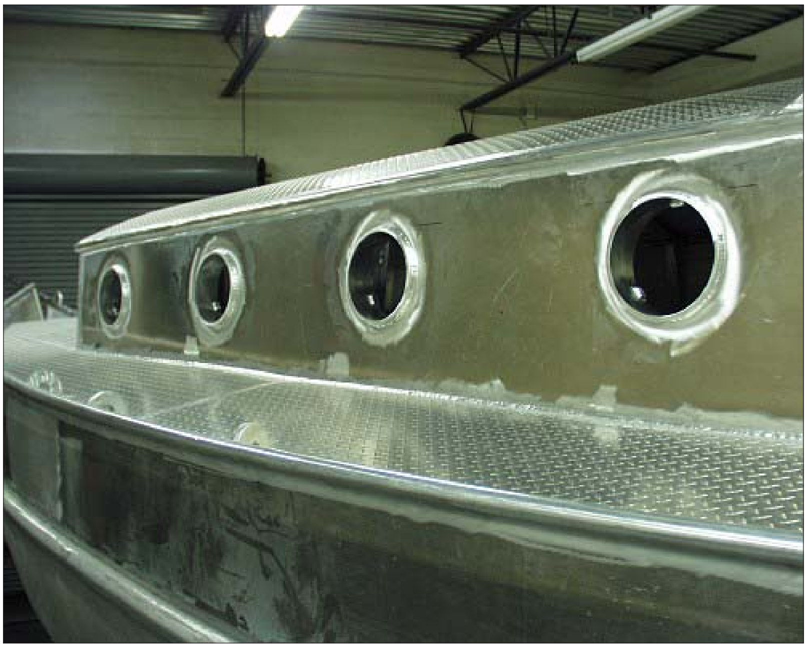
LEFT:
Here is a general view of the aft end of the pilot house.

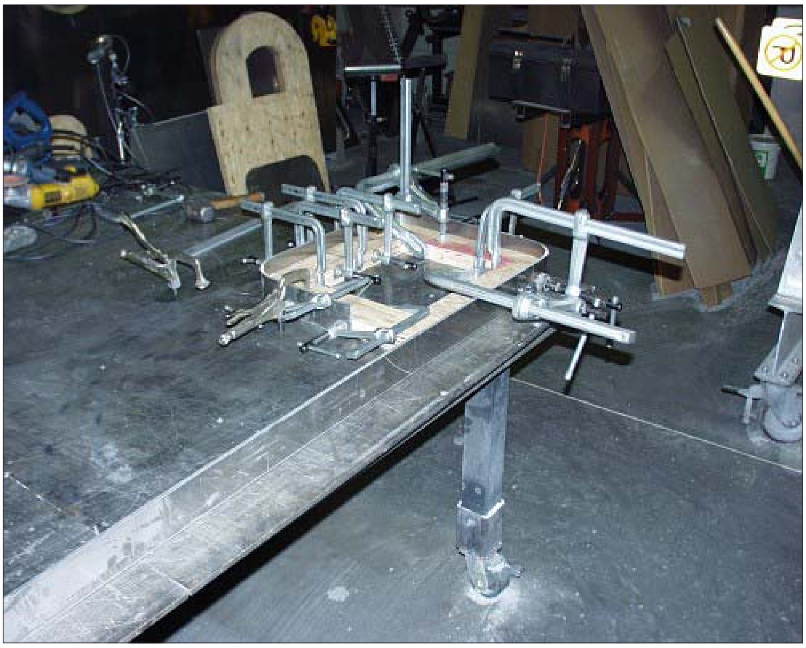
RIGHT:
This sequence of photographs shows the preparation of the port holes that will be assembled and installed on this Spray 28-31

LEFT:
Note the ingenuity of the builder in the way he uses various clamping devices to hold parts prior to tack welding together; we can lean a lot here.

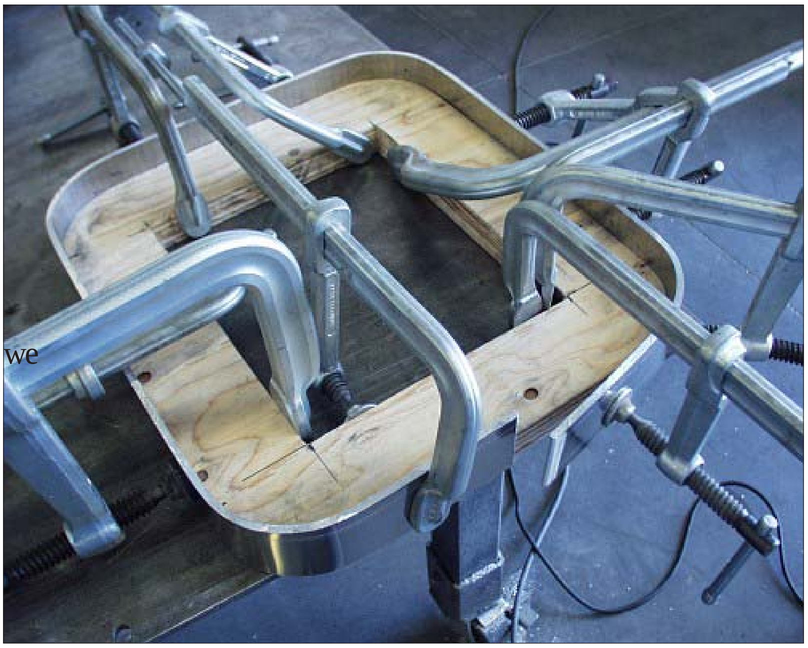
LEFT:
Here the preparation of the port holes is going well.

RIGHT:
This sequence of photographs is complete when we see the ports installed in the fore-cabin side.





LEFT:
Just look at those clamps; this is one tool at you need in abundance.



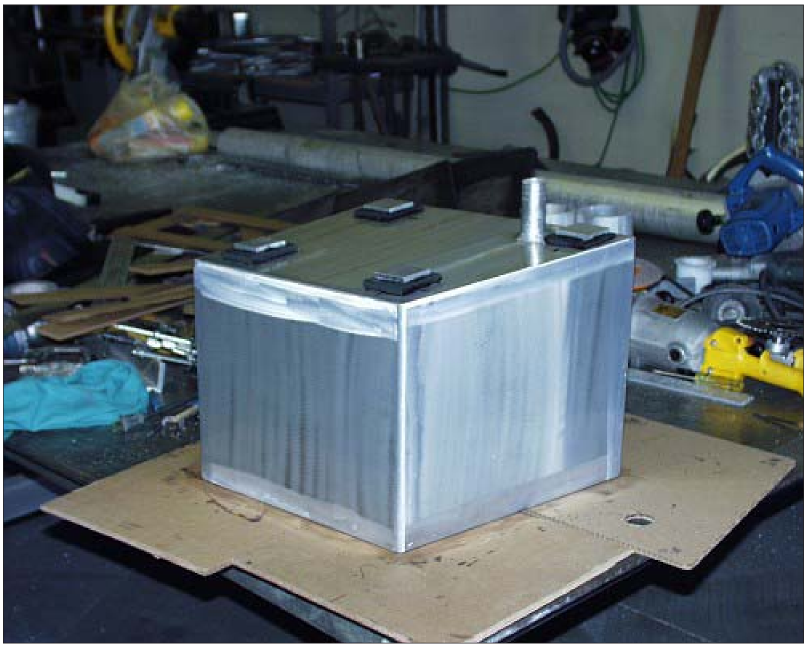
LEFT:
Here we see pilot house window frames being constructed

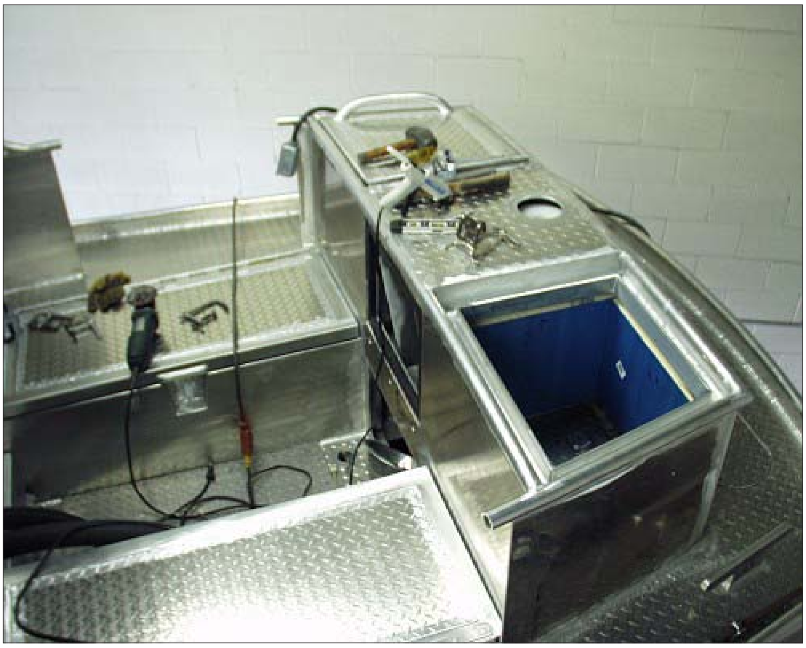
RIGHT:
Here the preparation of the window frames for the pilot house sides is going well.

LEFT:
The first of the window frames is now installed in the pilot house side.

LEFT:
Here is a view of the ports and window frames.

RIGHT:
There are several tanks in this boat. Tanks should always (in my opinion) be made outside the hull and tested for leaks with 3 lb per cu ft of air before installation in the hull.





LEFT:
Here the installation of the aft deck locker is going well.

LEFT:
The deck locker is now almost completed

RIGHT:
Finally completed and quite a hansome job it is too..

LEFT:
Many parts can be fabricated easily when using metal and I have to admit the aluminum is the easiest to work with,

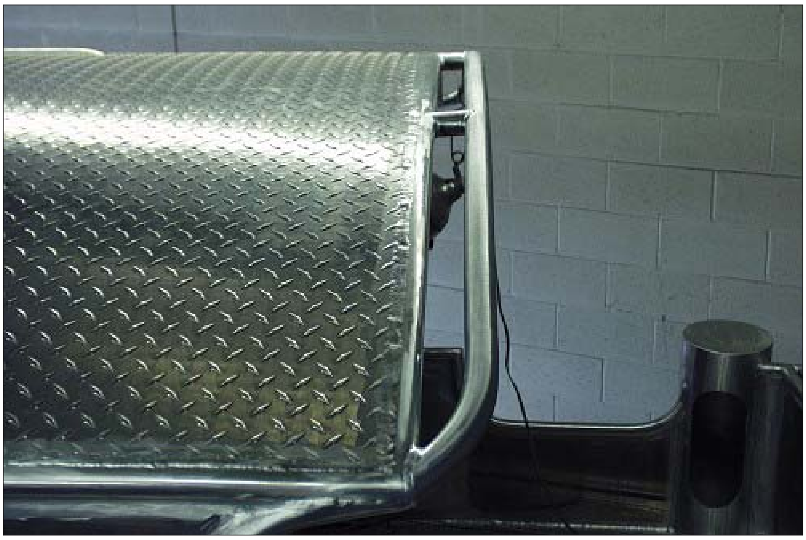
LEFT:
Here we have a vent built into the aft deck.

RIGHT:
Here is another view of the vent built into the aft deck.

LEFT:
First bending for the bow sprit. The plans for this bowsprit are included in the plans for all Bruce Roberts designed sail-boats.

LEFT:
Here is a view of the completed bow sprit.

RIGHT:
You can hardly have too many handrails on any boat !



LEFT:
An overview of the fore-cabin-top and the pilot house front. Note vents and hatch being installed in the fore-cabin-top.

LEFT:
These combinaton bollard / vent are very popular and do work well in practice.

RIGHT:
More hand rails which are placed where they will be needed.

LEFT:
Always make sure your partner is involved in the boatbuilding project.

LEFT:
View of fore-cabin-top, pulpit and life rails. Pipe rails are OK so long as the material is light enough; in this case aluminum or that boat is large enough to support this feature. In general pipe rails are the best on cruising sailboats

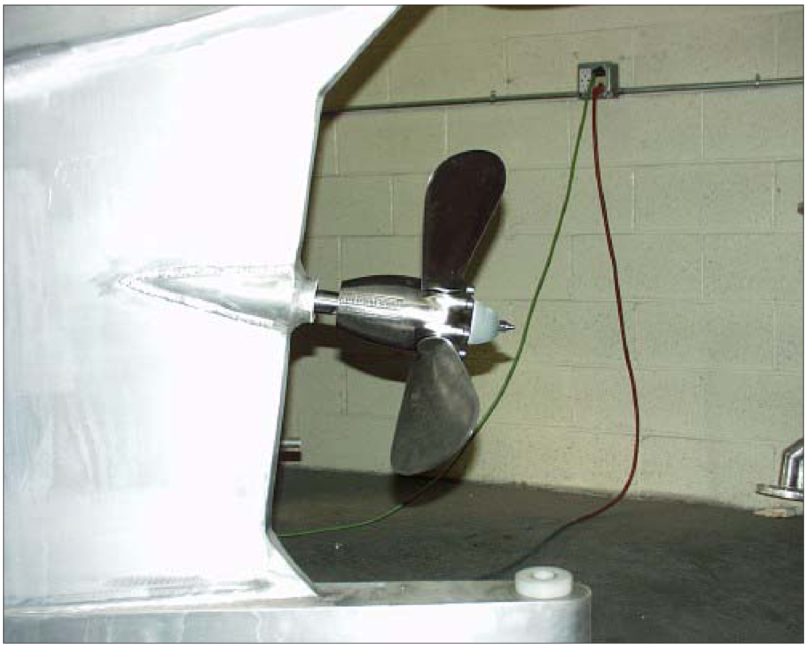
RIGHT:
These rails protect the vent which would otherwise be likely suffer damage at some stage.

LEFT:
Make sure you equip yourself with a good set of steps as soon as your hull is upright.

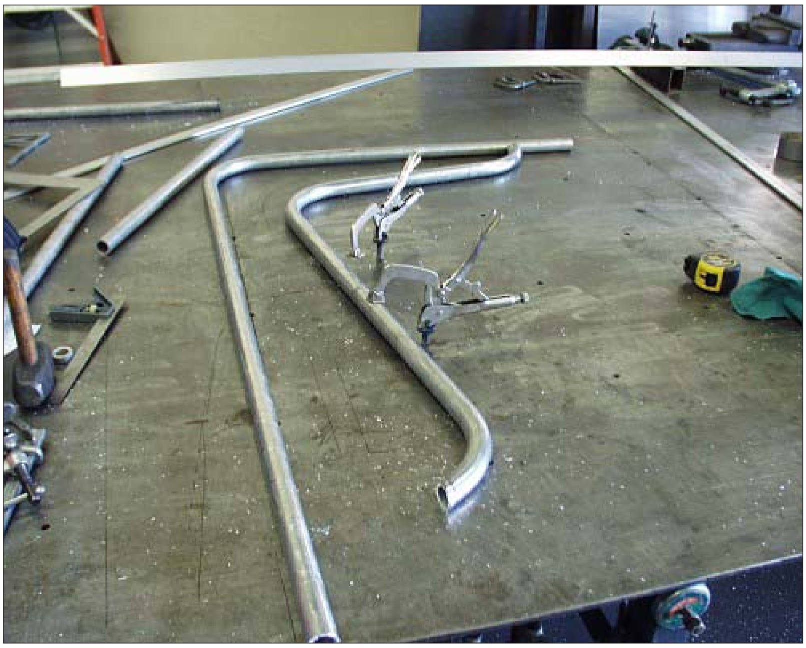
LEFT:
Study this overview of the foredeck and cabin top etc. There are a number of good shown ideas here.

RIGHT:
Close up of the rails that protect the vents.

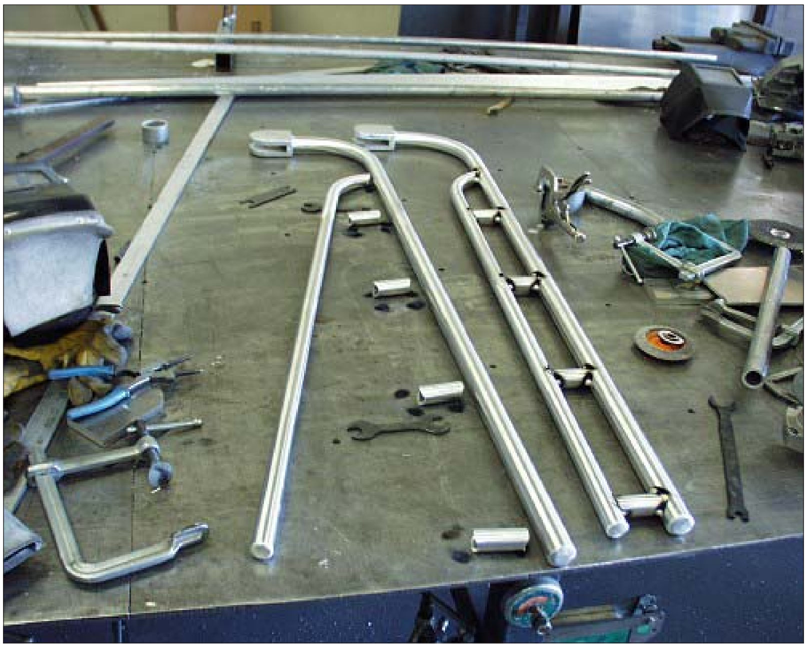
LEFT:
On this size of boat 31 ft / 9.5 m the cockpit is smaller than usual as the pilot house and aft deck locker do take up extra room. The climate you sail in may dictate the layout you prefer.



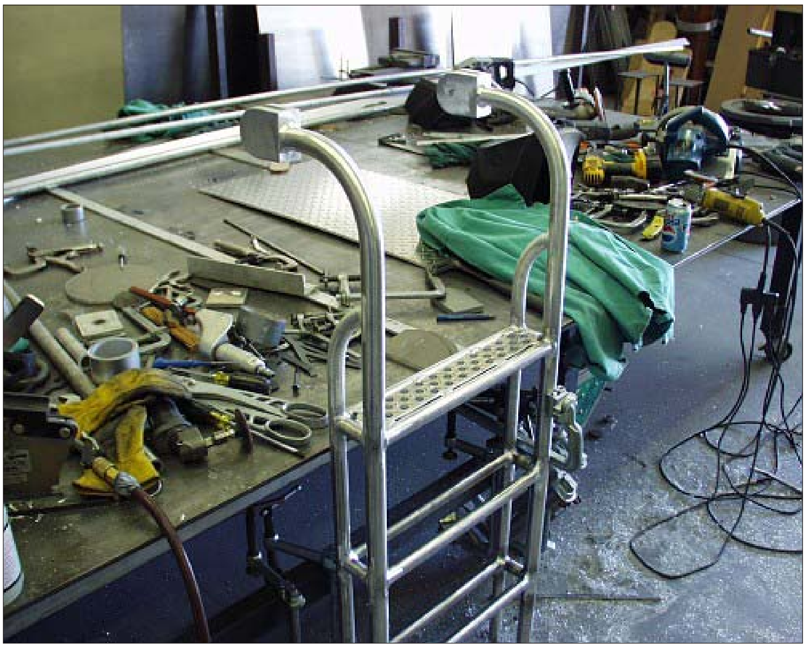
LEFT:
Close up of the variable pitch propeller



RIGHT:
First bending of the pipe that will go to making the aft boarding ladder.

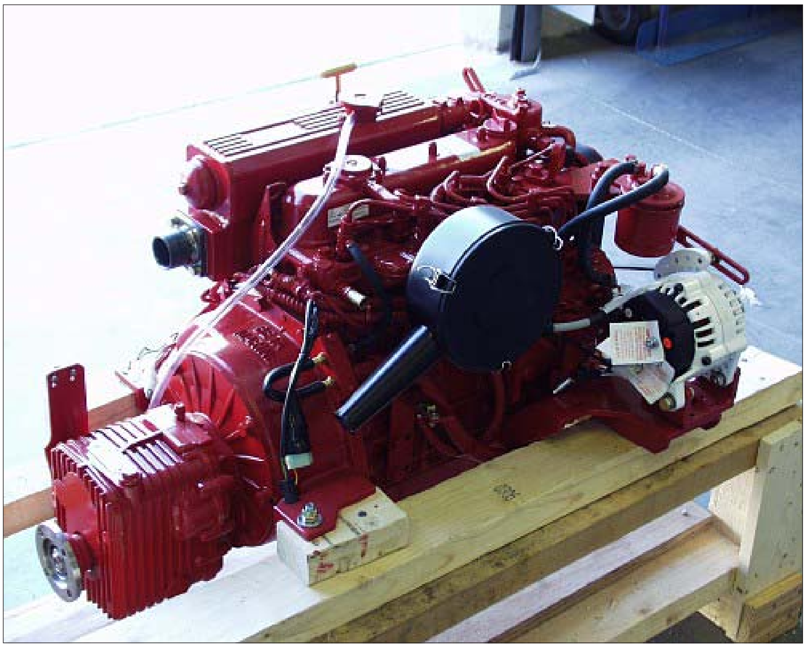


LEFT:
Close up of the sections of pipe for the ladder.

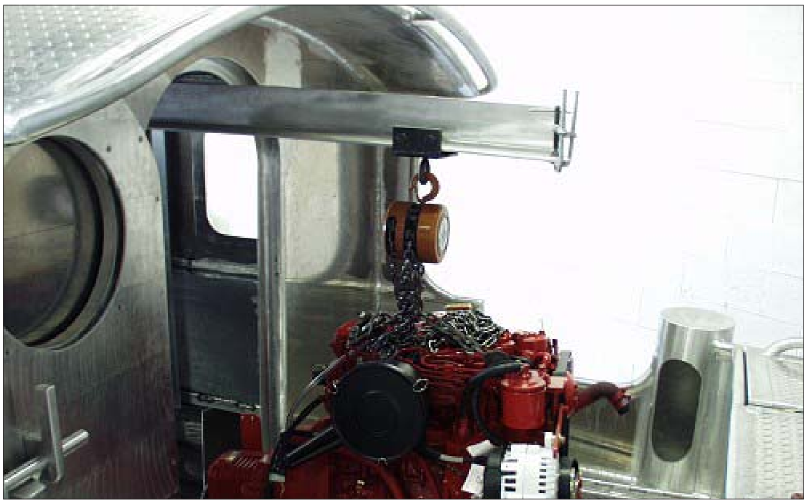


LEFT:
Ladder is nearly complete and ready for installation on the transom of this Spray 28-31

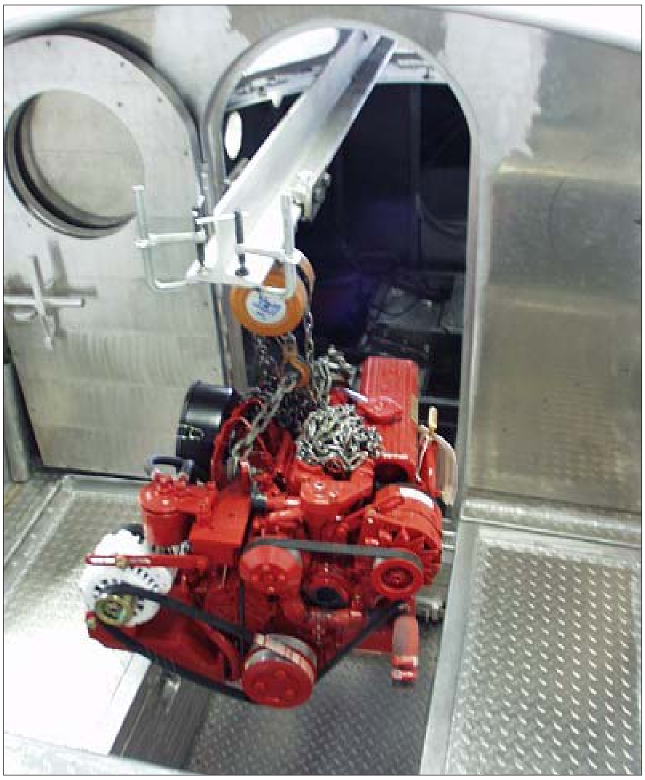
RIGHT:
Close up of the ladder and davits.



LEFT:
Here is the engine ready to be installed in the hull. It is a good idea to have the engine on site as soon as practical; preferably when you turn the hull.

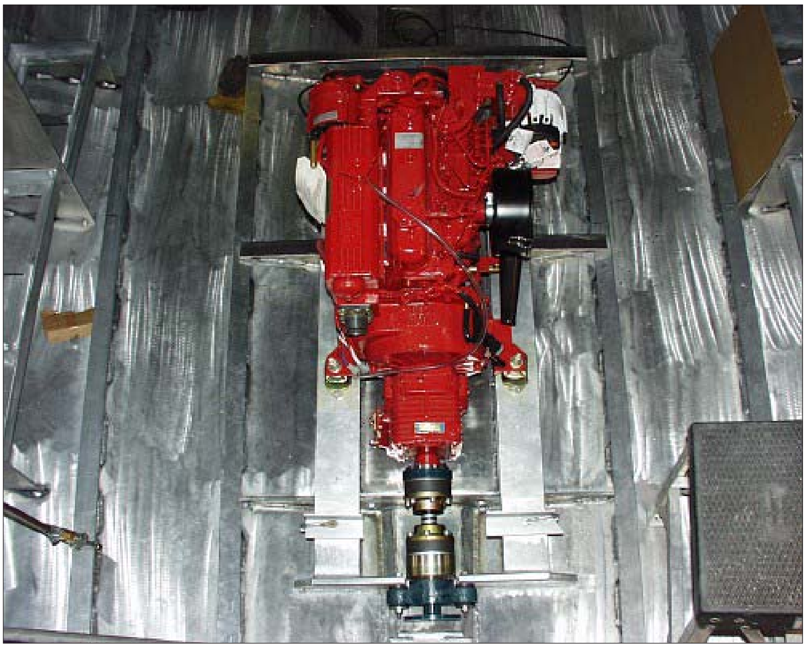


LEFT:
This beam will be used to slide the engine into position so it can be lowered on to the engine beds.



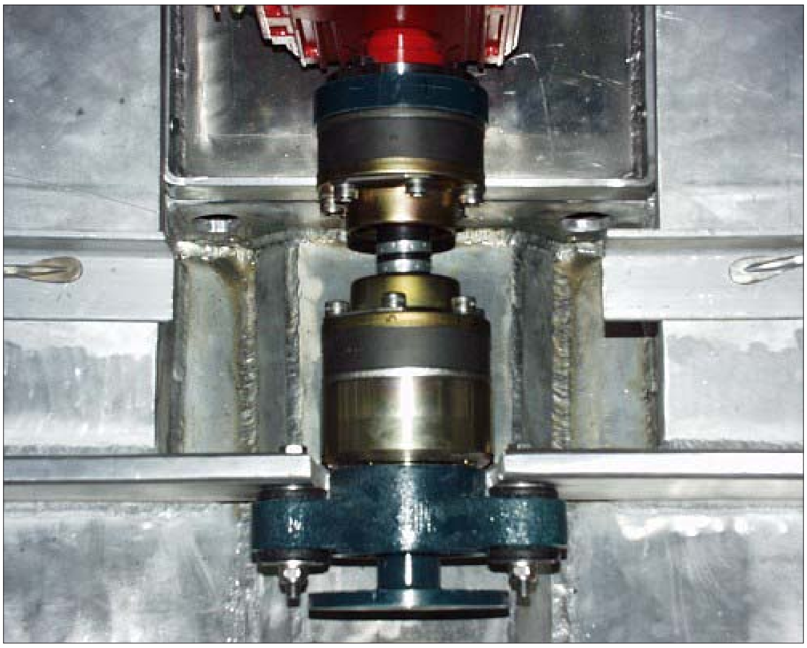
RIGHT:
Engine ready to be installed.

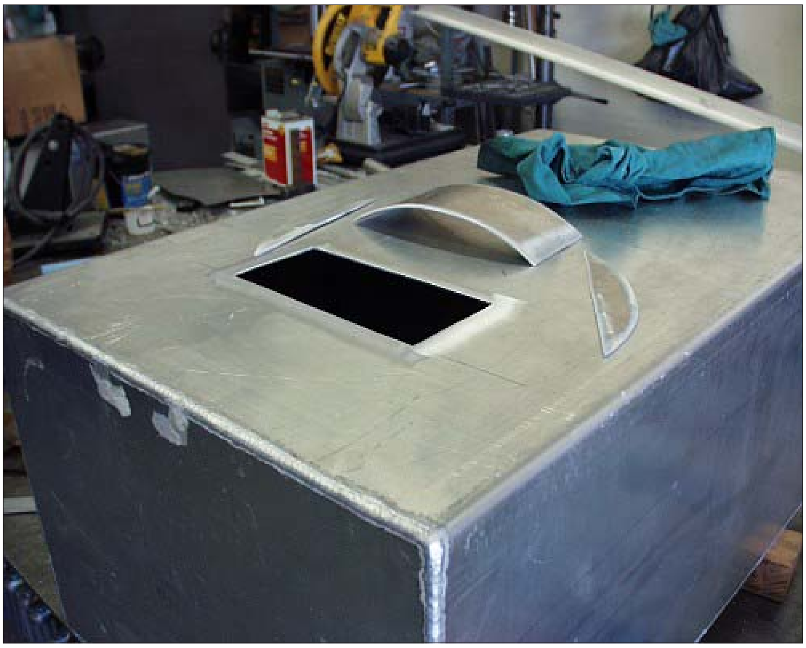
LEFT:
Success ! The engine is now safely on the beds where hopefully it will remain forever !



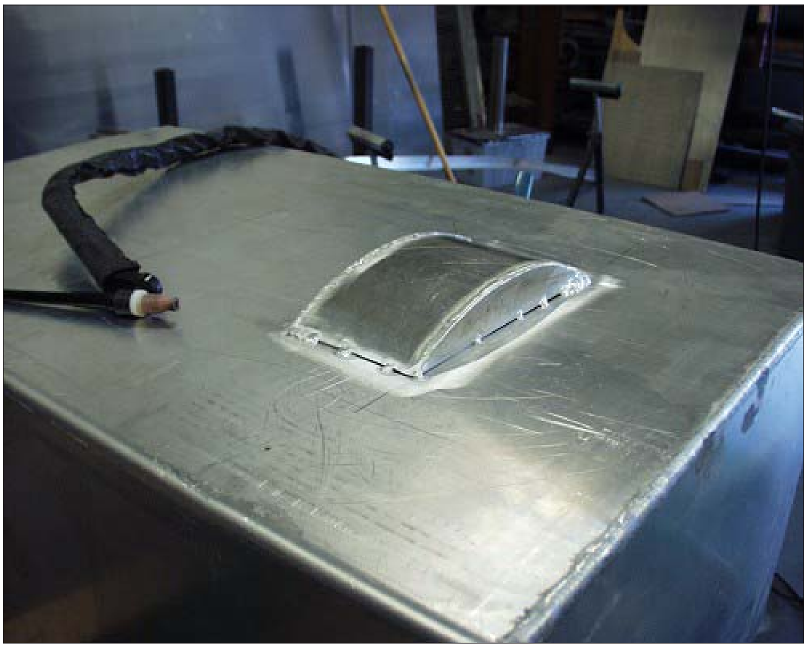
LEFT:
Another view of the engine.

RIGHT:
The arrangement here allows for slight miss-alignment. There is more than one manufacturer of this equipment so choose well!



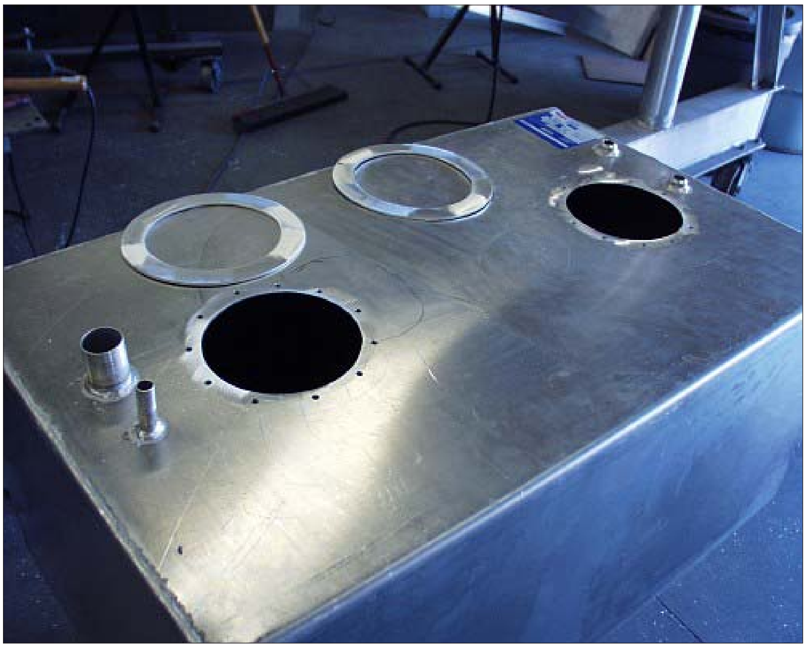


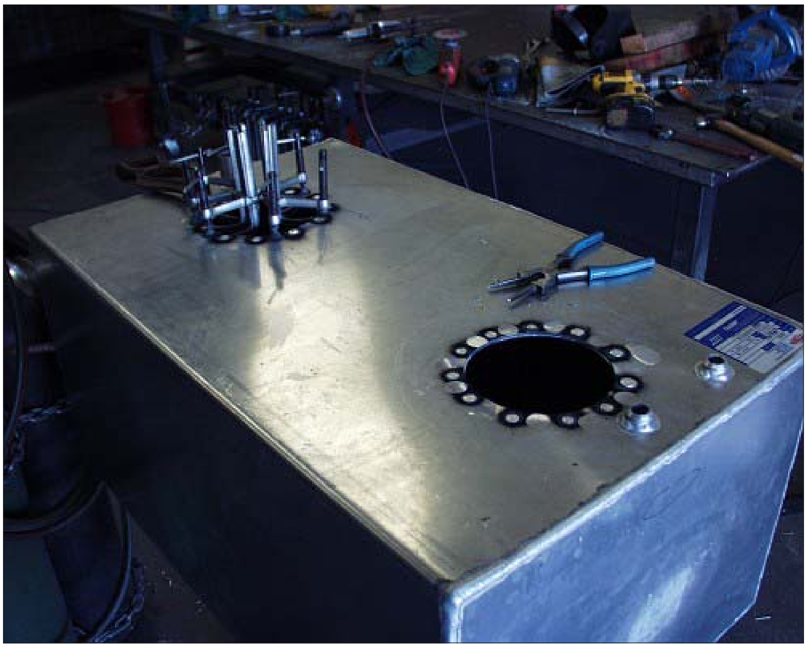
LEFT:
More tank; note the very careful welding to form this tank.



LEFT:
Here is a view of the completed tank.

RIGHT:
Make sure the inspection holes and covers are carefully made and located where they can be accessed without dismantling the boat !

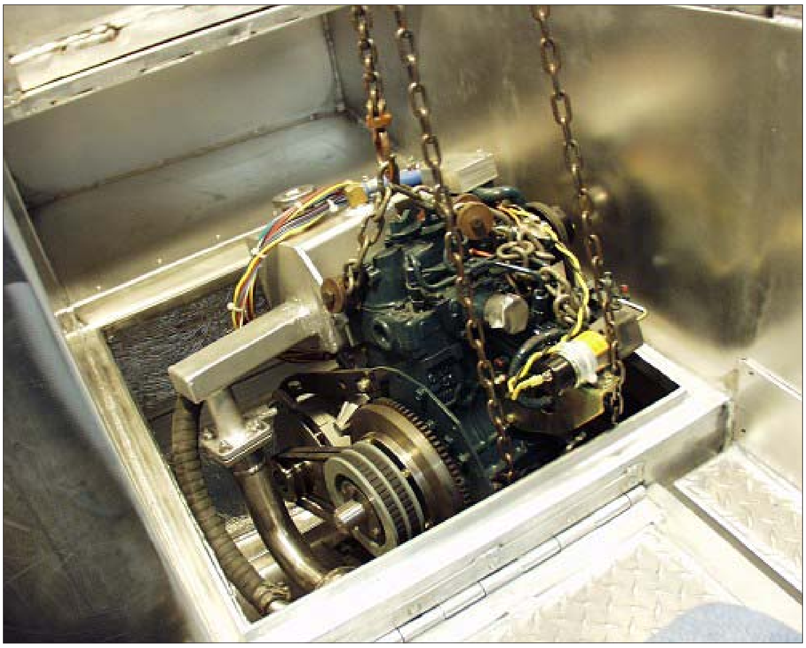




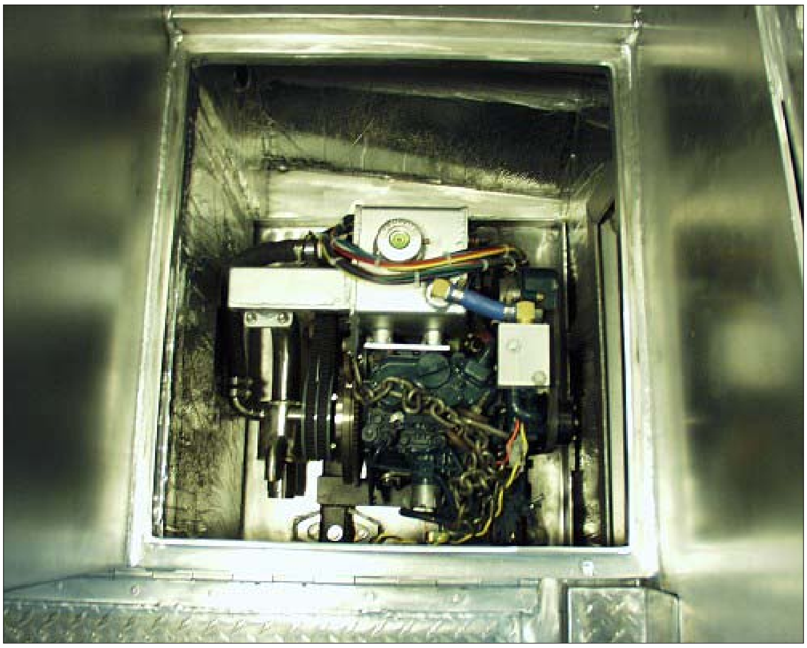
LEFT:
Note the use of clamps to hold parts before they are tack welded in place.

LEFT:
View of the entry to the pilot house and also note door between the PH and the forecabin.

RIGHT:
This pre-prepared box will be used to contain the Gen set.



LEFT:
Gen set being lowered into its home.



LEFT:
Gen set in its home.

RIGHT:
Here we see the rudder complete with the flanges used to connect it to the rudder shaft and to the stub shaft into the heel.

LEFT:
General view of the command station in the pilot house.

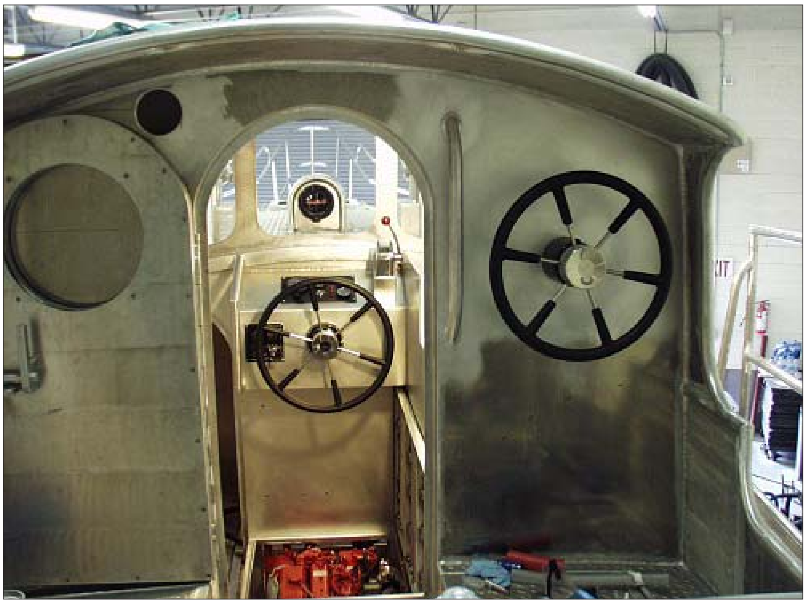
LEFT:
Make sure that you have adquete fuel filters on your engine. Use two more than are aupplied with the engine and make sure that one or more can be by-passed if it gets blocked.

RIGHT:
Make sure to double clamp any pipes that are not connected by thread as most are in this instance.

LEFT:
Close up of pipework.

LEFT:
Close up of some of the pipes and valves installed on this Spray 28-31

LEFT:
Here we can see the two steering stations.



LEFT:
View looking forward; note the pipe that will house the bow thruster.

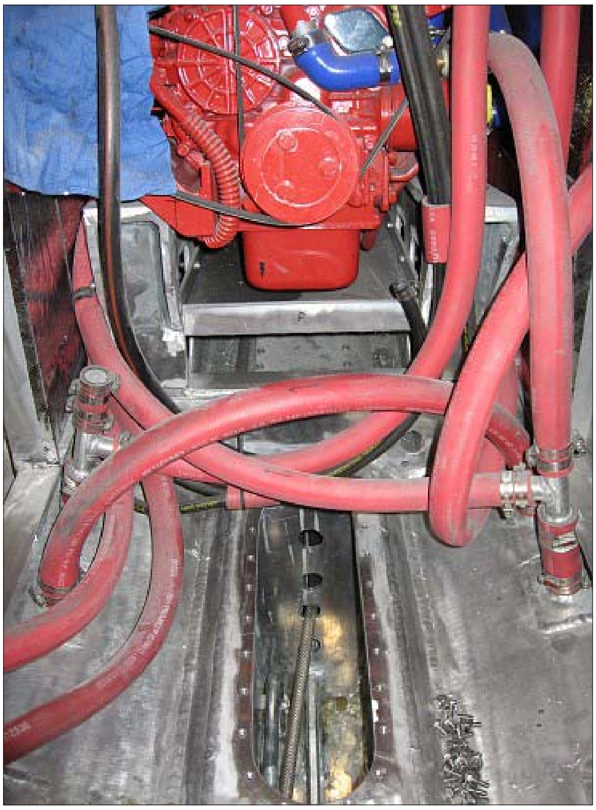
LEFT:
Tank snugly in place. make sure that all tanks are firmly and strongly attached to the hull as a tank breaking loose in a seaway is a disaster !

LEFT:
Note some of the coatings used in this boat.

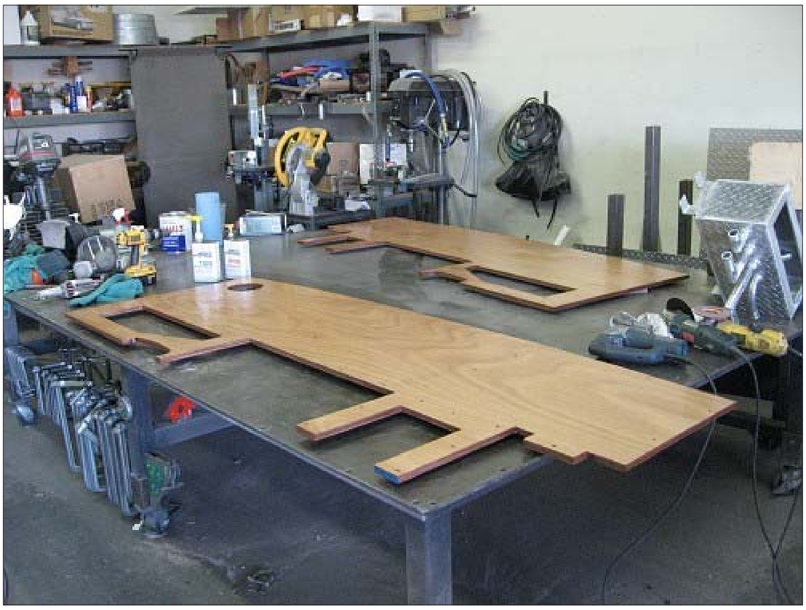
LEFT:
Nice even finish; even though it will be covered up with the interior joinery etc., make every step the best you can manage.

LEFT:
Another view of some of the interior coating.

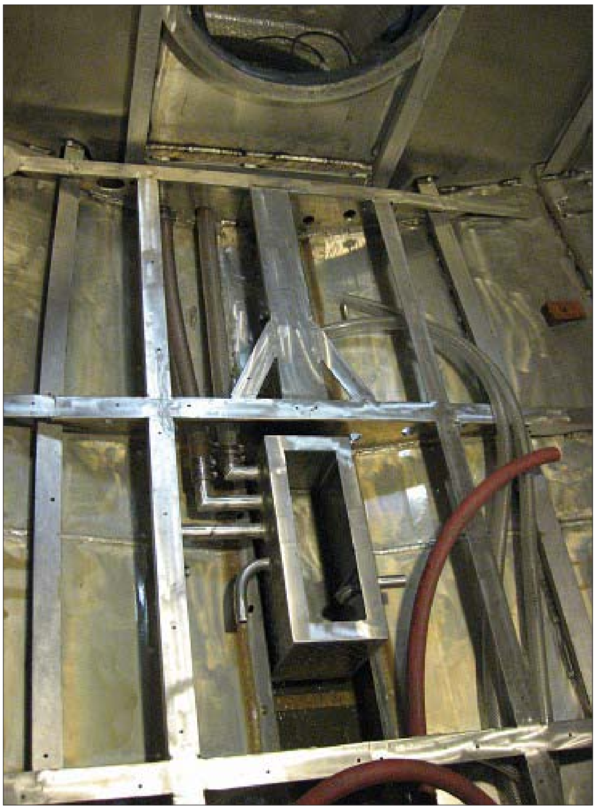
RIGHT:
Note some of the coatings used in this boat.



LEFT:
More pipework; you will be surprised just how much piping is used in even a boat of this size.



LEFT:
More patterns, these are for part of the sole.



RIGHT:
This is where that ply sole will be installed.

LEFT:
Note the access cut-outs in the sole. Some of these cut-outs will have covers.

LEFT:
Do not make the sole too shiny as it can be slippery when wet!

RIGHT:
Lining being installed in the cabin sides.

LEFT:
More lining; this time on the bulkhead.

RIGHT:
Note the instulation in the deck head.

LEFT:
See how the deck head lining panel was pre formed before being installed.

RIGHT:
The result of the preperation shown in the preceeding photo.

LEFT:
More lining.

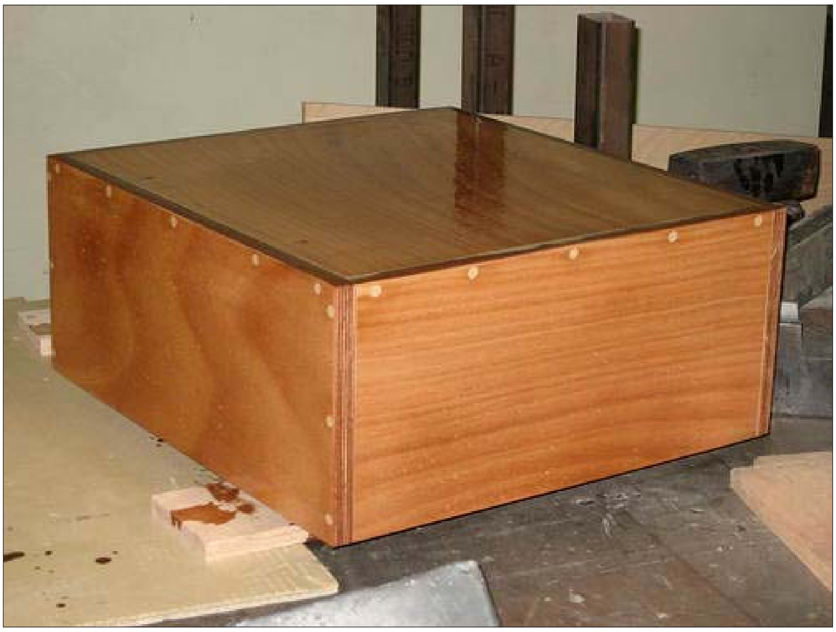
RIGHT:
Unless you provide access, make sure all electrical wiring and plumbing are in place before the lining commences.

RIGHT:
Here we see the Porthole trim installed.

LEFT:
Some of the ports are of the opening variety. These look up to the job !

RIGHT:
Wiew of the two ports shown above.

LEFT:
More opening ports and an general view of the fore-cabin side.



LEFT:
Note some of the joinery can best be pre-fabricated outside the hull.

RIGHT:
Make sure you make a good job of the joinery. I have seen many boats with beautiful hulls that were let down with the poor quality of the interior fit-out. Seek help if you need it to do a good job in this area.

LEFT:
As you can see this builder is as careful in the fit-out as he was in building the hull.

LEFT:
More joinery

BELOW:
Note the construction of the hatch to be used on the box below.

LEFT:
Box and hatch construction.

LEFT:
More joinery.

RIGHT:
Close-up of the locker shown above.

LEFT:
Make sure that all drawers have strong runners and also have a means of preventing them from coming open in a seaway.

LEFT:
Another view of the drawer.

RIGHT:
In this case the builder used a mix of aluminum, timber and plywood the achieve what looks like being an attractive fit-out.

LEFT:
Toilet in place.

LEFT:
Testing for electrical leaks.

RIGHT:
These strips will be used as part of the lining of the hull.

LEFT:
The strips are now in place; better known by the misleading name of ceiling planking!

LEFT:
View of stove from above.

RIGHT:
The neat installation of the stove shows a lot of thought has gone into this area.

LEFT:
There are lots of , tanks, pipes and valves in any boat.

ROUND BILGE STEEL

Building a boat in round bilge steel is only suitable for professional metal workers or experienced steel boatbuilders. If you are thinking of building a round bilge steel Spray and you do not have the experience as outlined above then you will need assistance by either having the hull professionally built or by hiring an experienced metal worker or steel boatbuilder to assist you with the work.

How you go about plating a round-bilge hull will depend upon the shape of the hull. Fortunately the round bilge Spray is a relatively easy shape. As the hull and keel meet either near, or at right angles, then the plating the keel of the round bilge hull will not present any undue problems.

Now you must examine the overall shape of the 'canoe body'. For instance the traditional Spray design has a very full 'golf ball' shaped bow that makes it a difficult plating job even for an experienced metal boat builder. In our round-bilge versions, (also in the chine hulls), of the Spray we have 'drawn out' the bow *above the waterline* to make the hull easier to plate. In the case of the Spray

The sequence of photos on this pages show how our round bilge Centennial Sprays are built from scratch. The plans include full size patterns for the frames and stem. The hulls can be built either upright or inverted as shown on the left..

The photos above illustrate the results of the construction methods used to build the Centennial Sprays as shown on the previous page. The Centennial Spray 36 shown above is also featured later in the Centennial Spray 36 design section.

this also improves the performance and comfort of the vessel in short steep waves. A careful study of the plans can give you some hints as to the 'plate-ability' of the hull in question.

Once you are confident that your chosen design features a hull shape that is within your plating capabilities, you can consider the best technique for fitting the plate. There are three ways to lay plate on a round bilge hull. They are longitudinally, in multi shaped sections or in diagonal strips. If the hull has a suitable shape then the diagonal method may suit the less experienced builder. The round bilge Spray hulls can be plated without undue problems.

RADIUS CHINE STEEL

For many years we have been searching for a way to create an easy to build radius chine steel Spray hull. It is only in recent months that the latest computer design software has become available to make this possible. Admittedly it takes even the most experienced naval architect on our staff considerably longer to create and fair the computer model for these radius chine hulls; we think it is worth the effort.

The first kit order we have received is for a radius chine Spray Trawler Yacht 475 is the first of these new designs and is offered as a kit featuring steel hull and aluminum superstructure. The superstructure is considerably larger than a sailboat version so aluminum superstructure is desirable to offer maximum stability for this vessel.

The sailboat versions can be built as all steel vessels. Armed with a kit which comes with pre-rolled and perfectly fitted radius plates, any competent welder can assemble one of these new radius chine Spray kits.

No matter which steel Spray you are building; you will get the best results if you tack weld the entire hull before finish welding any part of the structure. Same goes for the decks and superstructure.

Shown here is the first photos of the Spray 475 Trawler Yacht being assembled in Seattle USA.

Above is shown a radius chine hull built to our design. It is just as easy to build in radius chine as it is to build a chine hull.

TURNING THE HULL

Generally speaking the building methods described above utilize the method of building the hull 'upside-down' so you need turn your hull to 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.

There are many different ways to turn a hull that has been built inverted; the method you use may depend on several factors including space and equipment that you have available. If in doubt seek advice from your Bruce Roberts office.

STARTING FROM A STEEL PRE-CUT KIT

It is now possible to purchase a kit of parts that have been cut from plate and your job is to assemble these into a hull deck and superstructure. As designers we have the capacity to prepare a special computer disk and with the parts 'nested' to allow economical cutting of the metal. It is necessary for the company producing these kits to have the automatic computerized cutting devices and be able to take the disk supplied by the designer and produce your kit. This service introduces relatively small additional costs in addition to the plans and the materials but you will find it a practical and economical way of getting your project off to a good start.

In our case use the design criteria is in accordance with Germanischer Lloyd for category 1 (unrestricted sailing area), which is much better than what CE-A requires.

All plate parts belonging to the hull, deck and superstructure that are accurately cut to size are included. The parts are marked with the appropriate part number and engraved matching marking lines to assist in the assembly and location of the part in its position.

Forward bulkhead. By studying the cut out shapes on the plans beforehand,all parts are readily identifiable.

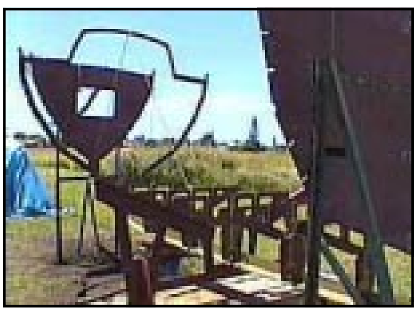
Frame part showing limber holes and the precut slots for the stringers to sit into.

All pieces are marked with code numbers that match with those shown on the plan.

The frames have been tacked together ready to be erected once keel and hull bottom plate have been laid.

Floor webs being tacked to keel. Note the lightening holes and the notches for sole supports and stringers.

Bulkheads erected and braced. Each kit has a minimum of three steel bulkheads supplied as part of the package.



Frames and bulkheads starting to be erected.

All bulkhead and frames standing ready to receive pre-cut plates.

Plating of decks and cabin all in place and tack welded.

TIME TAKEN TO ASSEMBLE THIS SPRAY 36 KIT:

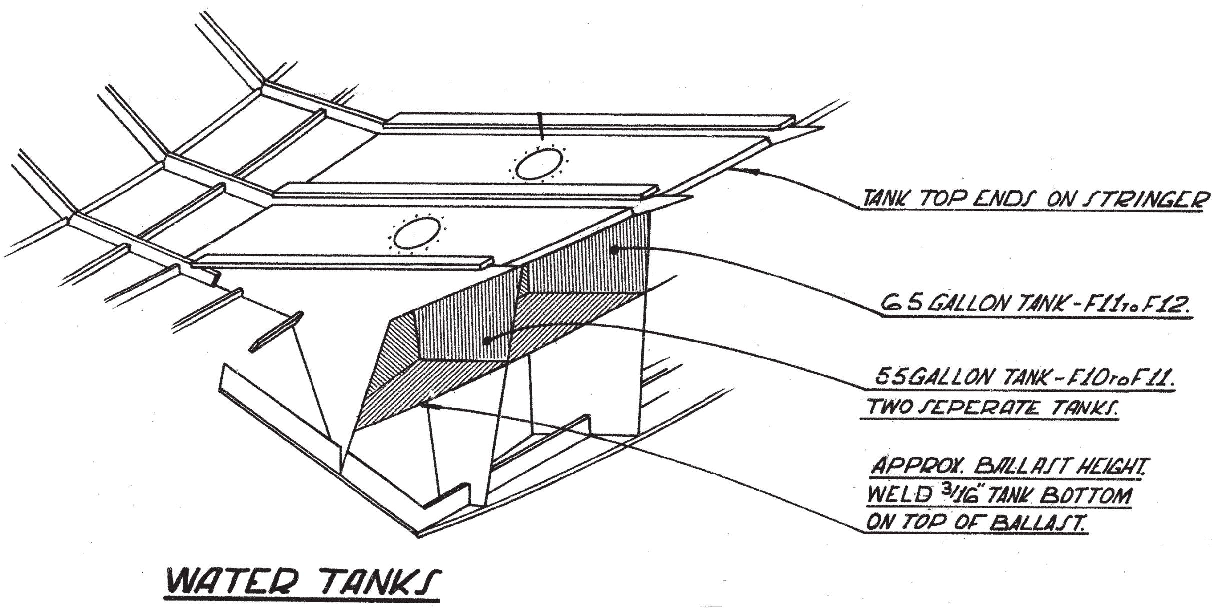
Arrival of Kit, sorting parts and preparing................ 2 men.......................1 days
Assembly of jig(s) and welding webframes................. 2 men.......................3 days
Assembly of Hull & Deck, tackwelding completely..... 2 men......................10 days
Finish welding Hull & Deck....................................... 2 men......................10days
Grinding visible welds... 1 men.......................4 days

Total time should be between 350 and 400 manhours.
The time is more or less reflected on the equipment and expertise available.

CHAPTER 10.

Sailboat ENGINEERING

You will find that some of this chapter is slanted towards steel boats and occasionally powerboats. The principles are the same so please read this chapter in full. The same advice can be offered as if you are planning to build a fiberglass or wood epoxy boat, please read the steel chapters as well; there is much to learn and much of the material in all chapters applies to building in all materials.



We prefer separate tanks, formed outside the boat but for those that insist in using integral tanks the above sketch can be used as a guide when installing tanks in either steel or fiberglass hulls.

ABOVE:
Engine compartment with auxiliary engine and generating set both installed with sufficient access to allow servicing.

LEFT:
Substantial P bracket supporting the propeller shaft and prop. Note the folding and adjustable propeller which is fine if you can afford the cost and the potential maintenance.

In our opinion, engines powered by gasoline (petrol) have no place in any metal boat—or in any other cruising boat, for that matter. Those who build or buy metal boats are usually thoughtful individuals, and safety is one of the reasons they choose metal. Petrol or gasoline engines do not fit this profile. We recommend diesel engines.

ENGINE COMPARTMENT

When you're choosing your engine, make sure that there's sufficient room to install (or retrofit) it. It isn't just a matter of shoehorning the engine into a given space; you'll also need room for insulation and servicing. The engine must be accessible. If access is difficult, then there is always the chance you'll neglect essential maintenance work. Make accessibility one of your primary concerns when installing the engine(s) and arranging your engine room space.

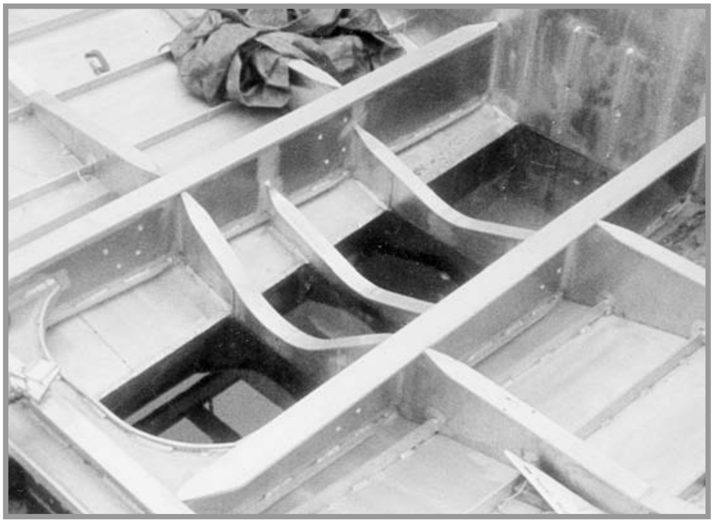
Out of the several boats we've owned, we have never been totally satisfied with the accessibility of all the items that need servicing on a regular basis. Unfortunately, total accessibility, although aimed for, is seldom achieved. For example, batteries need regular inspection, testing with a multimeter and/or hydrometer, and topping up with distilled water. These inspections are likely to be far less frequent if the batteries are in some difficult-to-reach location. The oil dipstick and the water filters should be inspected every day that the boat is in service. Primary fuel filters fitted with water traps need to be drained on a regular basis. Water impellers need to be changed occasionally, sometimes in a hurry. Main fuel taps should be easily accessible; and the list goes on. Can you easily reach the injectors, stuffing box, and fuel-tank inspection hatches?

Some single-engine, semidisplacement powerboats have insulated engine boxes in addition to an insulated engine room. This makes for very quiet running but it does restrict accessibility to some items on and around the engine. In sailboats, the engine often intrudes into the accommodation, where it is inaccessible and almost impossible to service. If you're building a new custom-designed boat, or rebuilding an older one, here's your chance to do yourself a huge favor: consider accessibility a number-one priority.

Engine room insulation in one form or another is essential if you want to keep noise down. In a sailboat, the engine box is usually a fairly close-fitting affair and the problem is also one of accessibility.

You can use several combinations of materials to insulate and quiet your engine, but however you do it, make sure the insulation won't give off toxic gases in the event of fire.

Here are some suggestions: aluminum-covered Styrofoam; fiberglass insulation with a lead insert; fiberglass and foam; and layers of lead, foam, and aluminum (or vinyl foam) sheeting. Most boatowners have found that a material that incorporates a layer of lead is usually the most effective in reducing noise. The classified pages of



These engine beds embody many of the features described in the text.

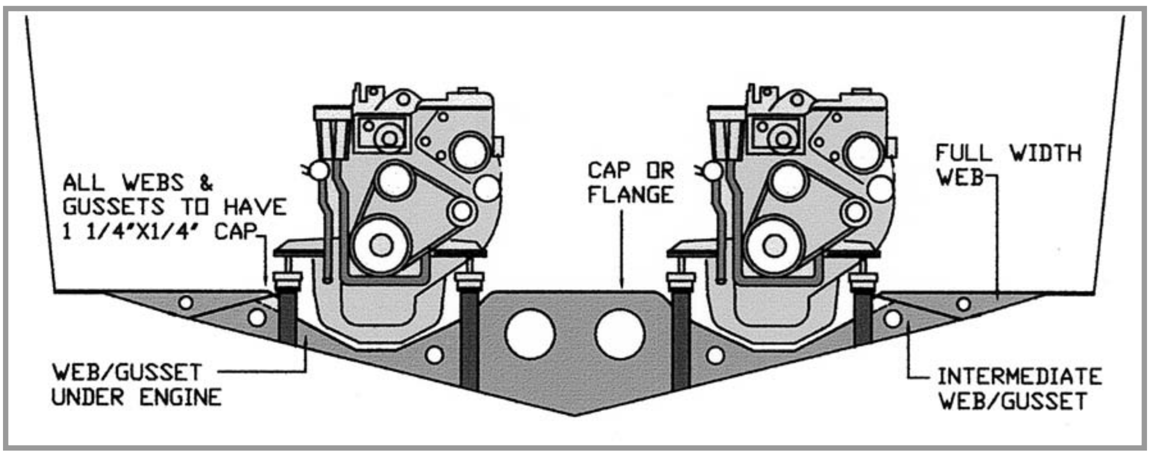
your local boating magazine or the advertising pages of your telephone directory will reveal many sources for these products.

Insulating the engine room in powerboats is relatively easy, as there is usually more room to lay out the insulation without interfering with access to the engine's vital organs. In some powerboats with relatively cavernous engine compartments, it's necessary to insulate the engine separately by having a separate, insulated box around the motor. In a single-engine powerboat, while an insulated sound box reduces the noise to almost a whisper, it does make access to the engine more difficult and it certainly earns its share of rude comments, especially during service checks.

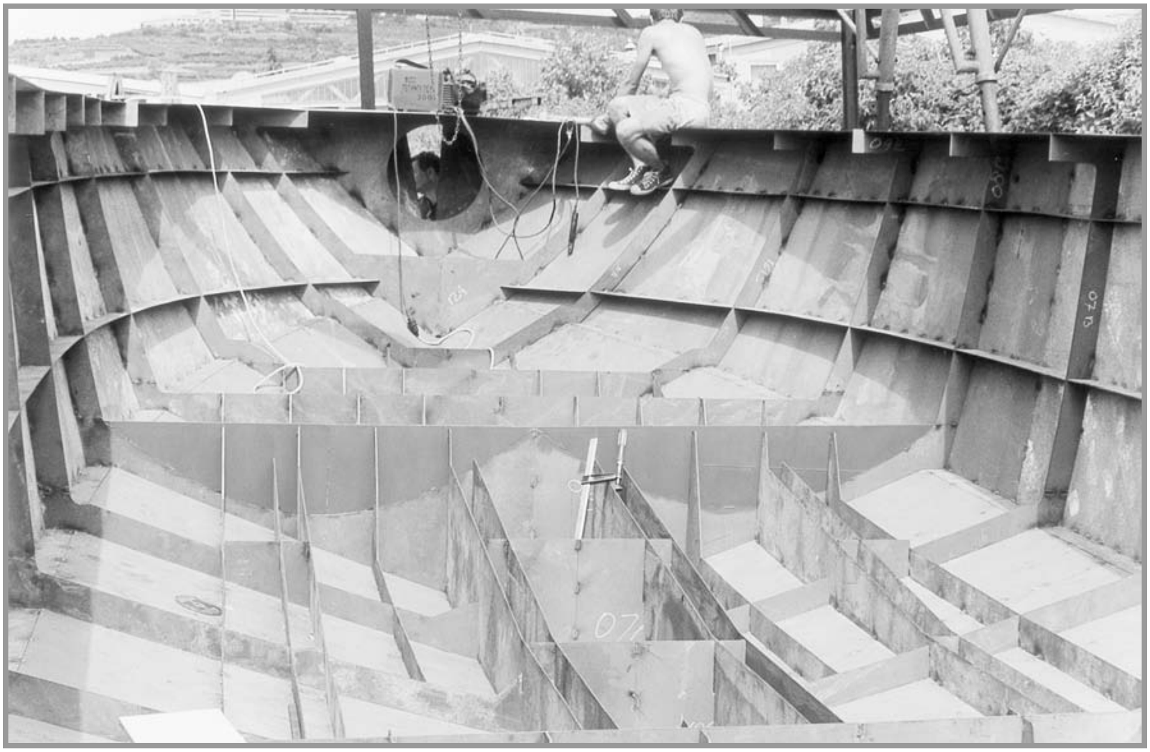
ENGINE BEARERS

The engine bearers, or beds, should be made as long as possible to spread adequately the various loads imposed by the engine. We recommend beds that are two or more times the length of the engine. Space restrictions may defeat this ideal, but make them as long as possible. In our powerboat designs, we always try to mate up the engine bearers with fore-and-aft webs that run almost the full length of the boat. These webs also add strength throughout the hull and have the secondary use of helping to support the sole.

The engine bearers should be made of plate that is two to two-and-a-half times the thickness of the hull plating. Naturally, the exact thickness should be specified in your plans. The size and horsepower of the engine, and its size compared with the hull, will also have to be considered when designing the beds and their supports.



This twin engine-bed arrangement will fit most powerboats over 35 feet (10.67 m) and leave room for fuel tanks outboard of each engine.



The engine bearers in the Almarine-built powerboat kit are precut and only need the tops added to complete the beds.

The transverse web supports in our designs are part of the regular frame web construction sequence, with additional webs added as required by the spacing of the frames. For example, if the frames of the hull are spaced at ten frames to the waterline length, then additional webs will be required between the stations.

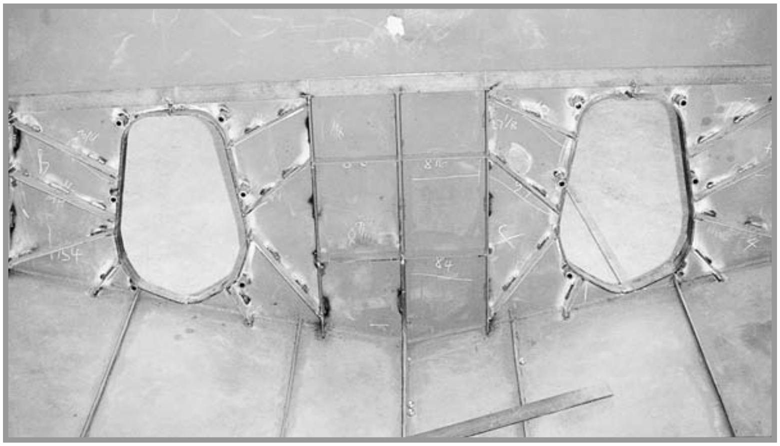
It's difficult to match the height of the beds with the line of the shaft and the stern bearing. If you don't already have the engine on-site, then using a three-dimensional plywood mock-up of the engine can help.

THE DRIVE TRAIN

You must consider the drive train of your engine, from transmission to propeller, to be a single, integrated unit. Most engines have flexible mountings and feature a suitable coupling, such as an Aqua Drive unit to complete the vibration-free installation. The Aqua Drive and similar units allow for slight misalignment between the shaft and the engine transmission. This is a necessary feature because when the engine is mounted on flexible mountings, there will be some movement between the engine coupling and the propeller shaft. Several marine engine manufacturers now have preangled transmission arrangements to allow the engine to be installed in a relatively level way; the shaft angle is allowed for in this arrangement.

Stuffing Box

You'll need some form of gland to prevent the water entering your boat where the propeller shaft passes through the hull. Your main choices will be between a traditional stuffing box and one of the newer devices, such as a Deep Sea Seal. If you choose a stuffing box, it may have an external grease-lubrication system or depend on the natural oils of the stuffing and the water for



This stiffener arrangement was used to beef up the transom when fitting a pair of diesel Volvo sterndrives to a steel Waverunner 342 built in Europe.

lubrication. Grease-fed stuffing boxes usually employ a remote cylinder that you have to pack with waterproof grease. One or two turns on the plunger each day forces enough grease through the line to the bearing; this helps to keep the water at bay. All stuffing boxes (also known as packing glands) will drip twice or so per minute and produce about a cupful of water per day. If they're overtightened, and don't drip, then the bearing and the shaft will probably suffer from excessive wear.

Patented Stern Bearings

Stern bearings, such as the unit marketed as the Deep Sea Seal, have long been used on large ships, but only in the past few years have they been installed in pleasure boats and workboats of all types. The Deep Sea Seal has an excellent reputation and has been fitted to many thousands of boats around the world. The basic DSS has been improved with the addition of an additional red clamp that allows the unit to be serviced while the boat is still afloat The basis of the Deep Sea Seal is a rubber bellows that is fitted with a bearing steel ring that runs on a bearing surface in such a way as to prevent water from entering the hull through the stern tube. The rubber bellows is adjusted to maintain constant pressure on the bearing surface. The unit is lubricated by some of the engine-cooling water being introduced through a spigot on the bearing surface.

The main advantage of installing a Deep Sea Seal–type stern bearing is that it doesn't drip, hence there's one less way for salt water to enter the hull and promote corrosion. Another advantage is that the unit needs only an occasional check to ensure that it's doing its job, as opposed to the constant attention required by the conventional stuffing box bearing.

There are other manufacturers of these devices, and you should investigate the various types, before making your choice.

If your boat has twin engines, it's a sure thing that on many occasions you will want to run on one engine. If your engines are equipped with Deep Sea Seals or similar water-lubricated stern bearings, you should consider the need to supplying water to the bearing of the shutdown engine. The Pedro 41 *Van Hoff*, a custom-built, steel trawler yacht with aluminum decks and superstructure, owned by our friends Mike and Caroline Hofman, is fitted with a cross-over water supply to both Deep Sea Seals. We confess we showed only moderate interest when Mike explained this system. The twin water supply was necessary, because, as with most twin-engine vessels, *Van Hoff* is often operated on one engine for the sake of fuel economy. In light of subsequent events not fully detailed here, we should have taken more notice! There follows a clue!

Even if you have only one engine, consider the possibility of engine failure. Then, when your vessel is towed, do you let the shaft rotate? If so, how do you provide water to the bearing? If the situation persists for more than a short time, unlubricated stern bearings can be damaged. It may even be wise to consider installing shaft-locking devices that are available to suit most size engine-shaft combinations.

Aft Shaft Bearings

Either a Y- or P-bracket is required to support the shaft between the hull and the propeller.

Your boat will require a bearing where the propeller shaft leaves the outer end of the tube. The choice is between a fiber bearing, a Tufnol bearing, and a Cutless rubber bearing. Cutless bearings are well proven and when properly set up with two small water scoops at the fore end of the tube to introduce lubricating water, they will give long and trouble-free service.

If the distance between the inboard stuffing box (or seal) and the outboard end of the tube is over say 6 feet 6 inches (2 m), you may require an intermediate bearing generally known as a plummer block. This may be another Cutless bearing that has been slid down the tube to the midpoint location.

If your shaft protrudes from the tube by more than a few inches, you may need a Y-bracket bearing to support the outer end immediately ahead of the propeller. Decisions as to whether you need an intermediate bearing and similar questions are best addressed to the designer of your boat or a qualified marine engineer.

EXHAUST SYSTEMS

Most diesel engines do not come completely equipped with a suitable exhaust system. In the past, one exception was the range of diesel auxiliaries supplied by Vetus den Ouden. Unfortunately, the engines and equipment are now sold separately. Vetus does have a good range of exhaust systems that are available all over the world.

Diesel engines fitted to sailboats and powerboats will need a properly engineered exhaust system. Engines mounted below the waterline—and most are—will need special antisiphon devices. There are two basic ways to cool an engine and both have a bearing on the type of exhaust system required. Most air-cooled (noisy) engines have a dry-exhaust system, which means that no water is added to the necessarily heavily insulated (lagged) exhaust. In the confines of a sailboat, dry exhausts are hot and noisy but this type of exhaust can be used to good effect in some types of traditional powerboats. Dry exhausts, combined with a vertical stack, are often seen on fishing boats and workboats.

A wet-exhaust system cools the exhaust gases with water soon after they leave the engine. The water and gases are expelled together. This system is necessarily interrelated with the cooling system of your engine. A stainless steel water-lift muffler is a nice addition to any exhaust system and will dampen noise.

Sterndrive engines and outboards have the exhaust systems built in. Outboard engines are beyond the scope of this book, but you may be considering a diesel powered sterndrive for your metal powerboat. Sterndrive exhausts usually exit via the center of the propeller, no doubt adding a minuscule amount of thrust in the process.

COOLING SYSTEMS

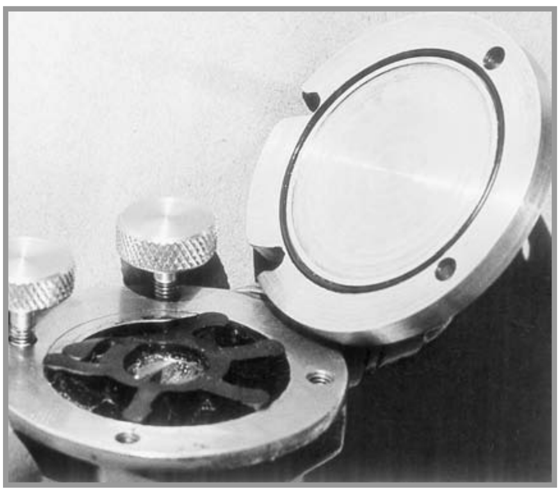
Heat Exchanger Cooling

Most modern diesel engines feature freshwater, heat exchanger cooling. This method uses a special tank of fresh water that runs through the engine's cooling system. The freshwater tank contains internal piping and is, in turn, cooled by seawater pumped through the pipes. This method prevents the internal cooling system of the engine coming into contact with salt water. Most modern diesel engines are cooled in this manner. One problem with this method is that if the outside intake for the cooling water becomes clogged, then the whole system overheats. A sensor in the system can warn you about this condition, before your engine overheats. Make sure each engine is equipped with this warning device.

Raw-water cooling is usually found on older diesels. The method is to pump outside water (seawater or fresh water) through the engine casing and then out through the exhaust, thus cooling the engine in the process.

Engine Water Pump

Most cooling systems include a water pump that draws water from outside the hull and forces it through the cooling system. The pump will include an impeller that will need replacing from time to time. Most water pumps, unfortunately, are located in inaccessible places. Make sure you know where yours is, and check that you have a spare impeller. Also, check the difficulty of removing the impeller and its cover plate. You can buy a special Speedseal cover plate that's attached with only two knurled screws. Because it can be removed and replaced quickly with one hand, you might want to replace your regular water pump cover with one.



This Speedseal cover plate makes changing the impeller a little easier and much faster; it's a handy addition to any engine installation.

Engine Water Filter

If your engine uses water drawn from outside, either directly as raw-water cooling or by way of a heat exchanger, you'll require a water filter to remove any foreign matter that could damage the water-pump impeller or otherwise clog the cooling system, and, in turn, cause the engine to overheat. The usual arrangement is to place the water filter immediately after the seacock where the outside water enters the system.

The filter should be easily accessible, as it should be checked daily—even more often if you're motoring in weed-infested waters. It's often made of clear plastic so you can see what's going on inside, but don't let this discourage you from removing the top for regular inspections. Plastic bags are one of the most common foreign bodies lurking in our waterways and they're not always visible without removing the top of the filter. Most filters have a rubber sealing ring, and you may find that a light coating of Vaseline will prevent the unit from sucking air. In any case, the rings will need replacement every two years or so. If you have a diesel-powered generating set, you should have a separate water filter for it. If possible, place the two filters close together so you can check both at the same time.

Keel Cooling and Similar Methods

There is a third method of cooling that requires no external water to be drawn into the boat. The most common of the self-contained cooling systems involves outside pipes that are usually tucked into the keel-hull intersection. Hot engine water flowing through them is cooled by the surrounding seawater. The most interesting version of this method is only possible with boats that have a hollow metal keel. It involves boxing off a section of the keel to store a 50-50 mixture of antifreeze coolant and fresh water. This mixture is run through the engines' cooling system, and provided that the surface area of the selected portion of the keel is adequate, the system works extremely well. This arrangement employs two header tanks, and works in a manner similar to the way your car's engine cooling system works.

There's another advantage to these engine cooling systems. You can incorporate an insulated hot-water tank, or calorifier. This tank has an internal pipe coil through which hot water from the engine cooling system is circulated. This pipe, in turn, heats the domestic hot water. In the sailboat we owned previously, *K*I*S*S*, we found that running the engine for about 20 minutes every other day was sufficient to provide hot water for two days of showers, plus other daily hot-water requirements.

Any internal cooling system that doesn't import raw water requires a lagged, dry exhaust. Considerable care is required in routing any exhaust line, especially the dry variety, which can get hot despite the lagging. If you have a dry exhaust, pay particular attention to the ventilation of your engine space and the surrounding area. The main negative feature of this arrangement is that dry exhausts are usually noisier than the water-cooled systems.

Mufflers

Many exhaust systems involve the use of a waterlift muffler. The engine cooling water is fed into the exhaust pipe just aft of where it leaves the engine, and then into the muffler, where the pressure of the incoming exhaust gases forces the water out of the boat. This system can be one of the quietest, and quietness in your exhaust system is a very desirable feature.

If you are purchasing a ready-built new or used metal boat, the engine cooling and exhaust systems will already be in place, and usually it's an expensive proposition to change from one system to another. If you're building your own boat, however, you should choose carefully. Check other boats; weigh up the advantages and disadvantages of each system before you make your final decision.

Raw-water cooling (no heat exchanger) is the least desirable because the innards of your engine are constantly exposed to the ravages of salt water or outside water containing all sorts of pollutants. Your choice should be between a system with a regular heat exchanger (using outside water to cool it) and a system that has outside piping to allow keel cooling. Alternatively, you can choose the fully internal system. The fully internal system is similar to keel cooling using external pipes, the difference being that a reservoir of coolant is arranged in a section of the keel instead of outside pipes. This system is not recommended for engines over about 120 hp or for the tropics, where the ousted water temperature would not have enough cooling effect.

No matter which system you choose, remember the advantages of having your hot-water tank (calorifier) as part of the engine cooling system.

SAILBOAT AUXILIARY POWER

You'll want to know whether your cruising boat has sufficient power to do the job. The auxiliary is often undervalued until you need it most. There are many formulas used to ensure it is up to the

ALTERNATIVE POWER

Hydraulic drives, electric drives, jet drives, and the like have no place in a sailboat. Over the past 30-odd years, we've been asked to design every imaginable type of "alternative" power arrangement. After completing many, sometimes long-winded, investigations, we've reached the conclusion that diesel power is the way to go. If you have a particular hobby, such as steam engineering, and you wish to combine this with your boating activity, then there may be an argument for installing an engine that allows you to indulge in your pet interest. But it's worth noting that you'll probably need to remove this unique installation before you sell the boat.

UNDERSTANDING HORSEPOWER

When you're considering horsepower, be aware that there are several terms used to describe the power generated by the engine at certain revolutions. One term you'll encounter is brake horsepower (bhp). This is the power produced by the engine without regard to the power loss caused by the transmission gearbox, or other losses from such items as the alternator, water pump, and general friction in the transmission system. Shaft horsepower (shp), on the other hand, represents the power available at the propeller.

Usually, more than one rating is shown. For instance, there's maximum power. This is the power you could get for a very short time before you burn up the engine. Then there's intermittent power, which is the power the engine can deliver for a limited period—usually 30 to 60 minutes—without problems. Continuous power is the rating at which the engine can operate for long periods without damage. This is the rating that will be of primary interest when you decide what horsepower you need to move your boat at the desired speed. Increasingly, you will find that the power ratings are given in kilowatts (kW). The Système International d'Unités, the overseeing body of the official metric system, gives the conversion as 1 kW = 1.341 hp and the reciprocal = 0.746; 746 watts = 1 hp.

task; for preliminary calculations, we use a power-versus-weight ratio. This calculation will reveal if your sailboat has enough power to propel it in the direction you want to go when, for one reason or another, the sails can't do the job.

We can start with a ballpark calculation and estimate that for any sailboat, 2 hp per 1,000 pounds (454 kg) displacement is a reasonable requirement. The addition or reduction of horsepower from the above calculation will depend on your philosophy. In general, American sailors prefer more power than their European counterparts.

Most inboard engines fitted to sailboats require gearing down by way of a transmission gearbox to produce the power required to drive the vessel in anything but a flat calm. We usually recommend a 2:1 reduction, thus halving the rotation rate of the propeller versus the engine revolutions. You'll find that most manufacturers have a range of reduction options between 1.9:1 and 2.15:1; any one of these can be considered to fall within the 2:1 recommendation. Generally speaking, the larger the reduction, the larger the propeller diameter required. For this reason, it's not practical to install a very small engine that is geared down to say 3:1 or 4:1. The large propeller required would destroy the sailing performance.

Single or twin engines? Unless your sailboat is over 55 feet (16.76 m) long, this is hardly worth discussing. And by over 55 feet, we mean considerably over!

METAL POWERBOAT ENGINES

Because of the variables involved, this is a much more complex subject than powering a sailboat. For want of space, we can only give a brief overview of this subject, but if you're interested in learning more, check out the recommended reading in Appendix 1.

Powering a Displacement Hull

Powering a displacement-hull motor vessel follows much the same rules as those used to calculate the requirements for sailboats. The exception is that while the sailboat has its sails to use in an emergency, the displacement powerboat relies totally on its engine. Most displacement powerboats are fitted with only one main powerplant, so you should select yours with care. To estimate the horsepower requirements, start with an estimate of 2 hp per 1,000 pounds (454 kg) of displacement. This should be taken as the minimum requirement.

You can gear down your engine to give max-

Table 11-1.
Brake horsepower for sailboat auxiliary engines.

This chart reflects data collected by the John Thornycroft Company (UK). The figures represent the various brake horsepower (bhp) requirements for auxiliary engines installed in sailboats. The calculations assume a three-bladed propeller. The bhp quoted is at the engine and allows 15 percent for engine and shaft losses.

Waterline Length	Tons Displ.	5 Knots	6 Knots	7 Knots	8 Knots	9 Knots
25 ft. (7.62 m)	2	5.0	5.0			
	3	6.5	6.5			
	4	8.7	8.7			
	5	12.0	12.0			
30 ft. (9.14 m)	2	1.9	3.6	6.4		
	3	2.5	5.0	9.7		
	4	2.9	6.4	13.0		
	5	3.3	7.7	16.0		
	6	3.5	8.8	19.0		
	8	4.0	11.0	26.0		
40 ft. (12.2 m)	4	2.8	5.2	8.5	13.0	
	6	3.5	7.0	12.0	25.0	
	8	4.0	8.4	15.0	26.0	
	10	4.4	9.9	18.0	33.0	
	12	4.6	11.0	21.0	40.0	
	14	5.0	12.0	24.0	46.0	
	16	5.2	13.0	27.0	53.0	
	18	5.6	14.0	30.0	59.0	
	20	5.9	15.0	33.0	66.0	
50 ft. (15.2 m)	8	4.1	7.2	13.0	19.0	28.0
	10	4.6	7.9	15.0	23.0	35.0
	12	5	8.8	17.0	27.0	42.0
	14	5.3	9.6	20.0	30.0	49.0
	16	5.6	10.0	11.0	34.0	56.0
	18	5.8	11.0	23.0	38.0	63.0
	20	6.0	12.0	25.0	41.0	70.0
	25	6.5	13.0	30.0	50.0	87.0
	30	7.0	14.0	34.0	57.0	105.0

imum performance at lower speeds and reduce the amount of power required to drive your vessel. This option results in a larger-diameter propeller, and there may not be room for it. There are also other disadvantages to taking this minimum-power route; one day you may need extra power to get out of a sticky situation, or tow another vessel. Conversely, a diesel engine likes to be worked moderately hard, so it's not advisable to have an installation where only 50 percent or less of the power can be used without driving the stern down to an unacceptable level. If you want more power, you may wish to consider a semidisplacement hull that can make better use of it.

Powering a Semidisplacement Hull

A fact you must consider is that it takes excessive power to drive a semidisplacement hull faster than 1.5 times the square root of its waterline length. For example, a semidisplacement hull measuring 36 feet (10.97 m) on the waterline would have a square root of 6. So 6 times 1.5 equals 9 knots. A broad definition of planing is when a boat reaches a speed in knots of twice the square root of the waterline length in feet.

Taking the 36 foot (10.97 m) example shown above, the square root of 36, times 2, gives us a 12-knot planing speed; at this speed, the necessary horsepower and fuel requirements will turn a comfortable, economical cruising boat into an expensive proposition. Please note that the formula given is only for the *start* of planing, and to make a semidisplacement hull reach a full (near-level) planing attitude will take considerably more power, and use more fuel than consumed by a similar-sized true planing hull. The point is that it makes no sense to grossly overpower any semidisplacement hull—you'll be just spinning your wheels or, in this case, your propellers. This whole subject will be fully covered in our e-book, *Choosing a Cruising Powerboat*. Go to bruceroberts.com for for details.

Next, we have to consider the weight of our vessel. Weight in this instance means *loaded* displacement. This includes not only the weight of the finished boat but also fuel, water, stores, and crew. In addition, there are all of those items that are brought aboard for a particular use or occasion and then never leave the boat.

Now, there are many kinds of semidisplacement hulls, ranging from a full displacement vessel through to almost a full planing hull. The degree of rise in the chine or buttock lines aft will determine how fast the hull may be driven. Simply put, the more stern there is in the water at rest, the faster the hull may be driven. Overpowering a hull will cause the stern to drop and create a large stern wave. In certain instances, this wave can overwhelm the vessel.

Powering a Planing Hull

Only a few years ago, it was thought impossible to build a successful small-to-medium-sized steel planing hull. Fortunately, modern building techniques and technical advances in design have not only made this possible, but practical as well. As mentioned above, planing occurs when the boat reaches a speed in knots equal to twice the square root of the waterline length in feet. A planing hull will then make the transition from "just about planing" to "full planing" with less fuss, less extra horsepower and less extra fuel than a similarly sized and equipped semidisplacement hull or semiplaning hull.

Aluminum has been used to build hundreds of thousands of small, medium, and large planing hulls. Although at first glance this material may appear to be the ideal metal for a fast hull, we have reservations about this material when used in any type of hull, preferring to recommend it for decks and superstructures. You'll find our thoughts on this material scattered through this book, so it's not necessary to repeat them here.

Now, for those who prefer aluminum: you'll find that the performance of planing hulls relates to *weight* and *power*. Unlike displacement hulls and (to a lesser extent) semidisplacement boats, waterline length plays a smaller part in the performance of a planing hull.

So, in simple terms, the more power and the less weight you have in your planing hull, the faster it will go. Fortunately for designers like us, however, it's not that simple. A well-designed planing hull with modest power will outperform an overpowered, poorly designed vessel.

"Get-You-Home" Engines

Before we consider the subject of single or twin engines, we should touch on the possibility of installing a "wing" engine, or using the diesel that powers the generating set as an emergency arrangement to get you home. Most owners prefer a separate wing engine consisting of a smaller diesel engine set off to one side and equipped with its own shaft and propeller. This engine is generally only required in the case of failure of the main engine, but of course it will need to be run from time to time for maintenance and testing purposes. For obvious reasons, the wing engine is only needed in boats with a single main engine. The wing engine and similar arrangements are often referred to as take-home engines. Some owners have installed an electric drive powered by the gen-set, and have used this as emergency propulsion.

Circumstances have caused us to give this matter considerable thought, and we have recently designed a range of long-distance power cruisers. These vessels are generally referred to as passagemakers and, to be successful, they need a minimum range of 3,000 miles. Some vessels in the 50-foot plus range (more than 15.25 m) can be built to cover up to 6,000 miles without refueling. For various reasons, most of these long-distance vessels are fitted with a single engine, hence the interest in alternative propulsion methods. As a safety factor, both for medium-distance and local cruising, my choice would be for a wing engine.

One or Two Engines?

As mentioned earlier, most displacement-hull vessels are traditionally fitted with a single engine. But many owners have twin installations, and the bulk of them quote safety as the prime reason for taking this route.

We've always maintained that when you install twin engines, as opposed to a single engine of the same total horsepower, you'll lose 20 percent in total output. More recently, we've decided that the effective loss of power may be even higher. Other examples show that the additional fuel consumption of the second engine is not justified by the small increase in performance when the two engines are used.

If you're considering a new boat, and you're considering twin engines in the interests of safety, you should be aware that in the interests of economy you might be operating only one engine for much of the time. You would be well advised to lay out your engines and systems with the above facts in mind. Owners who regularly take this course use each engine alternately on a four-hourly or daily basis.

PROPELLERS

It would be convenient if we could buy a propeller to match our hull material. Builders using copper-nickel are fortunate; the bronze propellers that are readily available are a close relative to the hull material, so the interaction between different metals that causes corrosion is at least reduced. Steel, or cast-steel, propellers are very difficult to obtain, so steel boat owners are forced to use the bronze versions, or to join their aluminum-boat-owning friends and opt for an expensive stainless steel "wheel." So there you have it: steel boat, bronze propeller; copper-nickel boat, nickel-aluminum-bronze propeller (must be more noble than the copper-nickel hull); aluminum boat, stainless steel propeller.

Propeller nomenclature is simple, but choosing the correct size and pitch of the wheel is somewhat more difficult. The *diameter* refers to the size of the circle scribed by the tips of the propeller blades. The *pitch* is the distance the propeller would travel in one full revolution if it were rotating in a solid. *RPM* refers to the revolutions that the shaft achieves in one minute; this figure is usually a factor of the engine rpm, but due to the transmission reduction (1.5:1, 2:1 and so forth) the shaft rpm will be different from the engine rpm. When calculating propeller sizes, it's the shaft rpm that is important. The *slip* refers to the loss of forward motion due to the fact that the propeller is rotating in a liquid, not a solid. Slip is the theoretical difference between what a propeller of a given pitch would travel, and what it actually is expected to achieve, usually expressed as a percentage. The *pitch ratio* is figured by dividing the pitch by the diameter. Fast powerboats sometimes have a diameter and pitch of the same number; this is referred to as a "square wheel."

Propellers for Powerboats

In powerboats, you'll want to install the most efficient propellers that will allow the engine to reach its operating and top rpm when required. In some designs, the propeller aperture is not sufficiently large enough to allow the correct propeller to be installed, and in this case a change from a three-bladed to a four-bladed wheel may prove successful. If you're experiencing cavitation because the tip clearance is too small, or because of the shape of your particular hull, then a change to four blades or even five blades may remedy the situation. You may need to discuss your particular problems with both the designer of your boat and the propeller manufacturer or supplier.

The design and matching of a propeller to the hull, engine, and reduction ratio is something of an occult art. As designers, we do our best, but even the most detailed calculations can result in a propeller match that can be improved during trials conducted over a variety of conditions. You can also contact one of the many well-known propeller manufacturers in the United States, Australia, the UK, and elsewhere. They will usually be most helpful. If you have a propeller problem, don't disregard it; seek assistance as required.

Propellers for Sailboats

The most efficient propeller from a sailing point of view is the two-bladed folding variety. Two blades mean a larger diameter, and this can cause problems where space is restricted. These may be considered if you're building a high-performance metal sailboat. Some of these two-bladed folding propellers are inefficient and others have a reputation for not always opening on demand, which could be disastrous. If you do decide to choose a two-bladed type, make sure you are able to get a first-hand recommendation from another person who has already had experience with the brand you favor.

The elimination of drag is the aim of every sailboat owner. One way around the problem is to use a *feathering* propeller. These units are complex and expensive. Finely engineered feathering propellers may be suitable for larger yachts, where the owners have the resources to cover the initial expense and possible high maintenance costs. Unless you have very deep pockets, you're best advised to accept a small loss of speed under sail and select a *fixed* three-bladed wheel.

Rope Cutters

These devices are mentioned here because they may require a slightly longer shaft to be fitted. Suitable for both sailboats and powerboats, rope cutters are designed to be clamped on your shaft just ahead of the propeller. They can be very effective in cutting rope or a similar obstruction that would otherwise foul your propeller.

FUEL FILTERS

Does your engine have a separate primary fuel filter? Not all boatbuilders or manufacturers supply or fit these essential items as standard. The fuel filter that comes with the engine is basically a secondary filter, so at least one good primary fuel filter that incorporates a water trap is needed between the fuel tank and the engine. The filter should have the capacity to handle a considerable amount of dirt and water. Twin primary filters can be arranged so one can continue while the other is unclogged or changed. The installation of twin primary fuel filters should be a serious consideration even in single-engine craft.

Filters with glass bowls have pros and cons. The sealed-filter units have expensive cartridges that need to be replaced completely, rather than simply replacing the internal filter. A major advantage of glass is that one can quickly observe if water is present. However, the glass-bowl filters are now outlawed in Europe for all boats and in the United States in gas-powered vessels, the argument being that in case of fire they present an additional danger.

Recently, we met the owner of a motor cruiser, a Dutch-built steel vessel of 34 feet (10.36 m), who got into trouble because of the glass bowl. This fellow, an experienced boater, was alone off the Spanish coast, near Barcelona, motoring along in heavy seas, when his single engine stopped. Upon investigation, he found that the glass bowl on the primary fuel filter had shattered. This had allowed diesel fuel to spray in all directions—and of course the engine stopped for lack of fuel. Fortunately, there was no fire. No replacement bowl was available and the engine was too hot, and the motion too violent, to allow the owner to deal with the situation. He was forced to swallow his pride and call out the Spanish Coast Guard, who responded promptly. Within an hour, the disabled vessel was safely in port. The owner believes he overtightened the glass bowl on the filter and when it expanded, due to the heat from the engine, it shattered. There are two lessons here: reconsider the use of glass-bowl filters, and don't overtighten them.

You'll need to change the filters at regular intervals. In the case of a fuel blockage, you'll need to change them as required. This is a very messy job and is one area of boat maintenance that you must understand. You should practice preventive maintenance wherever possible. When you're reassembling filter units, make sure you have the sealing O-rings in the correct order and position; sometimes the top and bottom rings look similar but are different enough to allow fuel or oil to leak out when the engine is fired up. Start the engine with caution after servicing these items.

VENTILATION

In all boats, ventilation of the engine space is an important feature. Your engine needs a considerable amount of fresh air. Install two vents of adequate size, one ducted below the engine to bring the fresh air in, and the other ducted high up in the engine space to take the hot air out. Generally, a blower is not required in northern latitudes. In hot climates, however, you may need one to turn the air over at the correct rate. An engine-space blower is simply a ducted fan that is designed to either import or export larger quantities of air than would circulate naturally.

INSTRUMENT PANELS

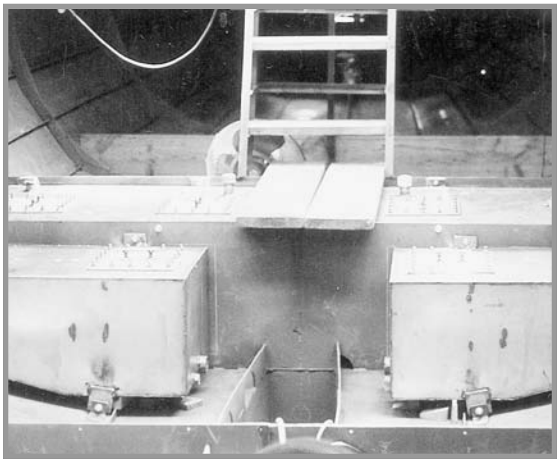
Your engine will usually be equipped with an instrument panel, but you may want to add to the instruments supplied in the standard package. The minimum engine instrumentation should include a tachometer (revolution counter), an engine-hour meter, a fuel gauge (notoriously inaccurate in boat installations; have a dipstick handy), and a volt/ampere meter. Regarding fuel gauges, we have always preferred a sight-glass gauge that is attached to the fuel tank and allows the level of fuel to be seen at a glance. For two reasons this feature may not be available to you; in some areas they are illegal (fire hazard) and if your tank in hidden from view then a sight gauge would be impractical. You'll require an instrument light switch, including a dimmer control for night use, an audible alarm to indicate if you fail to switch off the ignition after the engine has been stopped, an engine stop control, and a water-temperature gauge. Warning lights and or buzzers may indicate some potential problems; in our opinion, warning lights are not as effective as proper gauges. Audible alarms are recommended for water temperature, alternator output, and the other vital life signs. Your electrical panel, complete with fuses, is usually located in a separate box; however, in some boats with inside steering, it may be incorporated in the main panel.

BILGE PUMPS

Take some time planning and laying out your bilge-pumping systems. Bilge pumps can be driven manually, electrically, or mechanically. Usually, the first line of defense is the automatic, electrically powered unit situated in the lowest point of the bilge. This bilge pump should be fitted with a strum box. This is a special perforated box, or strainer, fitted over the end of the bilge pump hose that is installed low in the bilge. If you have an automatic shower pumpout system, this can double as another bilge pump. The shower and toilet pumps will often be located in a different compartment to the main unit.

You'll need at least one, preferably two, hand-operated bilge pumps and one of these should be a large-capacity, portable unit mounted on a board, thus allowing it to be operated in any part of the vessel. The Edson 18 and the Whale Titan are both excellent hand-operated pumps.

You'll also need to arrange a sump or suitable collection point for bilge water. This sump is usually under, or nearly under, the engine so that any spilt diesel fuel and other unwanted liquids can be pumped or sponged out. A hand-operated bilge pump with a hose attached is useful in this area so that you can pump any contaminated water into a separate container for proper disposal ashore. U.S. federal law prohibits the pumping of oily bilge water directly into the surrounding water. For instance, in Florida a heavy fine can be the result of pumping even the smallest amounts of polluted water into the local canals. Any bilge pumps located in the sump or elsewhere should be fitted with a strainer. In the event of any large particles being present, you need to ensure that they will not find their way into, and totally block, the pump.



These tanks were fabricated and tested outside the hull and then installed as shown. As it is usually impossible to remove tanks without destroying interior joinery, you must make sure that your tanks are thoroughly tested before installation.

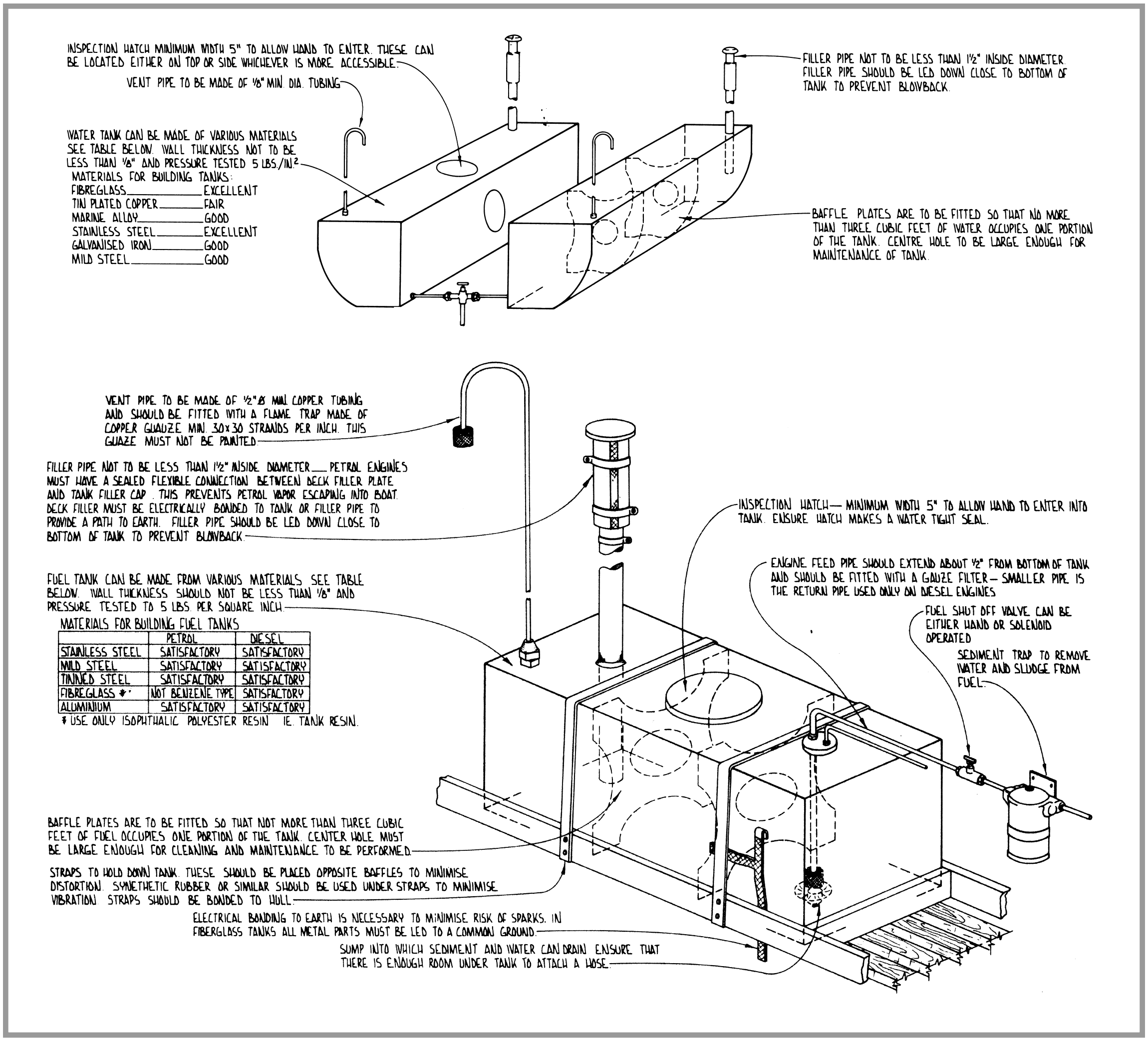
Tanks can be neatly arranged under the sole. Note the inspection and cleaning hatches in the tank tops.

FUEL TANKS

Aluminum is often used for fuel tanks, but there have been many problems. Aluminum tanks are susceptible to vibration and can fracture along the weld lines where baffles are attached inside. If you do use aluminum for tanks, make sure they are made from a high-magnesium alloy such as 5083 or 5086 specification. It may be better to consider tanks made of, or molded from, polypropylene.

Aluminum and steel tanks are sometimes built with the hull acting as one side of the tank. It's preferable to have the tanks built as a separate unit and tested before installation in the boat, because this will ensure that there are no leaks. Air pressure of about 3 pounds per square inch (psi) can be used to test the tanks. *On no account simply connect the tanks to a high-pressure air hose.* You may cause the tank to explode. Because of the risk of explosion, some experts recommend hydrostatic testing rather than the air test mentioned above.

Diesel fuel tanks may be built from a variety of materials, including high-density polyethylene, stainless steel, aluminum, or mild steel. Most builders choose regular mild steel. This material has the advantage of low cost, ease of fabrication, and low maintenance. The diesel fuel inside the tank prevents interior corrosion, and provided you keep the outside well painted, your steel fuel tanks should give you long service.



Your tanks should embody all of the features in these sketches. See the text.

Tank capacity is a contentious subject. Most designers specify small, easy-to-remove tanks. The builder wants large tanks so he can offer a cruising range greater than the competition. The owner often requests an *enormous* cruising range under power. Keep your tanks to a reasonable size; remember that diesel fuel gets stale; and it is subject to attack by various bugs when not changed on a regular basis.

All tanks should be fitted with inspection hatches and be capable of being cleaned through these openings. Fuel is drawn off by way of a pipe that enters the tank from the top and extends to within 1 inch (25 mm) of the bottom. Arrange the tank and fuel line so that any sludge will collect below the drawing-off line. A drain cock from the bottom of the tanks will allow you to flush out the tank. In the United States, these drains are not legal. Outside the United States, check local regulations before fitting the bottom drain. All tanks will need breather pipes—see the illustration on page XXX for these and other details. If you are purchasing a used or new production boat, your tanks may not meet all the criteria outlined in this chapter, and they may need attention in one or more areas that we have already mentioned.

If you're installing new tanks, or replacing old ones, choose tanks that give you a sensible cruising range. If you plan to have a diesel-powered generating set, a diesel cooking stove, and/or a diesel-powered heating system, take the usage of these items into your calculations. Remember that to avoid condensation and to minimize the chance of bugs infecting your fuel, you should keep your fuel tanks topped up whenever possible. In any case, it doesn't make sense to be carrying excessive weight in the form of too much diesel fuel. So the size of your fuel tanks is important. Large is not always the answer.

Sailboat owners should make careful calculations of their requirements. Armed with the knowledge that you will need to use the engine for a percentage of the time, allow for this and then add the other uses, such as diesel heating. Now decide on the size of your fuel tanks.

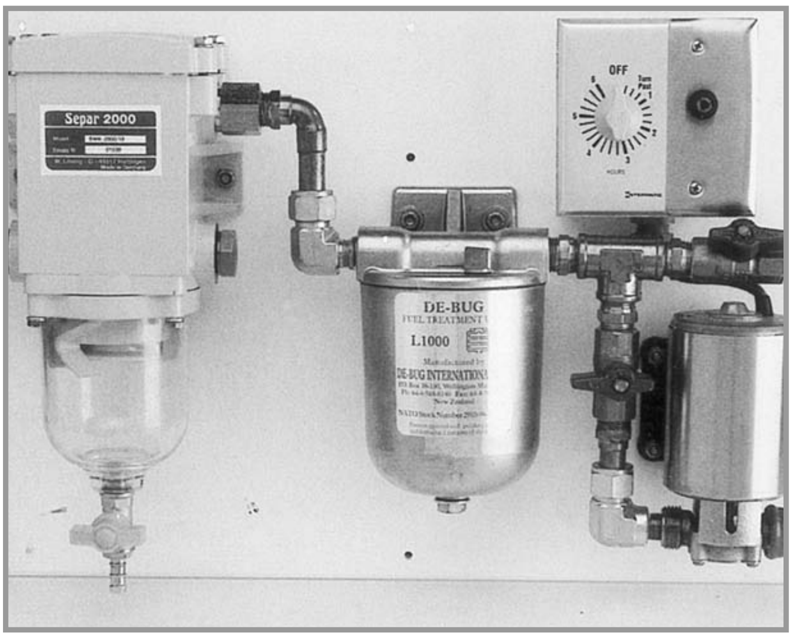
No matter what type of material you choose for the fuel tanks (or any other tanks), make sure they're firmly anchored in place. The thought of a loose tank, full or otherwise, charging about the boat in a rough seaway, should be enough to make you check all tank supports and containment arrangements very carefully.

MICROORGANISM CONTAMINATION

All diesel fuel systems can be contaminated by microorganisms. Neglected or unprepared fuel systems will continue to provide life support to these pests once they are introduced into the system. Problems show up in shortened fuel life, clogged fuel lines, and increasingly corroded fuel system components, including the tanks.

The degree to which microorganisms grow and prosper in the fuel system is relative to how fast the fuel is used up. Boats with small fuel tanks or with high-horsepower engines are less likely to have this problem. For several reasons already covered, cruising sailboats tend to have larger tanks and keep the fuel longer.

If you leave your boat for extended periods without making sure that the fuel tanks are totally full, then you run the risk of allowing microorganisms, or "fuel bugs," to breed in the tank. Partially empty tanks allow water to condense there, and the least effect of this is that your water trap and fuel filter will be working overtime. These bugs—in the form of algae, bacteria, yeast, mold, and fungi—all thrive when water is present. All owners and operators of diesel engines face this problem, no matter where the engines are located or what type of transport the engines are installed in. Boats used and laid up in warmer climates are most susceptible to the bug but



A fuel recirculation system is an effective solution to maintaining onboard fuel. The unit pictured is the ESI-Clean Fuel System.

many cases have occurred in the UK and colder parts of the United States, so this problem is not confined to tropical areas.

To eliminate bugs from your fuel, you need to understand how they breed. The various microorganisms need water to survive, since they live at the interface between the water and the diesel fuel, and they use the fuel as a food source. Diesel contains carbon, hydrogen, and dissolved oxygen, so it's a good source of nutrition for the bugs.

Once you've removed water from the system, you still need to take preventive measures against microbial growth. In a marine environment moisture is always present, and diesel bugs can grow quite rapidly. They can be present in the air, or in fuel taken aboard after you thought you had cured the problem. Some bacteria can grow into a mass many times their original size in just 24 hours. Other types can corrode fuel systems without being so obvious. They may show up as black grit, resembling coffee grounds, either in the filter, or, if you still have one, in the water-separator sight bowl.

Biocides

If you purchase a boat that hasn't been used for some time, you'd be wise to remove all the existing fuel from the tanks and have them flushed out and filled with fresh fuel. If you're in doubt about the cleanliness of the existing fuel, or if you're refilling after flushing out the tanks, you should add a biocide to your fuel. This will ensure that any remaining bugs are destroyed before they multiply and clog your fuel system at some inappropriate moment.

There are many brands of biocides available and they have one major factor in common. They are all expensive, usually costing around $25 (£15) for an amount sufficient to treat a 150-gallon (680 L) fuel tank. Another shared feature is that they are all composed of highly toxic chemicals; so highly concentrated, in fact, that they need to be handled with utmost care. It's as well to keep in mind that over time biocides lose their effectiveness and have to be replenished. If you have a bad case of the bug, don't be afraid to give your fuel tank a double dose of biocides. Select a safe storage method and wear disposable rubber gloves when handling biocides. Needless to say, keep these chemicals well away from children.

Water Dispersants

These additives are only successful when you use them as a preventive, rather than as a cure. The biocides should be used if your tank is already infected with the bug. Water dispersants are designed to absorb water into the fuel and in this way remove it before the fuel reaches the filters. Before using these additives, you must first drain as much water as possible. There are other benefits claimed for these products, including the fact that they inhibit separation of the waxes and gums that are present in diesel fuels. Only use dispersants if you have minor water problems or as a preventive method.

Enzyme Treatments

Having tried several methods to cure the chronic attack of "diesel bug" that attacked the diesel fuel in one of my own steel boats, I finally tried an additive called Soltron. This product was developed in Japan, but my supplies came from the UK. After three treatments, my diesel fuel system was finally free of the bug that had clogged my filters on several occasions. Soltron is a clear, enzyme-based liquid, and about half a pint treats 660 gallons. An Internet searchshould locate a source near you (www.soltron.co.uk in the UK and www.solpower.com in the U.S.).

Microorganism Fuel Filters

The system as described here is best used as part of your overall fuel-scrubbing system. Since not all diesel fuel sold at the various waterside filling stations is equal, it's possible to introduce unwanted additives to your fuel tanks just by filling up at an unknown fuel dock. This can be especially troublesome overseas. The best solution to this problem is to have a system in which all the fuel is cleaned before it reaches the main engine filters.

The De-Bug filter is part of an overall fuel-filtering and scrubbing system marketed by the manufacturer. The De-Bug filter doesn't only kill the diesel bug, it also gets rid of the bodies. Those of you who plan to operate your boats under conditions where the fuel bug is likely to be an ongoing problem may want to consider a more positive solution to microorganism growth. Developed over 10 years ago in New Zealand, the De-Bug Fuel Decontamination unit uses patented and unique "multi magnet" technology to kill microorganisms. When it's correctly sized to the fuel flow of the particular engine installation, this unit kills 97 percent of the bugs in a single pass.

The De-Bug filter produces magnetic fields from ceramic-coated magnets. They destroy the microorganisms as they flow through the filter. This unit is a one-time installation; it has no moving parts and no electrical power is required. Replacement filters are not necessary and the only maintenance required is an occasional cleaning. Unlike the chemical biocides, the dead bacteria cells are destroyed in a way that does not result in a messy residue that will clog filters.

The De-Bug filter comes in various sizes and has been used in all types of diesel-powered applications, both ashore and afloat. The smaller unit is capable of handling up to 35 gallons (160 L) per hour. Larger sizes of this unit can handle amounts ranging from 265 gallons (1 kL) to 5,000 gallons (18.925 kL) per hour, and remembering that a 97 percent bug kill is claimed, this is one of the most efficient pieces of equipment you could add to your boat. Do you need it? We do, after the experience of losing engine power in a rather embarrassing situation—and all due to "the bug." Our boat is now fitted with this device.

SPARE PARTS, TOOLS, AND MATERIALS

The field of spares alone covers a multitude of possible items. Add some construction materials, and you can see that a large number of items could be assembled under this heading. Perhaps this is a good time to review those items that you have already decided to install, and to decide if you really need them. Now consider how likely they are to need spare parts in order to remain in service.

You'll need to carry an adequate number of spares for your engine, of course. For instance, you must have at least two replacement sets for each filter installed on your boat. If you have more than one type of filter, then you need two spare filters for each one. Filters clog up at the most inopportune moments. Usually, one set of spares is just not enough. Don't forget the spare oil filters. While they're not needed as often as fuel filters are, they're required at regular intervals.

Hoses, cooling fan belts, alternator belts, impellers; the list goes on. Ask your engine supplier to suggest a complete list covering your expected requirements. Most manufacturers have recommended lists for local, coastal, and offshore cruising. Look over these lists and choose the one most appropriate for your needs.

On the subject of marine engine manufacturers, the word "manufacturer" is misleading. Most marine engines are assembled or "marinized" from another manufacturers' basic engines. Many of the filters, fan belts, and other consumable spare parts are available at less cost when some other manufacturer supplies them. The engine manufacturers naturally discourage you from obtaining these outside-sourced spares. You'll need to decide for yourself whether to buy and use these less expensive, unofficial spare parts.

CHAPTER 11.

Sailboat ELECTRICS

Glossary. Electrical installations. Domestic Batteries. Engine starting batteries. Battery chargers. Generating sets. Testing devices. Solar panels. Wind generators. Inverters

Before we start to discuss your boats electrical system here is a glossary of terms that apply to this subject; usually these lists are located in appendices in the back of most books however I feel they will be of more use to you here.

AC (alternating current) = 220 or 240 Volt (UK, Europe, Australia etc.) or 120 volt (North America) household power, shore power and also is the type of power *usually* supplied by your generating set. Some Generating sets can supply 12 volt DC power, more on that later.
Ampere or amp or A = The unit of measure of flow rate of current through a circuit.
Ampere-hour or Amp hour or AH = A unit of measure of the battery's electrical storage capacity, obtained by multiplying the current in amperes by the time in hours of the discharge.
AWG = American wire gauge.
AH Capacity = The ability of a fully charged battery to deliver a specified amount of electricity at a given rate for a definite period of time. This number may give a false impression because you can not use all of the AH or you will flatten the battery, and the AH capacity of any battery will vary with age and condition, see later in chapter.
Circuit = An electric circuit is the path of an electric current; a closed circuit has a complete path and an open circuit has a broken or disconnected path.
Current = The rate of flow that is best described by comparing it to a stream of water; the unit of measure is an ampere.
Cycle = One discharge plus one recharge is one battery cycle.
Dip Switch = A series of small switches used for alternate programming in all types of electrical and electronic devices.
Direct current. DC = Power that is stored in any battery or supplied by an alternator or a 12V battery charger.
Discharge or discharging = When a battery is delivering current it is said to be discharging.
Equalize charge = A controlled overcharge of the batteries which brings all cells up to the same voltage.
Gel cell battery = A type of battery, it has the electrolyte in gel form.
Ground = Used in automobiles when the negative battery cable is attached to the body or frame of the car, not recommended or generally used in boats.
ISO = This is a European standard of wire sizes quoted in cross sectional area mm2
LED = Light emitting diode, often used as an indicator light.
Negative = The negative terminal is the point from which electrons flow during discharge.
Ni-cad battery = Nickel cadmium battery, rechargeable and used in small appliances, larger varieties are too expensive for most boats.
Ohm = A unit for measuring electrical resistance.
Positive = opposite to negative.
Volt = The unit of measure for electric potential.
Watt = The unit for measuring electrical power, a measure of the amount of power.

This system is one part of your cruising boat that unless you are well versed in the subject, you should seek professional help in either fitting or surveying your boats electrical installations.

A boat is one of the worst environments for operating electrical appliances. In today's world we are adding more and more of these items to our boats. It is advisable to make an early decision regarding your philosophy regarding just how many electrical items you have in your boat. A good rule is, the more extended your voyaging the fewer electrical items you are likely to be able to successfully maintain under cruising conditions. Look at it this way, operating electrical appliances takes power, the more long distance sailing you plan the less motoring you may be doing and the less power generated by your alternator. The further you are from home the more expensive are repairs and maintenance of your electrical items.

Now having made the above statement, I have to admit that many cruising sailors spend a considerable amount of time either under power or motor sailing. Certain areas of the world seem to dictate that more time is spent motor sailing than others. If you observe sail boats seen in the Mediterranean, many are under power or at least motor sailing. Chester and Norma Lemon told me that they were obliged to motor sail or motor for about 50% of the time during their 50,000 mile cruise in their well equipped sailboat *Honeymead* .
If your cruising is local or coastal in nature and your boat is large enough then you will most likely want to consider having all the same goodies on board that you use at home; I have nothing against modern electrical appliances and labour saving devices; it is just that they may not mix well with the practicalities of *long distance* cruising.

Before you decide on how you are going to satisfy your waterborne electrical requirement, you must decide exactly what appliances and other electrically driven devices you are going to install in your boat. The easiest and best way is to take the worst case power draw, and make estimates from the literature or better still the nameplates of the appliances you are planning or have already installed. Make an estimate of how many of these items are running at any one time and take 100% of this total; now select a power source, generating set, solar panels, wind generator or other alternative that will supply at least 80% of the total load. As generating sets

There are two simple equations that you should write in your log and learn by heart:

$$\text{Volts} \times \text{Amps} = \text{Watts}$$

and

$$\text{Watts} \div \text{Volts} = \text{Amps}$$

OHM'S LAW

As you become more involved in studying your boat's electrical system, you may wish to refer to these formulas:

voltage	$E = I \times R$ or $E = P/I$
current	$I = E/R$ or $I = P/E$
resistance	$R = E/I$ or $R = E2/P$ or $R = P/I2$
power	$P = E \times I$ or $P = I2 \times R$ or $E2/R$

E = VOLTAGE in volts
I = CURRENT in amps
R = RESISTANCE in ohms

Because electrics will play a large part in owning and operating your metal boat, you must learn all you can about this subject. Unless you become well versed in marine electrics, you will need to seek professional help in either fitting or surveying your boat's electrical installations. Whenever you're required to seek professional assistance, look over the shoulder of the technician so that you can learn to make a similar installation or repair yourself. To increase your understanding of all of these items, make sure you're around when the experts are working on your electrical system. You can gain as much from asking questions and absorbing knowledge as you can from having the work performed on your boat. This advice extends to any area where you need to employ outside labor.

Make an early decision regarding how many electrical items you're going to install. If your cruising is local or coastal in nature, and your boat is large enough, you'll most likely want to consider having all the same goodies on board that you use at home. Metal boats intended for long-distance voyaging may benefit from an electrical system that's simpler and easier to maintain.

Before you decide on how you are going to satisfy your metal boat's electrical requirements, you must decide how many appliances and other electrically driven devices you're going to install. Take the worst-case power requirements and make estimates from the literature or the nameplates of the appliances. Estimate how many of these items will be running at one time. Now select the power sources you plan to install, such as alternators, generating sets, solar panels, wind generators, or other alternatives that will supply the total load. You should be aware that generating sets prefer to be run with loads of at least 40 percent (and up to 75 percent) of their capacity, so you may be forced to actually waste electricity if you overestimate your requirements.

BATTERIES

We're referring here to lead-acid, wet-cell batteries. Later in this section, we outline some of the claims made for gel-cell batteries. You can choose either type with the knowledge that 50 percent of the battery "experts" will agree with your choice.

In Europe, batteries are sized by quoting amp-hours and in the United States the size may be quoted as a "group" or a "D" followed by a number. As the numbers are not always consistent between manufacturers, you should inquire further to establish the actual storage capacity of the particular battery in amp-hours.

A few examples of the U.S. system of denoting capacity are as follows:

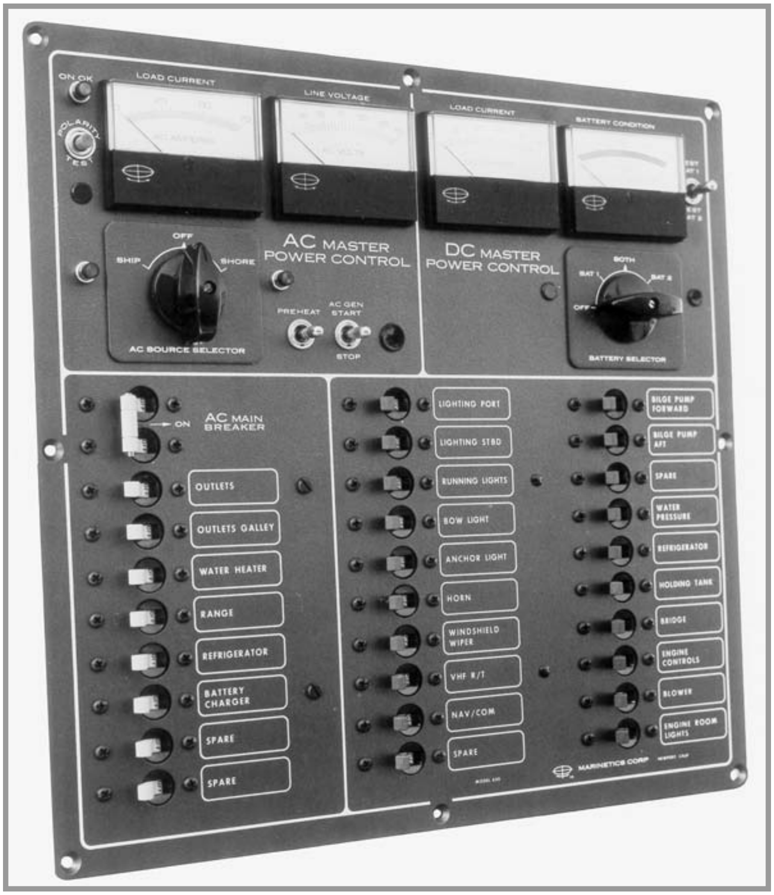
Group 24 = 70 to 85 amp-hours; Group 27 = 85 to 105 amp-hours; 4D = 160 to 180 amp-hours; 8D = 210 to 225 amp-hours. A 6-volt golf cart battery is usually 180 to 215 amp-hours.

It's sometimes hard to remember in what order to connect and disconnect the battery terminals. The negative terminal is removed first and connected last.

Traditionally, the batteries have been divided into two or more banks, one for starting the engine and one or more for everything else. As batteries have become more reliable, there are some battery experts who argue that it's no longer necessary to divide the battery banks into domestic and starting units. If you have a generating set with its own starting battery, you can fire it up to charge batteries and start the main engine. In a worst-case scenario, you may be able to use a set of jumper cables to connect the generating set's battery to start the main engine. Considering the last option, it may be worthwhile to include a larger-than-normal battery for use with the gen-set.

If you're planning long-distance offshore voyaging, versus local coastal cruising, your electrical requirements (and especially the methods of satisfying those needs) will be different. When you're coastal cruising you'll often have access to shore power; this allows you to conserve your battery power and enables you to top off your batteries using your battery charger.

You'll most likely have more than one battery for domestic use. When this is the case, the installation is called a battery bank. It's preferable that all of the separate batteries in the bank



A suitable main panel is required when laying out your electrical system. This Marinetics model is thoughtfully arranged and would suit many builders.

are of the same amp-hour capacity, or at least similar capacities. If the sizes vary, then the smallest battery may control the system and can halt the charging process when it's fully charged; this can often occur well before its larger companions have reached full capacity.

Generally speaking, sailboats need fewer batteries than equivalent-sized powerboats do. Below are estimates for sailboats. For powerboats, add at least 50 percent to the suggested capacity. These estimates are not recommendations of actual amp-hour requirements but rather an indication of the numbers involved. If you're planning to carry the appliances that many consider as necessities, then you can use these figures as a starting point. Based on sailboat length and assuming there's a crew of two to four people, you're most likely to require the following domestic battery amp-hour storage capacity:

Boat Size	Amp-Hour Needs
28 feet (8.53 m)	150 to 250
35 feet (10.67 m)	400 to 600
45 feet (13.72 m)	800 to 1,000
55 feet (16.76 m)	1,200 to 1,500
65 feet (19.81 m)	1,500 to 2,000

The connections between separate batteries are made in series or in parallel. Connecting batteries in series is done to increase the voltage, for instance if you connect two 12-volt batteries in series you will achieve 24 volts, not recommended on a 12-volt system! To connect two 12-volt batteries in series to achieve 24 volts, connect the positive pole number on one battery to the ship's systems, and connect the negative pole on the number 1 battery to the positive pole on number 2 battery the negative pole in the number 2 battery is connected to the ship's system, thus completing the 24-volt system. The same rules apply to connect two 6-volt batteries to achieve a 12-volt system.

Connecting batteries in parallel is done to expand the amp-hour capacity of a system; the voltage remains the same, but the system has access to additional amp-hours. To connect two or more batteries in parallel, connect the batteries positive to positive and negative to negative, then attach leads to negative pole on one battery and lead to system and one lead to positive pole on the same battery and to the system.

If you require large battery capacity, there's a sensible limit to the size of each individual battery. Unfortunately, in the case of large capacities it's seldom possible to keep each individual unit to a size easily handled by one person, so give this matter consideration when arranging your batteries. If you have more than one 12-volt battery, and you want to create a bank of batteries, then you would connect these batteries in parallel so they remain and act as one 12-volt battery of larger capacity. If you want to create a 24-volt battery (often used on larger pleasure boats and many commercial boats), then you can connect two 12-volt batteries in series, or four 6-volt batteries in series. Golf cart or similar deep-cycle, heavy-duty batteries are often available in 6-volt sizes and are becoming more widely used to make up large battery banks where large amp-hour capacities (for example, 2,000 amp-hours) are required. Most boats will have a number of 12-volt batteries connected in parallel to make up their 12-volt domestic battery bank.

Remember that you must balance your battery capacity against your power usage. It takes considerably longer to put back the amperage than to take it out. Batteries do not accept a charge at the same speed as they can discharge.

Deep-Cycle Versus Starting Batteries

The batteries you choose for domestic storage should be the deep-cycle variety. These batteries are constructed differently from those used for engine starting. Deep-cycle batteries are designed and built to accept a moderate load over an extended period. The plates are thicker, the cases are usually heavier, and they are better equipped to accept regular discharges of up to 50 percent and then be recharged on a regular cycling basis.

The construction of the starting battery is different from that of the deep-cycle type. The plates are thinner, and they're designed to release high power in short bursts. Once the engine is running, the charge from the alternator quickly replenishes the battery.

This is one reason why, when you check your engine-start battery, you'll often find that it's fully charged. In fact, you must be careful not to overcharge it even though your regulator is designed to prevent this happening. Because this battery seldom gives trouble, it's sometimes neglected. Make sure you regularly check the level of the water (electrolyte), the voltage level, and the general condition of the battery.

In the past, it's always been a rule that the engine-starting battery should be capable of being totally isolated. One reason is that you may want to leave the domestic battery system switched on to power an automatic bilge pump, alarm, or similar device. In some cases, you may wish to wire bilge pumps and alarms directly to the battery, so they are not accidentally turned off when you leave the boat.

Be aware that any 12-volt battery in operational condition will actually have a voltage higher than 12. If you're using a voltmeter, and you take a reading soon after you've stopped charging, your meter will most likely register more than 13 volts. After a few hours (without any discharge due to usage) your battery will read 12.8 volts if it's fully charged and somewhat less if it has not reached full capacity. A battery that reads 12.2 volts is 50 percent discharged. A battery that reads 11.6 volts is almost fully discharged and may be damaged beyond further use if you leave it in this condition for long.

Alternative Batteries

Nicad batteries are sometimes used as domestic batteries on boats, and they were installed on *K*I*S*S* when we purchased her. They worked well on this relatively low-tech sailboat. Nicads are expensive, but are reputed to have an extremely long life. It may be worth investigating this option if you're building a new boat, or refitting an existing one.

It's well to remember that nicad batteries do need recycling on a regular basis, and that they also present some health hazard in that they have to be disposed of as a hazardous waste.

Gel-cell batteries are lead-acid batteries, and are similar to the common wet-cell battery, but the differences in their chemistry and construction do give them some unique features. There is no need to add water, so the tops of these batteries stay clean. Unlike wet-cell batteries, the gel will hold its charge for months when left sitting with no load and no float charge. They can be stored in the off-season without the need for a constant float charge, and without fear of freezing. Gel-cell batteries will accept a higher rate of charge than the wet-cells do, and usually deliver better performance when connected to an inverter. The combination of acids in the gel-cell prevents sulfation and eliminates the need for battery equalization. Before you choose this type of battery, remember that 50 percent of the experts prefer wet-cell batteries!

Absorbed glass mat (AGM) batteries are becoming more popular. These batteries hold the electrolyte in a sponge-like material. You may want to investigate them if you're initially fitting a new set, or replacing an entire bank.

Finally, don't confuse gel-cell batteries with the so-called maintenance-free batteries. Water cannot be added and these batteries are totally unsuitable for marine use.

Battery Boxes

The first time you meet rough weather shouldn't be the time you decide that your batteries need to be installed more securely. Batteries, complete with fluid, weigh around 0.875 pounds (400 g) per amp-hour capacity. A 220-amp-hour, or 8D, battery weighs about 160 pounds (75 kg). It doesn't take much imagination to envisage what would happen if one of those monsters broke loose in a seaway. Batteries need to be installed in securely, and the best way is to house them in their own boxes. A battery box can be built out of ¾-inch (20 mm) waterproof plywood, and is best lined with fiberglass so that any spills are contained. The box should be bolted to, or otherwise securely fastened to, a suitable structural member.

When selecting the location for your batteries, remember that during the time you own the boat, they probably will need to be removed or exchanged for new ones. If the batteries are not already fitted with strong handles, make sure you install straps under them so you can remove the batteries from the box. Although many authorities insist on a vented lid for the battery box, we believe that provided the batteries are strapped in place, they are unlikely to jump out of the box, and the open top is better for ventilation. More importantly, it's one less obstacle to regularly checking the battery fluid levels.

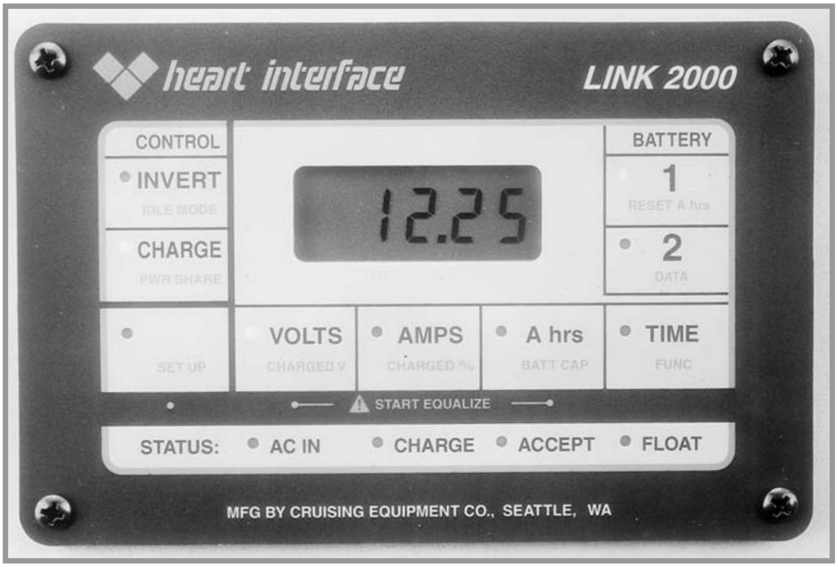
Keep the terminals and the top of the case absolutely clean. One reason for the recommended battery box covers, is to prevent accidental shorting out of the battery and electrical system when some metal article like a spanner or wrench is dropped across the terminals. If you're considering a large battery bank, you should see if you can locate at least a large percentage of your batteries low in the hull, perhaps in the keel or bilge area. In this case, you'll need to make sure they don't contact the bilge water.

Battery Chargers

Most battery chargers are operated at alternating-current (AC) voltages of 120, 220, or 240. They're usually left running when you are connected to shore power or an AC generator. There is a great variety of 12-volt DC battery chargers capable of delivering between 5 and 100 amps. When you

A well-designed and proven combination battery charger/inverter, such as this Heart unit, is an essential item in any well-found cruising boat; choose yours carefully.

run a 240-volt AC battery charger on 220 volts, you'll find that it will deliver only 80 percent, or less, of its rated output. The amount of amperage you need from a charger will be calculated at the same time as you are totaling amperage income from other sources such as the engine alternator, solar panels, a wind generator, and so on.



You will need an efficient control panel to monitor the various electrical charging and usage aboard your boat.

Single-stage battery chargers only deliver their full output when the battery is deeply discharged. For example, if you start charging a battery with a 30-amp charger (and assuming your batteries are 50 percent discharged at the start of the cycle) you'll note via your charging gauge that the needle immediately registers a 30-amp input. But after a period (depending on the capacity of the battery bank), the input amperage needle will drop back to 20, 15, and eventually 1 or 2 amps. This is how most battery chargers are designed to work; they will give your battery as much power as they're designed to deliver only until the battery reaches around 80 percent of its capacity. Then the input becomes much less. You'll note that if you turn on a 12-volt DC appliance during this period when the charger is not delivering full capacity, the charge will increase to cover the amount of amperage you are using. We find this feature to be useful in giving a general estimate of the amperage used by a particular appliance.

The internal setting of your battery charger will determine how many volts your charger can deliver. It may be possible to alter a voltage that has been preset at the factory. Check with the manufacturer of the unit before you start making changes to these settings. If your charger delivers too high a voltage, it can cause your batteries to boil or gas, and you may permanently damage them. Grossly overcharged batteries have been known to explode, so take precautions when working on your batteries. As a minimum safety measure, always wear protective clothing and safety glasses.

Equalizing Batteries

This method of rejuvenating your batteries is one that should only be considered if you feel comfortable with your system and when you consider you have the experience to handle the process with complete safely. For a complete description of the process, see Equalizing Batteries by Max Pillie, in my book *Choosing for Cruising* (see Appendix 1). While a battery is being discharged, sulfuric acid in the electrolyte reacts with the lead plates in a chemical reaction that produces electricity and lead sulfate. During recharging, electricity flows back into the battery and causes the reverse chemical reaction, which turns the lead sulfate back into lead and sulfuric acid.

With each discharge and recharge cycle, a small amount of lead sulfate will remain on the plates. If this sulfate is left in place for very long, it will harden or crystallize and eventually reduce

ELECTRICAL SYSTEMS IN METAL BOATS

The following is from notes written by experienced marine electrical engineer Del F. Kahan of Newport Beach, California, and is included here with his permission.

The information contained here was prepared specifically in response to questions posed by many friends and associates in the marine industry: naval architects, marine engineers, production and plant managers, and individuals. All have been apprehensive about the special features that might be applied to aluminum- or steel-hulled vessels for which they are responsible. On several occasions, inquiries have been submitted after unfortunate and catastrophic experiences. It can be embarrassing indeed, to have a lovely vessel sink at the dock, suddenly lose bottom paint over a wide area, or suffer extensive underwater corrosion.

Generally, a metal-hulled vessel differs from one of fiberglass or wood (for the purposes of this text) only with respect to certain special precautions that relate to galvanic corrosion and electrical systems' insulation integrity. Basic electrical system concepts and design procedures should otherwise be identical.

Unless the vessel is to be moored and used in very pure fresh water (an unlikely circumstance in these times) either salt water or fresh water should be considered to be an electrolyte capable of accelerating galvanic corrosion—that which is attributed to dissimilar metals in contact, or electrically interconnected.

The designer's and builder's task, particularly with respect to aluminum hulls, includes selection of an appropriate corrosion-resistant alloy for the hull plating, proper welding alloy selection and procedure, and contact insulation with respect to dissimilar materials. Through-hulls should be nonmetallic, or suitably insulated. The propeller shaft should also be insulated from the hull through the use of appropriate nonmetallic bearings and coupling insulators. Cathodic protection of the hull through the use of sacrificial anodes such as zincs may be employed through the classical attachment methods or by means of "throw-over" zincs connected to the hull only when the vessel is dockside. Frequently, it is found that bottom-paint-lifting problems are simply the result of improper priming and painting procedures, and are not at all related to the "electrolysis bogeyman." Another phenomenon, deterioration of the trailing edges and other discontinuities, is frequently found to result from mechanical erosion due to cavitation or water turbulence. The above factors are mentioned here because it is common to blame the ship's electrical system for deficiencies that are totally unrelated.

Stray-current corrosion attributable to faulty DC electrical system installation or to subsequent deterioration can be prevented through proper system design and installation procedures. With respect to design, the author is of the firm conviction (reflecting both analysis and practical experience) that an isolated DC system *is neither essential nor desirable*. Typically, the smaller engines employed utilize single-terminal (engine grounded) electrical accessories and the cost to isolate these items and to maintain that isolation, is difficult to justify. The classical, negatively grounded DC system has been proven to be quite acceptable provided that certain simple precautions are adhered to as follows:

1. The negative ground shall be provided at a *single* point, the propulsion engine. Note: on a twin-screw vessel, a hull ground shall be provided at each engine—this will still be considered a single point.

   All circuit returns shall be by means of suitable insulated conductors, and shall terminate ultimately at the single point.
2. All circuit-protection devices (fuses or, preferably, automatic non-self-reset circuit breakers) and control switches shall be located in the positive conductors.
3. DC equipment should, for maximum insulation integrity, be mounted on insulating pads, off the ship's ground (hull). This need not apply to engine mounted (thus grounded) accessories such as the engine's starting motor, alternator, instruments, and warning senders, etc. All remote pumps, blowers, electronic equipment, etc., should have the cases and metallic mounting ears

isolated from ground. The purpose of this procedure is to ensure that the deterioration of the internal insulation will not result in leakage of currents to and through the hull plating.

Should it be deemed desirable to provide a radio-frequency (RF) ground near the radiotelephone transmitter, rather than to accept the DC single-point engine ground for the purpose, a blocking capacitor should be incorporated to confine the ground to RF currents only.

4. All wiring installation shall be made only with the best materials and procedures to insure high-quality integrity. Conductors must be carefully bundled and strapped in place and precautions taken to prevent chafe. The latter is particularly important where wire bundles are led around corners, past ribs or gussets, and through metallic bulkheads. Liberal utilization of protective neoprene hose, as a sheath, represents good procedure where hazards exist. Conductors that penetrate metallic bulkheads should be protected by means of plastic grommets or stuffing tubes.

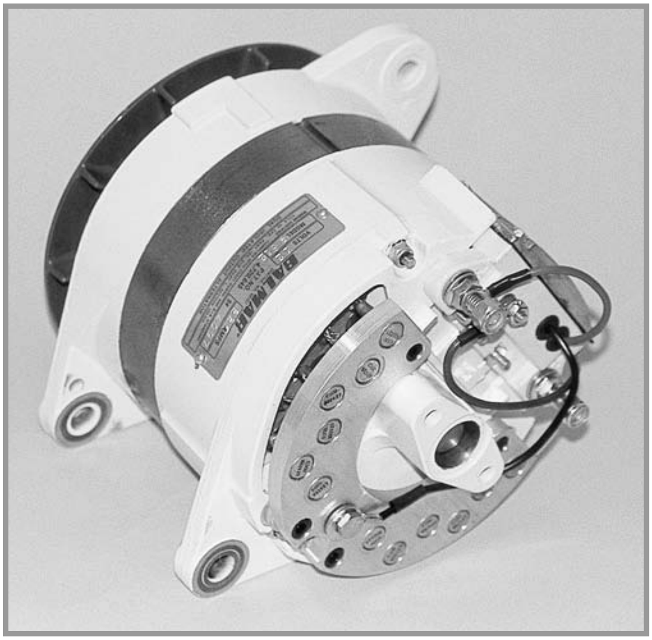
It should be kept in mind that initial installation is not the only consideration. The effects of shock and vibration can cause shifting of improperly secured wiring. In addition, the activities of repair or servicing personnel with respect to other equipment (i.e., engine servicing) can dislodge or damage wiring unless suitable protection has been provided.

The disciplines essential to AC system installation are especially important. All of the principles described above must be conscientiously applied; in addition, special care must be directed toward the AC shore-power supply interface. There are those who promote the use of various forms of so-called galvanic isolators as a solution to the problems of the ship's ground connection to the AC grounding conductor (green wire) brought in with the utility shore-power connector. Some manufacturers of these devices are conscientious in their attempts to fashion well-designed products of this nature and to reinforce confidence in their product through sophisticated quality-control measures. Accordingly, a case can be made for the use of these devices with shore-power services brought aboard whose ship's ground system is intended to be connected to the AC grounding conductor (i.e., in accordance with ABYC or similar recommendations). With metal-hulled craft, the risk of any degree of failure or compromise of "isolation quality" is difficult to accept. By any measure, the most acceptable design principle mandates the employment of a high quality isolation transformer to ensure that no common electrical circuit will exist with respect to the shoreside utility power system. The best method for connection of the isolation transformer is in accordance with ABYC recommendations.

the battery's capacity, increase internal resistance, and destroy the battery's ability to deliver an adequate amount of power. When this occurs, even an equalizing charge cannot remove the sulfate and the battery becomes useless except for recycling purposes.

GENERATING SETS

If you require a great deal of electricity, a diesel-powered generating set will be your next option. There are three types of power-generating sets capable of making the large quantities of AC electricity demanded by modern appliances. You may select a fully installed diesel-powered unit; a unit that is driven by a power take-off from the main engine; or a portable unit powered by gasoline (petrol). There's one additional type of high-capacity gen-set that is unique because it generates 12-volt DC power as opposed to most units, which deliver 120-volt or 220-volt AC current. Make sure you turn off all appliances, especially the 12-volt DC ones, before you fire up your generating set. When a generating set is first started there can be a surge of power that can harm your appliances.



Large-capacity alternators like this Balmar model can add 75 to 100 amps to your charging system.

Before considering installing these units, sailboat owners should estimate if their needs can be met by a combination of solar panels, wind-generated power, and the alternator on your main engine. Powerboaters will have greater requirements, and are not so inclined toward wind generators. Many powerboats have one or two solar panels of sufficient capacity to maintain the battery charge when the boat is not in use.

Although you may use some AC power, most of the electricity generated by a 120-volt or 220-volt AC unit is converted to 12-volt DC current via a battery charger before it is used on your boat. Perhaps it would be more efficient to start off with a 12-volt generating set and use the alternator's output to provide the minimal amounts of 120-volt or 220-volt AC you need, by way of an inverter (see the Inverters near the end of this chapter). The 12-volt gen-set is covered below.

Portable generators are inexpensive but they're not suitable for metal sailboats or powerboats. In most cases, they're very noisy. They introduce the need for you to carry gasoline (petrol) aboard and are not up to powering the range of appliances that made you consider a generating set in the first place.

For those on a budget, a power take-off (PTO) generator could be the answer. PTO units have a centrifugal clutch arrangement that enables them to keep generating at varying engine speeds. Suitable PTO generators, including the U.S.-made M90 Marine Cruising Generator, are capable of considerable output, and units of 3 kW to 6.5 kW are readily available. These units produce enough power to keep most appliance-happy cruising families satisfied.

If you've considered using your main engine and the regular alternator as a primary source of generating 12-volt DC power, it's as well to remember that you should have some load on the engine; in other words, we don't recommended that you run your diesel engine at low revolutions without some load being applied.

The load of a large alternator may be enough to offset the fact that the boat is stationary and out of gear. I have often wondered about the advice not to run a diesel engine without some load, when at the ski slopes one sees stationary diesel buses running sometimes for more than 24 hours. My advice is that if you plan to rely on the main engine to generate 12-volt power, then fit a decent-sized alternator to not only load the engine but also to get the job done as quickly as possible. The rule of thumb is that the horsepower required is twice the number of kW produced, hence a 100-watt alternator charging at 13.8 volts would account for nearly 3 hp. You might also consider having a special take-off pulley fitted to your main engine so that you could engage and disengage a sizable alternator at will.

For the larger boats, a conventional diesel-powered generating set offers power at a reasonable price. These units can supply AC power from around 3 kVA up to almost any size that you could require. The quietest units are powered by a water-cooled diesel engine with at least two cylinders. The entire unit must either be already installed in an well-insulated cabinet, or capable of being insulated and contained in a soundproof box.

Most gen-sets are reliable and deliver the amount of rated power promised by the manufacturer, so the difference between a good set and the best set comes down to noise. Try to hear more than one gen-set running before you make a final decision. Sound problems can come from the exhaust water rather than from the diesel or the generating unit; it's possible to reduce this noise greatly by using a water-lift exhaust muffler that can be arranged to exit the water below or above the waterline. In the case of the gen-set just arrange the muffler to exit below the water. Generally speaking most gen-sets are quiet and fuel-efficient. They can be tucked away in otherwise unused space in or near the engine compartment. But no matter how quiet and efficient your gen-set, you will not want to run it more than, say, two to four hours each day.

A generating system that produces large quantities of 12-volt DC power makes sense when you consider that most appliances likely to be found on even the most completely (electrically) equipped cruising sailboat can be run on 12-volt DC power. If you choose this option, you might want to install more batteries than you would normally. Powerboat owners, because of larger current demand, will probably prefer to install a 110-volt or 220-volt AC gen-set.

There are several 12-volt DC generating systems now available, including a combination unit manufactured by Balmar in the United States. This unit is arranged to provide constant 12-volt DC power to operate a watermaker and a deep-freeze, as well as to keep the batteries in a constant state of charge.

All of the major components are readily available, and you may wish to build a unit to suit your requirements. If you're planning to use an all-12-volt-DC system, or mostly so, then you will need a battery capacity in the top end of the quoted estimates.

Most cruising boats with a regular AC-generating system fitted need to run it for 2 to 3 hours per day. With the all-12-volt DC system, it's estimated that you should only need to run your generating set for the same amount once every two to three days. This factor alone may be sufficient to encourage you to consider this setup. One disadvantage of the all-12-volt DC system is that it requires much heavier wiring and fuses. The main requirement is that you must be able to produce larger-than-usual amounts of 12-volt DC power, so your batteries can be replenished at a rapid rate. This is necessary to balance the two- or three-day charging cycle. Your 12-volt charging system will need to be able to produce between 150 and 300 amps to make the system work; it can be done.

The charging end of the unit will consist of one or more high-output alternators coupled with a dedicated, suitably sized, water-cooled diesel engine. The recommended procedure is to decide how much output you will require to charge your batteries in the desired time. Now match the output of the alternator(s) to this requirement and then select a suitably sized diesel engine. Between 10 and 20 hp should be sufficient to power the alternator(s). The engine will not require a transmission unit but you will need a shaft that can be bolted to the flywheel, and this in turn will accept the one or two pulleys used to drive the alternators via a suitable V-belt arrangement.

A reliable regulator will be part of this system. The last thing you want to do is to cook all those expensive batteries. You'll need to have the entire unit housed in a soundproof box similar to that used for an AC gen-set. The cost of this 12-volt DC generating set should not exceed the cost of a similarly sized AC unit. Your decision can be based purely on the convenience factor and on the requirements of your electrical system.

SOLAR PANELS

When your boat is left unattended, you may find solar panels useful to keep the batteries charged. They have been successfully installed to run all types of appliances, including small refrigeration units. Solar panels (when they produce 1 amp or more) should be run through a regulator so that there's no chance of overcharging the battery. These devices are capable of taking power out of your battery at night; make sure you prevent a reverse flow of current by installing a blocking diode for each panel or bank of panels. Each diode uses 0.4 amp, so remember that when calculating input. If in doubt about your abilities in this area, have the units installed by a competent person.

Solar panels are becoming more efficient and can be mounted on many areas of your boat. You'll need to study the position of the sun in relation to the intended location of the panels. If you're able to rotate or angle the panels to take account of the boat's position in relation to the sun, they'll produce more electricity. You would probably soon tire of adjusting the angle of the panels several times each day, so you should calculate a reasonable average angle to suit the area where you're operating, and settle for around 75 percent efficiency. When you're mounting the panels, make sure you allow for air to circulate around the whole unit, otherwise the excessive heat generated will seriously decrease the panel's output.

Once you've made the initial investment, the power you receive is free. Most solar panels have a long, maintenance-free life, usually 10 years or longer. As with most other capital expenses, you'll need to decide if you'll receive a reasonable return on your investment. In the case of solar panels, if you plan to be cruising at least 25 percent of the time, then they are a good investment. In any case, you should install a small unit that is capable of topping up the batteries when you're away from your boat.

The starting power of solar panels is 0.30 amps, which is ideal for battery replenishment. One panel per bank of batteries will avoid the need for a regulator in the system. Larger panels can produce up to 3.5 amps, ideal for the offshore sailor. If you consider solar power as a serious source of electricity, install several panels designed to produce a total of around 20 amps. Make sure to select solar panels whose rated voltage, at the temperature where you're operating, is at least 14.8. This allows for the blocking diode's 0.6-volt draw and gives net voltage of 14.2. This is the voltage required to fully charge lead-acid batteries.

WIND-POWERED GENERATORS

Cruising sailboats use wind generators more often than powerboats do. Many experienced cruising people argue that wind generators are more efficient and cost-effective than solar panels are. If your boat is intended for serious offshore cruising, then why not install both types of generating equipment and you can reap all of the benefits. The thought of those blades whizzing around will ensure that most people consider the safety aspects when deciding whether or not to install one.

To prevent damage to the charging unit and the blades, some types need to be shut down when winds reach 30 to 50 knots. Other manufactures include automatic speed control and shutdown. You should look for these features, as stopping the blades in high winds could be a risky operation. Most generators you will be considering will have blades of around 5 feet (1.52 m) in diameter. Don't let the above comments put you off considering a wind generator; they are a wonderful source of electricity and the warnings are intended to make sure you treat these wind machines with respect.

Wind generators do make noise; the amount depends on the model. We have noticed over the years that they are becoming quieter. The number of blades does not usually increase the output, but additional blades make for a quieter unit. Try to inspect the various models under operating conditions to see for yourself how much noise, and what type of noise, is involved.

Wind generators will require some maintenance. They are basically electric motors running in reverse, so they have all of the same components as an electric motor. Brushes, and even bearings, will need periodic replacement. Check with the manufacturer on what the maintenance procedures are, and how often replacement parts are required for their particular unit.

INVERTERS

It's well to note that inverters are users, rather than manufacturers, of electricity. They simply take one form of power and turn it into another, keeping a little for their trouble. The best models only consume around 5 percent during the conversion process.

There are many inverters capable of converting the 12-volt or 24-volt DC power stored in your batteries into 220/240-volt or 120-volts AC. They are generally available in sizes with outputs ranging from 50 watts to 2,500 watts. If you intend to run most of your electrical appliances from 120-volt or 220/240-volt AC power supplied by your inverter, then, before you purchase, you'll need to know the total power requirements of all the appliances you plan to run at any one time. If you have a relatively small sailboat, and are only intending to run one small AC appliance, then a simple strip-based 200-watt inverter may suit you best. One of these small units may cost you as little as $150 (£100) or less. Owners of larger liveaboard cruising boats often underestimate their requirements, so it's most important that you calculate your expected needs carefully. Allow some room for expanded usage. You will need the 12-volt DC battery storage capacity to back up this usage, and this will temper your appetite for AC appliances. Remember to convert your requirements to the same units, either amps or watts, before you start to estimate your total requirements; see the conversion formula at the start of this chapter. There are several manufacturers of these appliances.

In early models, the current produced by inverters was not the same as that supplied to your home by the local power company. The inverter produces a square, stepped, or what is generally referred to as a modified sine wave. An onboard generating set delivers the same pure-sine-wave power that your local power company generates. Why do you need to know this? Because the power from an inverter may not properly run certain AC appliances; problems may occur when inverters are coupled with television or computer screens, radar, and similar units. These problems are being addressed and largely overcome, but it's wise to check with manufacturers regarding the compatibility of their units with the appliances you wish to operate. In recent years there has been a vast improvement in the way inverters operate. You should be able to find one that will suit your requirements and will also give you trouble free service.

When you're considering what appliances you can run on your inverter, you'll need to consider the starting amperage required by many pieces of electrical equipment. For example, an electric drill that operates on 1,000 watts will normally take a considerably larger amount of power during the first few seconds of operation to get going. This is sufficient to create an overload and trip out the whole circuit. Because inverter technology is constantly changing, you should investigate the various makes and models to ensure that the unit you select will properly run your AC appliances.

MULTIMETERS AND HYDROMETERS

To assist in managing your electrical supply and demand, you need one or more test instruments. They will enable you to check the state of charge of your batteries and keep track of the general health of your electrical system.

One of the first items you should acquire is a handheld multimeter. Most of these instruments not only read volts on the DC and AC scale, but also read ohms and amps. Most units are capable of reading a wide range of voltages from a small percentage of 1 volt through to 500 volts AC or more. On a cruising boat, the main interest will lie in the 12-volt DC, and the 120- or 220-volt AC ranges. Multimeters are available in two basic configurations, analog or digital. Like many people, we started off with an analog instrument. However, we soon found that the digital version was capable of being read more accurately. These instruments are relatively inexpensive and good-quality ones are available for a little as $30 (£18). This instrument can be used to test circuits and is the first thing you reach for (after you've checked the fuses) when any electrical appliance or instrument fails to operate.

For those of us who need to know the exact state of our batteries and associated equipment at all times, there are a number of monitoring instruments that can be permanently installed in the electrical system. These instruments provide information on demand.

The Link 10 Meter is manufactured in the United States by Xantrex. The Link 10 Meter measures most of the battery functions of interest to you. It measures the amp-hours remaining in your batteries. It measures voltage, amperage, and the time remaining until the battery would be discharged. The remaining amp-hours can be displayed on the light-emitting diode (LED) display, or as a percentage of the battery capacity. The meter is powered by the battery system to which it is attached, but the drain is so low as to be negligible in most systems.

There are many other battery-monitoring devices that keep an eye on every battery function. I have featured this product because it represents such outstanding value for the money. There are battery monitors that have even more functions than the Link 10, and you may find these useful.

The hydrometer is another measuring instrument that you should have on board. This device consists of a glass tube with a rubber bulb on one end and a thin tube on the other. Inside is a float, marked off in one or more scales designed to give various readings. When used to draw off a small amount of electrolyte from each cell, it depicts the state of charge. If one cell registers a reading considerably lower than another, then you may well have a problem, not only with that cell but also with the battery. One dead cell will render the whole battery useless, and it will have to be replaced.

Many hydrometers also have a scale to measure specific gravity. This scale can be used to test, among other things, the state of the coolant in your engine's heat exchanger system. As temperature can play a part in the operation of your batteries, some hydrometers are fitted with a thermometer. In our opinion, this is overkill and there are less expensive ways of determining and factoring in the temperature.

The fluid you draw off the battery when testing with a hydrometer has a high sulfuric acid content, so be aware that it's capable of burning your skin and eyes. Make sure you are adequately protected. Your clothing and fabrics used in the interior of your boat are especially vulnerable to even the smallest amount of battery acid. Always rinse out the instrument in fresh, clean water after use; don't put contaminated water down the sink. Always use a separate glass jar for rinsing, and dispose of the water in an appropriate manner.

Now that you have some understanding of the complexities of the subject of marine electrics you may wish to study further; the subject is fully covered in several specialized books—see Appendix 1.

CHAPTER 12.

Sailboat INTERIORS

HOW MANY WILL IT SLEEP?

When enquiring about a particular boat many people ask 'how many will it sleep' and although this is a serious question it should not be the overriding consideration. How many will it live ? although un-grammatical, would be a more sensible enquiry.

Make sure your cruising boat is set up for the *least* number of people you intend to have occupying the boat on a long term basis. Sometimes one is tempted to treat boats like houses; you may not need a four bedroom home other than for the resale value. Resale value of a boat is very important but the number of berths alone will never sell a boat to a knowledgeable person. As you are setting up your boat for cruising, your most likely buyer will be someone who wants to use the boat for the same purpose. If too many berths are included at the expense of other items then you will not only have suffered the inconvenience of a less than perfect layout, but you will find your boat difficult to sell when you are ready to move on.

The most likely numbers of crew for a cruising boat are the two owners with either two children or another couple as occasional crew or as charterers. If you think you are likely to want to sleep a total of six occasionally then the lounge or dinette can easily be arranged to sleep the extra two as required. So we now have the perfect cruising boat that sleeps two in luxury, two in some comfort and two on a temporary basis.

Even if you intend to charter to one or two couples or a couple with two children, you can then give over your own accommodation to the paying passengers and use the dinette or other convertible accommodation for yourselves. You will almost certainly be last to bed and first to rise so this arrangement will work better than you might think.

To give an example of my own arrangements; our boat *K*I*S*S* a Spray 28 which has a comfortable double cabin in the bow and a make up double or single in the pilot house. The settees were too short to sleep any but the smallest child. Naturally my wife Gwenda and I used the forward cabins. However, we found that when we had visitors it was easier for us (last to bed first to rise) to give the guests the forward cabin and use the pilot house berths for ourselves. Our current boat is 38 ft [11.58 M] and much more luxurious however we deliberately chose a similar layout and we still follow the same philosophy as far as the sleeping arrangements are concerned.

For offshore cruising you will probably require a least two single berths that are located in a part of the vessel where the motion is the least. These 'sea berths' should be fitted with lee cloths and generally designed to accommodate the off watch crew in maximum comfort and should be if possible not be adjacent to the high traffic areas such as the galley, chart table or the head. Unfortunately this perfect recipe for seclusion and comfort when off watch is not possible on most cruising boats. For sleeping in port a double berth is the ultimate for most couples. Add the convertible dinette to round out the full compliment of sleeping accommodation. All that I have said in the previous paragraphs applies to boats between 35 ft (10.67m) and 45 ft (13.72

LOCKERS AND SHELVING

As mentioned earlier there will be many areas under the sole where you are able to arrange additional stowage lockers; this area is ideally suited for stowage of those items you wish to keep cool. Under the berths you can arrange lockers in the outward facing areas plus additional stowage accessed through the top of the berth; the latter is most suitable for stowing items that may be bulky and/or less often required. Often it will be possible to arrange lockers or shelving above and outboard of the berths, the choice will depend on the space available in the particular area. When arranging lockers and shelves

LEFT:
This double berth in a Roberts 532 looks very comfortable and note the excellent headroom above the berth; this is a feature that is desirable and often hard to achieve in a boats with a stern master suite.

LEFT & ABOVE:
Here we see some more photographs of Roberts 532 interiors.

remember that it is always wise to stow heavier items as low in the boat as is practical. The first rough weather you encounter will surely concentrate your mind when it comes to good and bad stowage practices. The saying 'a place for everything and everything in its place' must surely have been coined by a sailor.

Unless you have a very large boat you should keep hanging lockers to a minimum. Over the past 30 years that I have been designing cruising boats I have seen the 'dress code' of the general population change from a standard where every occasion required a set form of dress to the modern norm where almost anything can be worn at any event. These changes along with easy-care fabrics used in modern clothing make the hanging locker almost obsolete. A 'wet locker' is still a necessity; it this can be arranged adjacent to the engine room or other area where heat is generated then the wet to dry process will be suitable enhanced.

A well thought out boat will have numerous spaces where lockers and shelves are installed; a careful assessment of your boat may reveal additional possibilities in areas overlooked by the designer or builder.

HANDHOLDS AND CORNERS
Check around the interior of your boat and see if you have a satisfactory number of grab points; the larger the interior spaces the more important it is to have grab points to hand. Vertical posts not only help to support the cabin top, they are great for using as handholds as you move about the boat in a seaway; you may find it useful to add one or two of these to any existing boat. Check for sharp corners; our previous boat *K*I*S*S* had many of these bruise causing features. My wife Gwenda commented on these corners to the owner/builder Hal Stufft. Hal told me he delayed launching his new boat because his wife Dorothy insisted that he change the interior to incorporate 'Gwenda corners' thus eliminating the problem on his new boat.

It is possible to power a small refrigeration unit with solar panel, wind generator or a combination of the two. It is worth mentioning that you will not be cruising very long before you will become involved in discussions regarding the various forms of charging your own electricity supply.

Any appliance or piece of equipment that you have aboard your boat will have to be maintained and you had better be prepared to acquire the necessary skills to keep all of your equipment working. You are unlikely to be able to undertake some major repairs but you will need to take care of all the minor ones. Fortunately there are other cruising folk out there who have professional skills and who will be willing to fulfill many of your needs.

Regarding the saloon table, here you have a myriad of choices. Many boats under 35 ft (10.67m) are still arranged with the table more or less on the centreline and when in use it is impossible for any person to move forward or aft. If you can arrange the main saloon table to be off to one side of the centreline and either incorporate an L or similar arrangement for the seating, you will leave a clear space for people to move about the boat. Centreline tables were popular when boats had a much narrower beam; now we have other choices.

The saloon table is one item where you should spend considerable time studying other boats. If possible talk to other owners as everyone has their own ideas. My preference is to have the saloon table combined with an L shaped settee and located opposite two comfortable chairs.

LEFT:
As you can see the generious beam of the Voyager 542 allows for a spacious layout below decks.

RIGHT:
For those who have children or if you want to be able to accomodate as many guests as possible the the twin berths located one above the other makes for maximum use of the available space.

LEFT:
This is either what we often refer to as a 'Cuddly double' or a generious single quarter berth.

LIGHTING

The lighting throughout your interior will need to be carefully arranged so you receive as much natural light in the daytime and economical artificial light after dark. As mentioned elsewhere, hatches with smoked or clear perspex inserts provide considerably more light than any number of portlights. Have fabric covers made for the larger hatches so on the hotter days you can keep the direct sunlight at bay. Windows and portlights do play a part in admitting light to the cabin areas however their main function is to allow the occupants to see out.

In the modern cruising boat the artificial lighting is mainly supplied by electricity. When you are cruising this normally means 12 volt power supplied by the domestic batteries. Small lights placed so they can be used for reading at the same time as supplying general lighting are preferred to single overhead units. Low powered long life bulbs are now available from the Dutch marine manufacturer Vetus Den Ouden. Halogen lamps and florescent tubes are also suitable for marine use and use less power than most other types.

Nothing beats the soft light given out by a paraffin (kerosene) lamp; unfortunately it does mean carrying another fuel and the lamps can smoke and sometimes smell. Candle light is also attractive but should be restricted for use when safely tied up in a quiet berth. Any lamp or candle that emits naked flame does present an additional hazard. One has to be careful to keep this type of light well away from the deck head as the heat directed up the glass chimney of a paraffin lamp can ignite the deck head covering. A protective hood installed above the lamp is essential.

HATCHES AND VENTILATORS

Adequate ventilation is essential in any boat. The arrangement has to be capable of letting air flow through the boat while not admitting water at the same time. Because opening portlights are often a constant source of leaks, you should look elsewhere when planning the air flow through your interior.

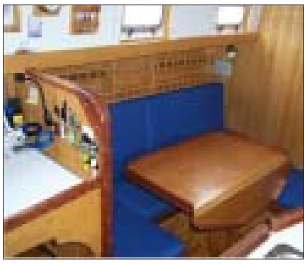
Deck hatches and ventilators are the prime source of fresh air. It is not just a matter of opening the hatches on a hot day; the correct airflow has to be established to achieve the desired result. When you are sailing you will want to be able to establish an efficient airflow without admitting spray; fortunately there are a number of ways to achieve this. There are a number of different style hatches available that can be opened in more than one direction. If you have a cabin heating stove then make sure your ventilation arrangements can be arranged to not interfere with the operation of this item.

You should have available one or more fabric wind-scoops that can be rigged at any one of your hatches to get the air moving in the direction you desire. Dorade, mushroom and similar vents can be made and installed in such a way as to allow air in and keep water out. One or two small 12 volt fans will also do wonders in moving air throughout the interior of your boat.

ABOVE: ***Traditional*** *master cabin on a Trader 65 charter boat.*

RIGHT: ***Modern*** *spacious master cabin in the recently launched NY 55 built by Ian and June Thorpe*

LEFT:
You need to decide on the best interior layout for your boat. The Centennial Spray 38 shown here can be laid out in different ways.



Just a few of the many R36

INSULATION

All cruising boats need some form of insulation. Even fiberglass boats need insulation, as they “sweat” in the same manner as metal and wood boats. Now is the time to select and install the insulation. If you are planning sprayed-in foam insulation, then this should be installed after the deck and superstructure are in place, but before you start work on the interior joinery. An alternative is to install bats—sheets of foam glued or held in place by the “ceiling.” (See the Lining Materials section for details on installing the ceiling planking.) My choice for foam insulation is the type of urethane foam that is fire-resistant and nontoxic, and is sprayed in place. In steel boats, the interior of the hull should first be gritblasted and primed (if it’s not built of preprimed materials). The foam will now be sprayed to a depth between

Sprayed-in foam offers the best insulation, and has another benefit: it can protect the interior metal. Install it in the hull (above the sole line) and in the deck and superstructure areas as well. Make sure you have adequate thickness and that you get what you pay for. See the text.

1 and 2 inches (25 to 50 mm); the thicker the better. It's a good idea to cover the stringers, and they will most likely be about 1¼ to 2 inches (30 to 50 mm) deep. The foam should be of a type that forms a skin on the surface that is impervious to water. Make sure you choose a variety that won't give off toxic fumes in the event of fire. You'll also need to make sure that the foam is of the self-extinguishing type.

The supplier of the foam usually has all the equipment needed to install the material, and charges by the cubic foot (cubic meter) or by the pound (kilogram). Make sure you obtain an estimate of the cost for the boat to be sprayed to the desired thickness. Be very careful that you get what you pay for. Measure the depth of the foam and check that it's a reasonably constant thickness throughout the boat. If you specify that they cover the stringers plus a bit (say ¼ inch [6 mm] or more) then you will be able to calculate what you need and check what you receive! If you end up with a smooth foam interior over the stringers, this will eliminate one possible source of corrosion due to condensation laying on the stringers. Spray-in foam usually has a skin that will resist moisture, so try not to damage outer area of the foam.

There is a new type of insulation that looks like a thick paint and this is being tried out by some of our current steel boat builders. We will make information available on the wonder (hopefully) material on our website, www.bruceroberts.com, as it becomes available.

LINING MATERIALS

There are a variety of materials that can be used to line the interior of your metal boat. This is one area where the wrong choice can damn your boat and scream "amateur!" If you want a decent resale value, then you'd better get it right.

If you're building a traditional-style metal boat, such as a Spray replica, or if you like the warmth of an all-timber interior, then ceiling planking can go a long way to achieving the right

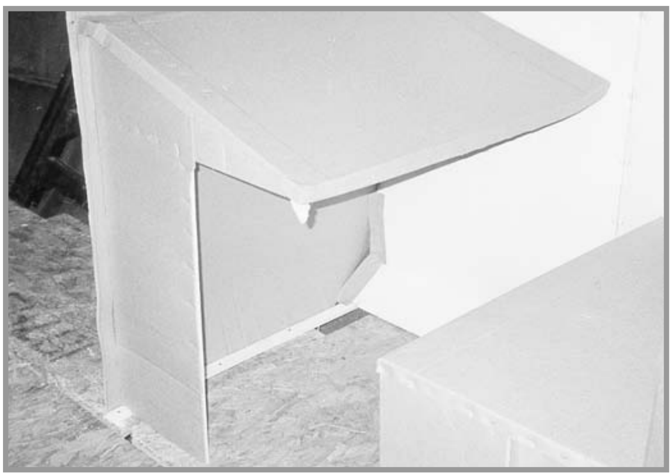
The overhead areas will need insulation, too; again sprayed-in foam is hard to beat.

effect. Ceiling material should be 1 by ⅝ inch (25 by 15 mm), light-colored, fine-grained timber that is rounded or beveled on the outer edges. Install the planks longitudinally and space them at about ¼ inch (6 mm) apart. You can plank only those areas that are visible after the joinery is complete, or you can plank the entire accommodation area and use the material as the lining for the various lockers. If you take this latter course, then you'd better reduce the spacing to say ⅛ inch (3 mm) so you will not lose small items through the gaps in the planking. If you use ceiling only where there are no lockers, you may have a problem getting a fair curve where there's no frame to which to attach one end of the planks.

The lockers can be lined with plywood. Leave the bottoms loose with a neat fit but not tight; you'll often want to get under and behind the locker to have access to cables and the inner hull. Don't forget to put finger holes in the lining.

Ceiling (timber planking) is a popular way to line the interior of the boat. Correctly installed, this material will allow air to circulate behind the planking and help keep the boat free of condensation.

Lining the entire interior of the accommodation with light, plain, painted or veneered fancy plywood can produce a pleasing result when combined with solid timber trim. Too much varnish, or areas of paintwork that are too large, can spoil the interior appearance, so you will need a balance between the two finishes. If you are unsure of this balance, use as much varnish as you like; you can always paint over it at a later stage. The reverse is obviously not so simple.



One builder used inexpensive cardboard to mock up his joinery; if you want to try out a piece of furniture, this looks like a great idea.

For overheads and the interiors of the cabintop, you can use painted plywood but this will look a bit amateurish if the plywood is not covered with some other lining material, such as marine-quality vinyl. Use some timber trim to relieve and break up the area. Timber planks, similar to that used for ceiling, but say 2 inches (50 mm) wide, can also be used to line overheads and cabintops. There are several alternative vinyl products that have a light foam backing and are ideally suited to overheads and certain bulkheads. Be careful when you use this material for bulkheads in the main living areas, however, as it can cheapen the look of your interior. The foam-backed vinyl can look acceptable in some parts of sleeping cabins. The use of vinyl is fine for overheads in any part of the boat. As suggested above use timber trim as needed to break up any large expanses of lining material.

In the past, some builders, both professional and amateur, used carpet and carpet-like materials for lining the hull and overheads. These materials are inexpensive and easy to install but can look cheap. We don't recommend this route; besides the interior will look dated.

CABIN SOLES

The sole framing will need considerable planning. Usually, T-bar (as supplied in most kits) or L-angle is used for the main sole area framing and some timber can be used where it would be attached to vertical plywood surfaces such as bunk fronts and dinette ends. The size of the angle will vary depending on the span and spacing of the framing. Your plans should give you a guide. If you change the accommodation layout, you may have to use your judgment. There are few things more annoying than a springy or squeaky sole.

These light companionway steps are practical and reasonably easy to construct.

Plywood is universally accepted as the material to use for cabin soles. The thickness will vary between ½ inch and ¾ inch (12 mm and 20 mm), depending on the spacing of the undersole framing. Usually, ⅝ inch (15 mm) is sufficient, and the thickness can be less if you plan to add teak or another timber surface. This is such an important area that you should try a sample before deciding on an overall thickness. A spongy sole is most undesirable, but you don't want to add unnecessary weight.

While you're still constructing the interior, you should only fit and lay the plywood in position; don't screw it down until the all of the joinery work is completed. It's advisable to arrange the sole so you can remove all parts of it, including those areas that form the bottoms of lockers and closets. This may mean additional undersole framing to provide a base at the edge of the particular area of the sole. Under no account build in areas of the sole so they are impossible to remove. The plywood can be screwed down with self-tapping stainless steel screws.

Make sure you have carefully planned hatches to those areas of the sole that will need frequent (or even infrequent) access. The hatches should be laid out in an orderly manner and have aluminum or similar trim around the edges and be provided with flush ring-pulls. Hatches in unseen areas such as inside lockers, may have finger holes in lieu of more expensive hardware. Where carpet is installed, aluminum edge trim is an important feature around the sole hatches.

Carpet-covered soles are fine in most powerboats and also in well-maintained and dry sailboats. If your cruising habits mean that you will be bringing a considerable amount of water into the cabin, then carpet is not a sensible option. I personally like carpet; it offers a good footing under most conditions, is warm and attractive and—considering the small area of a boat interior—it can be replaced at very little cost.

Don't finish a teak-and-holly sole to a high gloss. Rather use a matte finish that will give you some chance of remaining upright in adverse conditions. A slippery surface can be deadly in anything of a seaway.

Forward V-berths are often too cramped for two adults, but they are useful for sleeping accomodations for the younger crew members. They're also sometimes used for general stowage.

BUNKS

Your first consideration will be how many permanent berths to build into your interior. Fewer is better! Our idea of the perfect number of berths is a spacious double for use in port and in suitable weather; two single berths, suitable for watchkeeping and for use in adverse weather conditions; and additional single berths for the permanent crew. The number of berths should not exceed four, plus those required for the permanent crew. Boats under, say, 38 feet (11.60 m) should not have more than one double and two single berths, otherwise too much of the interior space is used up.

All boats are compromises. You may have to be creative to provide the necessary sleeping accommodation without turning the boat into one large dormitory. Avoid berths that are too narrow. Singles should be a minimum of 2 feet (610 mm) wide and preferably just a little wider. Doubles should not bear that title unless they have a minimum width of 4 feet (1.22 m) and preferably more. You will find 4 feet, 6 inches (1.37 m) is ideal, and up to 5 feet (1.52 m) in width is fine in a larger boat. For designers and builders, achieving adequate berth length is always a problem. It's a fact that as each generation becomes taller, they require longer berths for a good night's sleep. In new designs, we use 6 feet 6 inches (1.98 m) as a reasonable length. It's hard to include longer berths than this without encroaching into other areas of the accommodation.

Berths can be framed up in 2 by 1½ inch (50 by 30 mm) timber, or 2 by 1 by ¼ inch (50 by 25 by 6 mm) L-angle. Depending on which metal you use to build your hull, framing in the same material may give satisfactory results. In steel boats, in the interests of saving weight, you may prefer to use timber framing throughout the interior. Plywood of ⅝-inch (15 mm) thickness will be adequate for all berths, and if you have adequate framing then ½-inch (12 mm) may be sufficient. Berths should have hatches in the top to allow access for stowage and inspection of the boxed-in areas of the hull. The plywood tops of the berth should also have a few 1-inch (25 mm) diameter holes bored at random to allow the air to circulate in the area under the mattress.

Face the berths with a timber board of around 6 by 1 inch (150 by 25 mm) and round off the top and bottom of this face plank to remove any sharp corners. This facing will hold the mattress in position and give a finished look to the berth.

The mattresses should be of good-quality foam, between 4 and 6 inches (100 to 150 mm) in thickness and covered with a light cotton or other suitable fabric. Hooray for the duvet! Duvets make the best bedding arrangement; they're easy to make up, especially where a berth doesn't have access from all sides. A fitted undersheet, combined with a duvet that's equipped with a slip-on cover, makes for perfect sleeping. This arrangement also provides easy bedmaking in the morning. Duvets used on settee berths have the additional advantage of being easy to stow.

HEAD AND SHOWER COMPARTMENTS

If space permits, a separate shower compartment is very desirable, especially on any boat intended as a liveaboard. The shower can be totally separate, with its own entrance, or simply a shower stall entered through the main head. On boats where the regular crew is four, we prefer two medium-sized heads and one separate shower compartment. Choices in this area are a personal matter, so you should discuss the options with your partner and family members who will be crewing regularly on the boat.

The floor of the shower/head can be formed from fiberglass and laminated as a one-piece unit. Don't forget to include a nonskid surface. The actual shower pan can be slightly lowered and fitted with teak slats. This arrangement may allow a wider sole, even if some areas include a slight slope. Separate shower stalls can have a tiled sole, a nice touch if your boat can accommodate the additional weight. The walls or bulkheads in the shower/head area should all be lined with a plastic finish such as Laminex or Formica. The entire floor area, as well as the bulkheads and cabinets, should be designed for easy cleaning.

If you're building, or own, a small or minimal boat, then you may be happy with a solar shower bag. These plastic bags are wonderfully efficient. Provided you have a reasonable amount of sunshine each day, one bag can provide hot showers for two. Shower bags are great water savers and recommended on vessels where replenishment of water tanks is infrequent. Shower bags can be a great backup device, and even if you only use them infrequently they'll pay handsomely for the small amount of stowage space they require.

Drainage for the shower can take many forms. In our sailboat the 28-foot (8.53 m) steel Spray *K*I*S*S*, the builder had fitted a fiberglass shower tray in the head and drained this into the main sump in the keel. The sump was emptied by way of a manual bilge pump in the cockpit. This pump also served as the emergency bilge pump—that arrangement was fine, except that you had to pump out the water soon after your shower, otherwise the sump would generate sufficient gas to set off the alarm intended to service the gas stove rather than the shower sump. A better arrangement would have been to have a separate gray-water tank to temporarily store the shower water, or an automatic pump. In our present boat we have a plastic sump about 1 foot (300 mm) square, fitted with a lid and an automatic Rule shower/bilge pump. The 800-gallon per hour (3 kL per hour) unit, has the same physical dimensions as those of smaller capacity and this unit provides a backup to the regular bilge-pumping arrangements. Shower pumps need regular cleaning, usually about once every week or more often if the facility is used by more than two persons.

Manual or vacuum toilets are recommended. Vacaum toilets work well and are especially suitable for larger craft. The electric varieties, while they do reduce the solids to a fine mist, are often somewhat noisy, so check before you buy and install as there is nothing worse on a boat, or anywhere else for that matter, than a noisy toilet. Unless you can find a quiet version, don't consider these devices. To those traditionalists who wonder, "What is this fellow doing talking about electric toilets?" please remember that not all metal boats are built as basic cruisers. Make sure, especially in a sailboat, that the plumbing for your toilet is such that it cannot back-siphon and sink the ship.

You should fit a reasonably sized hand basin. If fresh water is at a premium, then the smaller variety saves water. One with a diameter of about 9 inches (228 mm) is the smallest that can be called a basin. On smaller boats, and boats with medium-sized head/shower combinations, a convenient arrangement is to have an economical shower rose serve as both the faucet for the basin and as a shower head. The flexible supply hose leads through the countertop and stows itself under the basin. You can then draw the rose out when you need a shower. When you're using this system, and if hot water is available, then a mixer faucet can serve both shower and basin. On all boats, the basin or sink should have a shutoff valve or seacock fitted, and its location should be familiar to all crew members. This advice applies to all inlets, outlets, and seacocks.

THE GALLEY

This is an important area of your boat and if you want to keep the cook happy, then you'd better get it right! In our book *Choosing for Cruising* and the e-book *Choosing a Cruising Powerboat*, we've covered the subject of designing a galley in considerable detail. These books have much more information on all aspects of design than space allows here (go to bruceroberts.com for more details).

You can arrange the galley benches to suit the available space. We've found that a U- or L-shaped arrangement usually works best. In a sailboat, the stove is best placed outboard, facing inboard. For easiest drainage, the sink on a sailboat should be as close to the centerline as practical. You can build galley benches from ¾-inch (20 mm) plywood and cover it with Formica, Laminex, or other laminated plastic. If saving weight isn't critical, then tiled bench tops add a nice touch to any galley. Make sure that you round off any corners, otherwise the cook will soon be covered in bruises.

Framing for the galley can be 2 by 1½ inch (50 by 40 mm) timber. The framework will generally be arranged to accommodate standard-sized doors and drawers. Unless you're fitting out a

Sailboats often have the galley located just inside the companionway, like this.

A rail protects and steadies the cook in front of this stove.

Dutch barge or some other vessel mainly intended for use in inland waters, we don't advise you to install the standard kitchen units available at the local home improvement store or lumberyard.

There are many suppliers of ready-made teak and mahogany door and drawer fronts that you can incorporate into your galley and elsewhere. They may be more expensive than those you construct yourself, but unless you can produce fine cabinet and joinery work, you're advised to investigate this option, at least. The resale value of your boat will be considerably affected by the quality of the interior finish of your vessel. Three-ply sliding galley doors with finger holes as openers may be inexpensive and easy to construct, but they'll add little to the resale value of your boat.

Your galley stove will get considerable use. First, you must decide which fuel you'll use. The choices include liquid petroleum gas (LPG), compressed natural gas (CNG, available only in certain areas), diesel fuel, alcohol, and kerosene (paraffin). Most galley stoves on sailboats are gimballed, but powerboats and stiff sailboats like the Spray types may not require gimballed stoves. Discuss this option with the stove manufacturer.

Today, many if not most, new sailboats and powerboats are fitted with LPG. You can get it in two main types, butane and propane. They're similar in usage, and each has its advocates. If you choose gas, then you'll probably choose the one that is more readily available in your area. Most appliances will burn either type; some may need minor adjustments to the burners to get the best results. If you choose gas as a cooking and/or heating fuel, you must have a certified technician install the system. Also check it over on a regular basis. LPG is a wonderful aid on any boat, but it's heavier than air and can lie in the bilge. Even a small amount of stray gas, when ignited in the confines of a boat, can cause a catastrophic explosion. You must locate the bottles in their own self-draining locker; fortunately this is easily arranged in most metal boats. Usually, two bottles are carried, thus en-

Diesel galley stoves can supply hot water as well as performing the normal cooking functions. See the text.

Another attractive galley. This one is situated partially in the walk-through on a Roberts 434 built in the UK.

suring continuity of supply; when one bottle runs out, you switch to the next, and refill the first one at the first available opportunity. We've had gas in our own boats, having followed our own advice regarding installation and servicing of the installation and the individual appliances. If you have gas aboard, then you must install a reliable gas detector with one or more sensors. One sensor is required for each gas appliance you have aboard. If your gas appliances are grouped in one area then a sensor may be arranged to suit the group.

Paraffin or kerosene stoves, once the mainstay of any galley, have largely given way to LPG. If you can stand the smell (although some fuels are now supposedly odor-free) and you don't mind the fiddly lighting procedure, then you may find kerosene an ideal fuel for the galley stove.

Galley stoves fired with diesel fuel would seem the obvious alternative. Diesel fuel does work well in a properly set up appliance. The drawback is that it takes these stoves some time to reach operating temperature. Perhaps diesel fuel stoves are more suited for use in colder climates. To be practical, you should be able to leave the stove on low heat between meal times.

STOWAGE FOR FOOD AND STORES

This is another area where the person who will actually be working in the galley should be consulted at the planning stage. The storage lockers or galley cupboards should be arranged to make best use of the available space. The plates, mugs, and eating utensils should be always at hand. Regularly used food such as condiments that do not need refrigeration should all be at eye level, more or less. Pots and pans will normally be stored in lower cupboards, and cleaning and dishwashing fluids may be under the sink or in nearby lockers. If you have steps nearby, they make excellent stowage areas if you give them hinged tops. If you lay out your galley along the lines of the kitchen of a regular house, taking into account the obvious space restrictions and with the necessary changes to suit a boat, you'll go a long way toward keeping the cook happy.

Undersole stowage for canned goods and other nonperishable foods is a great idea. Try to arrange these lockers so that the cook is able to reach them without having to disrupt the area around the galley. Properly fitted hatches in the sole and drop-in plastic bins are most useful. You can store most general foodstuffs, except items that need refrigerating, in under-sole lockers. You should equip all hatches in the sole with ring-pulls or finger holes.

You should also ventilate lockers in the galley and elsewhere. You'll need louvered doors, or doors with built-in vents or other arrangements, to encourage air to circulate freely in these areas. You'll need a garbage locker, too, and one can often be fitted on the end of one of the lower galley benches. The bin can be hinged at the bottom to open outward, and designed to accept a medium-sized garbage bag. Most cruising folks and liveaboards use supermarket bags as liners for garbage and trash bins.

REFRIGERATORS AND ICEBOXES

This is another subject too complex to be covered in detail in this text; however, there are a few comments we'd like to make. Firstly, avoid most ready-built refrigerators powered only by 12-volt DC power. They can consume large quantities of your valuable battery storage capacity. In powerboats, you can use gas refrigeration, and this is generally very efficient. It does generate a considerable amount of heat, though, so make sure it's properly ventilated.

Iceboxes are useful but need to be very well insulated to be of any value. The most practical arrangement is an icebox that can accept one of the freezer-conversion kits. A freezer compressor powered by a take-off from the main engine can be a good alternative in cruising or liveaboard vessels.

This shows a good design for an owner-built icebox, or built-in refrigerator, a welcome addition to any boat.

In my opinion, a diesel-powered heater is an essential part of any boat, sail or power. These stoves work well and they give out an incredible amount of heat for a small fuel cost.

This attractive heating stove was made by the builder of a steel Roberts 53.

HEATING THE CABIN

On traditional boats you may want to consider a wood-burning stove. For this type you will need a good supply of fuel, that in turn requires adequate stowage space. For cabin heating, the diesel-fueled heater has no peer. A drip-feed version is ideal for installation in any boat; one per cabin, if you have a large cruiser. These heaters are trouble-free and throw out great quantities of heat for a miserly usage of diesel fuel. Dickinson (Canada and U.S.) and Taylor (UK) are two popular makes, but there are several others available in various parts of the world. All fuel-consuming appliances require good ventilation, so keep this in mind when installing your heaters and similar items.

Diesel-powered, forced-air heating can be a troublesome partner aboard any boat. While forced-air heating with multiple outlets is a great convenience, the Eberspächer and similar units need lots of tender loving care to keep them operating. Recent models of forced-air heating appliances have improved over the past few years, but ask around among your cruising friends before you make a final selection .

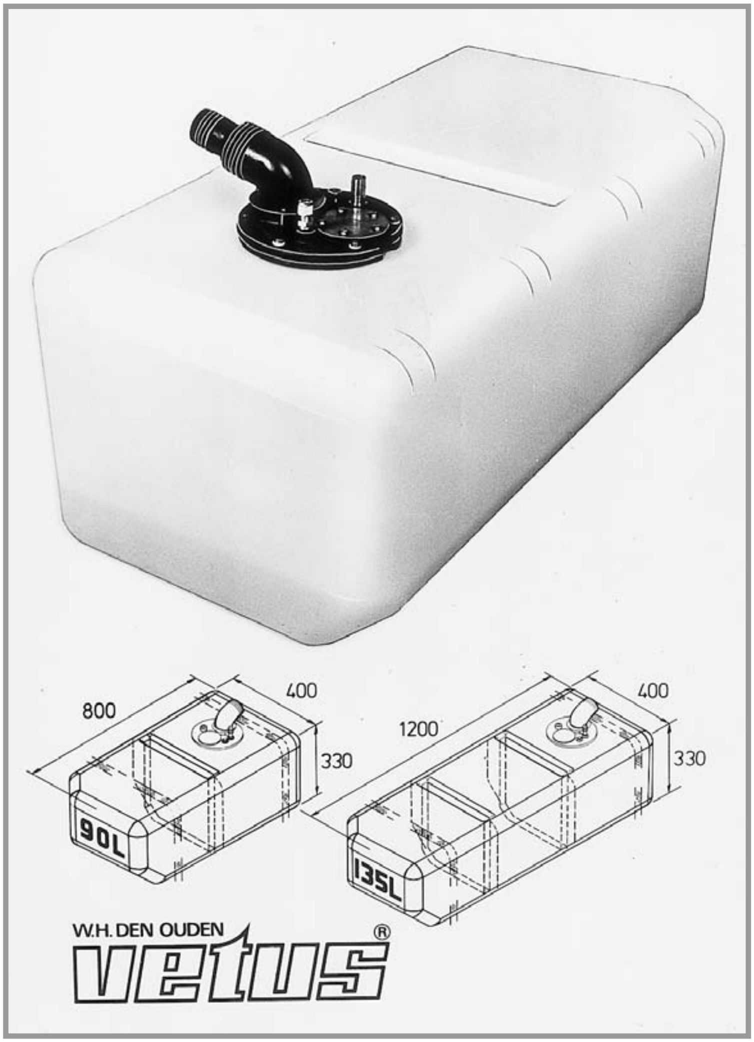
FRESHWATER TANKS

This is another area where modern technology has made inroads into our cruising lifestyle. Watermakers have removed the need for large water tanks on the modern sailboat or power cruiser. Powerboats and sailboats that cruise locally need to carry only about three to five days' worth of fresh water. Watering points are now available in all marinas and other havens, so replenishing supplies presents few problems.

That said, those with long-distance cruising in mind will still need to give this subject considerable thought. The choices lie between modest tankage with severe economy, and large-capacity tanks with a better lifestyle. The best solution may be a combination of reasonable tankage, backed up by replenishment techniques, including rain collection and the use of a watermaker.

Although it's possible to build water tanks from mild steel, they do need to be coated inside, and we don't recommend this combination for storing fresh water. Aluminum tanks can have various problems, so this leaves stainless steel, sheet or molded plastic, fiberglass, or inflatable tanks.

Our choice is either stainless steel or molded plastic with fiberglass as a last alternative. Our experience is that tanks fabricated from sheet plastic have not proven successful. All tanks should be fabricated outside the hull and tested against leaks with air pressure of 3 psi. Take care when testing tanks. We once heard of a builder simply connecting a compressor to the steel tanks; goodness knows how he managed to avoid an almighty explosion. Tanks need only modest air pressure to reveal leaks. Vetus Den Ouden manufactures a fine line of plastic tanks in several shapes and many sizes; they're available with matching hardware and could well suit all but the largest metal boats.



Vetus produces a range of molded plastic water tanks in a range of shapes and sizes.

FRESHWATER PUMPS

The type of pump you select to dispense your fresh water, will have a great influence on the amount of tankage required. Serious offshore sailboats are usually fitted with hand- or foot-operated pumps. These manual pumps may be in addition to a more convenient electrical pumping system. You can turn the latter off during long passages; then everyone uses the manual pumps. If your boat is fitted with a gas-fired, on-demand, hot-water system, then you'll have to install an automatic electric pressure water pump. At least one saltwater (or outside freshwater) manual pump should be installed in every boat.

Most powerboats are fitted with automatic electric water pumps as standard equipment. Rarely will a manual backup, or alternative hand-operated system be installed. Electrically operated pressure water pumps are a great convenience, but you should install at least one hand-operated backup pump in your boat. Some of you may prefer to carry extensive spares for your electric unit. The "outside" water should be available through a hand-operated pump; in a powerboat, this is often arranged via an electrically powered, deck-wash unit.

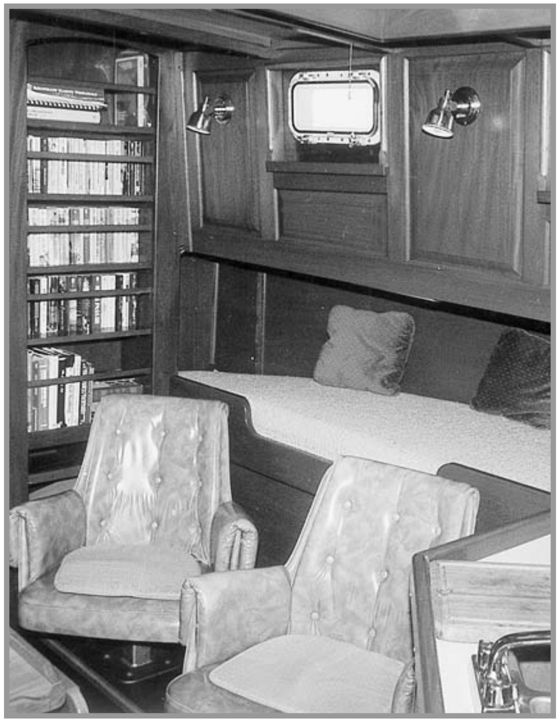
SEATING

It's surprising how many boats don't have even one really comfortable seat. When you're planning your accommodation, give this matter considerable thought, and provide a comfortable seat for each member of the crew. In the case of a couple, two really comfortable lounge-type chairs are required and the remainder can be normal dinette or settee seating. On all but the smallest metal boats it's possible to arrange two really comfortable seats.

Seats can be too wide as well as too narrow. This may be a problem when designing and building settee berth arrangements. A settee berth that is wide enough to make a comfortable single berth is too wide as a seat. These problems can be overcome by arranging the back cushions to sit on top of the settee berth, the cushions can be stowed when the area is used as a berth.

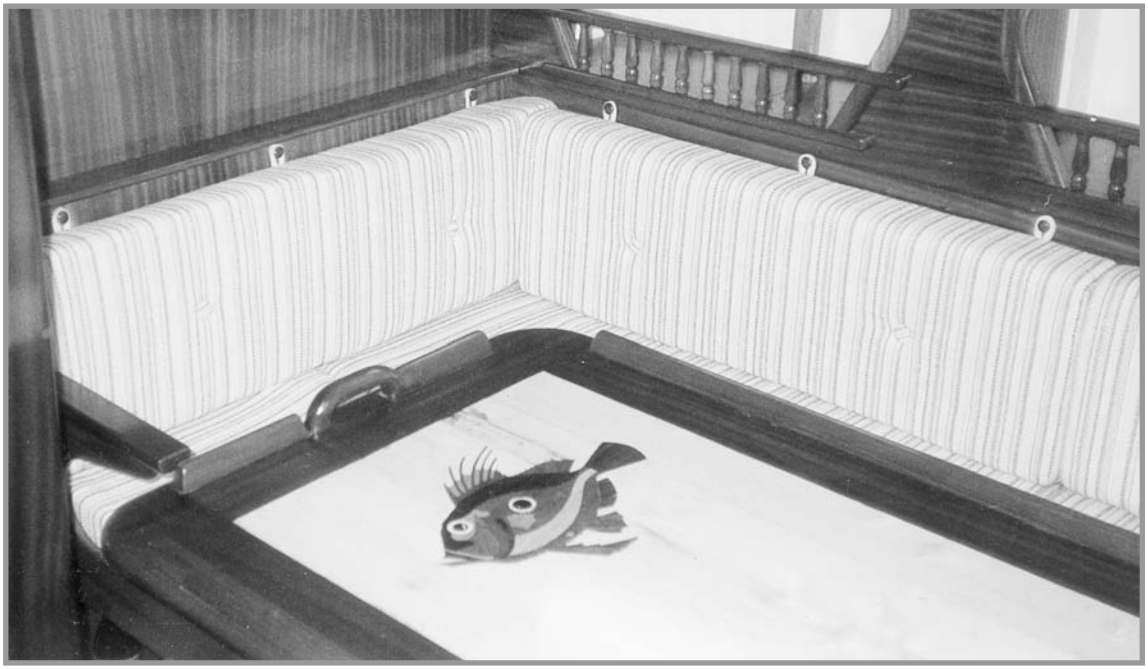
CHART TABLE AND NAVIGATION STATION

Thanks to advances in electronic navigational aids, especially global positioning systems (GPS) and GPS-linked plotters, the need for a large chart table has been reduced. The chart table is still an important part of any cruising boat, and in all but the smallest cruisers it should be possible to arrange a permanent, purpose-built navigation area. A satisfactory arrangement is to use the inboard end of a quarter berth as a seat, and build



When designing a boat for myself, two comfortable chairs similar to the ones shown here would be the first items to be placed in the interior layout.

Dinettes come in all shapes and sizes. Some convert to double berths.



Some builders spend a considerable amount of time adding attractive finishing touches to their boatbuilding projects, as evidenced in this Roberts 36 built by Don Reynolds.

Note the comfortable forward-facing navigation station tucked out of the traffic in the walk-through on this Roberts 434. A selection of repeater instruments was added to this area.

the chart table just ahead of it. Not only does this utilize some of the space for two purposes (very important in any but the largest boat) but also it locates the chart table athwartships and places the navigator facing forward; the ideal arrangement.

In most powerboats, the "chart table" is an area immediately adjacent to the helmsman where the navigational aids are visible. The layout is quite different to that required in a slower-moving sailboat (if you'll excuse the generalization). Persons who are moving from sail to power may have a problem in giving up a purpose-built navigation station located well away from the helm.

You'll appreciate space at or near the chart table for folded or rolled charts and electronic equipment such as radio(s), GPS, and other navigational aids. Even if your boat carries mainly portable navigational equipment, it should have a regular stowage area.

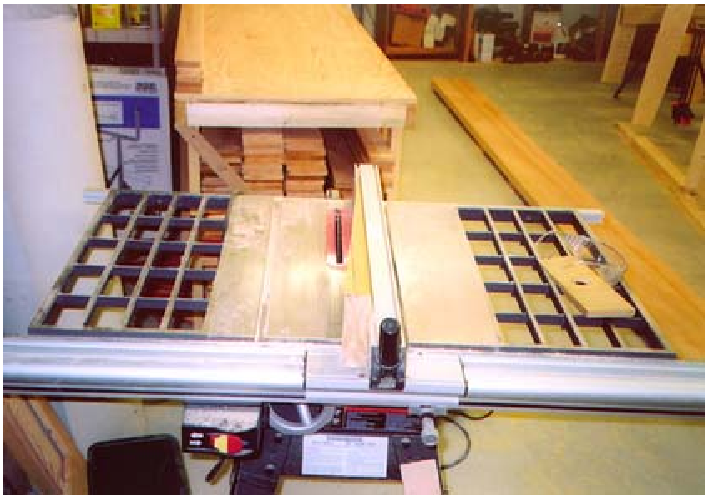
Some navigators prefer to work standing up. Others prefer to allocate any spare space to another priority and use the main saloon table for laying out the charts. Given the option, unless you're prepared to have your chartwork disturbed by a variety of other activities, you'd be better served with a dedicated navigation area, no matter how it's arranged.

SAIL STOWAGE

In the not-so-distant past, the sail locker was one of the more important areas of the vessel and considerable space was provided for this purpose. Today, many sails are stowed on, or adjacent to, the areas where they're used. Mainsails are stowed on the boom, in the boom, or inside the mast. Headsails are fewer in number, and are left rolled in place on the headsail furler. Depending on the layout of the rig and what systems are chosen for reefing and stowage, it's important to provide covers for the sails when you're not using them. On sailboats that are used seasonally, you should remove the sails (and other selected gear) during the off-season and stow them ashore.

There will still be some sails that will need to be stowed aboard when they're not in use, including spinnakers, light-weather genoas, and special storm sails. On most sailboats, these sails represent a small percentage of the sail wardrobe, but you still need space for them. The sail stowage area can be combined with one of several other areas, including the chain locker or workshop area. Or, as is often the case, they can be stowed in the forward cabin, or on (or preferably under) the V-berths.

CABINET MAKING AND JOINERY. The foregoing photos and illustrations together with your own research will by now have given you some idea of how you prefer to layout the interior of your trawler or cruising powerboat. It is outside the scope of this book to give precise instructions on how to build every item of joinery but we have indicated basic measurements for some of the furniture and there follows some illustrations and photos that will assist you with your fitting out program. See the appendix for suggested reading on this subject.



If you are doing your own fitting out make sure you have a sawbench that can be used both inside and outside the boat. Note the presence of the sizeable bench that will also be required.

Building a carboard mock-up of the interior of your boat can insure that you will be satisfied with the final accomodation arrangements.

Rounded corners are reasonably easy to achieve by using laminated plywood formed to the desired shape.

Here is one idea for building a double or queen size berth either forward or aft stateroom. This first step involves temporarily installing the platform to check space requirements etc. Use 1 in / 25 mm plywood.

Next step is to build the base which may be smaller than the mattress area as shown and can be pre-fitted and fabricated before sliding into position as shown.

Here we see the finished berth. This method of construction can be used in either forward or aft master staterooms. You may want to shape the structure to accept a ready made mattress.

Here we see the framing and part of the plywood facing for construction of a dinette. Note the raised platform that forms part of the structure; this feature will often be needed to allow the crew to see out from the seated position.

ABOVE: ***Settees can be simple or fabricated using laminations of plywood as shown here.***

BELOW: The arrangement for twin berths one above the other can be ideal for children.

You will often find that you will need to shape the joinery to fit the hull as is shown here.

It is adviseable to install the larger items such as baths and arrange the plumbing before building and installing the surrounding joinery.

Installing refigerators and associated plumbing is best completed before building the benches and cabinets.

Base galley cabnets are often best designed and built with rounded ends so as to make moving about the boat less likely to cause bruses on the crew.

Overhead cabinets will need to be fitted to the deck head so as to not leave gaps that not only collect dust but give the interior of your boat an unfinished appearance.

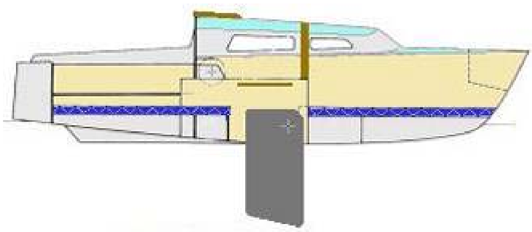
Here we see the galley area framed out and ready to receive the doors and drawers to complete the job.

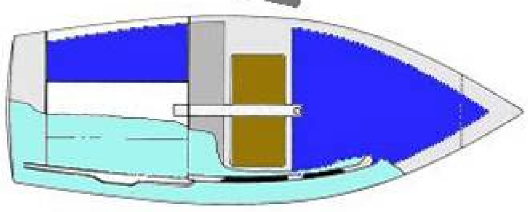
CHAPTER 13.

Sailboats 19'-30' - 5.8m -9.1m

ROBERTS 19 Trailerable Sailboat

L.O.A.. 5.86 m 19' 3"
L.W.L.. 5.40 m 16' 7"
BEAM.. 2.20 m 7' 1"
DRAFT...................................... C/B up 0.27cm 0' 10" C/B down 1.08 m 3' 7"
DISPLACEMENT.. 939 kg 1,850 lb
BALLAST... 209 kg 350 lb





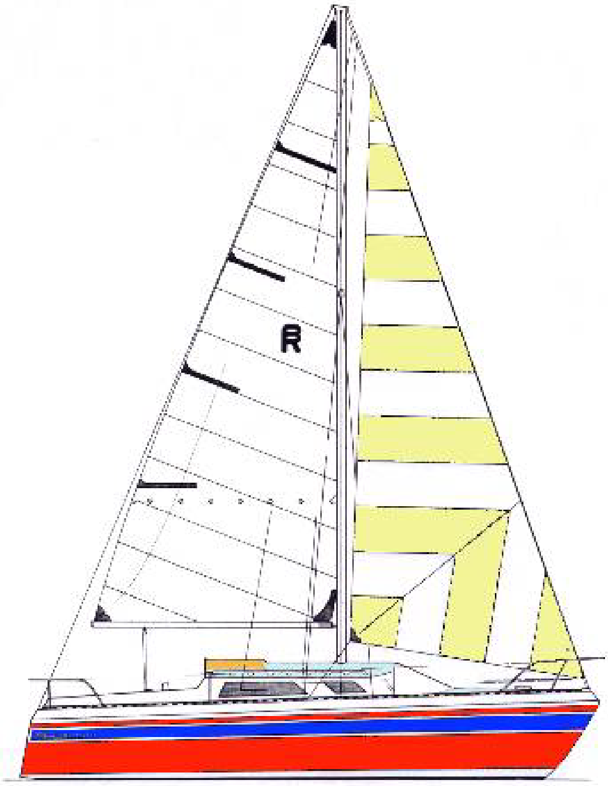
This design is available as two different concepts. Version A or Version B. Version A has a centreboard made from 12mm (1/2") steel plate and an outboard rudder that can be arranged as either a kick up or dagger board type This means that with both raised the Roberts 19 only draws 270mm (10") draft. Version B features a raised deck which, with the trunk cabin, give's a minimum of 1350mm (4' 6") headroom. It also features a fixed keel which, as it only draws 600mm (2'), makes it easily trailerable.
Both Versions are included in the study plans or complete plans package.
The Roberts 19 can be built in Wood Epoxy by the Molded Plywood method. A complete set of plans and full size patterns are available for either Wood Epoxy or Fibreglass. Trailer plans are included in the complete set of plans package.

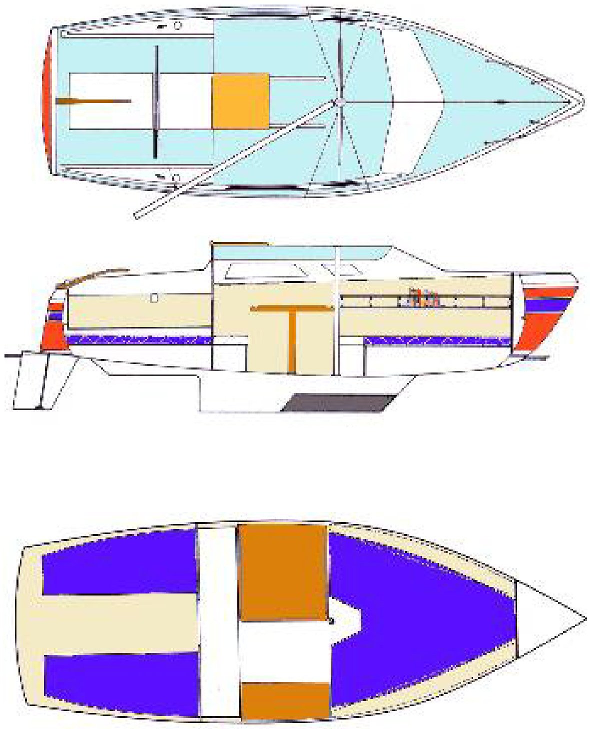
FIBERGLASS OR WOOD / EPOXY

The STUDY PLAN PACKAGE ON CD has details of all of the construction techniques and includes materials lists, and accommodation layouts for both trunk cabin or motor sailer versions.

ROBERTS 19 Fixed keel version

This version can be trailed or left on a perminent mooring or dock.





Genevieve Desjardins
Yacht "Pere Peinard"
Brisbane AUSTRALIA

"PERE PEINARD"
A Bruce Roberts Trailer Sailor 18 on the Big Duck Pond

From Montreal, Canada to Brisbane, Australia 18 "Pere Peinard" has failed miserably to live up to it’s designation as a trailer-sailor. But in order to complete the circumnavigation, we will have to fulfil our promise to the Lock-Keeper in Montreal, and trailer the length of the lock since our boat is Officially Undersize by strict regulations governing safe passage through the lock. He let us through the first time, but only because Claude’s father kept hissing to Claude to "sit down! Stay low! When you stand up you make the boat look small!" Fortunately, we had no such restrictions in passing the Panama Canal.

Since most would say the main advantage to mini boats is their trailerability, it is perhaps strange to have chosen to build such a boat for offshore cruising over long distances rather than highway mileage. But Claude, at the age of 18, wanted a boat capable of sailing anywhere despite the limitations of budget, so he decided that he could make up for size in sheer quality. This explanation satisfied me until I saw the worksite, his father’s garage – the glue droppings left from the cold-moulded construction make a perfect outline on the floor with a few inches to spare… "Pere Peinard was the absolute maximum size permitted by the available space. Still building at home enabled him to continue a carpentry job and college as well as working on the boat for the two years it took till launching.

Guided by the principle "Trop fort, na jamais manquer" (too strong, never miss) and doubtless influenced by the screaming winter winds of Quebec, Claude now feels he overbuilt. Be that as it may, it is undoubtedly the one vessel best able to withstand capsize, pitchpole, dropping off waves or other such untried calamities, with flotation built in watertight bulkheads and blown (in the form of insulating foam) floatation coating the inside of the hull. No thru-hull fittings, a hollow skeg and a watertight deck keep the integrity of the whole. And then, besides security, comfort was a primary concern. This is simply a "question of organisation" which means that with thoughtful effort, it is possible to be as well, if not better, equipped than many a bigger boat. It also needs a rather ruthless elimination of "stuff", after which you can still carry a full set of power tools, generator, typewriter, library, files, sewing machine, and whatever projects especially amuse you. With nine sails aboard, three anchors/chain/line, two sextants, two SW radios, a UHF radio, a spare windvane, etc. we don't feel that the problem is space at all – our worry is weight rather than room. Being a buoyant stable design, with a fairly flat bottom and twin keels as well as broad beam, the boat sails best with plenty of wind and is not bothered overmuch by sea conditions.

Given a long-term passage, "Pere Peinard" keeps pace with the 25' cruising set with astonishing ease. This may be due to factors obviously other than the 'waterline formula' for speed under sail. Because the rig is comparatively strong, we push the boat to an extreme. Because we are as lazy as the next crew, we get a lot more result out of the same effort spent on sail change aboard a larger boat when more sail is needed… but we are even lazier than the average when it comes to reducing sail. We get a genuine thrill out of surfing at ± 7 knots, and have on occasion been so excessively carried away that the speedometer's stuck at 10 knots. By way of illustration, we made the 900-mile doldrum leg between Panama and the Galapagos in 21 days; bigger boats took longer still during the same period unless using diesel power. But the 3000 miles from the Galapagos to the Marquesas sped by in 26 days – 120 miles a day average. For three consecutive days during the run we averaged 143 miles… we arrived in the Marquesas only two days after our fleet of big-boat friends. So, although we sometimes have the discouraged urge to go Faster, this handicap of slowness has never jeopardized our safety, nor has it slowed us down in the long run.

Nevertheless we continue to lighten the boat as much as possible. In all, there's not much more we could ask of any boat than we are not already given by "Pere "Peinard". Maybe it hasn't been much of a trailer sailer, but as home to us and our cats, it has given us all kinds of different scenery out the windows.

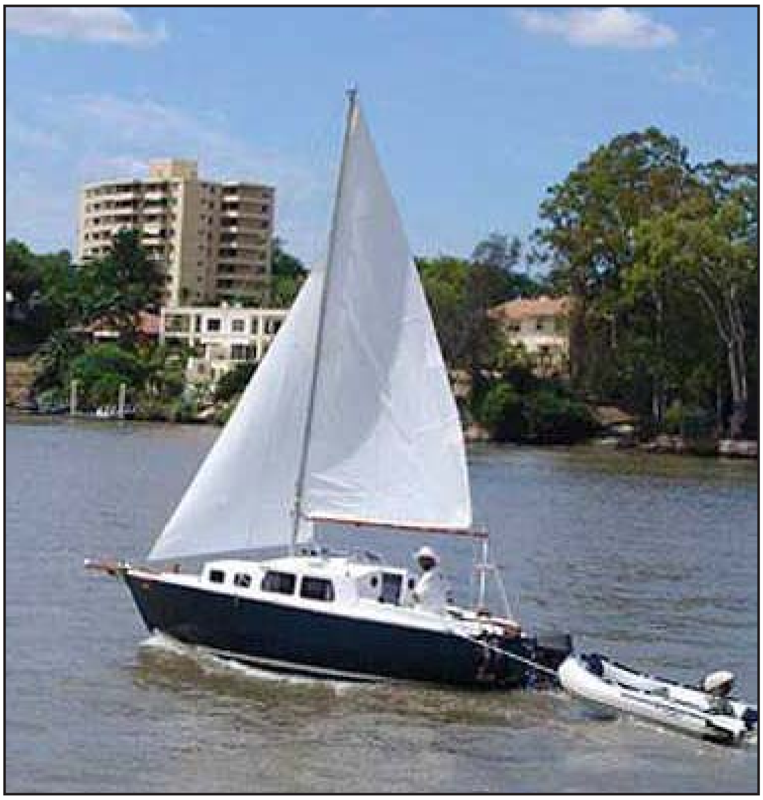
Signed Genevieve Desjardins

ROBERTS 19 (cont.)

The Roberts 19 is a very easy boat to build and you can choose either fiberglass or wood / epoxy as your primary building material.

ABOVE AND RIGHT: Here we see two photos of a Roberts 19 that was built in wood epoxy; as you can see the owner builder is doing a very nice job of building his own boat !

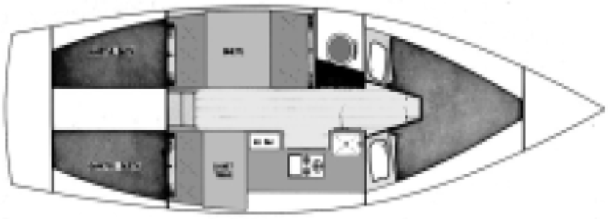
ROBERTS 19 (cont.)

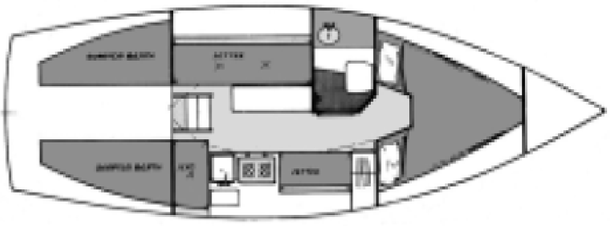


ABOVE: *Here are a selection of photographs of Roberts 19's that have been built by their owners. One builder made his own sails; not a bad idea; when you are out cruising when the ability to repair and even replace sails sails will come in handy !*

ROBERTS 25.

LOD .... 25'-3" / 7.70 M
LWL .... 20'-10" / 6.34 M
BEAM .... 8'-0" / 2.43 M
DRAFT .... .2'-6" / 0.76 M
Trailerable weight .... 3,500 lbs / 1,587 Kg





Designed in 1975 the Roberts 25 is proof that a well designed boat can be popular over a long period. Over 1,000 examples have been built and sailed throughout the world. This is truly a boat that can take you wherever you are capable of taking her! SEE MORE ON OUR WEB SITE **www.bruceroberts.com**

Marlin Berry writes: We are having as much fun sailing her as we did building her and I just wanted to let you know what a truly fine boat the Roberts 25 is. I have had nothing but praise from all you have sailed in her.

John F LeMoine writes: Monday it was blowing 25 gusting 30 kts and I single handed with a double reef main, she tracked straight with no weather helm to speak of. When I had to make adjustments on the foredeck I could do so with no trouble. The boat does everything I hoped it would. Thanks for all the help and inspiration during the building process.

Victor Pomper writes: We trailed our Roberts 25 from Florida at 55 to 60 mph and everywhere we stopped we got comments like "beautiful boat you have there, what is she a 30 footer? And sail, does she ever sail and room believe me there is more room in my Roberts 25 than my friends 30 footer. Thanks for a super design, a super boat and great value. Am I ever having fun!

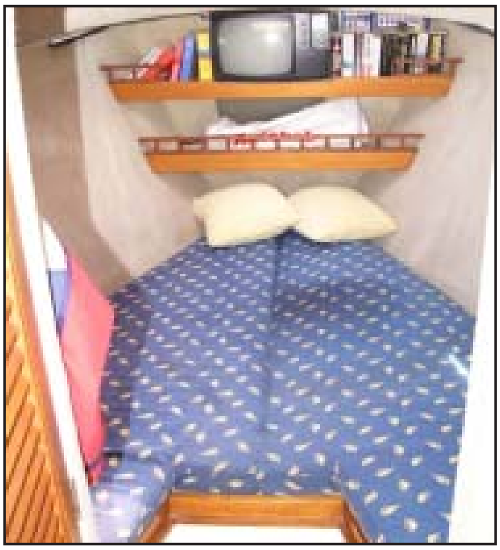
We have dozens of letters from owners of this fine boat and you can build yours in Fiberglass or W/E. Regular or shoal draft versions included in the plans and full size pattern package**Super Study plan package available.**

ABOVE: *One of the first over 1,000 Roberts 25's that were built in Australia*

BELOW: *This Roberts 25 was exibited at the Newport Beach boatshow and severl were sold at that time to owners from sll over the Western USA*

ROBERTS 25 (cont.)

Here see just a few of the many photos we have available of the Roberts 25. Note the three options of steering, tiller, outside wheel and inside wheel in the pilot house version



Builders of the Roberts 25 have created many and varied acommodation layouts. Some have arranged a seperate toilet and shower, a nice luxury in a boat of this size and made possible by the full standing headroom throughout the interior.







Here we see the process of building a Wood / Epoxy Roberts 25 hull

Tom Thumb 26

An earlier design, the steel Tom Thumb 24 has proven to be a very popular boat; this larger version was commissioned by a client in the USA who intends to have the boat built in Europe. After some time spent cruising the beautiful canals of Holland and France, the boat will be sailed or shipped back to the US.

Like its smaller sister this design can be built utilizing frameless steel construction techniques. The object is to provide the undoubted strength of steel while allowing the construction to be kept relatively light. Tom Thumb 2c can also be built from aluminum.

One owner writes:

Tom Thumb, as her name denotes is no giant. She is just under 8 meters / 26 ft long; she is however, made of steel. That means she displaces a considerable 9,000 lbs / 4,082 Kg and the waves think twice before throwing her around.

She is frameless and this as well as her generous 10 ft- 4 in / 3.15 M beam, cambered cabin top and side decks renders Tom Thumb a very large interior. Headroom is 6 ft-3 in / 1.90 M. With her plumb ends and long waterline she has a surprising turn of speed. Her hull speed is a tad over 6 knots.

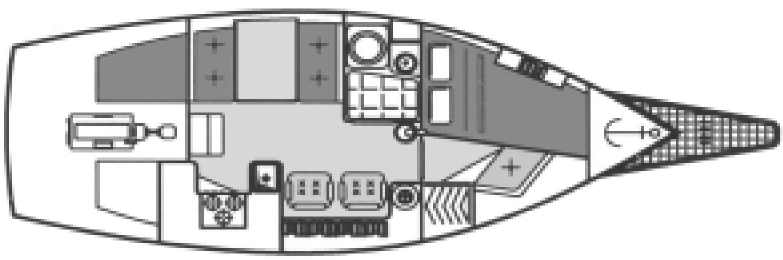
An enclosed head and workman-like galley are just two of Tom Thumb's features in this mini cruiser. Tom Thumb will take you anywhere you are capable of taking her.

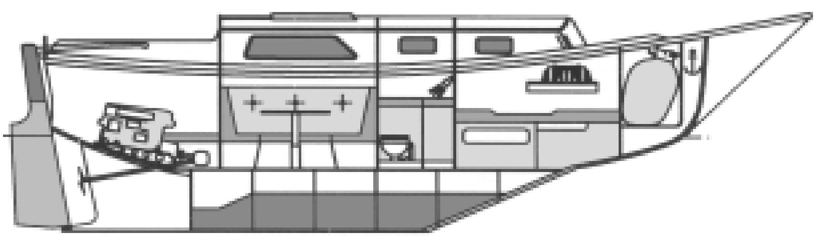
Already several Tom Thumb's have been completed and the above comments are just a sample of many letters and other favorable communications we have received about this great little cruising boat.

Study plan packages:

These include Gaff sloop, Bmu. sloop and Cat rigs available.

TOM THUMB 26





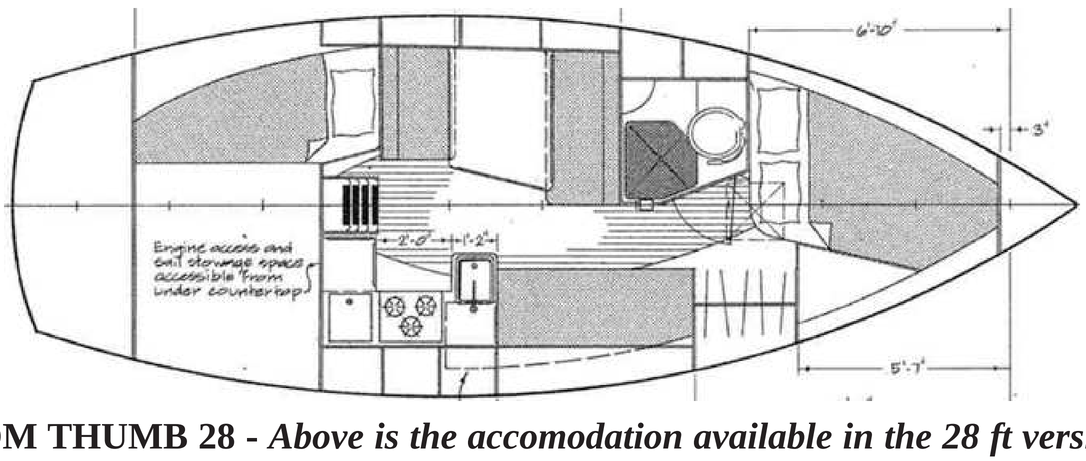
LOD .... 25'-11" 7.92 M	DISPL .... .9,000 LB 4,082 KG
LWL .... 23'- 9" 7.24 M	BALLAST .... 3,000 LB 1,360 K
BEAM .... 10'- 4" 3.15 M	SAIL AREA ... 465 SQ FT 43 SQM
DRAFT .... 4'- 0" 1.22 M	MATERIAL .... STEEL OR ALU

SEVERAL ALTERNATE SAIL PLANS ARE AVAILABLE FOR THIS BOAT

I built a tom thumb 26 and I would like to thank you for this perfect design. I add a boomkin and a long bow also cutter rig. And I add additional 250 kg in keel because of larger sail area. Round shape and teak deck and mahogany works for traditional boat appearance. She is cruising perfect and she can reach 6 - 7 knot easily in between 3-7 beufort with sails. I also change the accomodation according to my requirements with mahogany work. I cruised over 1000 miles in this summer with her and I totally satisfied. I proud of her.

I strongly recommend this perfect design for all the sailors that want to built their boat by themselves.

Thanks and best Regards, Hakan GOKMEN



TOM THUMB 28 - ***Above is the accomodation available in the 28 ft version.***

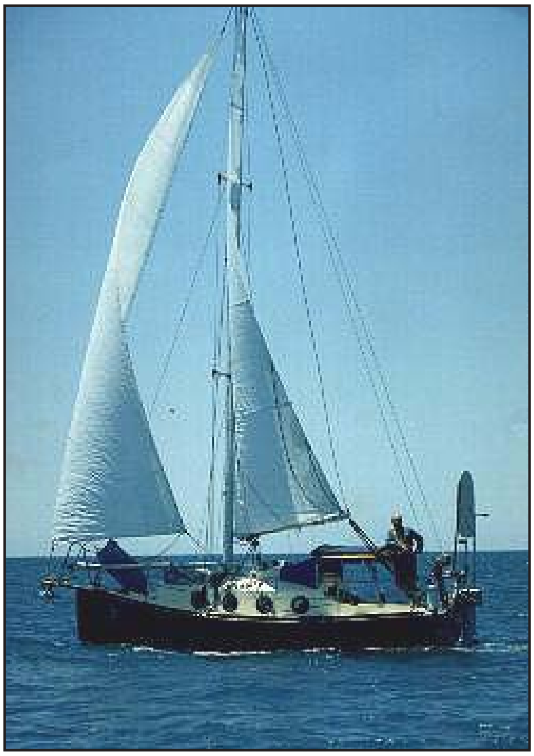
Here we see a fine example of the Tom Thumb 26 beating to windward without too much fuss !

As you can see it is possible to trail the Tom Thumb 26 but you may need a permit to meet your local road rules.

Here is a picture of "Margarita" crewed by my nephews, headed south again ...This shot is on Indian River in Cocoa Fla...They are headed for Bahamas and Turks...I launched this boat in 1990 and she looks like a newborn 20 yrs. later...and even better...Someday I might get her back but in the meantime she is turning heads....Please use the pictures and script as you wish...Regards. John

Tony Fountain, (former owner of Spray 33 and founder of Australian Spray Society) recently purchased a Roberts Tom Thumb steel cutter called "Striking Viking"

BELOW: More Tom Thumb 26's

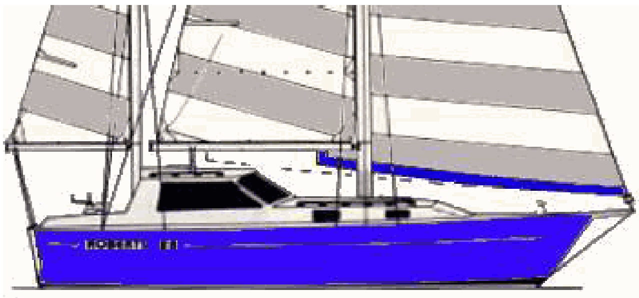


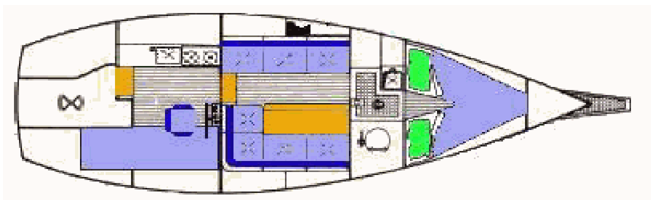
Here are some interior photos of three different Tom Thumb 26's

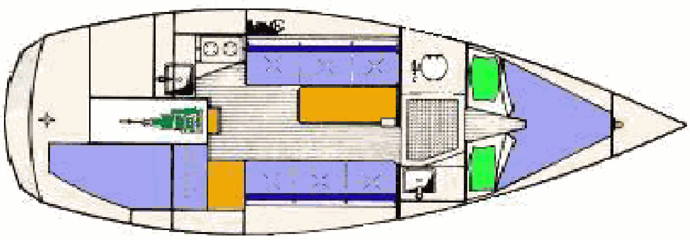
ROBERTS 28 MULTI CHINE STEEL

Designed for STEEL construction, this design is available with long or short keel options, as well as trunk cabin or pilot house layouts, and is an excellent small steel cruiser for family use. The boat can be built as either a Sloop or Ketch rig and can easily be handled by one person**.** There are over 200 of this design already sailing and as many again currently under construction throughout the world.

LOD...27’-8” / 8.43 m
LWL...24’-2” / 37 m
BEAM..10’-2” / 3.10 m
DRAFT ....4’-9” / 1.45 m







Hi Bruce, I purchased plans for the Roberts 28 last month. I received them and they are GREAT. Very satisfied with the quality of the plans. I plan on using my boat for extended cruising in the Gulf of Mexico / Caribbean so I want to make SURE that everything is as ideal as it can be. Thanks again Todd Stinnette

ROBERTS 28 (cont.)

The transom of the Roberts 28 can be arranged to suit your requirements; vertical, reverse with or without sugar scoop stern or boarding area or with boarding ladder or steps.

Built in steps in the transom are a popular feature shown on this Roberts 28.

Reverse transom with boarding ladder is shown on this Roberts 28

ROBERTS 28 (cont.)

Roberts 28 interior looking forward on starboard side.

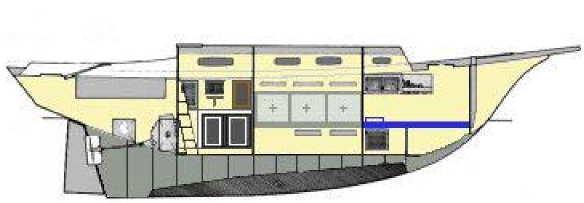
Roberts 28 interior looking aft on port side, note the roomy quarter berth adjacent the companionway.

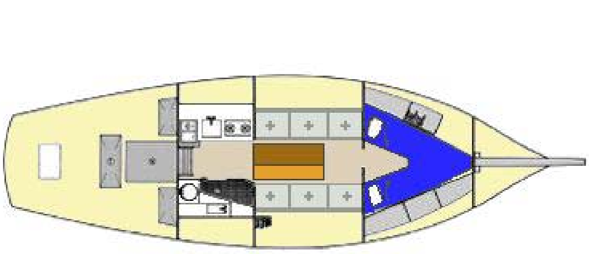
Roberts 28 interior looking forward showing the comfortable V berth arrangement combined with extra seating.

CHAPTER 14.
Sailboats 31'- 40' - 9.5m -12.2m

ROBERTS 31

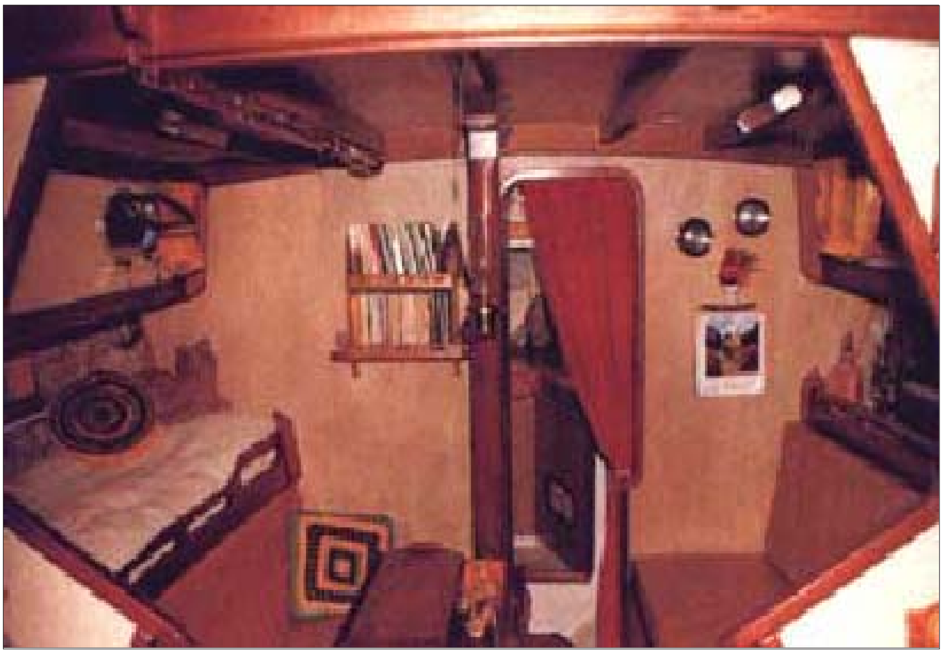
LOD .... 31'-11" / 9.73 m
LWL..24'-2" / 7.35 m
BEAM...10'-0" / 3.05 m
DRAFT... 4'-6" / 1.87 m





ROBERTS 31 (Cont.)

FIBERGLASS or STRIP PLANK. Over 100 of this design have been built in various part of the world. Several have made trans ocean voyages. The Roberts 31 can be rigged as a Schooner or Cutter. A very pretty traditional sailboat.

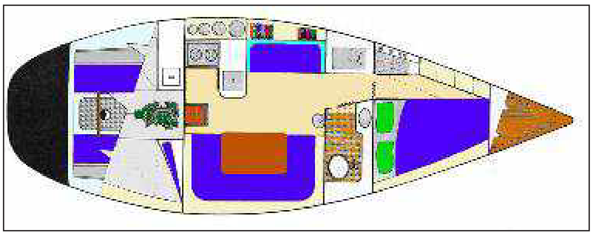


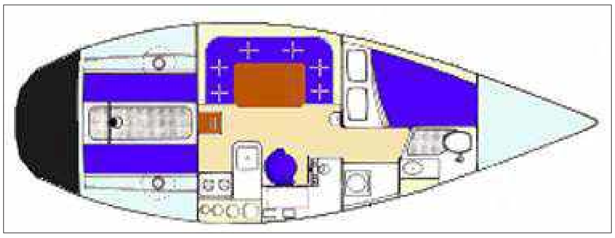
So far over 50 Roberts 31's have been completed and here are three - two of the boats pictured have cruised world-wide and the third is located in Tasmania Australia.

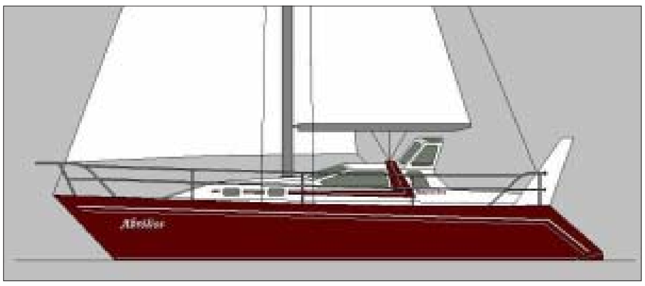
ROBERTS 310

LOD .... 31’-0” / 9.45 m
LWL... 25’-6” / 7.77 m
BEAM .... 10’-6” / 3.20 m
DRAFT.Shoal................................. 3’-6” / 1.07 m
DRAFT.Regular .... 5’-6” / - 1.66 m
DISPL..9,669 lb 4316 kg
BALLAST.................................... 4,500 lb2009 kg
AUX. PWR....................................... 20 TO 33 hp

GLASS, M/C or R/C STEEL or ALU OR W/E Over 100 of this design have been built in several different configurations. This boat can be rigged as a sloop or cutter combined with a variety of general arrangements. The Roberts 310 is a VERY fast boat. **The Study Plan Package on CD tells all you want to know about this design.**

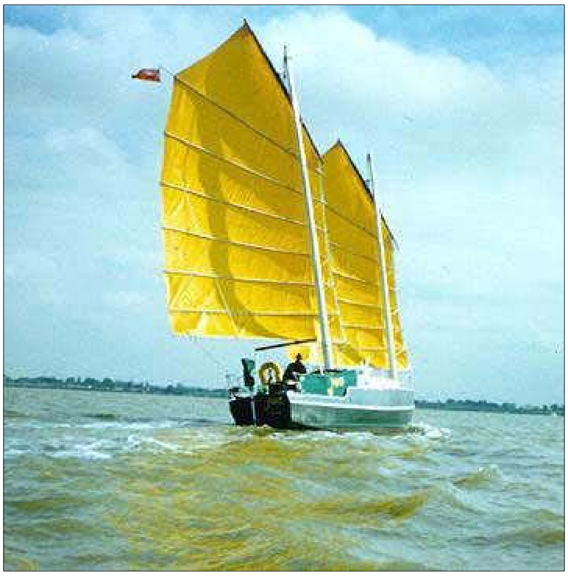




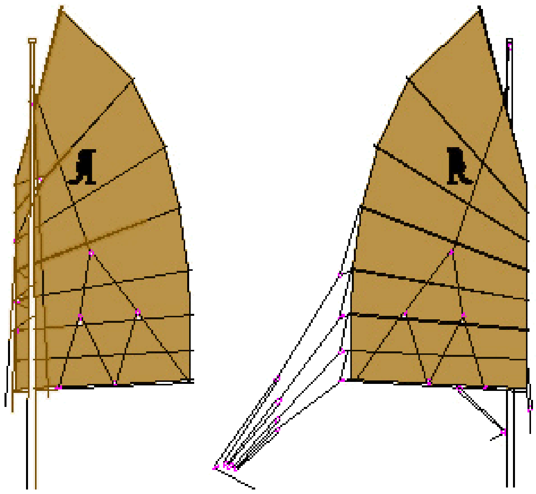


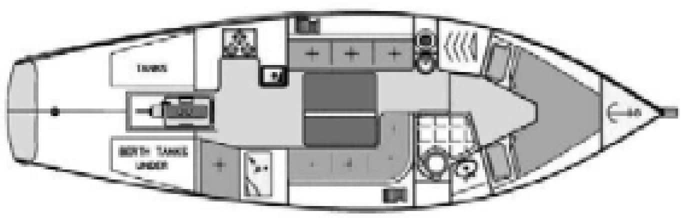
GOLDEN HIND 34 Multi Chine Steel

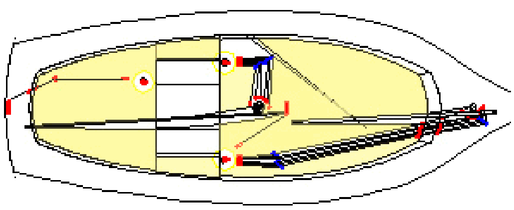
The first example of this design has made made several trans ocean voyages This design is a well proven MAURICE GRIFFITH world cruiser as many are currently sailing in different parts of the world and the reports are excellent. It can be rigged as a Cutter or Junk Schooner ... other rigs possible. You can build the GOLDEN HIND in MULTI-CHINE STEEL. The complete plans package include many sheets of large-scale drawings, plus full-size patterns for the hull etc.Already the first example of this design has undertaken thousands of miles of offshore cruising including crossing the Atlantic both ways. The husband and wife owners of this Golden Hind 34 gave the boat a glowing report and said she lived up to all expections.

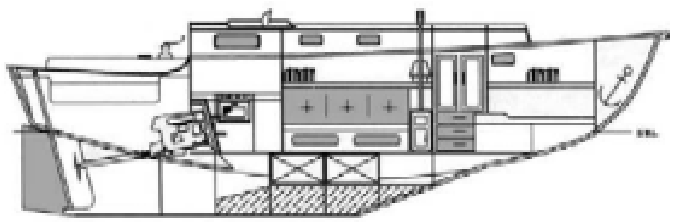


L.O.D...............................**10.40 m 34' 0"**
L.W.L............................... **8.59 m 28' 2"**
BEAM............................... **3.12 m 10' 3"**
DRAFT.............................. **1.37 cm 4' 6"**
DISPL...........................**6441 kg 16,250 lb**
AUX........................ **POWER 20 to 35 hp**







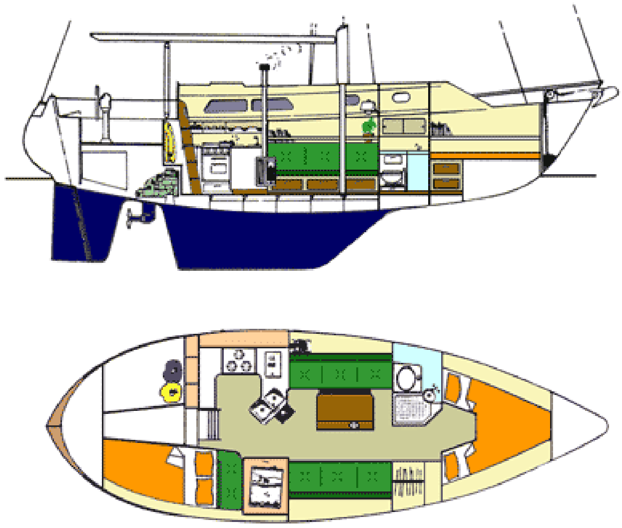


Designs for which the gaff rig is suitable are available with complete details of how to install and operate this rig. Contact Bruce Roberts-Goodson for more details.

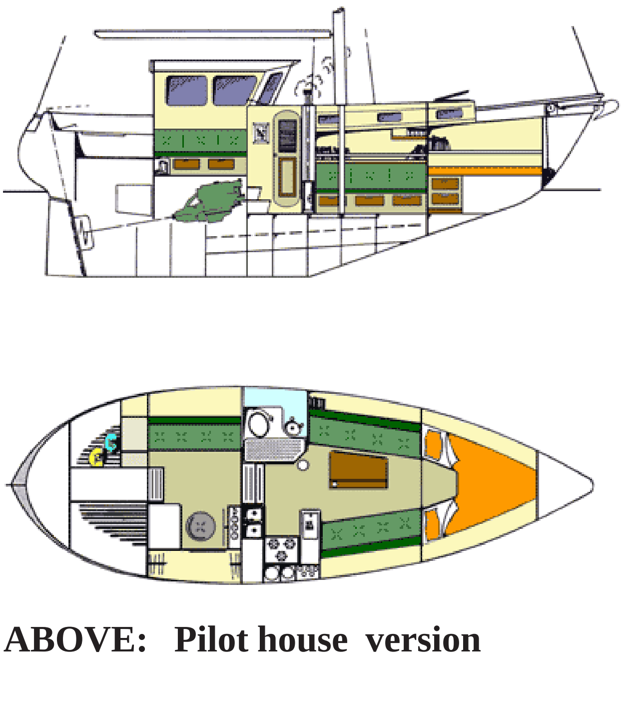
ROBERTS 341 CANOE STERN SAILBOAT

Plans and frame patterns are available to build this boat in FIBERGLASS.
Over 100 of this fine cruising sailboat are in service world-wide. Designed for those of you that are looking for the sea going qualities of a canoe stern then this is the design for you. The R341 design was prepared for those people who are looking for a modern, high performance cruising boat that is based on the traditional Scottish fishing vessel. This strong, sea-worthy, double-ender is available with full or long fin keel, and can be rigged as a sloop or a cutter with a basic sail area of either 621 sq ft for the cutter or 559 sq ft for the sloop. Two accommodation layouts are provided, one for the aft cockpit version (A) and one for the Pilothouse version (B). This design has construction plans available in FIBERGLASS only. Study plans on CD are available for this plan. These are intended to give you an overview of the particular design and include all available Accommodation plans, Sail plans, Material lists & Construction sheets covering available construction materials.

L.O.A.	10.39 m 34' 1"
L.W.L	8.64 m 28' 4"
BEAM	3.50 m 11' 6"
DRAFT	.52 m to 1.68 m 5' 0" or 5' 6"
SAIL AREA	62 sq m 621 sq ft
BALLAST	2950 kg 6,500 lb
DISPLACEMENT	7200 kg 20,750 lb
AUX. PWR	20 - 30 hp

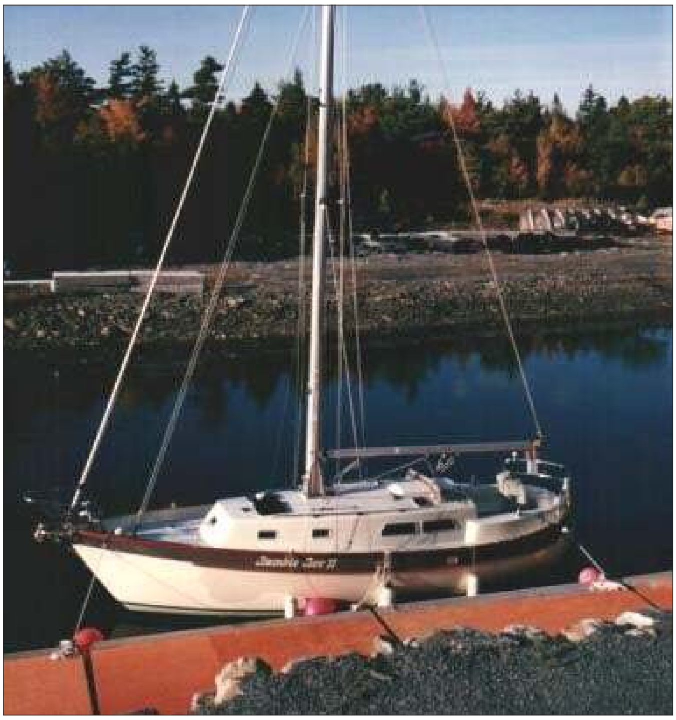


ABOVE: Regular trunk cabin version



ABOVE: Pilot house version

ROBERTS 341



Dear Mr. Roberts,
Some years ago (approx.1983) I purchased the plans for the Roberts 341A and built it over the span of many years. I have now been sailing it since 1990 off the shores of Halifax Nova Scotia. I am very pleased and impressed with the sailing characteristics and appearance of the boat. I would very much like to build a model of the boat for my basement as a center-piece. However, the drawings are full size and I was wondering if I could get a 1/10 version or an offset table to produce the lines. Yours truly, Wolfgang Dzimbowski ... BRUCE replied ... no problem and sent Wolfgang some specially sized patterns.

Here are 4 photos of different examles of the regular version of the Roberts 341; note that one owner has installed a 'dog house' over the companionway.

The spacious forward cabin-top on this pilot house version would be a good place to store your small dinghy inverted of course.

This profile view of the pilot house version reveals an attactive sheer that is a feature of thie design.

These photos are just a few of the many we have available for the Roberts 341. Most study plan packages on CD include a good number of photos of each design.

ROBERTS 345

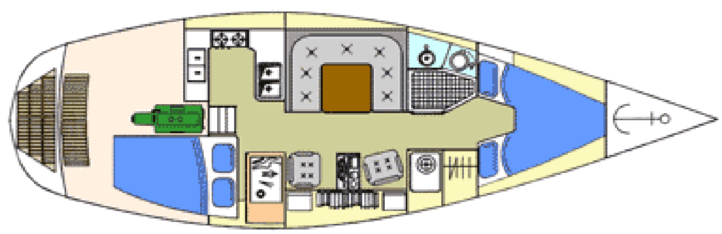
FIBERGLASS, M/C or R/C STEEL or ALUMINUM OR W/E.

Over 300 of this design have been completed. The R345 can be rigged as a sloop or cutter. A variety of keel and general arrangements are included in full plans. **This is a well proven and very fast boat.**

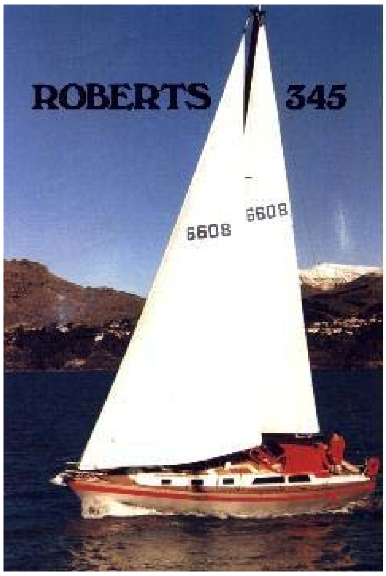
LOD .... 34'-5" / 10.50 m
LWL .... 28'-9" / 8.76 m
BEAM .... 11'-7" / .52 m
DRAFT ....5'-9" / 1.3 - 1.75 m
DISPL .... 10,500 LBS / 4,762 KG

It is now many years since the Roberts 345 replaced the popular Roberts 34 design. Over 1,000 Roberts 34's were built and many are currently cruising the world. Several Roberts34's are used in sailing schoools and others successfully took part in long distances races. A great boat and a hard act to follow...however, now we have the Roberts 345 which features a longer waterline and other updated features that have made this new design just as popular as its predecessor. So far there are over 300 Roberts 345's completed and sailing in various parts of the world. One of the many Roberts 345's that was built in England, was later sold by her builder and the new owners sailed her from England to Australia. Another UK built boat is currently cruising in the Mediterranean. We have been fortunate in having the opportuinity of sailing on several different examples of this design and discussing the boats performance and handling with the owners. This is a great boat and has an excellent turn of speed on all points of sail. For those who like to do their cruising in comfort we offer the Pilot house version which can be laid out in a variety of ways, some of which are shown in the Super Study plan package.

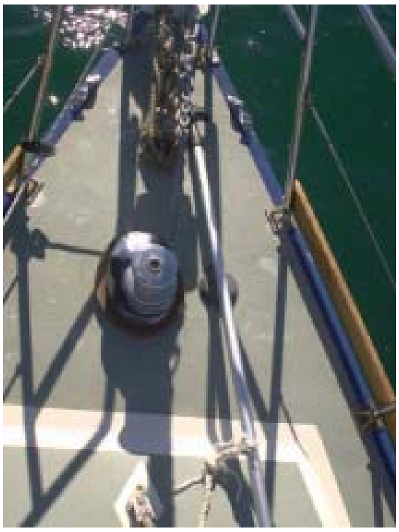
CUTTER OR SLOOP.
REGULAR & PILOT HOUSE



ROBERTS 345 (Cont.)

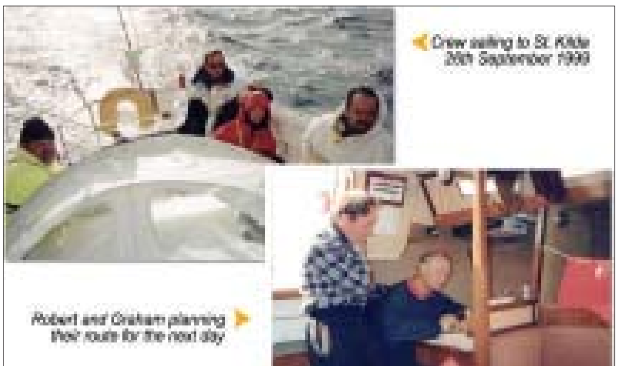


ROBERTS 345 (Cont.)



ROBERTS 345 (Cont.)

X Quarter Cabin



Crew sailing to St. Kilda 26th September 1999

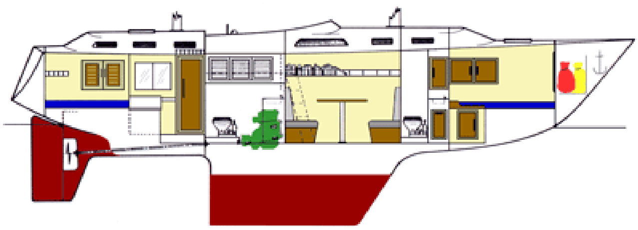
Robert and Graham planning their route for the next day

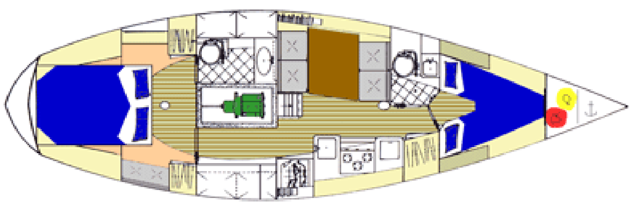
Just a few of the many Roberts 345 photos !

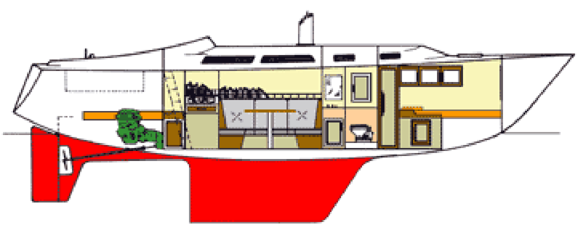
ROBERTS 35 Fiberglass or MC Steel

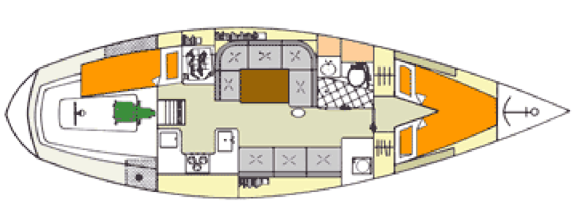
This design is a well proven world cruiser as OVER 200 are currently sailing in different parts of the world and the reports are excellent. It can be rigged as a cutter or ketch and different layouts are available. You can build the Roberts 35 in either Round Bilge Fibreglass or in Multi Chine Steel or Aluminium . The complete plans package include many sheets of large-scale drawings, plus full-size patterns for the hull, deck and cabin top beams, etc.

L.O.A......................................10.82 m 35' 6"
L.W.L....................................... 8.41 m 27' 6"
BEAM....................................... 3.35 m 11' 0"
DRAFT....................................... 1.68 m 5' 6"
SAIL AREA......................... 49.4 sq m 532 sq ft
HEADROOM...............................1.96 m 6' 5"
DISPL..................................5,951 kg 13,120 lb
BALLAST............................. 2,268 kg 5,000 lb
AUX. PWR...33 hp









ROBERTS 35 (Cont.)

This flush deck version of the Roberts 35 provides a very spacious interior.

This is a fiberglass Roberts 35 version B which features a center cockpit layout.

Here we see a Roberts 35 multi-chine steel flush deck version.

ROBERTS 35 (Cont.)

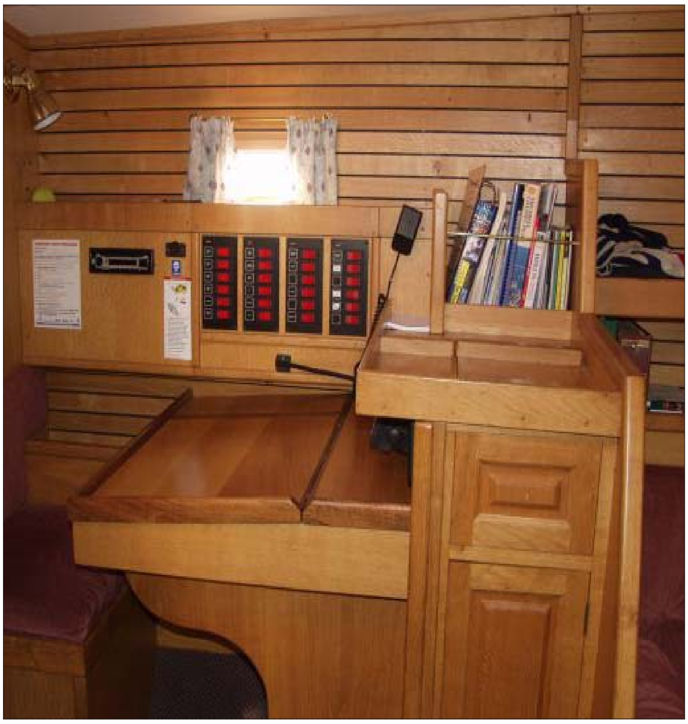
On the left we see a Roberts 35 multi-chine steel flush deck version.

Below are shown just a few of the many Roberts 35 photographs that are included in the study plans on CD package.

ROBERTS 35 (Cont.)

LEFT: *Note the spacious cockpit is a feature of the flush deck Roberts 35*

BELOW *and on the following page are shown just a few of the many photographs that you get to see when you order the study plans on CD for the Roberts 35*



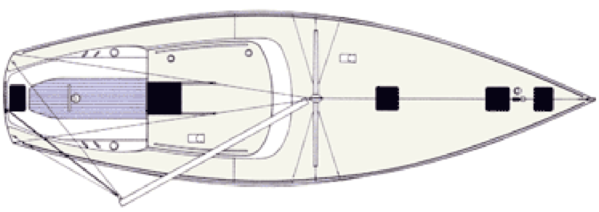
ROBERTS 35 (Cont.)

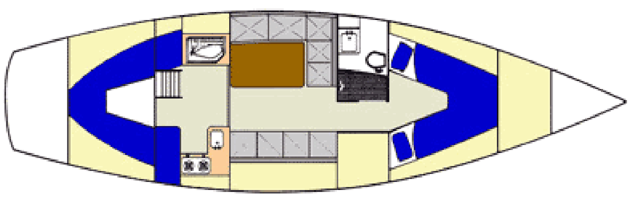
ROBERTS 36

This design is a well proven world cruiser as over 500 are currently sailing in different parts of the world and the reports are excellent. It can be rigged as a cutter or ketch and different layouts are available. You can build the Roberts 36 in Multi Chine Steel or Aluminium . The complete plans package include many sheets of large-scale drawings, plus full-size patterns for the hull, deck and cabin top beams, etc.

L.O.D	**11.20 m 36' 9"**
L.W.L	**8.76 m 28' 9"**
BEAM	**3.35 m 11' 0"**
DRAFT	**4' 0" - 4' 9"**
DISPL	**(steel) 18,000 lb**
BALLAST	**6,275 lb**
AUX. PWR	**20 TO 33 hp**

Roberts 36 B Trunk cabin version



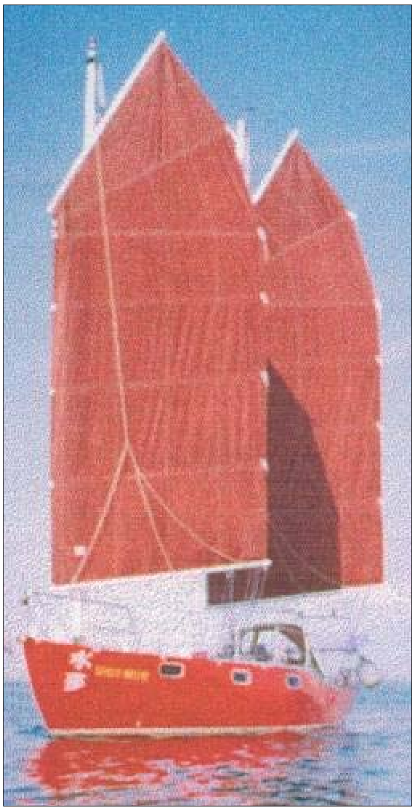


Roberts 36 A Raised Deck version

ROBERTS 36 (Cont.)

ROBERTS 36 (Cont.)

Roberts 36 "Lucy 2" built Rhea Adams. The raised deck version of this design has proven to be a very popular.



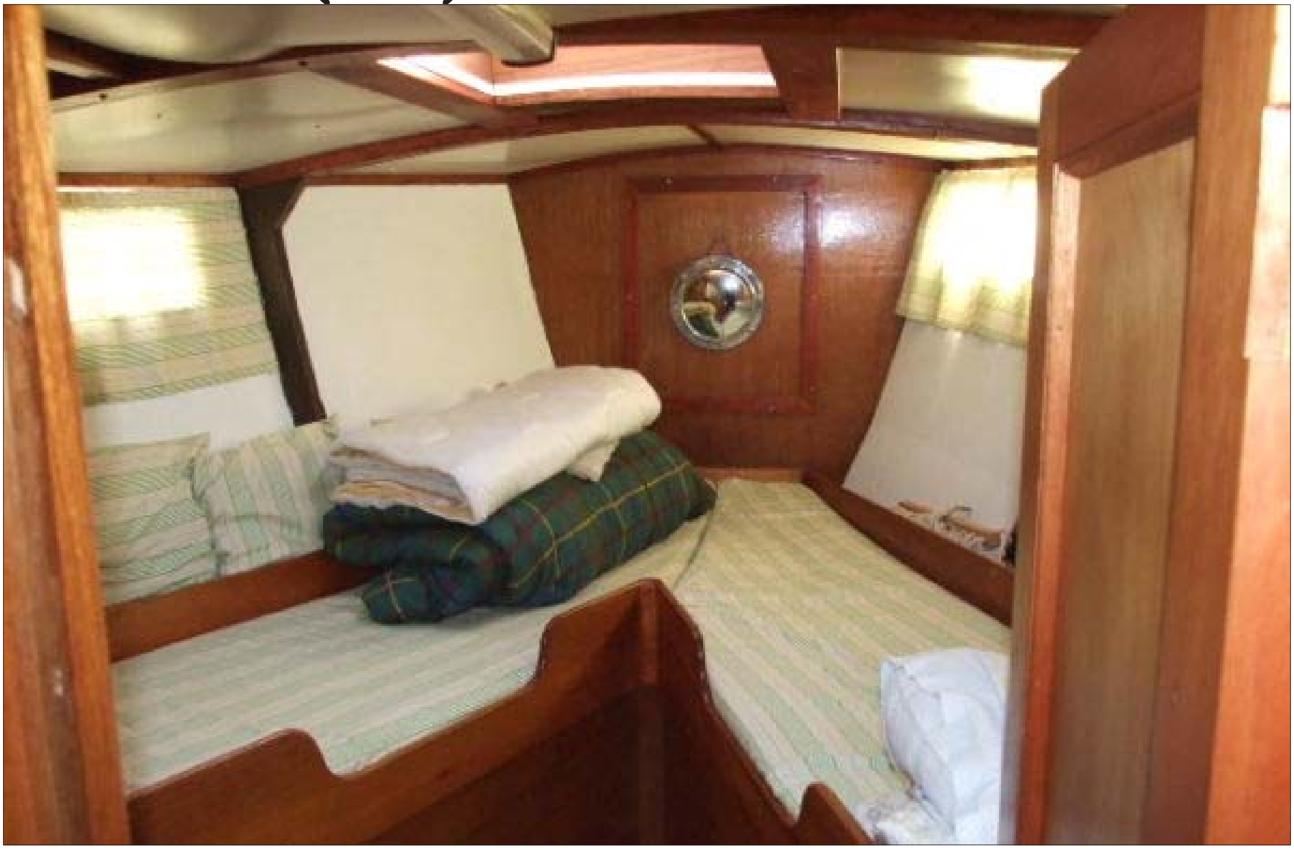
Hey Bruce

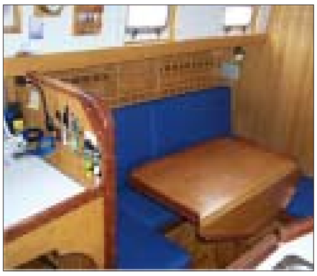
Oh my god!, My dad built that 36footer Junk rig!!! I lived on her for four years. We had to sell her a couple of years back, and i look for her everywhere we go where there is water. Always looking for the short timber masts. I had another dream that I found her, so i decided to type 'Roberts 36 junk rig' into google, and there she was, i cant believe it.

Do you know where she was last? Or what her name is, it used to be Minerva 3,? Last we heard she had changed hands twice and was with a guy named Bill. Those pictures, of the bulkhead and that, i drew them when i was 10 or eleven, just before we sold her. I cant believe they are still on her, happy but this has made my day, you cant believe. I loved that boat so much, coz she has a bath and no one else's yacht has a bath, not back then anyway.

Sad to say we are land lubbers now, but if you can tell me anything about her, it would be so awesome. Best boat you ever designed! Your Sincerely Joannam   Coleman, 16

ROBERTS 36 (Cont.)



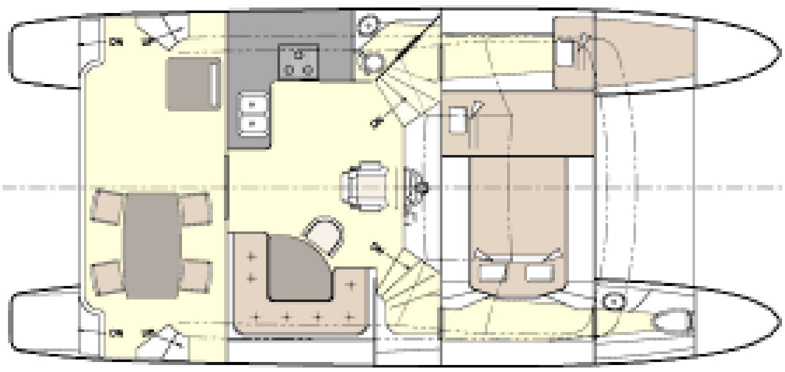


Just a few of the many R36 interior photos in our files.

CAT 36 POWER SAILER

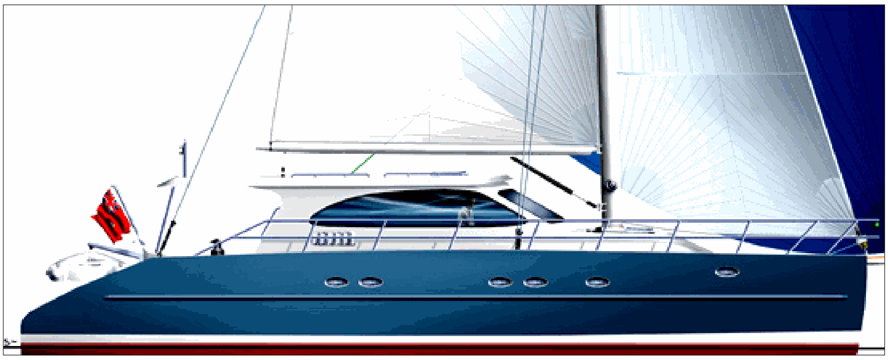
A CAT Power Sailer is a power cat capable of 12 to 30 knots under power and 12 to 18 knots under sail. These catamarans were designed to be built using the fibreglass panel construction techniques. The method is very simple to use and perfect for the inexperienced builder. All of the developing is done in the computer and patterns are supplied for the female frame formers. Special pre-scaled drawings are supplied for each hull panel making it simple for the builder to laminate all of the hull and superstructure on a flat table. The panels are set inside the pre-erected framework and laminated together similar to the plywood Stitch and Glue method. This is a POWER-SAILER CAT .. the bias is about 60% power and 40% sail ... the boat can be built as a power only vessel or with the added rig as shown. As for pure sailing cats; although we have considerable multi hull experience going back to 1961 and we do design cruising cats. You may find that one of the Cat Power Sailers would suit you.

LOA: ....10.83 m 35’ 6”
BOA:........................ 5.18 m 17-0"
Speed Max:........................... 30 kn
Speed Cruise:....................... 20 kn
Displ:............................. 9,000 KG
Draft:.................... 0.550 m 1’ 10”
Headroom ....1.9 m 6’-3”
Fuel capacity:..................400 litres
Water capacity:................300 litres
Motor: 2 x Diesels.......125 - 205hp
Construction......Fiberglass & foam



The accomodation plan may be varied to suit your requirements - this is an easy boat to build and the The Complete plans and frame patterns make the construction easy to understand & execute. These new study plans have lists of materials & equipment required to build and equip your boat ... these lists will help you to cost out the complete building project. Each CD contains - ALL the drawings of your choices of ONE or TWO or THREE plans with up to 25 sheets per plan! Technical information.

CAT 39 POWER SAILER



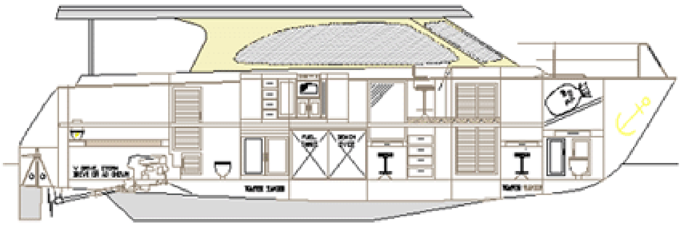
L.O.A.......12.10 m 39' 10"

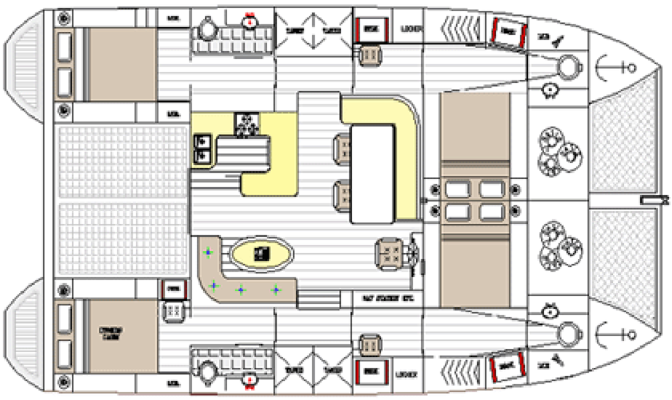
L.W.L..... 11.12 m 36' 6"

DRAFT.........1.07 m 3' 6"

BEAM........7.16 m. 23' 6"

POWER.....100 TO 500 hp





The accomodation plan may be varied to suit your requirements - this is an easy boat to build and the The Complete plans and frame patterns make the construction easy to understand & execute. These new study plans have lists of materials & equipment required to build and equip your boat ... these lists will help you to cost out the complete building project. Each CD contains - ALL the drawings of your choices of ONE or TWO or THREE plans with up to 25 sheets per plan! Technical information

In this sequence of photographs we show how the fiberglass Cat Power Sailers are built using the Roberts Panal construction techniques.

ABOVE: *Computer generated veiew of the Cat Power Sailer.*

LEFT: *First the frames are made using the full size patterns that are supplied with the plans.*

BELOW: *The frames are erected and spaced as shown on the plans*

ON THESE PAGES:
Once the frames are erected and the supporting batten stringers are installed then the panels that have been pre-formed on the laminating table can be fitted in place. If you carefully study these photos you will get the idea.

The study plans with come with over large scale 100 photos as well as plan drawings; these will show you exactly how it is done !

TOP: ***This view shows the panels which have the core material laminated to the inner surface now in place in the mold former.***

ABOVE: ***Here the inner laminate is being installed which aslo ties the panels togetner.***

RIGHT: ***The panels are laid up on the laminating table as shown in this photograph.***

ABOVE: ***The bulge of one of the the tunnel sterns can be seen in this photograph***

TOP and RIGHT: ***The webs and bulkheads are also laid up on the laminating table.***

ABOVE and BELOW: ***The hulls are now lifted out of the batten mold, what you are seeing is the clear glass and the core material showing through. Normally the boat would be completed before this is done; in this case a fewmale mold is to be taken off the hulls so they are inverted and coated and polished so the molds can be made; then they will be turned upright and the interior and superstructure will be completed.***

ABOVE: ***The hulls have now be inverted and ready to receive the interior and superstructure.***

LEFT: ***This view from the stern shows part of the aft deck and the steps.***

BELOW: ***The centerline break-water has been added; this was the clients idea and we are awaiting to see the results before altering the plans to incorporate this feature.***

TOP LEFT: ***Here we see another view from aft. Only part of the window has be cut out at this stage.***

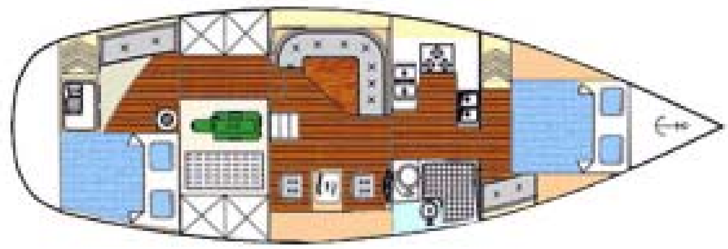
LEFT and ABOVE: ***First parts of the furniture is now being installed including the seating on the aft deck as shown on left.***

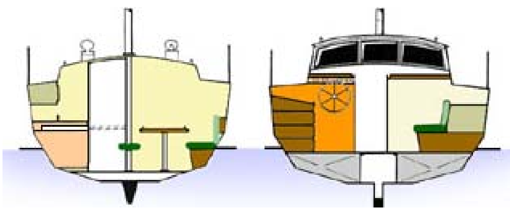
BELOW: ***Here is an overview of the hull deck and superstructure. In this case the owner opted for the optional flybridge.***

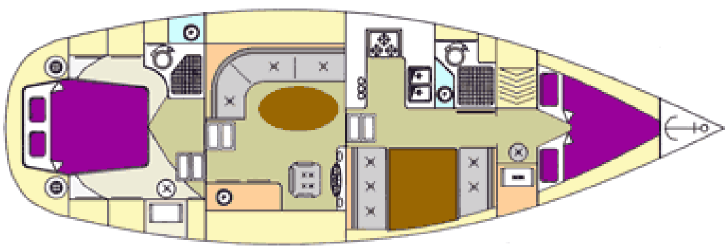
ROBERTS 370

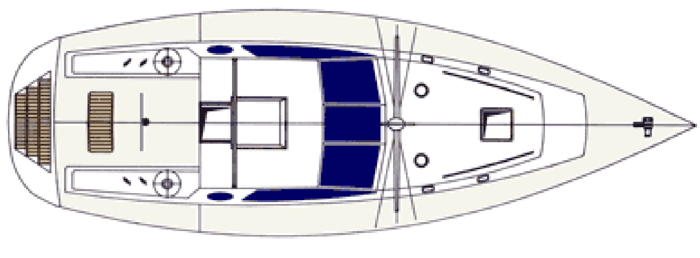
This is one of our most popular designs and there are over 1,000 examples sailing in all parts of the world. As you can see by the information on this and following pages there many options and combinations that you can choose when you build this cruising sailboat. Designed as a performance cruiser while retaining those features popular with families, the R 370 is truly a boat that has something for everyone. Big enough to be used as a liveaboard, fast enough to win Club championships, rugged enough to undertake World cruising and versatile enough to be built in any of the popular boat building materials; this could be the boat for you. There is even a **DROP KEEL** version, this may suit you if the waters are particulary shallow in the areas where you plan to cruise.

LOD .... 37'-2" 11.32 m
LWL.................................... 31'-8" 9.66 m
BEAM .... 12'-4" 3.76 m
DRAFT-SHOAL................... L4'-9" 1.45 m
DRAFT-DEEP......................... 6'-6" 1.98 m
DISPL....................... 18750 LBS 8,512 Kg
BALST........................ 8,000 LBS 3632 Kg
AUX. PWR........................... 20 TO 50 HP
SAIL................ SLOOP, CUTTER, KETCH



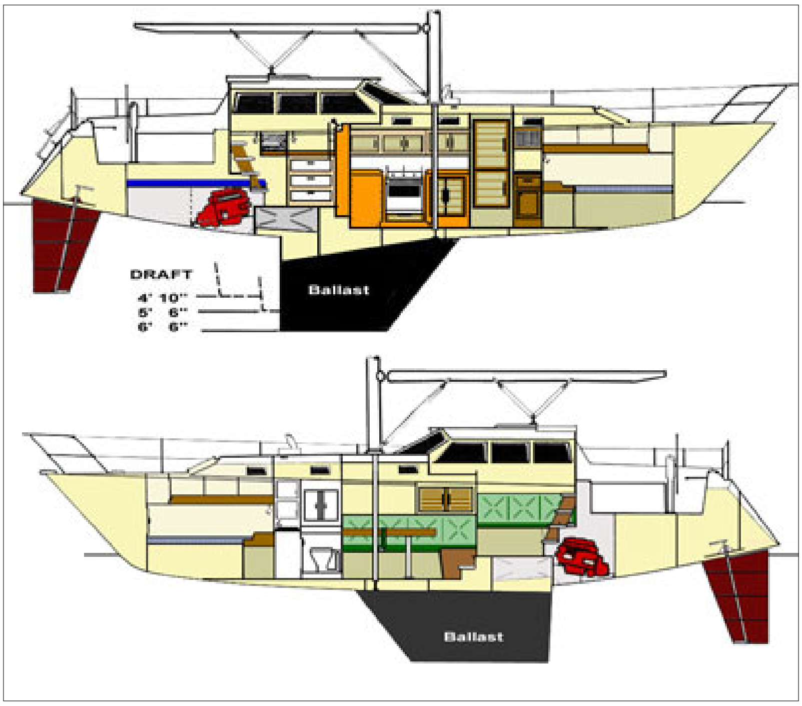


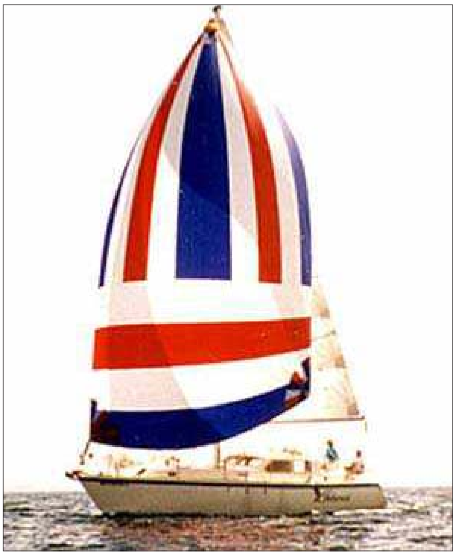




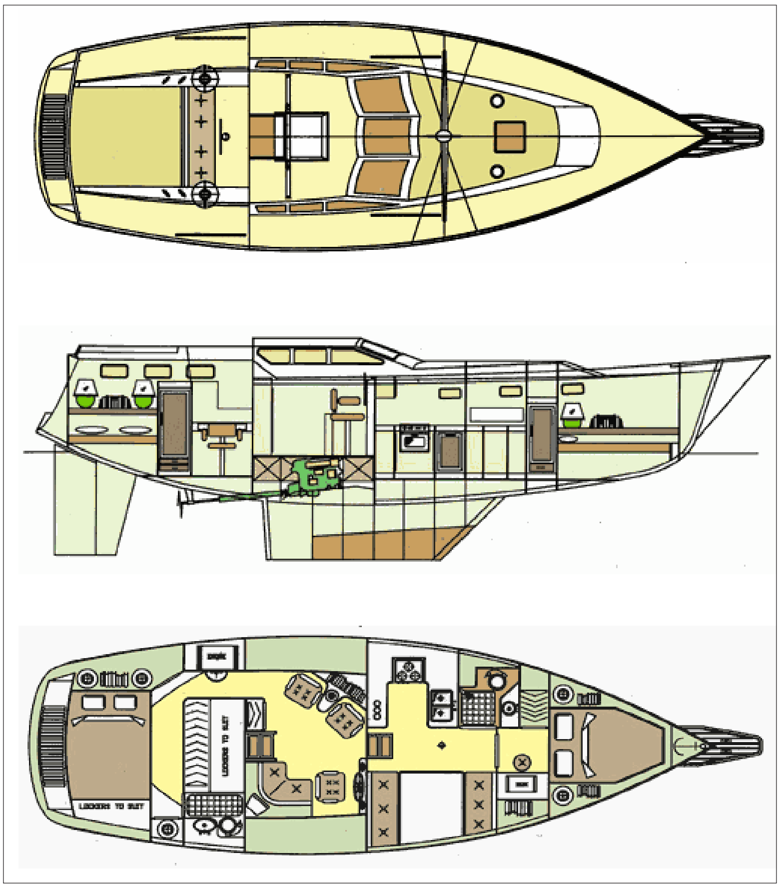
There are many versions of the Roberts 370 A - F and all can and have been built in Fiberglass, Steel or Wood / Epoxy - the following pages will give you some of this design but it is so extensive that we do recommend the study plans on CD if this boat interests you.

ROBERTS 370 (Cont.)





Voyager 382 Build from a KIT or Cutting files



LOA..........................39'-0" 11.89 m
LWL.......................34'-10" 10.63 m
BEAM........................13'-2" 4.02 m
DRAFT...............(deep) 6'-0" 1.83 m
Draft...................(Shoal)5'-6" 1.71 m
Sail Area.........1,174 sq ft 109.06 s/m

This new Radius chine kit boat is based on our highly successful Roberts 370 and Roberts 392 designs. Over 500 of these designs are sailing the oceans of the world. This new design is available in kit form only. The VOYAGER 388 is slightly longer than the R370 and we have taken the opportunity to heighten the cabin roof to give a greater feeling of spaciousness below.

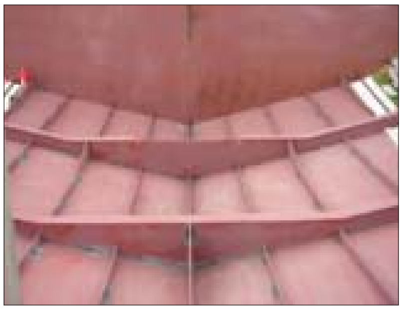
These cruising sailboats are designed in accordance with Lloyds for category 1 (unrestricted operating / sailing area), which is much better than the EU and other Classification Societies and the CE-A require. Complete stability calculations to USCG offshore requirements are included in the design package. All calculations are also cross referenced against ABS requirements to ensure that the design meets worldwide standards and specifications.

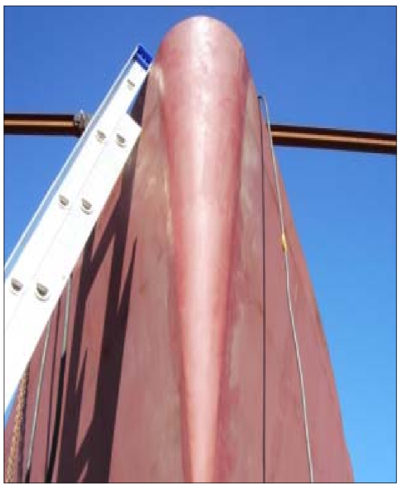
In the case of KITS, all plate parts belonging to the hull, deck and superstructure that are accurately cut to size are included. The parts are marked with the appropriate part number and engraved matching marking lines to assist in the assembly and location of the part in its position. Cutting method is Plasma / Oxygen, ensuring highest accuracy and smooth edges.

Plate parts are cut from Lloyds approved A Grade Shipbuilding quality STEEL that has been coated with factory applied Sigma weld MC welding primer. We use steel plate that has the official designation ISO standard 10474 or EN 10204 with 3.1.B certificate.

V388 BUILDER WHO VISITED ANOTHER

Hi Bruce, I got down to visit Myron Fox about 10 days ago and saw this project. We visited for about 5 hours and I learned lots. Mostly it just gave me confidence that an average guy with patience and some common sense can do just fine. A worthwhile visit. Hal Whitacre in your Annapolis office has also been very good at answering some of my amateur Q's. Thanks, Rob Skelly.

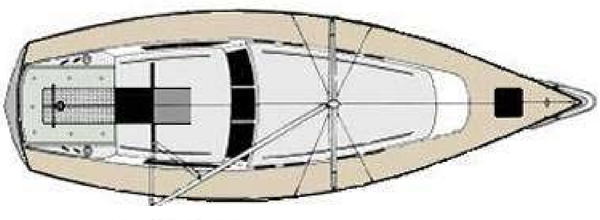


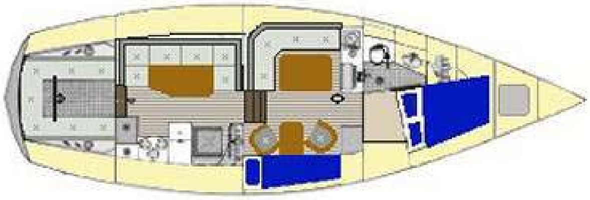


ROBERTS 39 Multi Chine STEEL

While this design is available only in multi-chine hull form, rigged as a sloop, we recently designed a radius chined companion ship called the Roberts 392 with very similar layouts. The Roberts 39 offers luxury cruising for a couple at a reasonable cost, and can be built with either a short keel giving 1.66m (5' 9") draft or a long keel with 1.51m (5' 3") draft. The complete plans and full size patterns include many sheets of large-scale drawings, plus full-size patterns for the hull, deck and cabin top beams, etc.

L.O.D......................................11.98 m 39' 4"
L.W.L ....9.88 m 32' 5"
BEAM ....3.89 m 2' 9"
DRAFT ....short keel 1.75 m 5' 9"
DRAFT........................long keel 1.60 m 5' 3"





ABOVE: ***Here we see an attactive Roberts 39 built by Terry Erskine in the UK***

RIGHT: ***Close-up ot the pilot house windows in a Roberts 39***

LEFT: ***This particular Roberts 39 has compact galley which has all the elements needed to serve up complete meals.***

ROBERTS 39 (Cont.)

Here we see part of the forward cabin in the Roberts 39. Note the lee rail on the berth; obviously this is the sleeping quarters for a younger member of the family.

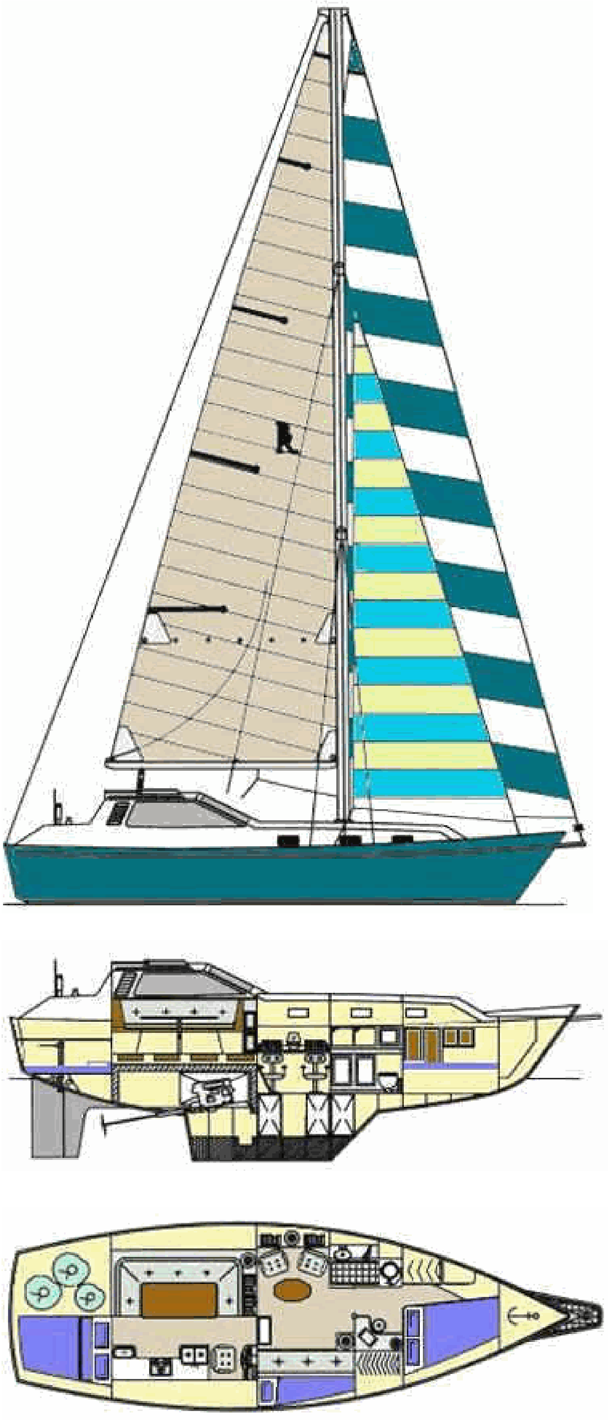
Looking aft in the Roberts 39. NO the skipper is not at prayers ... he is obviously performing some maintenance chore or perhaps retrieving a beer from under the steps !

This shot shows us looking forward from the pilot house into the salon and a glimse of the forward cabin

ROBERTS 392 R/C Steel or Fiberglass

This design is a companion to the Roberts 39 which isavailable only i n multi-chine hull form. Due to the great demand for radius chine steel and aluminum plus fiberglass plans for the Roberts 39 we have designed the Roberts 392 to meet these requests. We have taken the opportunity to add several alternate versions to this new design. You can build the Roberts 392 in round bilge fiberglass, radius chine steel or radius chine aluminum. The complete plans and full size patterns include many sheets of large-scale drawings, plus full-size patterns for the hull, deck and cabin top beams, etc. There are several versions including center cockpit, two different pilot house versions and an aft cockpit version. The sail plans include cutter, sloop & ketch. Short and long keel versions are now available for the R392.

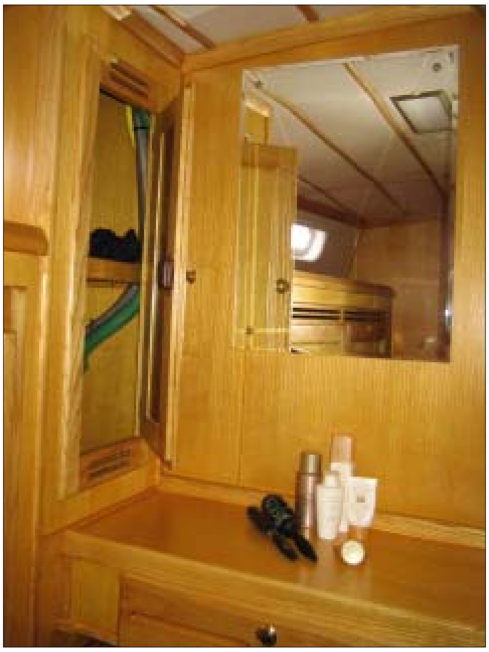
L.O.D...12.20 m 39' 9"
LWL..10.37 m 34' 0"
BEAM...3.96 m 13' 0"
DRAFT............................Short keel 1.75 m 5' 9"
DRAFT............................Long keel 1.60 m 5' 3"
DISPL............................Steel 12,238 kg 26,957 lb
F/G or Alloy..........................11 ,409 kg 25,131 lb
BALLAST.................................3,405 kg 7,500 lb
SAIL AREA...........................82.68 sq.m 890 sq.ft.



ROBERTS 392 version A

ROBERTS 392 version B

The Roberts 392 shown above and on the next two pages was built by John Boast who as a fire officer managed to build his boat in his spare time ... As you can see he did a wonderful job.



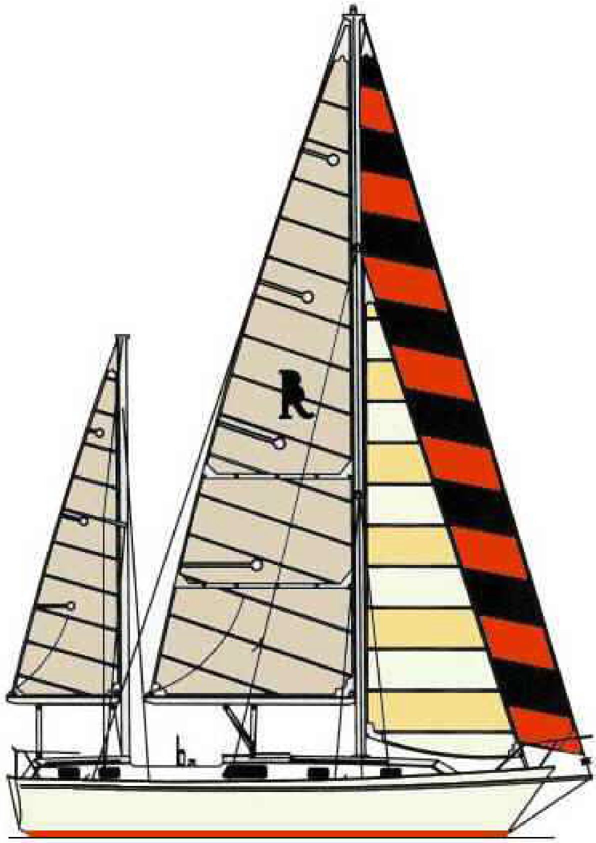
Here are three views of the interior of John Boast's Roberts 392

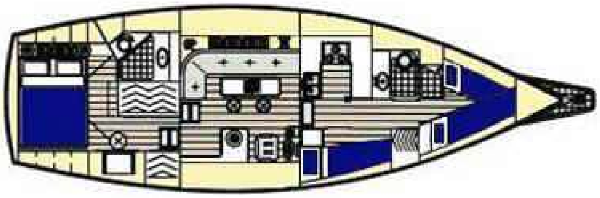
Note the gimballed stove in the galley of this Roberts 392

See the comfortable pilot chair located adjacent the navigation table in this Roberts 392

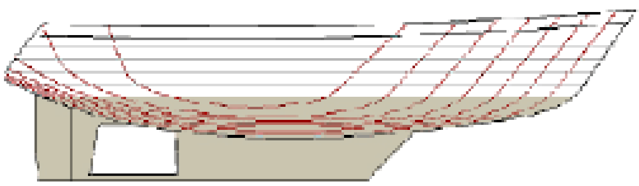
Note the shelves and lockers in this Roberts 392. Make sure your boat has plently of storage space available for all the crew.

ROBERTS 392 R/C Steel or Fiberglass





Above: *Roberts 392 C*



ABOVE*: The Roberts 392 is now available with the Roberts Safety Skeg.*

Larry Rauh who writes: Last year I purchased a steel PH built in the 1990's in Bellingham, Washington. This design was a modification of the Roberts 392 and the increase in length is due to an aft swim platform. It is beautifully finished inside using lots of Oak. We like our PH and although we have not used it as much as we would like, hopefully in a few years we will be able to take her and go cruising.

ABOVE: ***The interior of the Roberts 392 owned by Larry Rauh. Larry is very proud of his boat !***

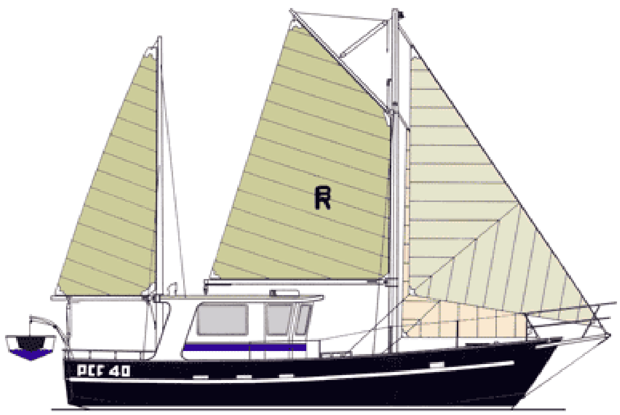
ABOVE: *Larry Rauh's Rpberts 392* **TOP:** *More Examles of the popular Robers 392*

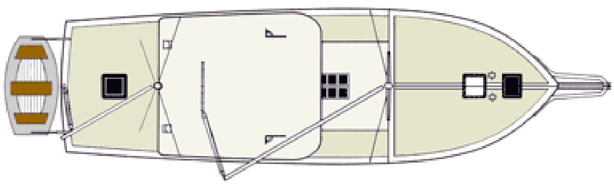
ROBERTS P.C.F. 40 Sailing Trawler

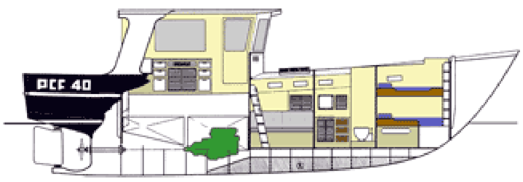
**FIBERGLASS or STEEL Plans and Frame patterns
or STEEL KIT or CUTTING FILES and plans.**

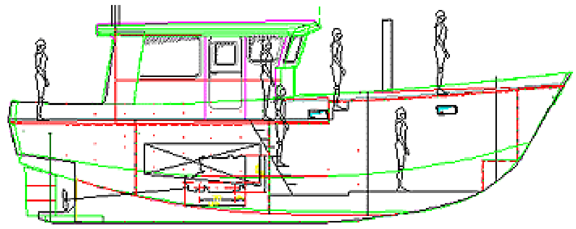
Over 200 PCF 40's have been built and are already in service world-wide. This design may be built as a motor sailer for family use, or, by adjusting the wheelhouse position, by the professional for fishing or trawling. It has a large fuel and water capacity plus space for a deep freezer. Also, being of full displacement it is also an economical passage maker and is quite capable of crossing oceans safely and surely. It can be built in either steel or fiberglass .... One example was motor sailed from Australia to UK and Ireland.

L.O.A.	*12.19 m*	*40' 0"*
L.W.L.	*10.67 m*	*35' 0"*
BEAM	*3.97 m*	*13' 0"*
DRAFT	*1.30 m*	*4' 3"*
DISPL	*14,061 kg*	*31,000 lb*

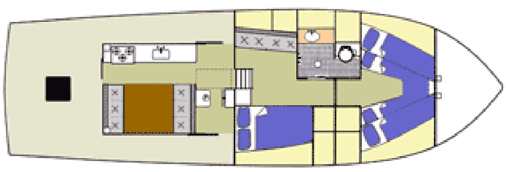


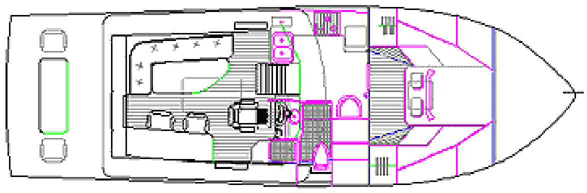


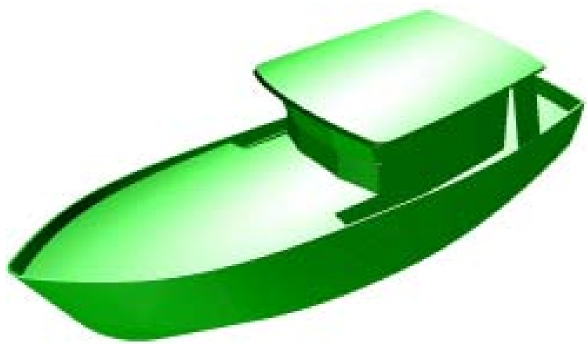




NEW ALTERNATIVE ACCOMODATION
ORIGINAL ACCOM. STILL FITS.







Here is a fine example of a Roberts PCF 40 and it pleases us that all the reports we have had from owners speak very comfortable motion under both power and sail

Note that the shoal draft of the PCF 40 hull allows her to anchor close off this beach. Also the shape of the hull allows the boat to be beached for anti-fouling and general hull checks.

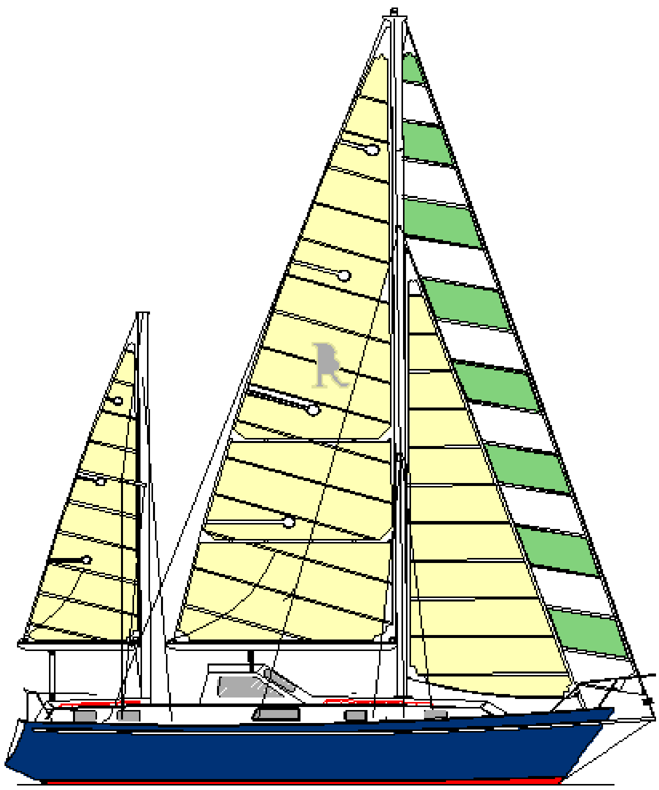
Here we can see just part of the accomodation in the deckhouse.

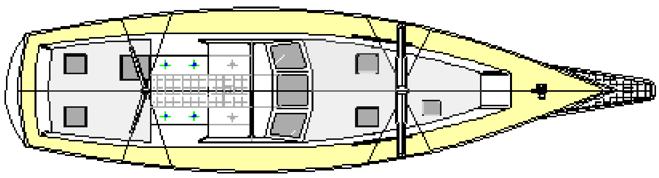
Here we can see how spacious the layout is below the fore-deck area. Flush decks do provide great accomodation spaces.

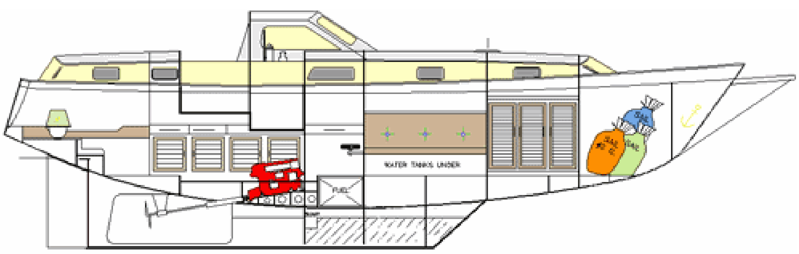
CHAPTER 15.

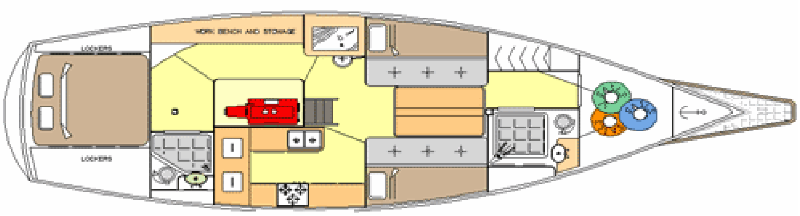
Sailboats 41'- 50' - 12.5m -15.2m

ROBERTS 410 R/C STEEL









This new design that features the Roberts safety skeg, may be built with either a regular trunk cabin or a dog house. It is a pleasant, speedy offshore cruising sailboat will find many admirers. It is also an economically sized yacht to build. This vessel is quite capable in terms of strength and comfort of sailing around the world.

You can build the Roberts 410 radius-chine hull using aluminium or steel as your building material. The complete plans include many sheets of large-scale drawings, plus full-size patterns for the hull frames, deck and cabin top beams, etc.

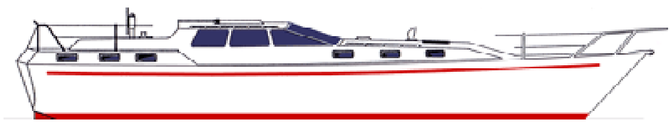
The 'dog house' showing here is optional and will provide excellent protection from the elements while allowing maximum usable accomodation below decks.

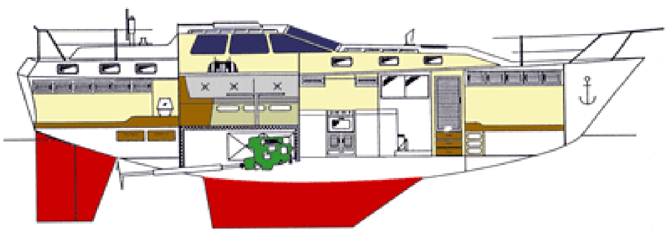
Radius chine steel or aluminum - The radius chine technique shown here makes it easy for any person capable of welding to achieve a beautiful and fair metal hull and this is an ideal method to build the new Roberts 410 The STUDY PLANS on CD show step by step photos on building your radius chine sailboat hull.

The accomodation may be varied to suit your particular requirements. Note the Roberts Safety skeg which is our answer providing a strong and efficient keel / skeg combination for your cruising boat.

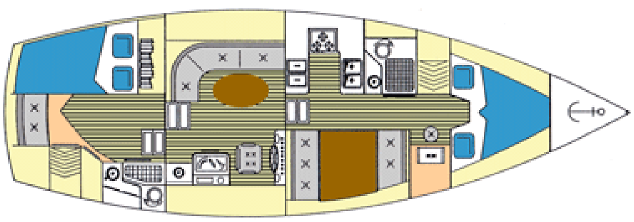
ROBERTS 420 Radius Chine Steel or Aluminum

L.O.D.	42'-9"	13.03 m
L.W.L.	36'-6"	11.12 m
BEAM	13'-0"	3.96 m
DRAFT	5'-8"	1.73 m
DISPL	31,455LB	14,267KG
Ballast	12,000 LB	5,443 KG
Sail Area	904 S/F	84 S/M
AUX. POWER	50 - 60 hp	





Available with the Roberts Safety Skeg.



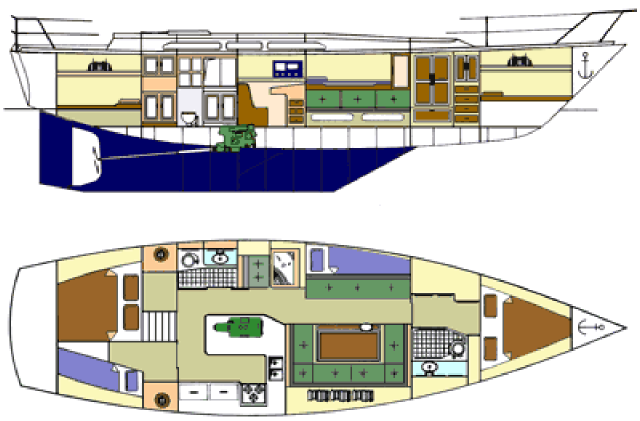
Over the past ten years we have been refining our radius chine hull techniques which are now widely accepted as the optimum method of building a round bilge metal boat. As we have received more feed-back from owners of boats already in service, we have been able to refine these hulls and building techniques to provide you with designs that offer high performance, combined with all of the features you consider desirable in a cruising sailboat.

As this design was developed it became apparent that this boat was taking on the appearance and characteristics of a smaller version of the hugely popular Roberts 53 G; this fact alone should ensure this boat a great future.

This design is a well proven world cruiser as many are currently sailing in different parts of the world and the reports are excellent. It can be rigged as a Cat Ketch, Ketch or Cutter. Alternate layouts are possible. You can build the Roberts 420 in radius chine steel or aluminum. The complete plans package include many sheets of large-scale drawings, plus full-size patterns for the hull etc.

Cat Schooner rig shown - Cutter and Ketch rigs also available

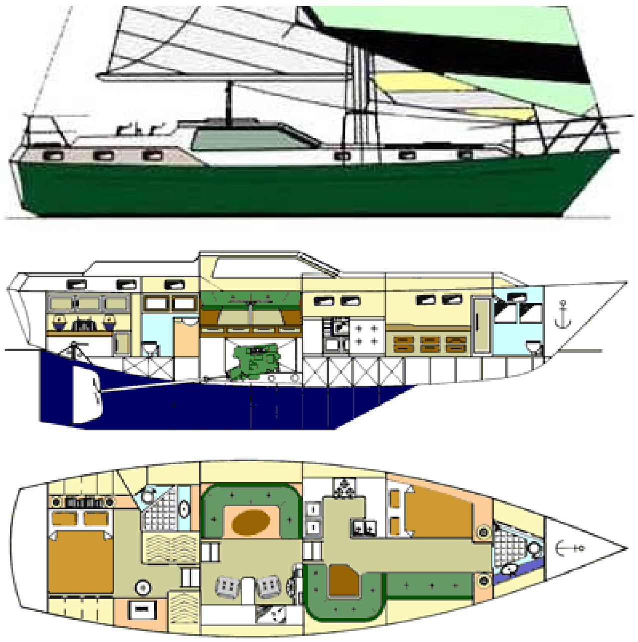
ROBERTS 432 Steel . Aluminum . Fiberglass



VERSION A above.

L.O.D....................................3.40 m 43' 11"
L.W.L....................................11.6 m 38' 0"
BEAM..................................4.10 m 13' 6"
DRAFT.(Shoal).......................1.60 m 5' 3"
DRAF.T (Deep).......................1.80 m 6' 0"
DISPL..........FG or Alu.11,793 kg 26,000 lb
DISPL................. Steel 13,539 kg 29,850 lb
BALLAST........................4,467 kg 9,000 lb

Mature customer writes - Moving from sail to one of our Trawler Yachts. I built Roberts-43 sailboat from your plans in 1977-81 in Alaska and sailed it approximately 10,000 nm before selling it. Wonderful sea-boat...admired everywhere..Fi berglass with balsa cored decks and cabin. Older now and into riding on the inside of the boat here in the Pacific Northwest. David K. Parker



VERSION B above.

ROBERTS 432 (Cont.)

LEFT: ***This diesel heating stove is well protected with safety rails and stainless steel lined compartment and represents well thought out installation.***

Frank Foster writes....I noticed your post to the "Justice" web site. Thought I would mention that I was the builder of the "Justice". We met once at the Newport Boat Show while she was under construction. She is mostly Roberts 432 with an "R-45" layout. Regards Frank

This attractive interior is typical of many Roberts designs that are built by their owners.

Some builders go to great lengths to customize their boat - this dinette table is typical of some of these owner / builder features built into these boats.

ROBERTS 432 (Cont.)

Note the comfortable pilot and navigation seating is built in to this Roberts 432.

ABOVE: This Roberts 43 sailed around the world from the UK. I met the owner at a wonderful "Boat Jumble" in the UK.

LATER: 2006 Hi Bruce, I was browsing through your website looking to see whether you designed the 43ft "Fisher/trawler" motor sailer we are about to have a look at when this jumped out at me! Thought you would like an update on Suleika, the yacht in the photo. She has just completed her second successful circumnavigation, 7 or 8 years I think, with her "new" owners, the folk who bought her from us in 1995.

We are now based in NZ and for several months Suleika was based in an adjacent marina berth, quite a coincidence.

I recall our encounter at the Beaulieu Boat Jumble, Hampshire England in 1995, hope you are doing well, best wishes Sally Gillet.

RIGHT: This Roberts 43 Pilot House version was built in 1970 and is still going strong.

Hi folks, I was looking through your website as I am considering buying another of your designs which was recently built here in Perth , a current model aft cockpit 43. After looking at many other options, I have come to the conclusion that the 43 ,value for money, safety & performance, you can't beat it.

Its interesting to see that the photo you are using for the pilot house version is an original photo of a boat named "Mellisylou", shown in the early publication of "Build for Less", built in Sydney in the mid 70's.

I owned the boat for 4 years and sold her in 94,after re-naming her "Pavanne" She has been sold since and I saw her yesterday at Fremantle Sailing Club.

I'm tempted to buy her back . However and more to the point, she's stylish and the design looks as good to-day as it did when it was drawn probably 30 years ago. Good on you Bruce , you're a legend. Kind Regards, Mike Capelle

TOP LEFT: *Note the sunshade over the helsmans position*

TOP RIGHT: *The 'Dog House' makes a great shelter for helsman and crew without encroaching into the accomodation spaces.*

RIGHT: *Another view of that dog house*

LEFT: *The crew who man this cockpit will need some shelter but perhaps they do not venture out in inclement weather; note the obervation bubble which used to be a feathre on many cruising yachts.*

LEFT: *Note the sunshade over the helsmans position*

RIGHT: *Deck boxes that can also be used as seats are a popular feature on the aft decks of many cruising yachts.*

LEFT: *Leading the halyards and some sheets aft to the cockpit make for easier handling especially during inclement weather.*

LEFT:
Sensible instrument layout on this builder constucted instrument panal

RIGHT:
Cockpit cushions are a must and buy the best you can afford as these items get a lot of hard usage.

LEFT:
Funtional anchor winch that will handle both anchor chain and rope

LEFT:
Roberts 432 moored in some beautiful location - could be Morea ?

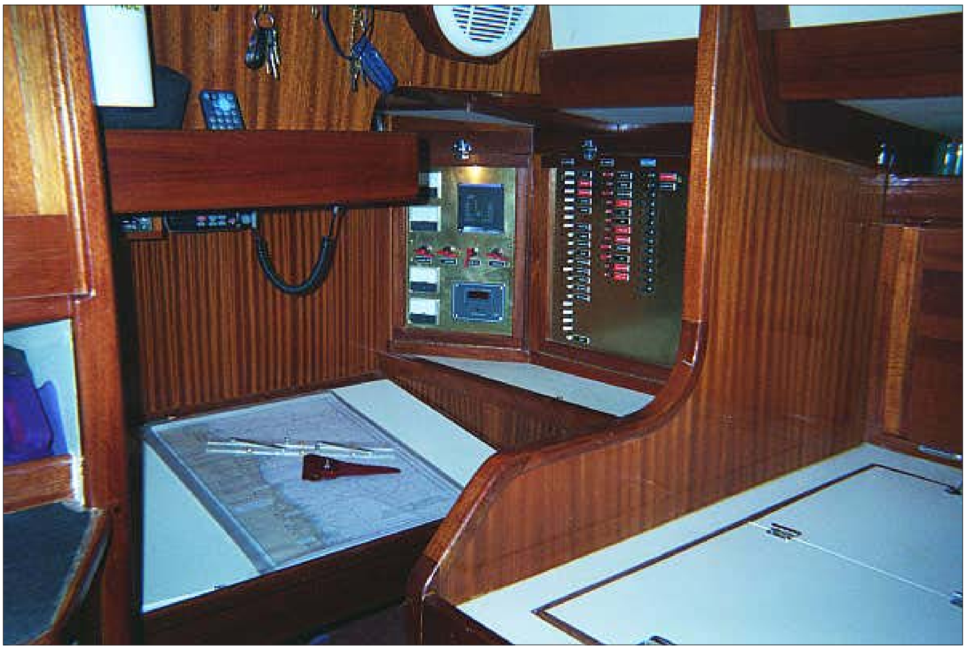
RIGHT:
The color you paint your sailboat will have a great effect on the apperance. Some colors are 'location' sensitive; for instance dark colors are not recommended for cruising in tropical areas.

LEFT:
This Roberts 432 sports a sensible deck color; avoic either white (glare) and dark colors (hot) when choosing the color for your deck.

Here we see a selection of interiors on various Roberts 432's

LEFT:
Here is the walk-through from main salon to aft cabin.

RIGHT:
Welcoming double berth where the indent in the aft bulkhead adds interest and some extra room too.



LEFT:
Tthis navigation station is tucked away out of the traffic pattern. We can just see the obviously sizable ice box cover in the foreground.

VOYAGER 432

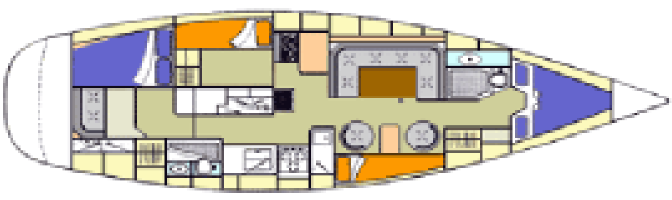
Radius Chine Steel or Aluminum Sailboat kit, cutting files.

The Voyager 432 can be rigged as a Cutter, Ketch, Sloop or Staysail Schooner & is shown here with the cutter rig; you can choose any rig that you prefer.

L.O.D.................................13.28 m 43' 7"
L.W.L.................................11.48 m 37' 8"
BEAM.................................. 4.32 m 14' 2"
DRAFT.................................. 1.83 m 6' 0"
AUX.PWR.................................. 33 - 60 hp

VOYAGER 432 (cont.)

ABOVE: ***This illustration shows the 'Contemporary' Long Keel as developed by Bruce Roberts with the feed-back & assistance of clients who have built boats with this now proven feature.***



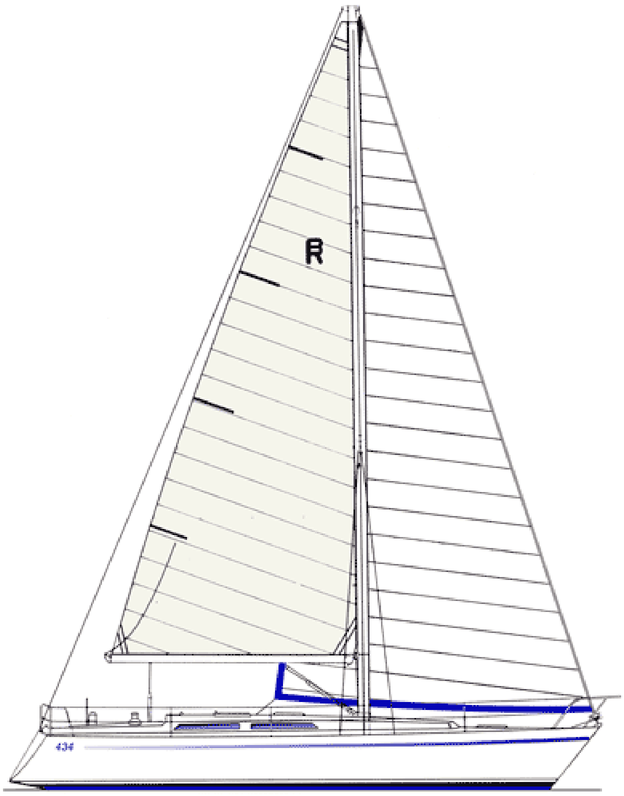
VOYAGER 432 (cont.)

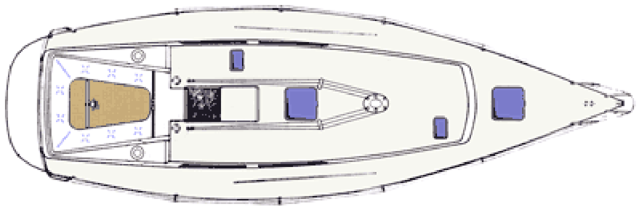
ABOVE & BELOW: ***Although I am not a great lover of teak decks (MAITENANCE) I admit that they do look great on this Roberts / Voyager 432***

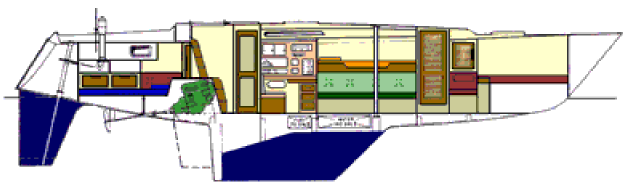
VOYAGER 432 (cont.)

ROBERTS 434 A

L.O.D.......................................13.20 m 43' 4"
L.W.L.......................................11.18 m 36' 8"
BEAM.......................................4.10 m 13' 6"
DRAFT............................(Deep) 1.83 m 6' 0"
DRAFT.............................(Shoal)1.50 m 5' 0"
DlSPL.(FG, Alu W/E).......11,567 kg 25,911 lb
DlSPL....................(Steel) 13,330 kg 29,859 lb
BALLAST............................3,996 Kg 8,809 lb

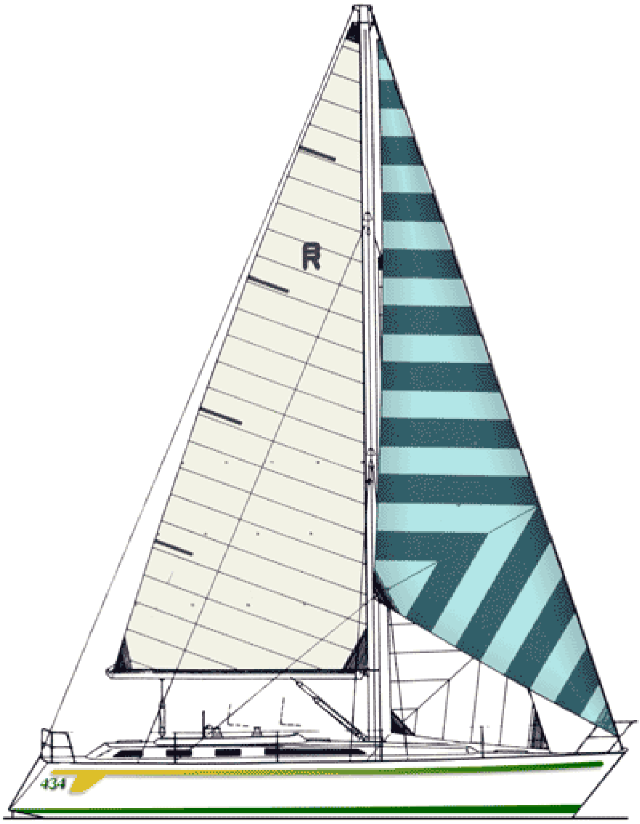






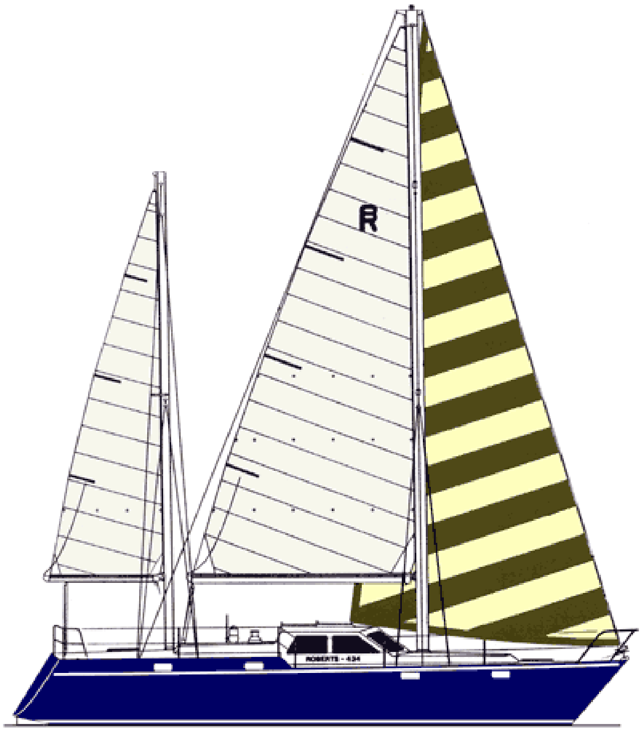
This design has appealed to many serious cruising sailors, and is another in our range of medium displacement, fast performance cruisers which can be built in either multi chine or radius chine STEEL or ALUMINUM, in round bilge FIBREGLASS or in round bilge WOOD EPOXY. Full size frame patterns as well as cut to size steel kits are also available for this design.
The Roberts 434 can be rigged as either a Cutter, Sloop or Ketch and the many different versions give you the choice of either a low profile aft cockpit, a center cockpit version and also a pilot house version. Already several versions of this design have made complete circumnavigation's - one was sailed single handed around the world in only 218 days. (Article printed below) Several others have taken part in round the world rallies. Many are being constructed in yards around the world with the pilot house version currently being one of our most popular designs.
You can purchase Study Plans, Complete Plans and Patterns, Pre-cut steel kits, Hull and Deck packages or complete boats built to this design. Please email for additional information.

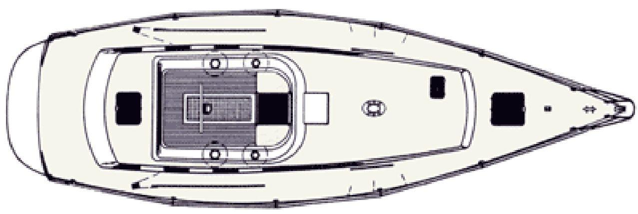
ROBERTS 434 B & C

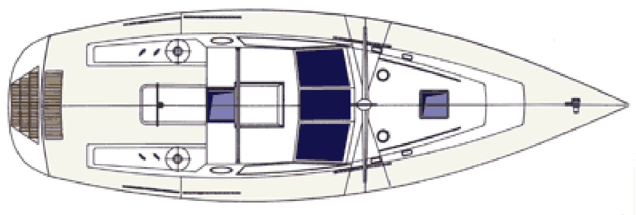


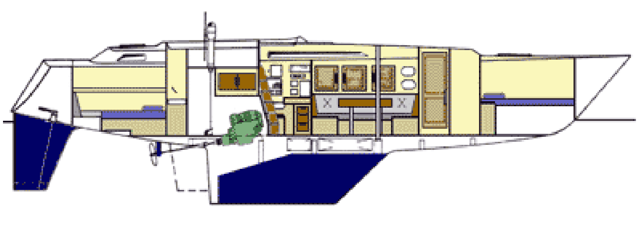
STEEL . FIBERGLASS . WOOD

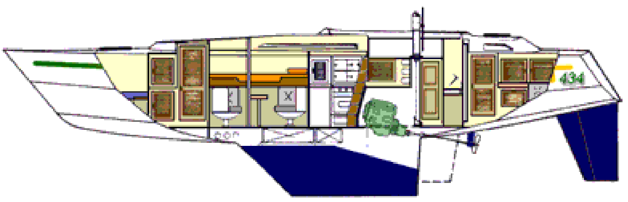
L.O.D..13.20 m 43' 4"
L.W.L..11.18 m 36' 8"
BEAM..4.10 m 13' 6"
DRAFT............................(Deep) 1.83 m 6' 0"
DRAFT.............................(Shoal)1.50 m 5' 0"
DlSPL.(FG, Alu W/E).......11,567 kg 25,911 lb
DlSPL....................(Steel) 13,330 kg 29,859 lb
BALLAST............................3,996 Kg 8,809 lb

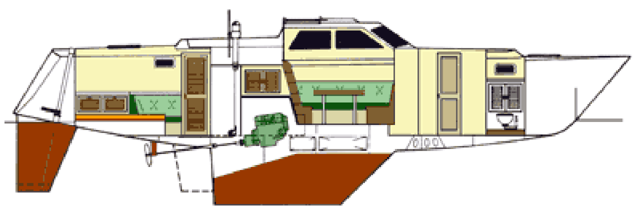


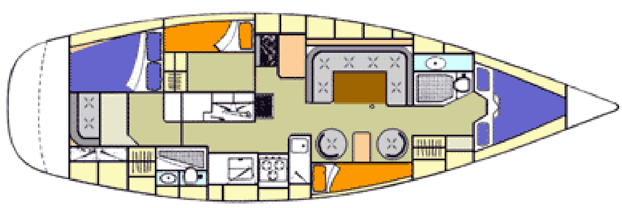


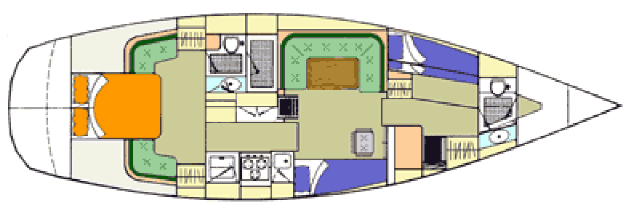








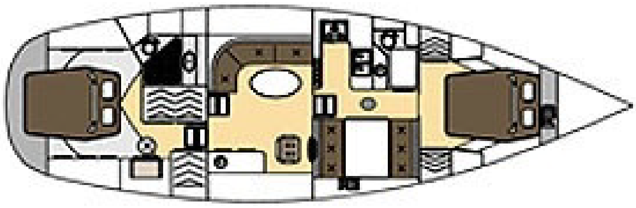


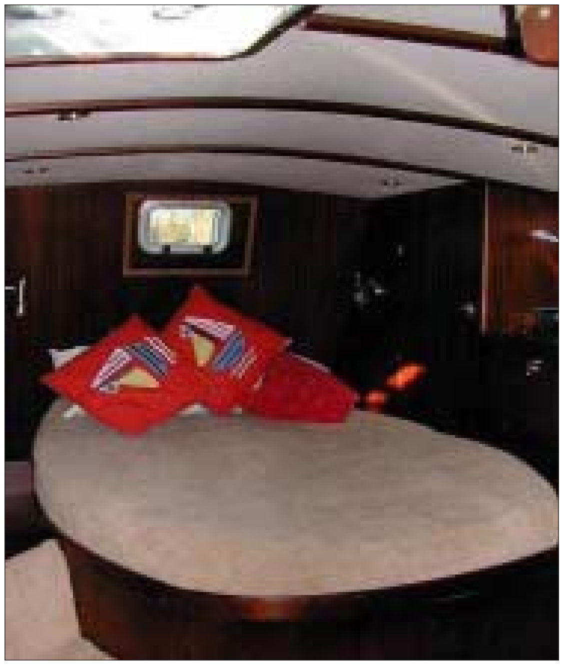


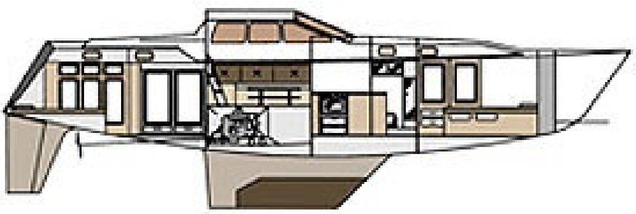
ROBERTS 434 D

STEEL . FIBERGLASS . WOOD

L.O.D.......................................13.20 m 43' 4"
L.W.L.......................................11.18 m 36' 8"
BEAM.......................................4.10 m 13' 6"
DRAFT............................(Deep) 1.83 m 6' 0"
DRAFT.............................(Shoal)1.50 m 5' 0"
DlSPL.(FG, Alu W/E).......11,567 kg 25,911 lb
DlSPL....................(Steel) 13,330 kg 29,859 lb
BALLAST............................3,996 Kg 8,809 lb





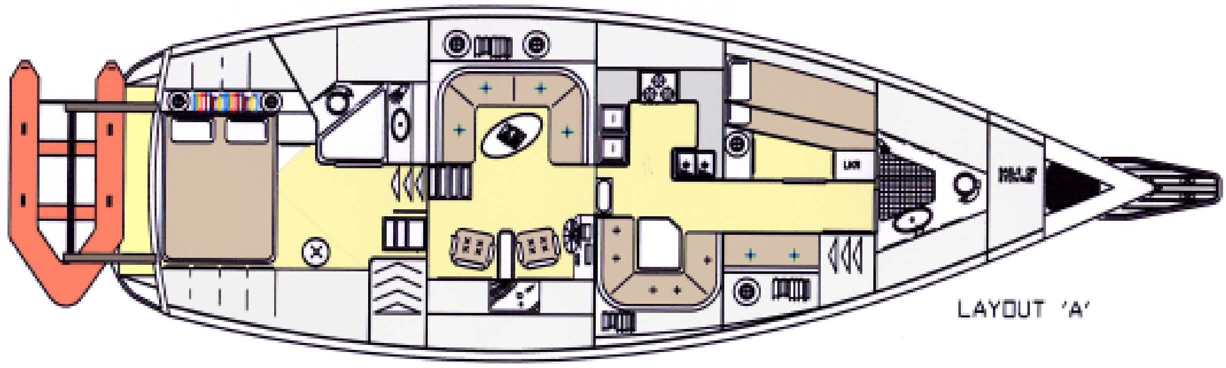


Note thecontrast between these two interiors - dark woods above and light lining below; the choice is yours. My preference is for white or cream deck-head with some timber trim and some painted surfaces on bulkheads and lockers with some varnished timber trim; but each to his or her own!

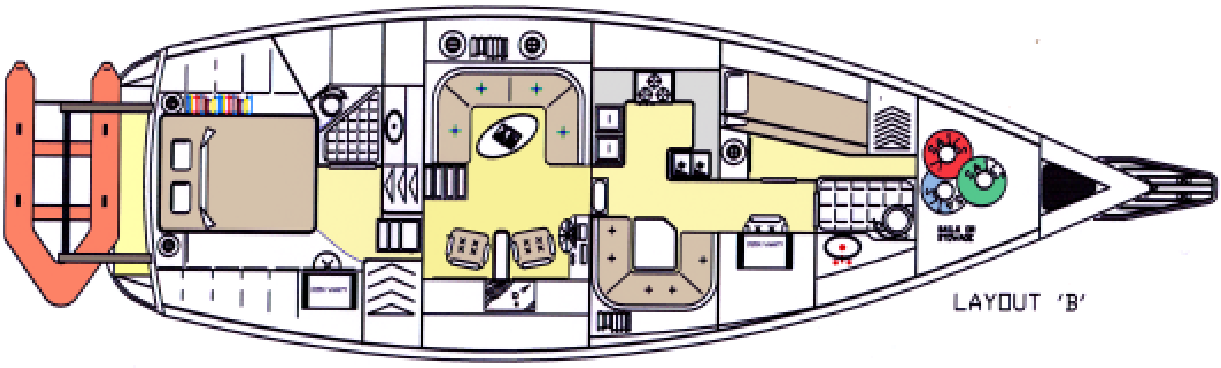
VOYAGER DS 440

Length - Hull...13.64 m 44'- 9"
Length - Deck ....12.95 m 42'-6"
Length – Waterline ....2.03 m 39'-6"
BEAM ....4.42 m 14'-6"
DRAFT...1.98 m 6'-6"
DRAFT...(SHOAL) 1.75 m 5'-9"
Headroom.. ....2.03 m 6'-8"

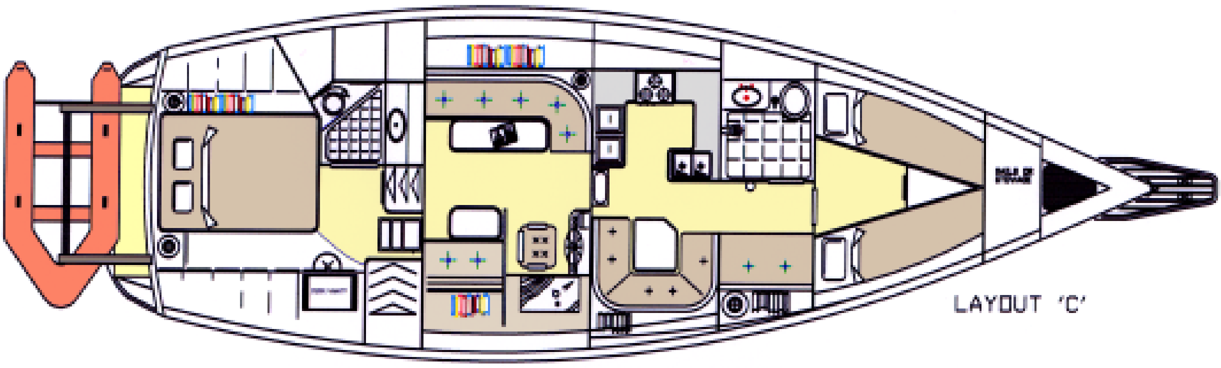
VOYAGER DS 440 (cont.)



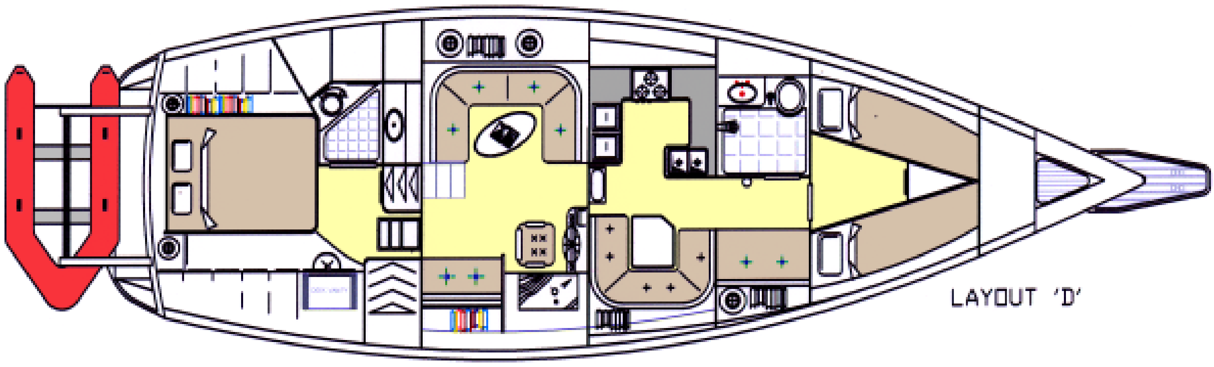
LAYOUT 'A'



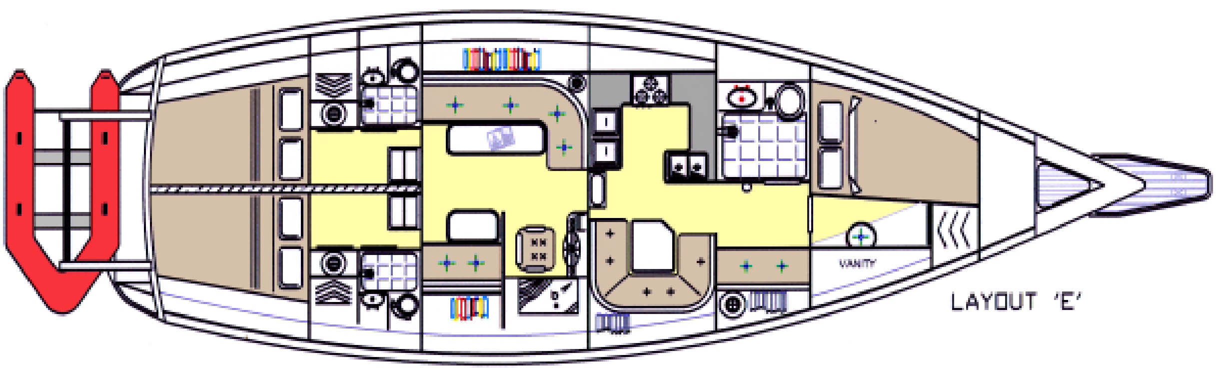
LAYOUT 'B'



LAYOUT 'C'



LAYOUT 'D'



LAYOUT 'E'

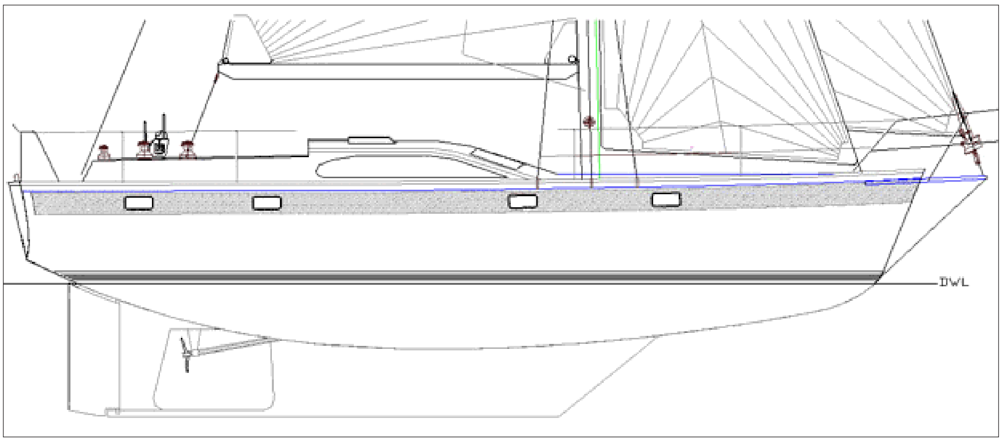
VOYAGER DS 440 (cont.)

VOYAGER DS 440 radius chine kit is the latest refinement of this world cruising sailboat and has all the qualities that the Bruce Roberts designs are famous for. This hull has been designed for fast passage making but is equally at home racing around the buoys. Alternate accommodation lay-outs, various cockpit arrangements are available.

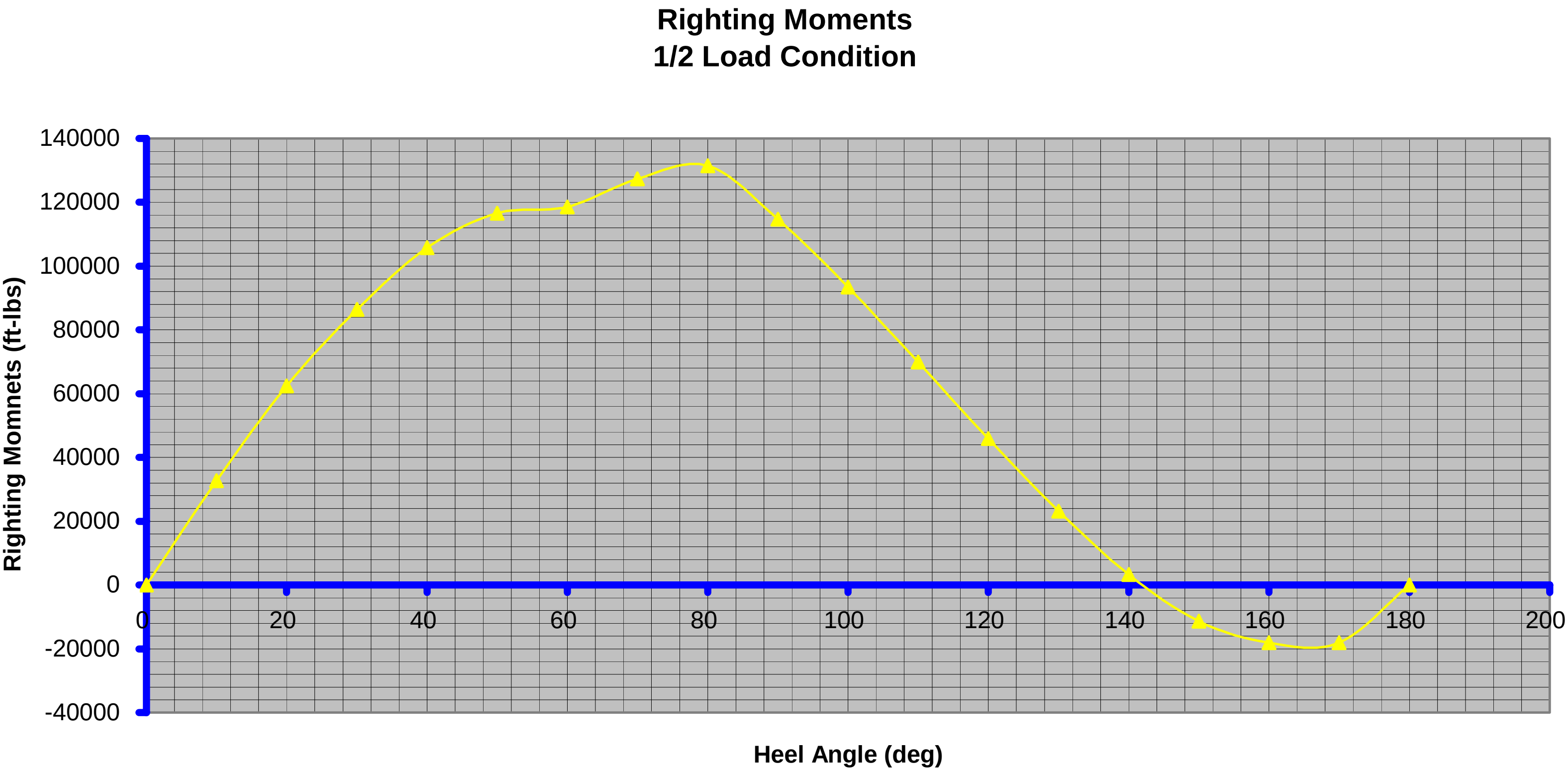
The VOYAGER DS 440 is one of the new series of sailboats that can be customized to suit YOUR requirements. We show several different possible accomodation layouts; these are arranged so you can mix & match by taking elements from one layout and switching it with another etc., PLUS of course you may have YOUR own ideas as to what would be best for your needs.

The VOYAGER DS 440 features the Roberts safety skeg which is designed to take the best features from the LONG FIN / SKEG combination & add a SAFETY FACTOR. You should be aware that skegs in general are vulnerable to damage so here is our answer to this problem. EMAIL Bruce to more details of this development.

The VOYAGER DS 440 features one unbroken sheerline and the latest in deck salon arrangements. By careful design we have managed to reduce the height of the sheerline thus reducing windage and improving performance. This is one great performance cruising boat that incorporates all the design information we have gathered during 38 years of designing & building thousands of offshore cruising sailboats.



The VOYAGER DS 440 - CLASSIC is available as a kit or cutting files so you can build this version. The obvious benefit of the Classic version is the addition of the aft deck behind the cockpit.



Voyager 440 DS

VCG= 0.08

<u>Range of Stability</u>

DISP=48,850 LBS   Ballast= 11500 LBS   LCG= 21.84   142 Degrees

FUEL= 428 LBS   57 GAL

VOYAGER DS 440 (cont.)

Here we see another arrangement from a Bruce Roberts sailboat that would work in this boat.

The Voyager DS 440 is an extremely spacious boat ... Here we see two different arrangements for the master suite, both from Bruce Roberts sailboats ... one somewhat traditional and the other leaning towards the modern 'light interior' look. Both work well in this boat.

The CUSTOM 440 has SIX different layouts including a 6 berth CHARTER version with twin cabins aft. The STUDY PLAN package shows all the alternate layouts and much more.

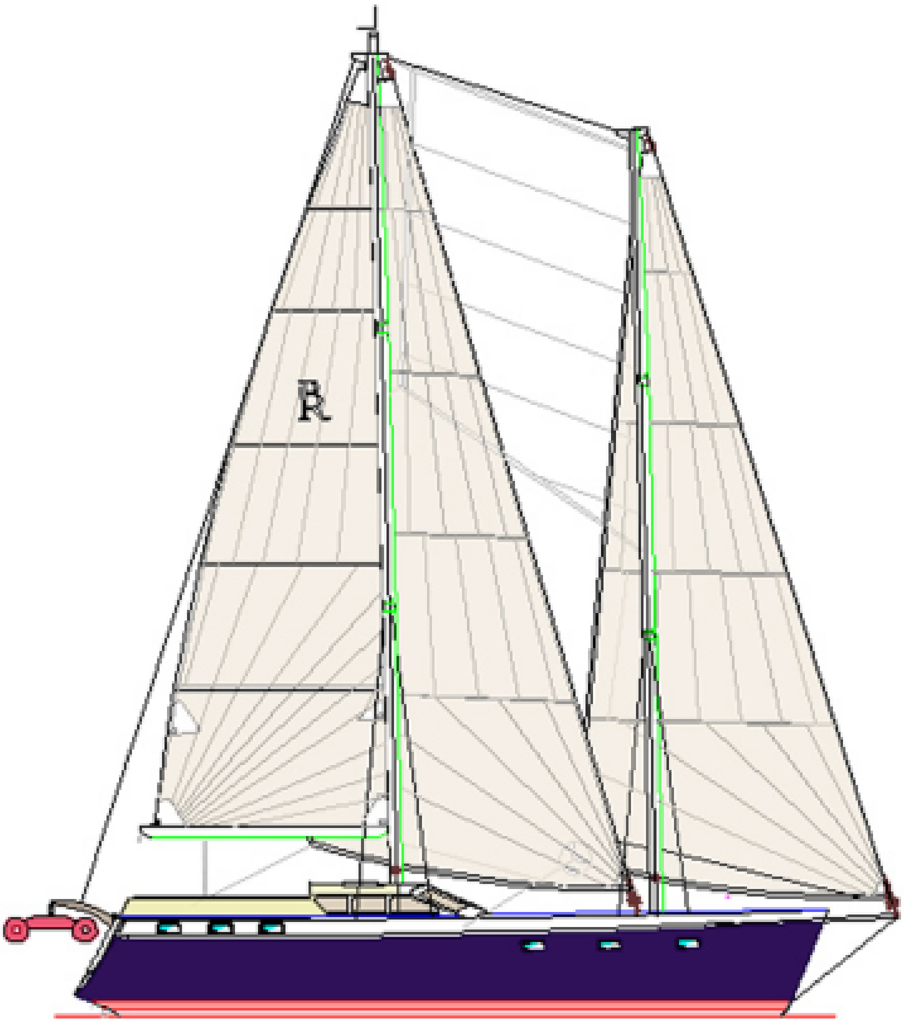
ABOVE: *View looking aft of the Voyager DS 440 hull being assembled by Norbert and Tamás Tóth supplied the photographs shown here.*
BELOW: *View of the Voyager DS 440 transom ans swim platform. Note the window in aft cabin.*

ABOVE: *View looking forward of the Voyager DS 440 . The study plans on CD include over 100 step by step assembly photos of this boat.*

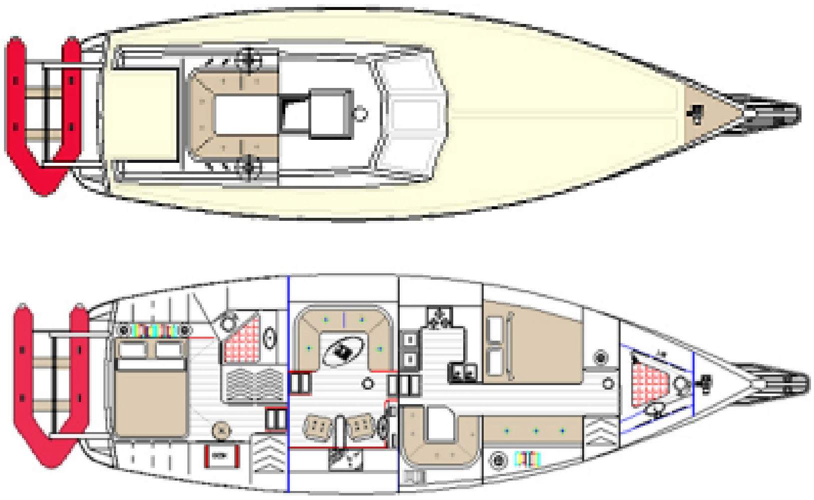
BELOW: *Close up of rounded corners where deck salon sides meet top on the Voyager DS 440.*

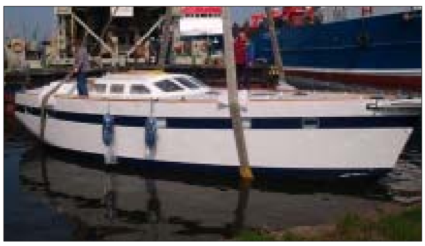
VOYAGER DS 450 Cutting files & plans.

L.O.A.	45'- 00"	13.72 m
L.W.L.	40'-08"	12.39 m
BEAM	14'- 10"	4.54 m
DRAFT.	6'-6"	1.98 m

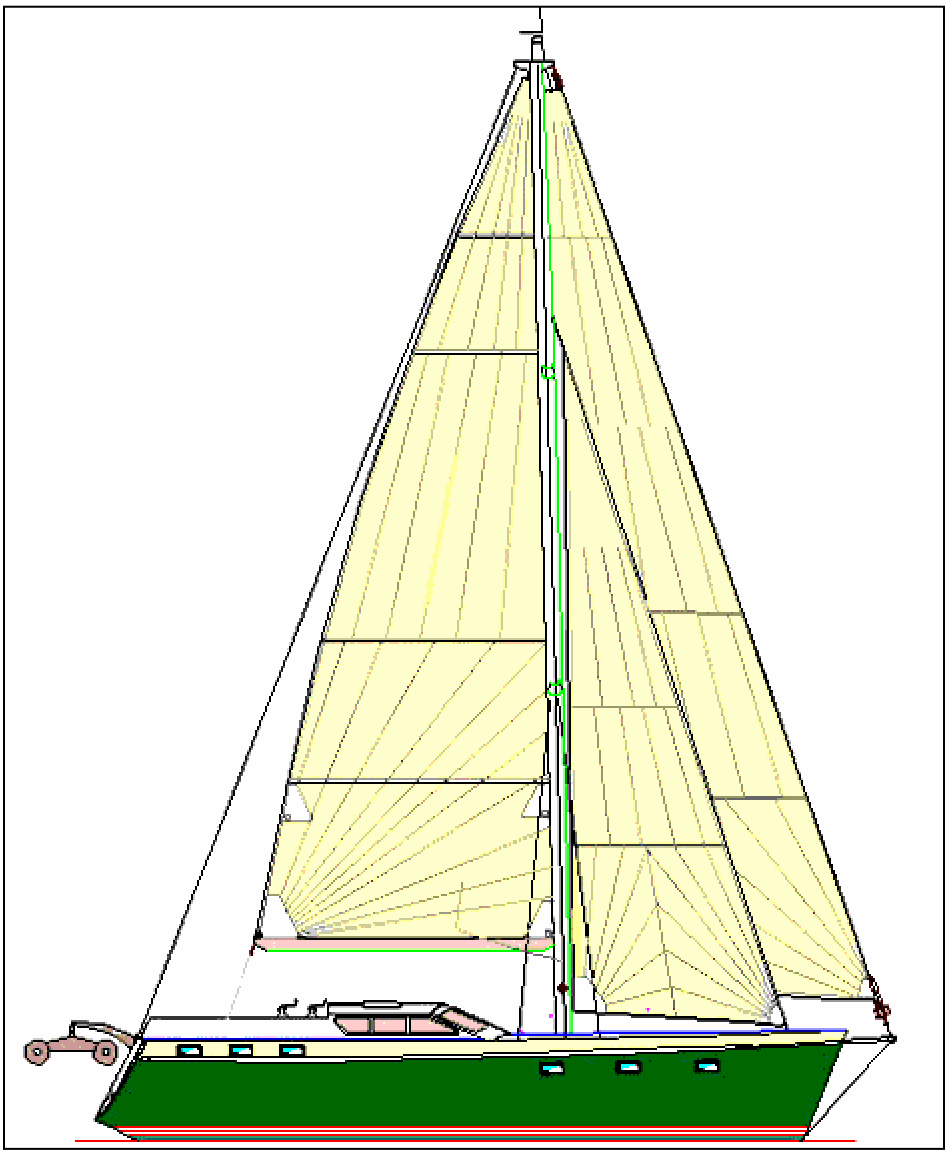


The Radius Chine Voyager 450 is based on our highly successful Voyager 495 design and incorporates several features from the Roberts 432 and Roberts 434 sailboats. The Voyager 450 has full standing headroom throughout.





Voyager 450
General Specifications and Calculations
Bruce Roberts Design



Design Notes on the Voyager 450

The Voyager 450 is an offshore passage making performance cruiser with a full keel configuration. She is based on our extremely successful Roberts 432 but with some a revised hull form similar to the hull used in out Voyager 495-2 & Voyager 542. Her styling is based on a nicely done Roberts 434, with a large flush deck and a very useful pilothouse. The V-450 has more space and performance than the Roberts 432 due to her longer waterline length and she will be an easily handled cruising sailboat for both shorthanded and fully crewed cruising.

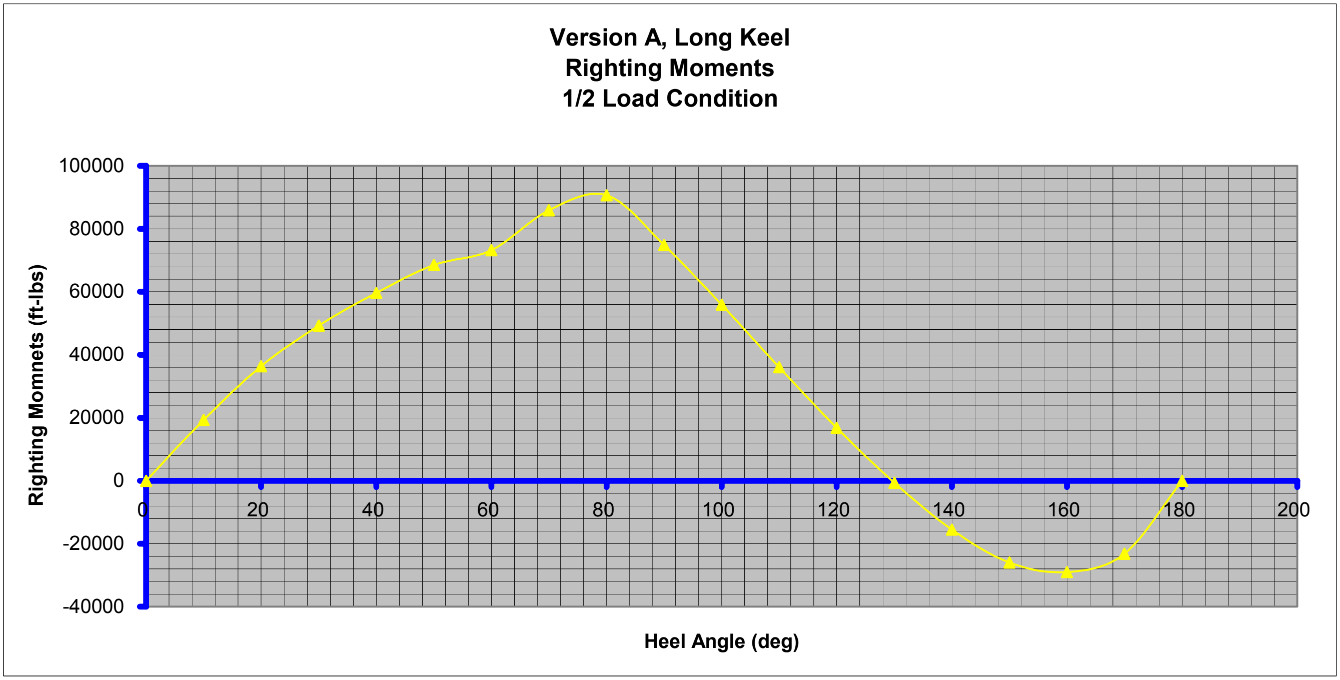
The layout of the Voyager 450 centers around the low profile pilothouse and the large flush deck. The pilothouse area has a full- featured helm station and a generous settee. The galley is situated down from the pilothouse and a settee is located opposite providing a comfortable space for eating and cooking. The basic arrangement has forward & aft double berth staterooms both with adjoining heads and showers. As with any of our kits, the arrangement can be custom tailored to suit your needs.

The Voyager 450 hullform is based on our extremely successful radius chine hull as we have used in our Voyager 495-2 and the Roberts 53's 434's. Radius chine hulls provide the best of both multichine and round bilge hulls. They are easy to assemble while retaining the good looks and hydrodynamic properties of a fully-round bilge hull. As in all BRUCE ROBERTS radius chine kits, the radius chine hull plates come pre-rolled from our cutting shop to further reduce assembly time.

As with all of Bruce Roberts Design's sailboat kits the Voyager 450 is structurally designed to meet or exceed ABS's requirements for offshore racing yachts and motor pleasure yachts. She is available as CNC cutting files or delivered as a steel or aluminum pre-cut package.

Voyager 450
Stability Curve

Below are the stability curves for both versions of the V450. The calculations were performed using assumed weights and centers for the interior and other gear items. These values could change depending on your outfitting. The displacement, ballast and center of gravity are shown on the plot.



Voyager 450

VCG= 1.25 Range of Stability

DISP= 56538 LBS Ballast= 11350 LBS LCG= 21.12 130 Degrees

FUEL= 1176 LBS 157 GAL

Below is a listing of the plates and other materials used in the kit

VOY 450 22028

Nr of plates	Length in mm	Width in mm	Surface in m2	Thickness in mm	Weight plate, 8kg/m2/mm	Total weight Kgs	Total weight Lbs
Steel plate grade A with welding primer Sigmaweld MC							
0	6000	2000	0	4	384	0	0
9	8000	2000	144	4	512	4608	10138
2	6000	2000	24	5	480	960	2112
8	8000	2000	128	5	640	5120	11264
0	6000	2000	0	6	576	0	0
2	8000	2000	32	6	768	1536	3379
0	6000	2000	0	8	768	0	0
0	8000	2000	0	8	1024	0	0
21	Plate with Sigmaweld total		328			12224	26893

Nr of plates	Length in mm	Width in mm	Surface in m2	Thickness in mm	Weight plate, 8kg/m2/mm	Total weight Kgs	
Black steel plate, no primer							
1	6000	2000	12	6	576	576	1267
1	8000	2000	16	6	768	768	1690
2	Black plate total		28			1344	2957
23	Total all plates		356			13568	29850

Quantity	Length in Mtr	Type	Dimensions	Thickness in mm	Weight per meter	Total weight Kgs	
Profile, with welding primer Sigmaweld MC							
3	6	flat bar	25	5	1.0	18	40
16	6	flat bar	40	5	1.6	153.6	338
12	6	flat bar	50	5	2.0	144	317
25	6	flat bar	60	5	2.4	360	792
2	6	flat bar	80	5	3.2	38.4	84
1	6	flat bar	90	5	3.6	22	48
2	6	flat bar	100	4	3.2	38	84
2	6	flat bar	110	15	13.2	158	348
1	6	flat bar	160	4	5.1	31	68
7	6	T-bar	50	6	4.4	186	410
8	6	Angle bar	70	7	7.3	348	766
1	6	Pipe	1"	S40	2.5	15	33
1	6	Pipe	1 1/2"	S40	4.0	24	53
1	6	Pipe	3.5"	S40	13.57	81.42	179
1	2	U-channel	100 x 50	6	8.79	17.58	39
TOTAL						1618	3560

VOYAGER DS 450 (Cont.)

Here we see a selection of the many photographs we have of the Voyager 450 including step by step construction photos and large scale photos of the interior . The Study Plans Package on CD has all these photos as a lot more information than there is room for on these pages.

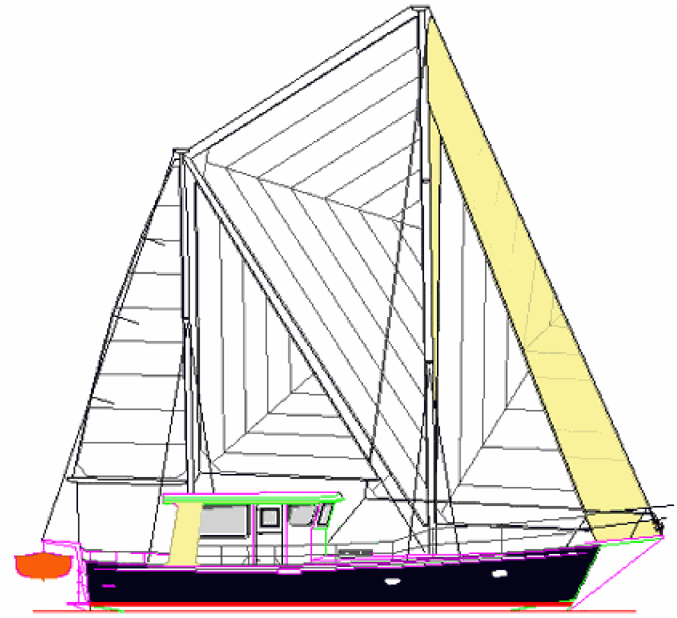
VOYAGER DS 450 (Cont.)

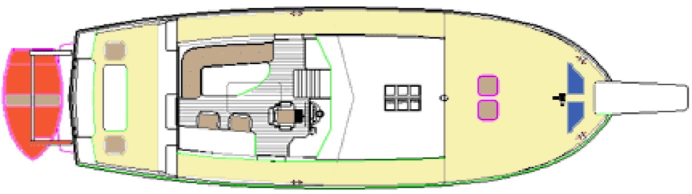
Here a frew more of the many photographs we have of the Voyager 450. The Study Plans Package on CD has all these photos in larger scale as well as a lot more information than there is room for on these pages.

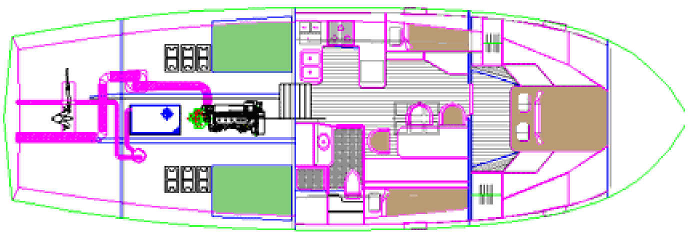
TRAVELER 45 Cutting files & plans.

L.O.H.	13.85 m 45'-6"
L.O.A.	20.71 m 51' 6"
L.W.L.	12.35 m 40' 6"
BEAM	4.60 m 20' 1"
DRAFT	1.37 m 4' 6"
DISPLACEMENT	23,525 kg 51,755 lb
SAIL AREA (Incl. 100 % FT)	105.2 sm 1,131 sq ft
BALLAST	3,636 kg 8,000 lbs

This design may be built as a motor sailer for family use, or, by adjusting the wheelhouse position, by the professional for fishing or trawling. It has a large fuel and water capacity plus space for a deep freezer. Also, being of full displacement it is also an economical passage maker and is quite capable of crossing oceans safely and surely. It can be built in either steel or fiberglass .... One example of the smaller version the PCF40 was motor sailed from Australia to UK and Ireland.







NEW YORK 46 Fiberglass . steel . aluminum

The New York 46 offers a choice of keel types combined with various draft options and alternate sail plans. This design can be customized to suit your requirements. Note that in the B version there are two double cabins in the aft section which combined with the extensive accommodation makes this boat ideal for charter operations. Already several New York 46's are already sailing and many more are being built in various parts of the world, some in radius chine steel and others in fiberglass.

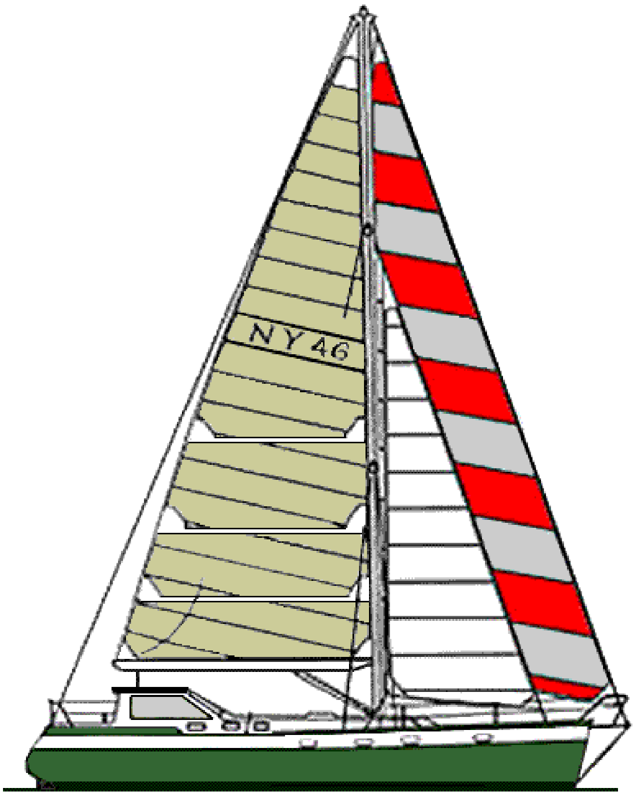
L O D	46'-10"	14.28 m
L W L	43'- 5"	13.24 m
BEAM	I3'- 1"	3.99 m
DRAFT	7'- 6"	2.29 m
SAIL AREA	1,200 S.F.	111 S.m
DISPLACEMENT	42,972 LBS	19,492 KG
BALLAST	12,750 LBS	5,783 KG
AUX. POWER	85 HP	

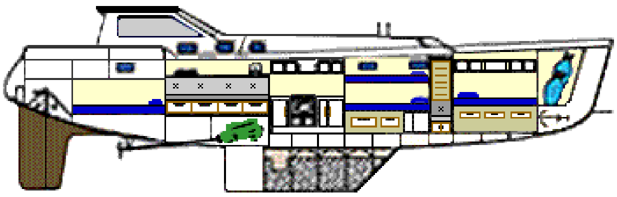
ABOVE: Version B.

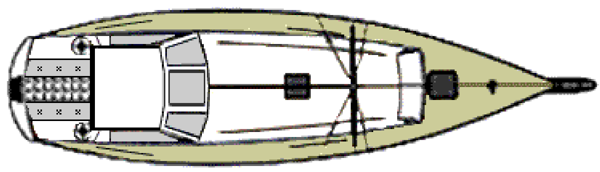
LEFT: Version A. *Many buiilders have with our help combined the versions to achieve exactjy what they wanted to have in their own sailboat. This is just one benifit of custom building; you can end up with the boat YOU want.*

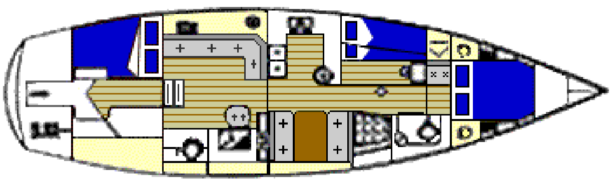
NEW YORK 46 Fiberglass . steel . aluminum

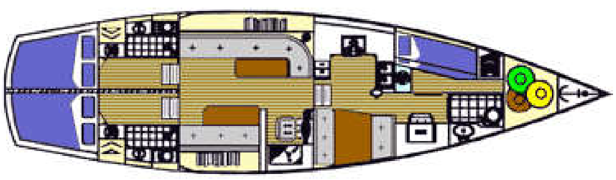
L O D	46'-10"	14.28 m
L W L	43'- 5"	13.24 m
BEAM	I3'- 1"	3.99 m
DRAFT	7'- 6"	2.29 m
SAIL AREA	1,200 S.F.	111 S.m
DISPLACEMENT	2 LBS	19,492 KG
BALLAST	12,750 LBS	5,783 KG
AUX. POWER	85 HP	











Sorry about the quality of this picture but this is indeed a beautiful New York 46 whose owner plans after some shake down voyages, to sail down to the Antarctic. Several of our sailboats have cruised in Antarctic and Arctic areas.

The NY 46 A This is the suggested accomodation plans for this version but the layout can be varied to suit your requirements.

This fiberglass NY 46 was built in Australia.

Close up of generious coaming area; lots of room to mount winches etc.

Close up of generious coaming area; lots of room to mount winches etc.

THIS PAGE & FOLLOWING PAGES: *This New York 46 was built in the UK and have already cruised extensivly in Europe. Note the unusual treatment of the pilot house windows.*

THIS PAGE & PREVIOUS PAGES:
This New York 46
has already cruised extensivly in Europe. Note the unusual treatment of the pilot house windows.

THIS PAGE & PREVIOUS PAGES:
The New York 46

This is the accomodation arrangement for the NY 46 B that this builder preferred ... beautiful interior.

This is the galley of the NY 46B

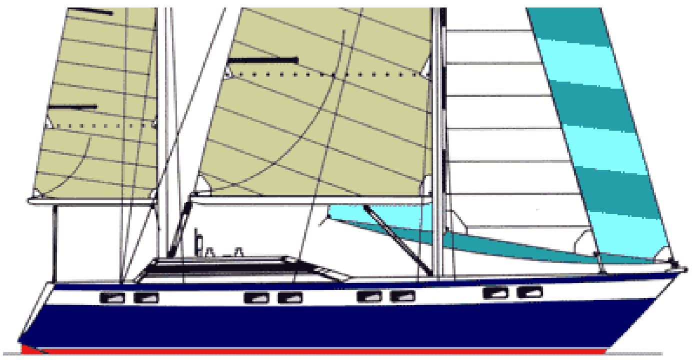
This is the navigation and command station area in the pilot house of the NY 46 B

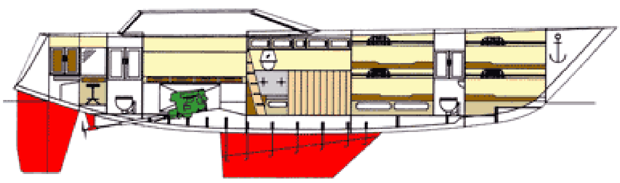
Here we see a portion of the cockpit of the NY 46 B

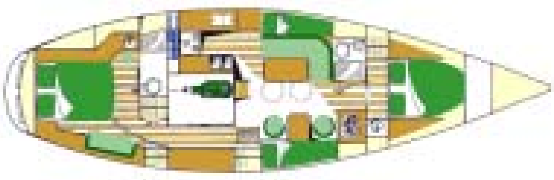
ROBERTS 470 WOOD EPOXY

The accommodation of this design has been laid out to suit two couples. The Roberts 470 makes a fine long distance cruising yacht. You can customise the interior to suit your particular requirements and many variations are possible. This is a fast cruising design which was original designed to accommodate a clients wishes who wanted a R 434 stretched to 14.5 meters. The result was a completely new plan that could be built in wood epoxy; now several years later there are many examples of this boat sailing in various parts of the world. If wood is your choice of construction materials then we recommend this fine well proven boat to you; the plans are very well detailed and easy to follow. YOU can build this boat !

L.O.D.14.49 m 47' 6"
L.W.L.11.92 m 39' 2"
BEAM4.27 m 14' 3"
DRAFT1.83 m 6' 0"
DISPL.20,876 kg 35,000 lb
BALLAST5,443 kg 12,000 lb
SAIL AREA103 sq m 1,111 sq ft







The study plans on CD have many more photos and other information about the Roberts 470

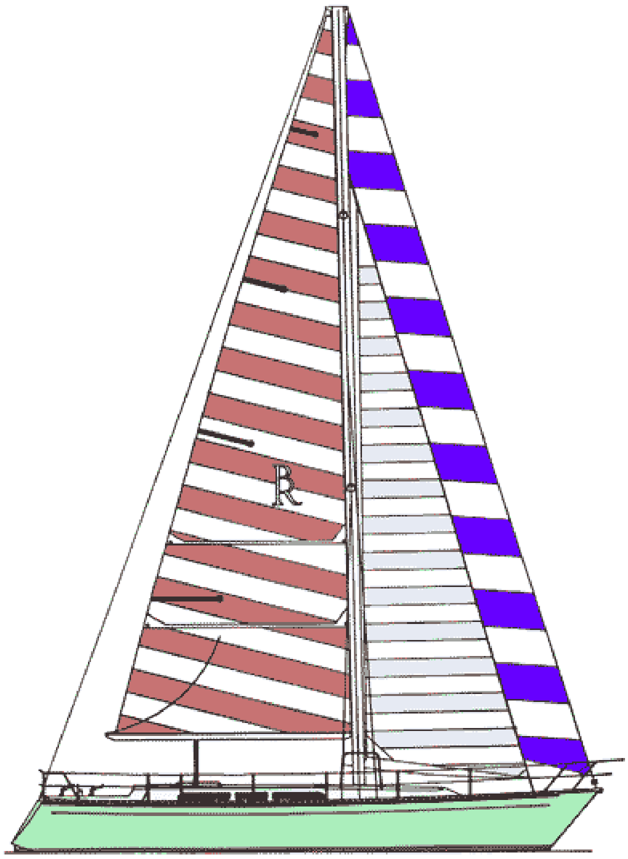
ROBERTS 470 (Cont.)

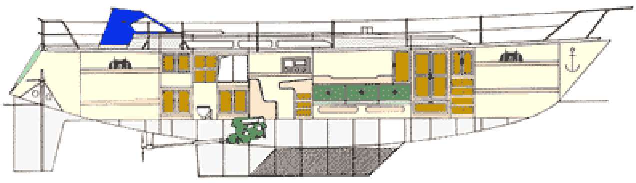

vivo
VESTEL
ACDelco

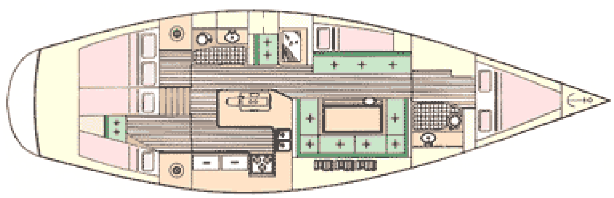
ROBERTS 482 STEEL OR ALUMINUM

The accommodation could be laid out in many ways and this boat is ideal if you would like to customize your interior. This is a fast cruising boat. Study plans include sample construction sheets as well as material lists etc.

L.O.D.	14.9 m	48' 10"
L.W.L.	12.6 m	41' 4"
BEAM	4.5 m	14' 9"
DRAFT	1.83 m	6' 0"
DISPL.	20,300 kg	44,754 lb
BALLAST	6,804 kg	20,000 lb
SAIL AREA	114.5 sq m	1,232 sq ft



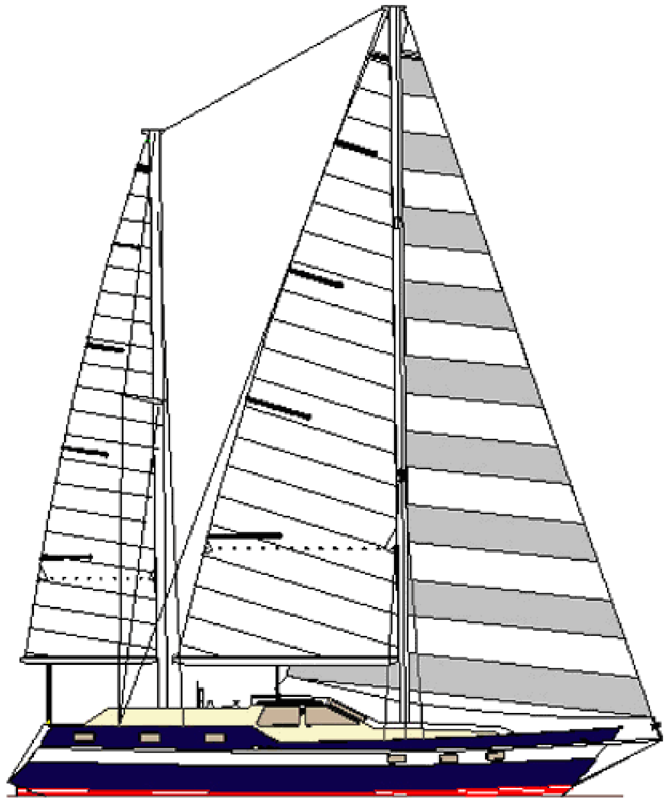




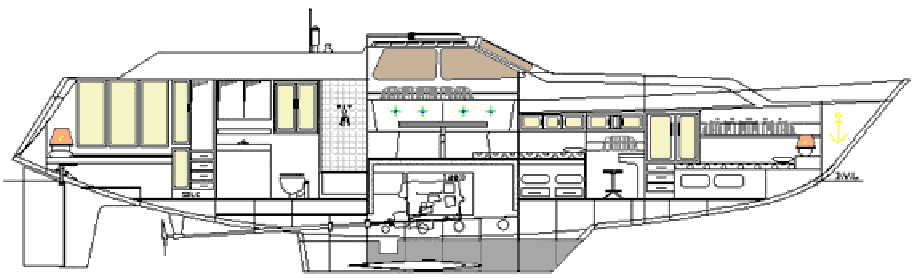
BELOW: These arrangements would fit nicely in this sailboat.

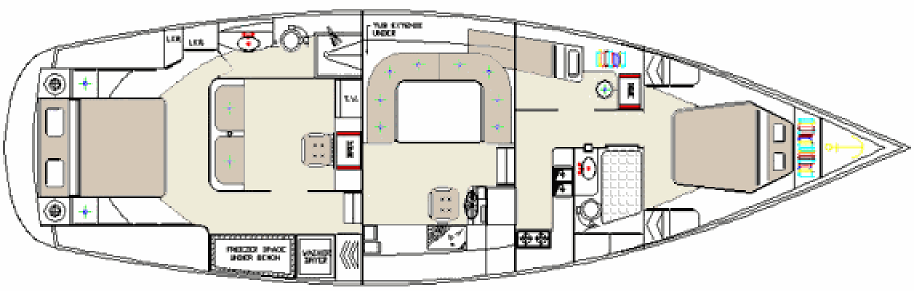
ROBERTS 493 Radius Steel or Fiberglass

L.O.A.	20.00 m 49' 3"
L.W.L.	11.90 m 39' 2"
BEAM	4.54 m 4' 10"
DRAFT	1.82 m 6' 00"
DISPL.	17,690 kg 39,000 lb
SAIL AREA	98sq. m 1,055 sq. ft
FUEL	785 lts 200 gal
WATER	2070 lts 400 gal
AUX.PWR.	60-100 hp



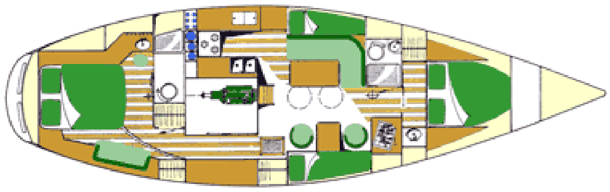
There are two different versions of this design - the Radius chine steel version that features a wing keel and the Fiberglass version that has a regular keel / skeg combination. This design has appealed to many serious cruising sailors. It is available for construction in Radius Chine Steel or Aluminum or FIBERGLASS in either C-Flex, Foam or Blsa Sandwich or Single Skin Glass. A recent wave of "performance cruising boats" from a number of designers has obscured the fact that a good design always strives for the beat performance consistent with it's objectives. The Roberts 493 is an example : a stylish luxury cruising yacht for four to six people, capable of making fast passages in any weather and on any point of sail.





ROBERTS 493 Radius Steel or Fiberglass

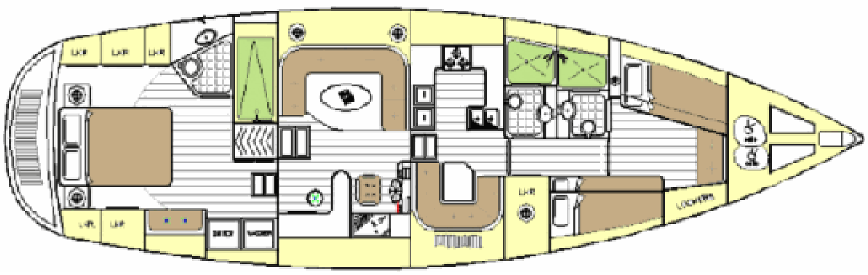
BELOW: Fiberglass version.

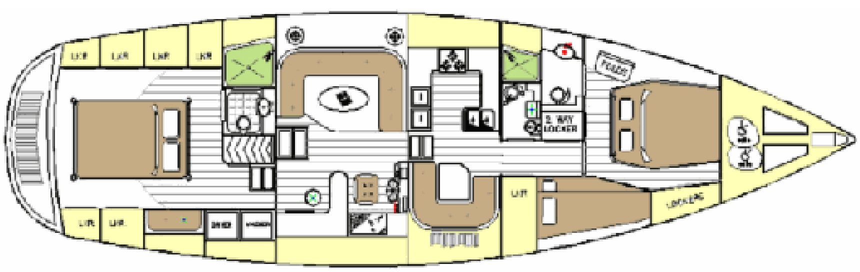


ROBERTS 493 Radius Steel or Fiberglass

VOYAGER 495 STEEL KIT or CUTTING FILES

Voyager 495 radius chine kit is the latest refinement of this world cruising sailboat & has all the qualities that the Bruce Roberts designs are famous for. This hull has been designed for fast passage making and is equally at home racing around the buoys. Alternate accommodation lay-outs & cockpit arrangements.





L.O.A..........20.85 m 52’-0”
L.O H...........14.94 m 49'-1"
L.W.L...........13.25 m 43'-5"
BEAM............4.47 m 14'-8"
DRAFT............1.98 m 6’-6”
Headroom.........2.03 m 6’-8”

FROM: Voyager 495 builder in Australia. Hi Bruce, Paul Grainger received this inspection report from the surveyor; the following is the paragraph from the report relating to our fabrication and the accuracy of your design.
"The work executed to date is of the highest tradesman like standards of cutting, alignment, mating up, trueness and fabrication to such an extent, that in the opinion of the writer, it could be expressed as far in excess of the acceptable normal standards of ship building practice." Robert Beale Maritime Surveyor

SEVERAL PHOTOS OF THIS BOAT ARE SHOWN ON THE STUDY PLANS ON CD
Hi Bruce, I send you in the enclosure photos of our Voyager 495, which sailed to Canary Islands just 6 hours before hurricane Delta. The yacht is only little bit scratched and has torn sail while the neighbouring yacht has broken mast after being torn out of the boat and another fiberglass yachts had broken bow from hitting to the pier.
Best regards Miloslav Kolomazník COMBATRA spol. s r.o.Czech Republic

VOYAGER 495 (Cont.)

LEFT and ABOVE:

Hi Bruce, We are sailing these weekend, wind was about 25 knots, small waves, FULL SAIL – genoa, JIB and main sail, simply ideal conditions for sailing !!!! Thank you and best regards from Brno Karel Navara

These photos are of the Voyager 495 built by Karel Navara in Czech Republic. Elswhere you will see photos of this boat barely clearing a bridge on its way from the building yard to launching site. YES as you can see by the other photos Karen's boat made it to the launching on time !

VOYAGER 495 (Cont.)

VOYAGER 495 (Cont.)

LEFT, ABOVE & FOLLOWING PAGE:

These photos are of the Voyager 495 interior as built by Karel Navara in Czech Republic. The hull decks and superstructure were assembled from a pre-cut kit. Both kits and cutting files are available for this boat; contact Bruce Roberts for details and prices .

VOYAGER 495 (Cont.)

VOYAGER 495 (Cont.)

This Voyager 495 Built by Bernie Loyer in Chile is now completed (Next photos)

Just a few weeks later and this Voyager 495 was completed; a few more weeks and with the rig in place Bernie went off on a shake-down cruise. V495 as built by Bernie Loyer in Chile from one of our pre cut kits.

VOYAGER 495 (Cont.)

Bernie sent me this photo - HIS caption appears below. About the photos Bernie says ....."Here is one of my favourites" .. Bruce, Sorry I have been hard to get hold of --- new job and not uncommon for me to travel around the world a couple of times a month. Hard to keep up on email. My 495 Voyager 'Pinguino' is currently in the Puerto Lucia Yacht Club in Salinas, Ecuador. She sails like a freight train and turns heads at the same time. Richard, I learned a lot during her construction and if I can be of assistance, please drop me an email. Next sail is from Salinas through the Panama and into Cartagena to wait out the hurricane season. Then on a rhumb line for Miami that will cut between Haiti and eastern shore of Cuba. Best Regards, Bernie Loyer

To her sailing, everyone into boating and sailing in the northern half of the country (Chile) knows of "Pinguino". She cuts an impressive figure and when she first crossed the bar, it was an awesome event for me and a whole bunch of friends that have been involved


FURUNO
INTERPHASE
B&G
B&G
B&G


NEXUS
FURUNO
INTERPHASE
B&G

VOYAGER 495 BUIIDER WRITES::

Norm Facey's Voyager 495 being built in Toronto. Hi Bruce - yes I sent a greeting card to you the other day - It's just an update shot of the V495 I'm building - got the transom up, and all the aft stringers installed, and was celebrating. In the future I'll e-mail any updates. I am confident I'll be celebrating again (placed the first aft deck plate tonight - everything lined up! It was wonderful! HI Bruce - continuing to do well with kit. The bow was amazing - the center bar came out right on the nose, matching exactly the deck scribe line on both hull side plates. To really concentrate to get it ready for our imminent move (and still not quite there yet). Latest photos attached: - likewise the radius chine plates have started out extremely well too - the upper & lower rolled bow plates fit with very slight edge trimming (just skimming the seam with a very thin blade in a couple of places). Overall, the kit has worked out incredibly well - I would never have had the patience (nor the skill) to put together a boat this well from scratch. Norm Facey
Hello Bruce - Hull plating went incredibly well, including the rolled radius chine plates - now have a crew of professional welders busy finish welding all the seams - being extremely careful to step weld, and very much control how much heat we put into the hull at one shot. Attached is latest photo - note that we've left the forward window out, and are ventilating the hull up through the keel opening, and out through the window - hull looks great! Norm Facey

VOYAGER 495 BUILDER WRITES:

Hi Bruce, glad you liked the photos. We do have more, David will send you some soon. As far as the handling of the boat goes, we found the boat very fast under power, with only a 75hp Yanmar diesel we were doing close to 9knots!
She also handles very nicely in confined spaces under power. We had her out with the new owner on a day with a 20 knot cross wind in the marina, and you could take your time turning her around in her own length.
She has a definite feel of control despite the fact that there is no bow thruster. Under sail she is just as fast. She handles her rig well and points well. She can handle a bit of a blow also. The day the photos were taken the wind was gusting to 30 k and the boat sailed like a freight train and seemed to be well balanced. Regards Brian.

VOYAGER 495 (Cont.)

Here are a few photos of the Voyager 495 built in Nova Scotia Canada.

VOYAGER 495 (Cont.)

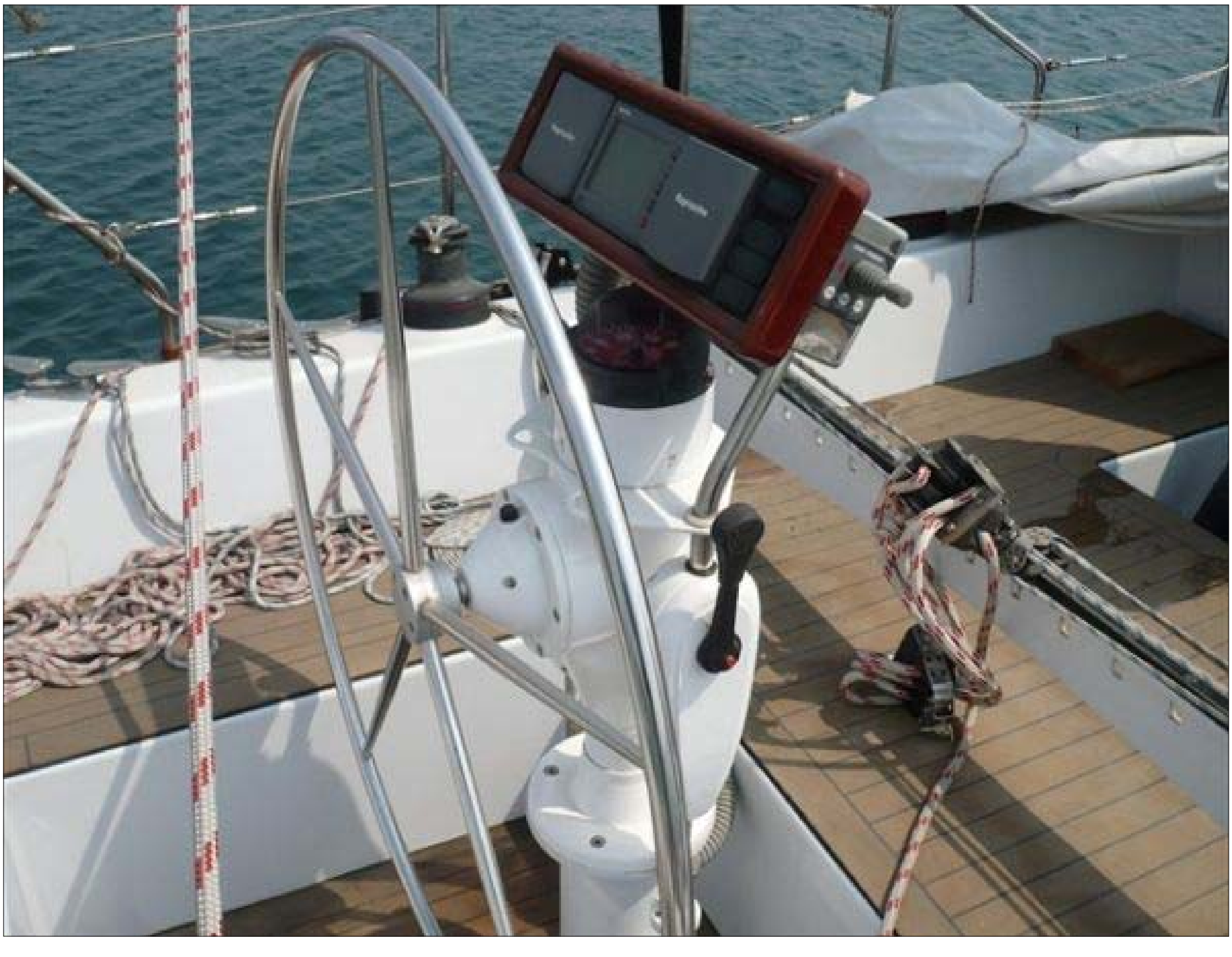
The photographs on this and the preceeding page show the aluminum version of the Voyager 495 being built in the Czech Republic.

The photographs on this page show the aluminum version of the Voyager 495 being built in the Czech Republic.

ABOVE & BELOW:
Another Voyager 495 that was built in Europe and is now cruising world wide.

VOYAGER 495

Built in Korea.



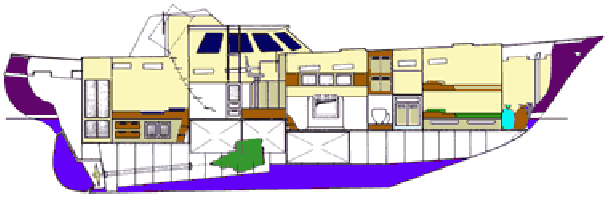


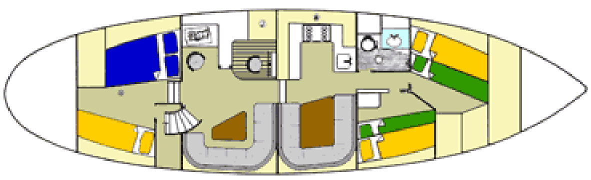





ROBERTS 50 Fiberglass Canoe stern

L.O.A...20.24 m 50' 0"
L.W.L..11.96 m 39' 3"
BEAM...4.27 m 14' 0"
DISPL...............................18,596 kg 41,000 lb
SAIL AREA.....................100sq. m 1,077sq. ft
AUX.PWR..60-100 hp





Bruce,
I recently purchased a GRP Roberts 50 called Solitaire. The boat was built in the mid 70s and as such must be one of the first Roberts 50s built. I understand the boat has circumnavigated and ended up in Brisbane in the mid 80s.

On another note, we have now covered over 2000 miles in the last 18 months both in a cruising mode and participating in the local ocean races. To date we have been very impressed with the boats performance, particularly whilst racing in Bass Strait in winds gusting over 50 knots.

I hope you will be able to assist in the information gathering . Thanks & Regards Mark Folley

CHAPTER 16.

Sailboats 51'- 60' - 15.5m -18.3m

Roberts 532, Voyager 542 & Voyager 544

The following designs are essentially the same ... all of the accomodation plans, deck plans, pilot house arrangments and rigs will work with the Roberts 532, Voyager 542 and Voyager 544. See below for a brief discription of the features of each version of these great cruising boats and following pages for more details.

ROBERTS 532 STEEL . FIBERGLASS

To build this boat from scratch you need the complete set of plans which include the full-size patterns for all of the hull frames as well as stem and other important components of the hull deck and superstructure. You can build this boat in Radius Chine steel or in Fiberglass. In either case you will be building from a quantity of materials that you with the assistanceof the plans and patterns will use to build your boat 'from scratch' as opposed to building from a steel or aluminum KIT .. see below for more information of kits and cutting files. Do NOT be afraid to build 'From Scratch'; over 30,000 of our boats have been built that way by people just like YOU! If you have more time than money then building from scatch may be for you. The radius-chine steel and aluminum hulls are designed, faired and lofted in the computer, so you will have accurate full-size patterns. Naturally, it's most important to have accurate patterns from which to make your frames, and computer lofting is the best way to achieve this As the radius sections are all of the same radius this means that you will not need to transfer all of the radius curves to your loft floor. Transfer only the straight frame sections.

VOYAGER 542 STEEL KIT OR CUTTING FILES

The Voyager 542 is a developement of the Roberts 532. The dimensions of the V542 are the same as the Roberts 532 so all of the deck, accomodation and sail plans will fit comfortably on both boats.

The Pre cut steel kit considts of all the metal parts required to build the complete boat. These parts are computer generated and NC Plasma cut before they are packed and delivered ready for you to start assembling and welding into the finished boat. We design and nest the package using our specialized computer programs, then cut on a computerized plasma-oxygen cutter.These kits are shipped world-wide, each in its own individual container.

This cruising sailboat is designed in accordance with German Lloyds for category 1 (unrestricted operating / sailing area), which is much better than the EU and other Classification Societies and the CE-A require. Complete stability calculations to USCG offshore requirements are included in the design package. All calculations are also cross referenced against ABS requirements to ensure that the design meets world-wide standards and specifications.

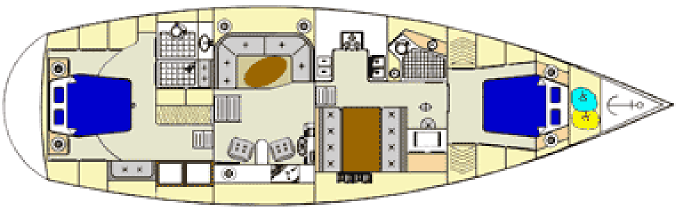
VOYAGER DS 544 KIT OR CUTTING FILES

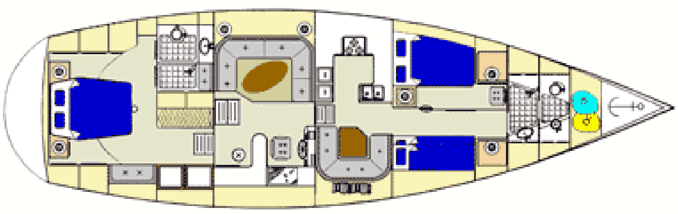
The Voyager DS 540 features one unbroken sheerline and the latest in deck salon arrangements. By careful design we have managed to reduce the height of the sheerline thus reducing windage and improving performance. The Voyager DS 540 features the Roberts safety skeg which is designed to take the best features from the LONG FIN / SKEG combination & add a SAFETY FACTOR. You should be aware that skegs in general are vulnerable to damage so here is our answer to this problem.

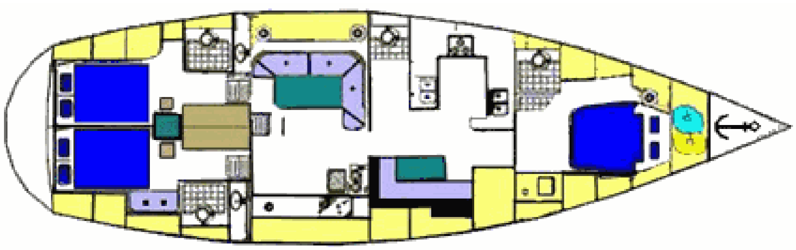
ROBERTS 532 STEEL . FIBERGLASS

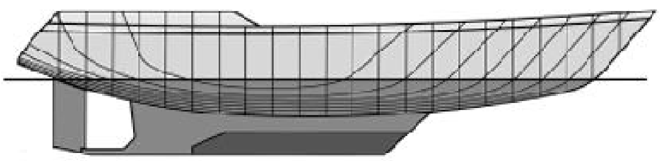
The Roberts 532 was developed from the successful Roberts 53 and over 500 of this design have already been built in fiberglass and steel. This one great cruising boat and a proven charter boat should you want to earn your living whilst sailing the oceans of the world.

L.O.D.............................16.45 m 54' 4"
L.W.L...............................14.8 m 48' 8"
BEAM................................4.9 m 16' 0"
DRAFT...............................2.03 m 7' 0"
DISPL......................30,845 kg 68,000 lb
BALLAST.................7,484 kg 22,000 lb
S/A - Displacement ratio.................20.86









Contemporary LONG KEELS: Above is the long keel design for the Voyager 542. This keel has been developed over the past 30 years and benefits from our own experience & the hundreds of reports from owners of Roberts designed boats plus the use of advanced computer design techniques.

Here we have shown just a few of the dozens of Roberts 532 photgraphs available & are included in the STUDY PLANS ON CD package.

LEFT:
Although I am not a great lover of spinnackers in crusing sailboats I have to admit that this Roberts 532 makes a fine sight.

RIGHT:
This is what it is all about; lounging comfortably in the cockpit with one foot gently resting on the wheel while otherwise occupied reading a favourite book !

LEFT:
Note the deck extension on the stern of this Roberts 532. This is essentially a European idea and I can not see any negative issues providing the weight of the structure is kept to a reasonable level.

LEFT:
Note the light interior of this Roberts 532 and compare it with boats with a more traditional fit-out where much if not all of the joinery is darker varnished timber. The choice between light and dark is purely a matter of personal taste.

BELOW:
Deck boxes on the stern deck are a great idea; good for stowage and make excellent seats.

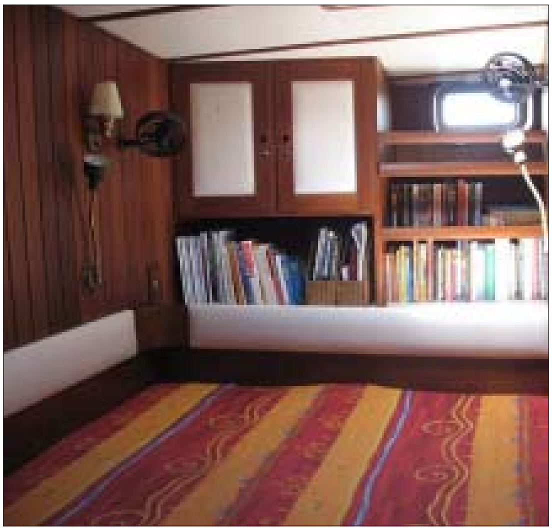
BELOW:
Two more views of Roberts 532. Note the shaped slatted seats in the cockpit; will need cushions for comfort but should provide a comfortable perch for the crew.

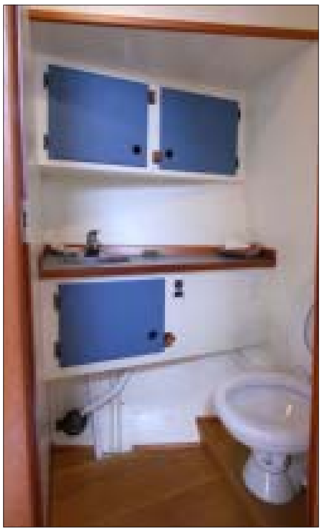
TOP:
This is the same Roberts 532 that is shown elsewhere in this e-book as a varnished hull that was built in Brazil. Note the staysail schooner rig and the fact that the hull is now painted instead of being finished in clear varnish !

ABOVE:
These steps may be practical but they look a bit 'stark' to my eyes; perhaps if painted the same color as the transom the overall appearance would be improved.

RIGHT:
Note the twin headstays with roller furling set up side by side; this arrangement could be successful providing there is adequate clearance between the equipment and the furled sails.

Here is a selection of photographs of several Roberts 532's Note that the study plans on CD feature many large scale photos of these boats.



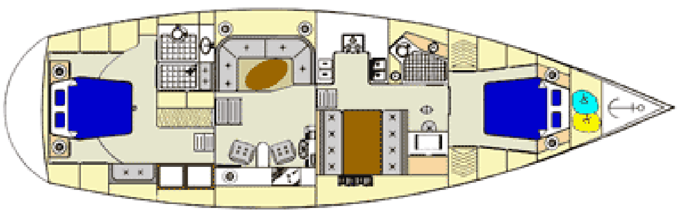


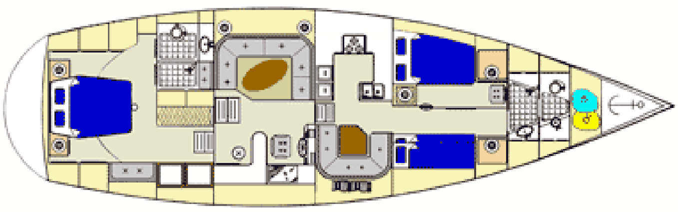
LEFT:
One of the favourable things about building your own boat is that you can customize it to suit your personal tastes. Providing you do not get carried away with unusual features you can hope that some prospective buyer in the future will love your ideas!

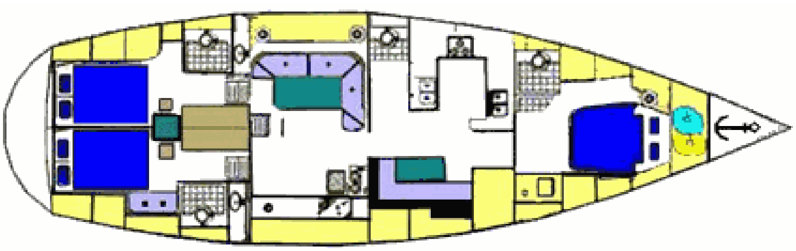
RIGHT:
The fish-eye equipped camera used to take the photographs on the right and below right has distorted the view but it still reveals a very attactive interior of this Roberts 532

VOYAGER 542

STEEL KIT OR CUTTIN FILES







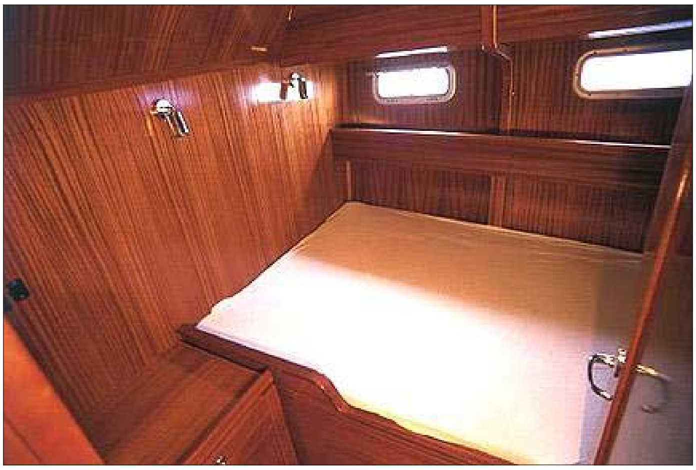
L.O.D..............................16.45 m 54' 4"
L.W.L................................14.8 m 48' 8"
BEAM 4.9 m..................................16' 0"
DRAFT.................................2.03 m 7' 0"
DISPL.......................30,845 kg 68,000 lb
BALLAST..................7,484 kg 22,000 lb
S/A - Displacement raio...................20.86

Hi Bruce. Hope you are well. We have spoken to numerous people who are interested and some have cruised with us to evaluate. The kit you supplied fitted great. Only way to go. On "Western Grace" we offer Private Charters or Join A Group trips in BC Canada and Mexico, and offshore passages of 1-3 weeks, Mexico to Hawaii.

Another year has gone by. Western Grace is now on here 4th voyage down South and we have now 43000 NM (In 3.5 years) under the keel. Needles to say we are now even more confident about her than ever. As we run a charter operation we are very much on a schedule and this means we need a all weather vessel what can take some punishment. The 532 is certainly the vessel for the job. By all standards we are a very heavy vessel but very comfortable. This spring on the passage from Hawaii to Victoria we encountered a full Gale of 55 Kts for about 24 hrs. Behind the low a secondary low formed, a small weather bomb. Around noon the barometer was at 1008 MB and be 2300 hrs 985. (45 KTS) Within 30 minutes down to 980 MB and winds of 75 KTS. Needles to say a bit of a ride but we all did stay dry and warm in the pilot house. By daylight seas where about 33' and breaking over the deck. A few grandaddies shook us up as we where a few time clobbered and had tons of water over the decks.

So if anyone who is considering serious offshore sailing we feel a moderate displacement steel vessel is the only way to go. well and the time savings are significant. Building from a kit is the only way to go. Till next time, Joanne & John Van Strien SV Western Grace

VOYAGER 542 (Cont.)



THIS PAGE:
Here we see a selection of photographs of the various features of the Voyager 542. Please remember that most of the accomodation, sail and deck plans are interchangable between the Roberts 532, Voyager 542 and Voyager 544

THIS PAGE:
Here we see a selection of photographs of the various arrangements that builders have chosen for their Vouyager 542 sailboats

LEFT:
As you can see the generious beam of the Voyager 542 allows for a spacious layout below decks.

RIGHT:
For those who have children or if you want to be able to accomodate as many guests as possible the the twin berths located one above the other makes for maximum use of the available space.

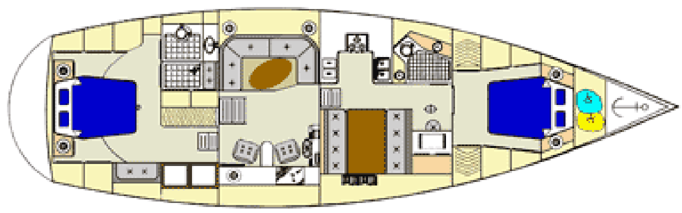
LEFT:
This is either what we often refer to as a 'Cuddly double' or a generious single quarter berth.

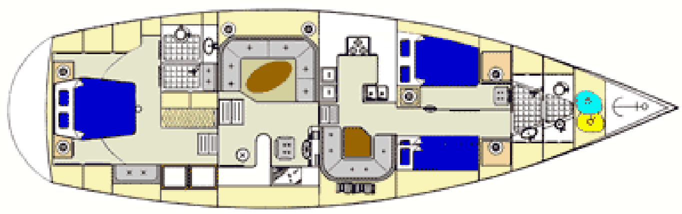
VOYAGER DS 544 KIT OR CUTTIN FILES

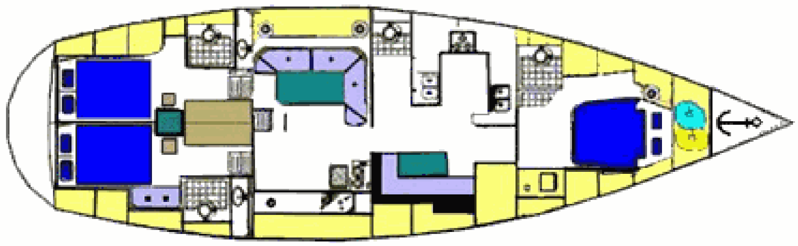
FEATURES DECK SALON & ROBERTS SAFETY SKEG.

L.O.D...............................16.45 m 54' 4"
L.W.L.................................14.8 m 48' 8"
BEAM 4.9 m...................................16' 0"
DRAFT.................................2.03 m 7' 0"
DISPL.......................30,845 kg 68,000 lb
BALLAST...................7,484 kg 22,000 lb
S/A - Displacement raio...................20.86

VOYAGER DS 544 radius chine kit is the latest refinement of this world cruising sailboat and has all the qualities that you will want in your cruising boat. This hull has been designed for fast passage maker and can be customized to suit YOUR requirements. We show possible accomodation layouts; you can mix & match by taking elements from one layout and switching it with another etc., ing but is equally at home racing around the buoys.







Bruce Roberts SAILBOAT KITS

Pre cut boat kits are all the metal parts required to build a complete boat. These parts are computer generated and NC Plasma cut before they are packed and delivered ready for you to start assembling and welding into the finished boat. We design and nest the package using our specialized computer programs, then cut on a computerized plasma-oxygen cutter. These kits are shipped world-wide, each in individual containers.

These cruising sailboats are designed in accordance with Lloyds category 1 unrestricted operating / sailing area, which is much better than the EU & other Classification Societies and the CE-A require. Complete stability calculations to USCG offshore requirements are included in the design package. All calculations are also cross referenced against ABS requirements to ensure that the design meets world-wide standards and specifications.

In the case of KITS, all plate parts belonging to the hull, deck and superstructure that are accurately cut to size are included. The parts are marked with the appropriate part number and engraved matching marking lines to assist in the assembly and location of the part in its position. Cutting method is Plasma / Oxygen, ensuring highest accuracy and smooth edges.

Plate parts are cut from Lloyds approved A Grade Shipbuilding quality STEEL that has been coated with factory applied Sigma weld MC welding primer. We use and recommend steel plate that has the official designation ISO standard 10474 or EN 10204 with 3.1.B certificate.

Voyager 542 & Voyager DS 544 kit assembly

The following photographs illustrate the assembly of this Voyager and also shows how you can add to and customize your own Voyager sailboat.

LEFT:
First thing to do after unloading all of the plates and profiles is to sort and check the parts against the list that is supplied with the kit. Make sure to advise the supplier as soon as possible in the unlikely event of shortages or damage to the plates or profiles; you will find it is much easier to have any faults rectified sooner rather than later!

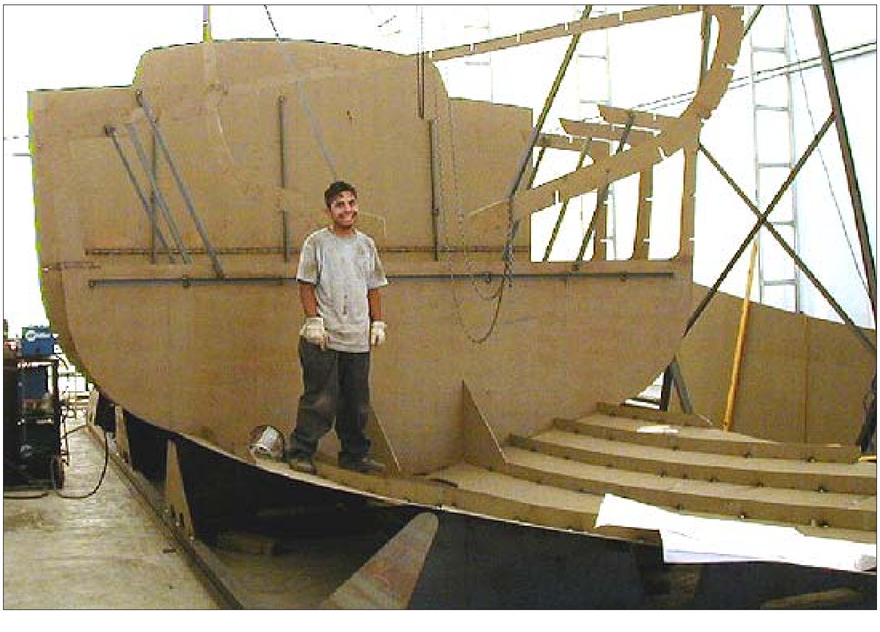
RIGHT:
Here we have the pre-assembled jig that is part of your kit and will be used to support the hull through to completion of the boat.

BELOW:
You will find simple to assemble the frames and bulkheads from the cut parts that come with your kit.

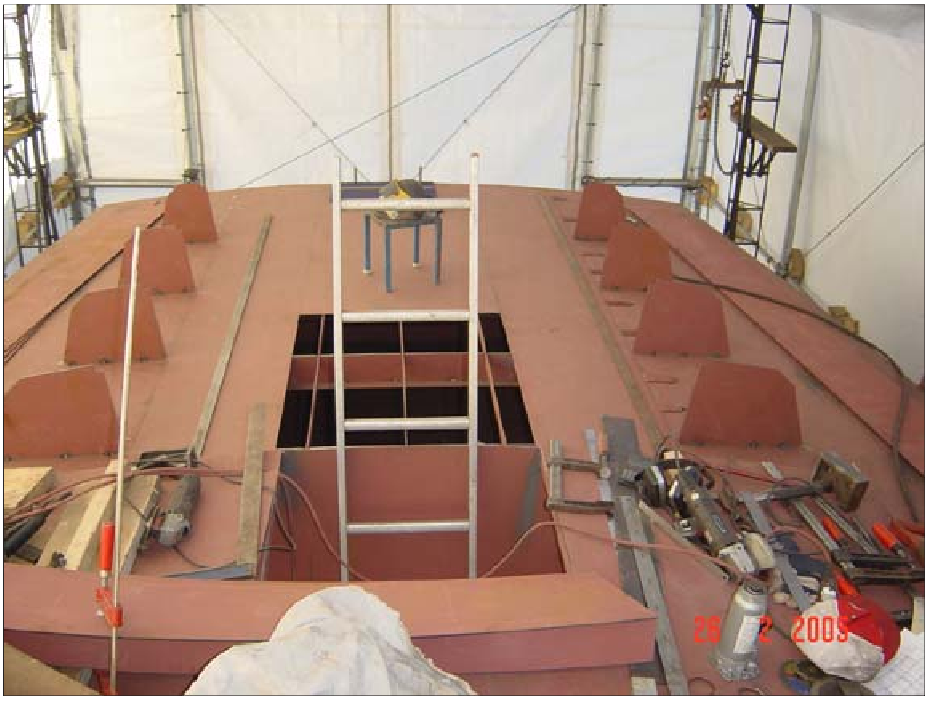
BELOW RIGHT:
The transom is easily and quickly assembled from the pre-cut parts.

LEFT:
The two bottom plates are placed on to the building jig; these plates naturally take up the required shape; The plates have been tack welded along the centerline. The holes on the centerline will be required later to give access to the keel for welding and for later stowing of trim ballast etc. The bottom stringers have been added and this will stiffen the structure at this early stage.

RIGHT:
Here we have the pre-assembled frames and bulkhead which has the stiffeners pre-installed and these can be either L or T angle depending on the materials specified and supplied with your particular kit.

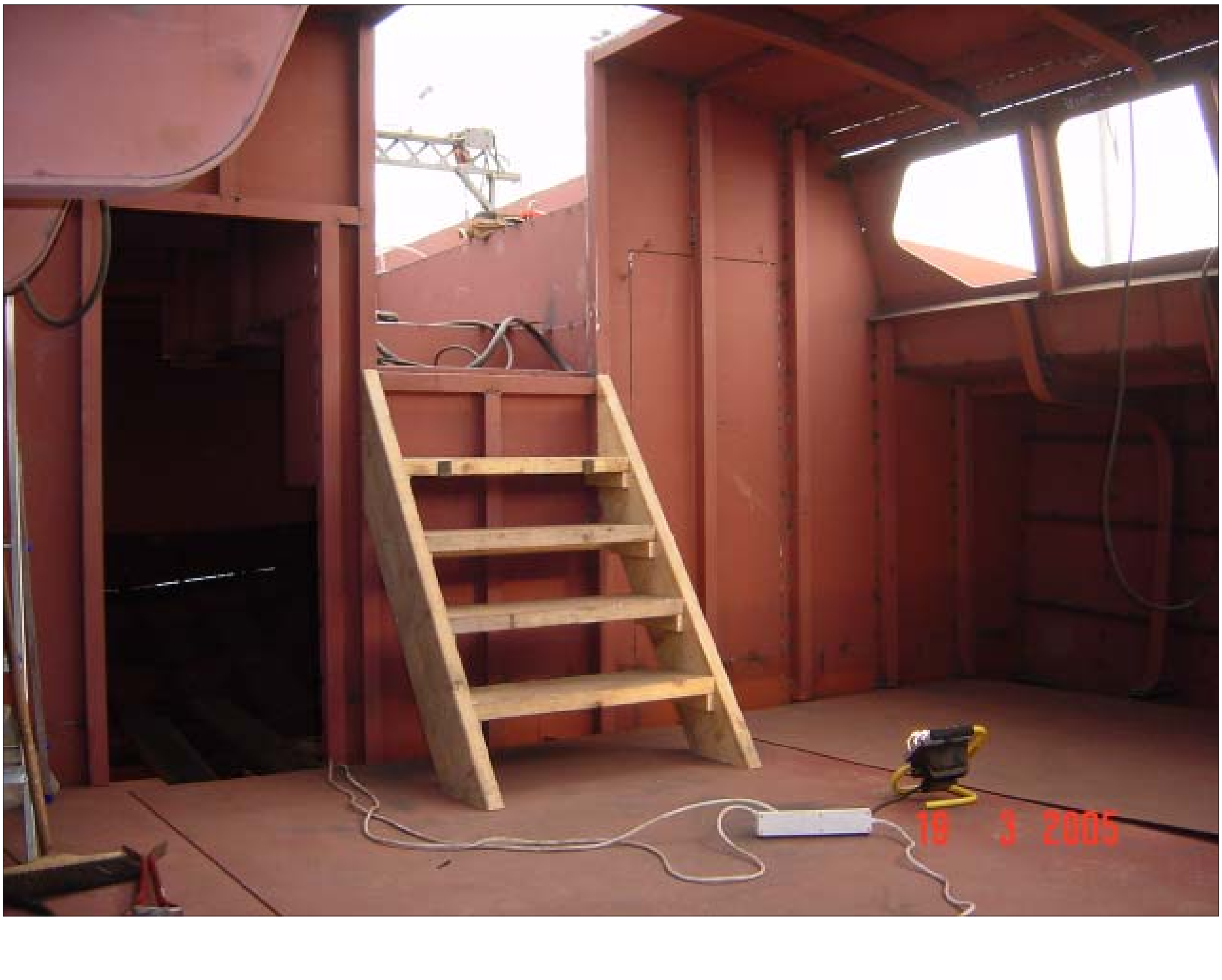


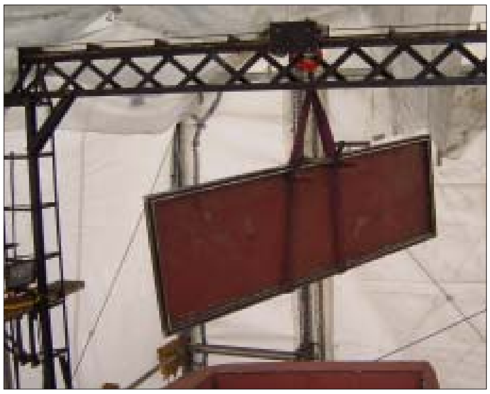
LEFT:
Note the cross bar that has been temporally welded across the bulkhead at the balance point; this will make handling, installing and final location of the bulkhead much easier to effect than if the weight is taken anywhere but at the balance point; this rule applies to any large part you are installing on you boat.



LEFT:
Here we see the side decks in place, cockpit space and the small webs that will support the coaming plates.

RIGHT:
Now the cockpit, seat and coaming plates are all tacked into position.





THIS & PROCEEDING PAGES:
These photographs tell the story. You will also receive written instructions as well as step by step photos with your kit or cutting files and plans.

ABOVE:
Note the main hatchway GARAGE that is now in place.

LEFT:
This is the method used to install the bow thruster tube. Not all saiboats use bow thrusters but they can be very useful when berthing in adverse conditions.

LEFT:
Here is an overview of the side decks and also note the cap rail is being installed at this stage.

BELOW:
The cap rail is now tacked in place. A reminder. NEVER fully weld any parts until the complete boat is TACKED welded together.

THIS PAGE:
Here we have the bowsprit being custom built using the plans that are supplied with your kit. This item along with life rail material can be ordered with the kit.

TOP: *Here we have the pre-assembled bow sprit installed on the bow of this Voyager 542*
ABOVE: *In these photos you can see considerable detail including the main sheet horse and other fittings that were custom made by this builder and installed on his Voyager 542 built in Sweden.*

LEFT AND ABOVE:
In these photos you can see details including the chain plates and many fittings that have been custom made by this builder and installed on his Voyager 542

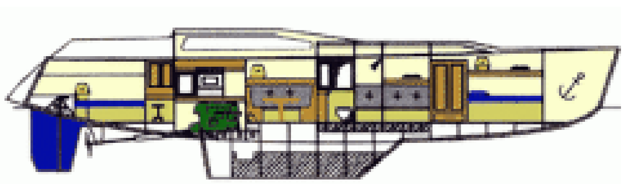
RIGHT:
These attractive and sturdy davits were custom built by the builder of this Voyager 542

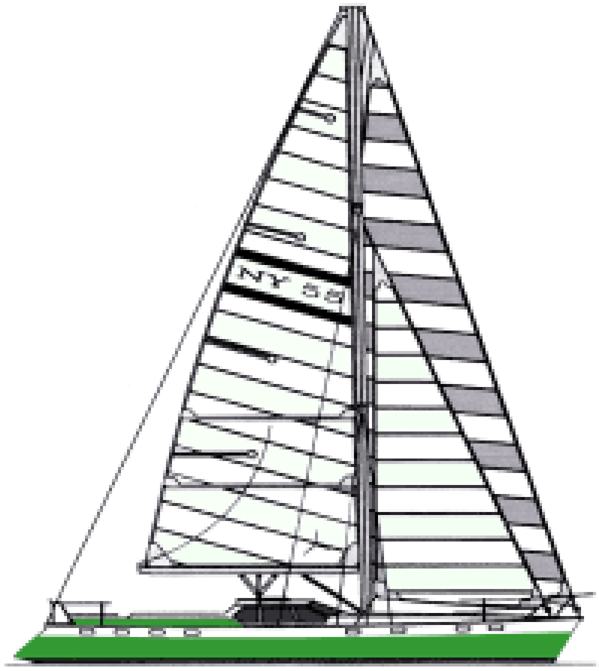
ABOVE: *In these photos you can see the fairing built over and just ahead of the companionway to accept the windscreen and bimini that may be added to give extra protection to those in the cockpit; these features are very popular in Europe where this Voyager 542 was constructed from our kit.*

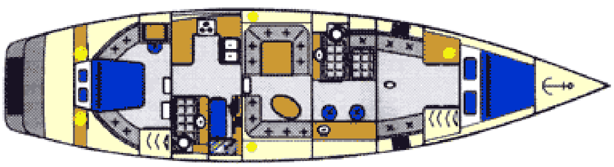
NEW YORK 55 Fiberglass . RC Steel . Aluminum

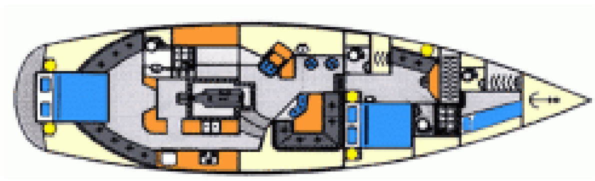
The first plans to be drawn for this design were for the fiberglass version, currently being built for a French customer. We have already drawn up other versions of this sailboat in radius chine steel and aluminum. We have refined this hull design using the latest versions of yacht design software. This is a very fast boat and one that will make extended passages with maximum speed and comfort. It is a large boat with a relatively low displacement length ratio of 220. This boat will be VERY fast and the cruising sail area of 1420 SQ FT (s/a Displ ratio 14) may be increased if you prefer a larger rig.

L.O.D..............................16.97 m 55' 8"
L.W.L..............................20.50 m 50' 10"
BEAM5................................05 m 16' 7"
DISPLACEMENT.....29,484 kg 65,000 lb
SAIL AREA................132 sq m 1,420 sq ft
AUX. POWER..................... 80 TO 120 hp









NEW YORK 55 - VERSION A

NEW YORK 55 - VERSION A

LEFT:
Here we see the large berth as featured in the master cabin ....Photos show a recently launched NY 55 built by Ian and June Thorpe

RIGHT:
Another view of the spacious master cabin in the NY 55 B ... Photos show a recently launched NY 55 built by Ian and June Thorpe

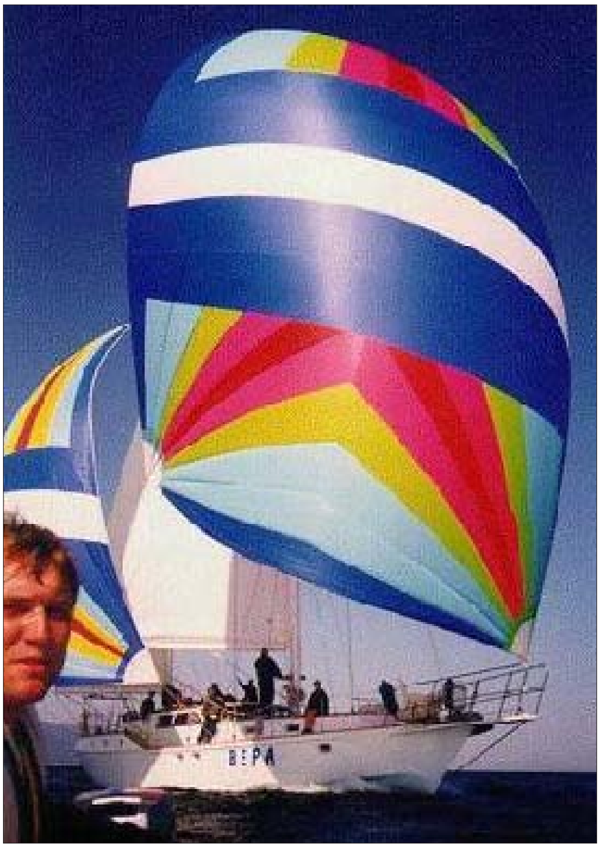
SAFETY SKEG IS AVAILABLE
The Roberts safety skeg is designed to take the best features from the LONG FIN / SKEG combination and add a SAFETY FACTOR. Many of you are aware that skegs in general are vulnerable to damage; here is our answer..

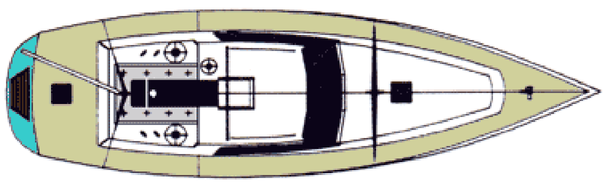
ABOVE & RIGHT:
Here are two more photographs of this beautiful New York 55 that was built by Ian and June Thorpe

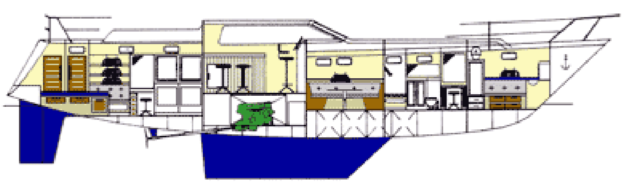
ROBERTS 58 STEEL . FIBERGLASS

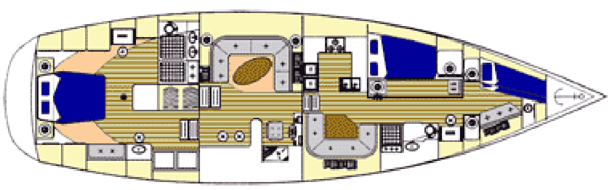
Several Roberts 58's have already been completed and have made extensive voyages including many crossings of Atlantic and Pacific oceans. The standard version of this design has a draft of 7'0" but this could be reduced by using a modified shoal keel. Custom keels and sail plans are available, as are custom interior layouts. The standard sail plan is a ketch rig and the layout as drawn has a spacious aft cabin. You can build the Roberts 58 in either Round Bilge Fibreglass or Radius Chine Steel or Aluminium. The complete plans and Full Size Patterns include many sheets of large-scale drawings, plus full-size patterns for the hull, deck and cabin top beams, etc.

L.O.A.	17.83 m	58' 6"
L.W.L.	14.71 m	48' 4"
BEAM	5.02 m	16' 6"
DRAFT	1.68 to 2.1 m	5' 6" to 7' 0"
DISPLACEMENT	27,216 kg	60,000 lb
BALLAST	9,072 kg	20,000 lb









Built in Russia by André who writes "We bought the project in 1993. We built yacht & called it Faith (VERA) sails on Lake Baykal in Siberia. Now we are building second boat also a Roberts 58 this Yacht - IS GOOD! Regards André

UPDATE: 1st NOVEMBER 2005

First of all let me express my deep respect towards you & your work. I am ordering the Plans CD for the Cat 60 A. If You remember there is a photo of my R58 built according to your plans still on your site. Sincerely Yours Andrei

LEFT:
Here is a very attractive wheel; also note the very comfortable cockpit cushions and the slope on the backrests; which are much more comfortable than the vertical ones the one occasionally sees on some boats

RIGHT:
Some builders have installed a traditional transom on their Roberts 58's; this does add extra deck room and interior space but you lose the boarding & swim platform & also be careful of the additional weight aft
.

LEFT & ABOVE:
Another two Roberts 58's

ABOVE: *Hi Bruce, We are currently the owners of a Roberts 58 steel ketch, very happy with it, and are considering building a large catamaran, such as yours. Cheers Richard Taylor*

ABOVE: *This ROBERTS 58 Amor Fati is a proven cruiser that has both been there and come back again. She is outfitted for the serious cruiser. Once again, she is on the high seas on her way from Rome to San Diego. She left in late October 2005, will depart the Canaries in late November to cross the Atlantic and arrive in Barbados before Christmas. Her sail plan then calls for stops in Martinique, St. Lucia, St. Vincent and Grenada before the New Year. In January, she will see Curacao, Bonair, Aruba, Cartagena, San Blas, Puerto Bello, and Colon Panama. She is expected to transit the Panama Canal in the third week of January and then head for the West Coast and San Diego.*

Roberts 58 Built by Put Veini in Latvia - No the gentleman is not a midget - this is one big sailboat !

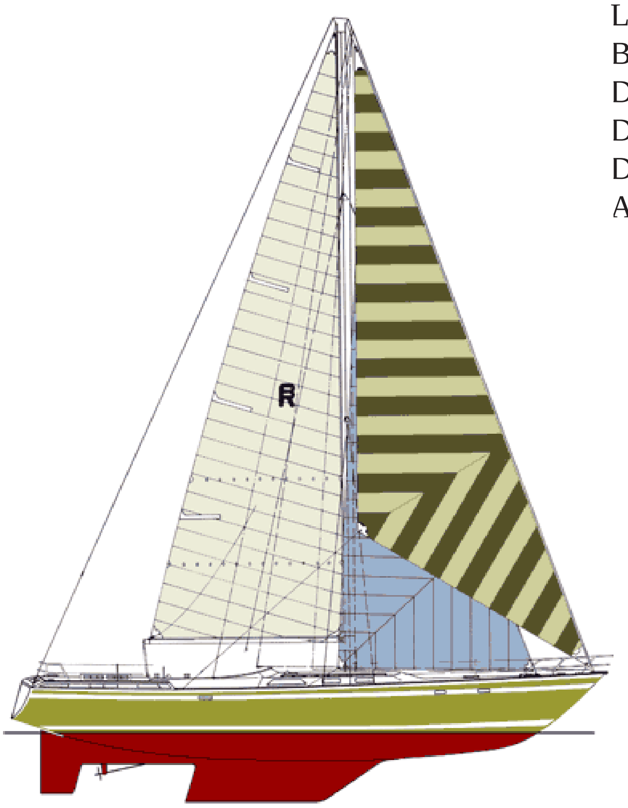
ABOVE: *Here we see a selection of interior photographs from two of the many Roberts 58's currently in service world-wide. The study plans on CD include many large scale photos of this design.*

CHAPTER 17.

Sailboats 61'- 80' - 18.6m -24.3m

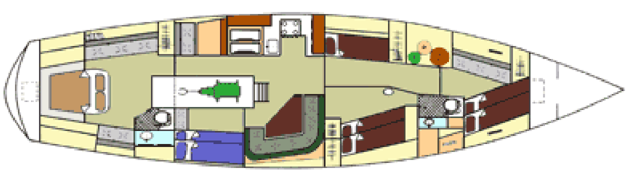
ROBERTS 64 **Steel . Aluminum . Fiberglass**

This design was originally based on the very successful Roberts 53 and is assured of acceptance by those builders who require a larger boat either for charter work or for extended cruising with a large party of guests. To date over 200 of these boats have been completed in Steel and Fibreglass. Several layouts are given including a small pilot house option. Both ketch and cutter rigs have been designed to work on this boat. Both rigs come with the study plan set.You may build the R64 in either multi chine steel or aluminium, radius chine steel, aluminium, also available for construction in Fibreglass.



L.O.A...19.50 m 64' 0"
L.W.L...16.00 m 52' 6"
BEAM..4.93 m 16' 2"
DRAFT...2.29 m 7' 6"
DISPLACEMENT.......(Steel) 35,901 kg 79,200 lb
DISPLACEMENT.....(Alum) 29,869 kg 65,850 lb
AUX POWER.....................................80 to 120 hp

The Roberts 64 is the same hull I went around Cape Horn in a few years back, the boat I was on was rigged as a ketch. I have seen the hull rigged as sloop though. The center cockpit makes it a dry boat offering a tremendous feeling of security. Captain Kevin Ledwell Yacht Delivery:Worldwide 508-620-7207



"Wandering Star" was built in Canada by a customer who had previously built a Roberts 53, he writes "We cruised at 10 knots + and first I thought

the Sumlog was out but on checking against shore sights I discovered that the Sumlog was actually a 10th of a knot SLOW. I have a very fast boat, even faster than my Roberts 53...congratulations to you as the designer.

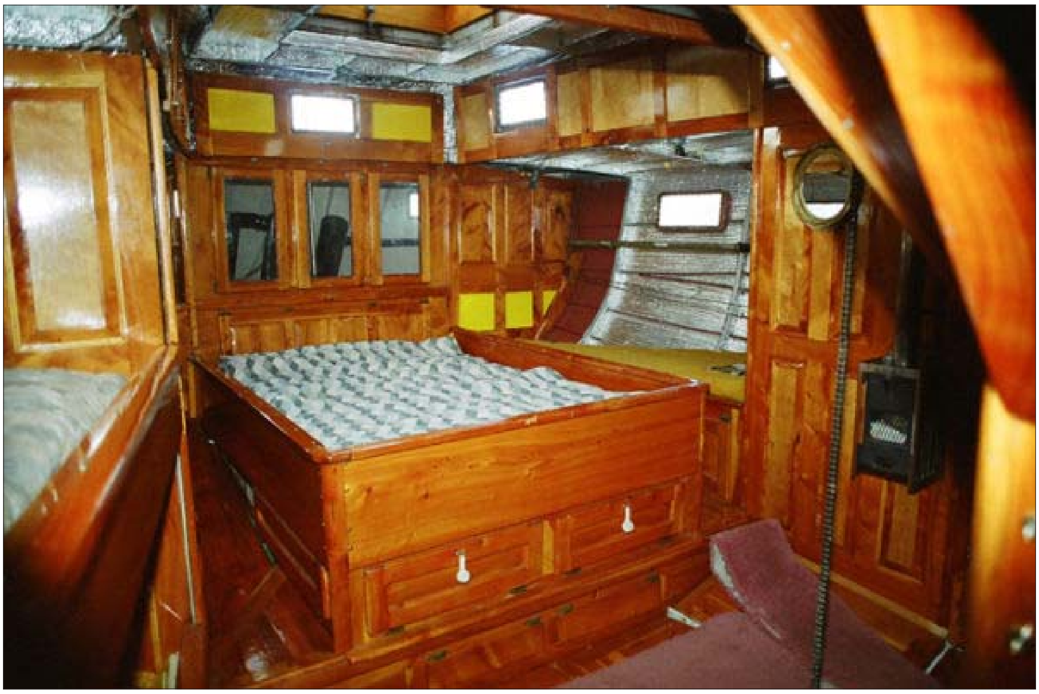
ROBERTS 64

RIGHT & BELOW:

Here we see more examples of the Roberts 64. This is a fine cruising boat and is a well proven design with many examples having covered hundreds of thousands of ocean over the past 10 years.

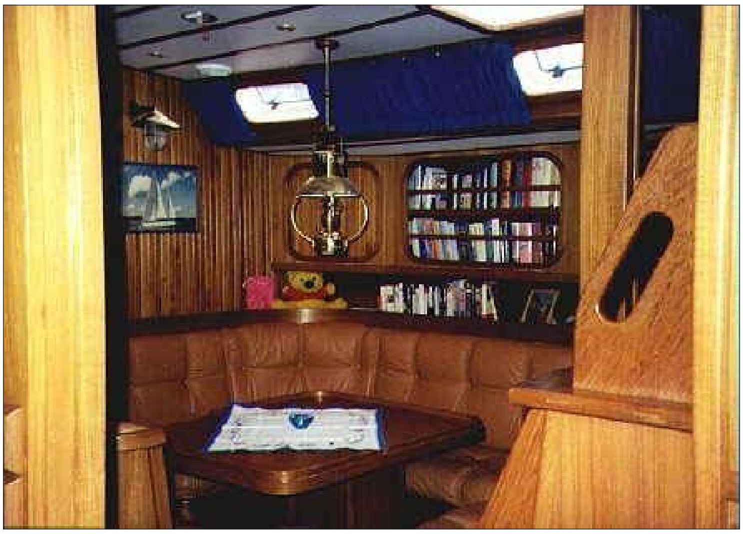
RIGHT:

Note the spacious aft master suite in this Roberts 64. The berth is a full King size.



RIGHT:

Make sure you have plendy of stowage for books as you will find that there is nothing so pleasant as settling down with a good book especially on long passages when the weather is cooperating and the boat is looking after iteself.



LEFT:

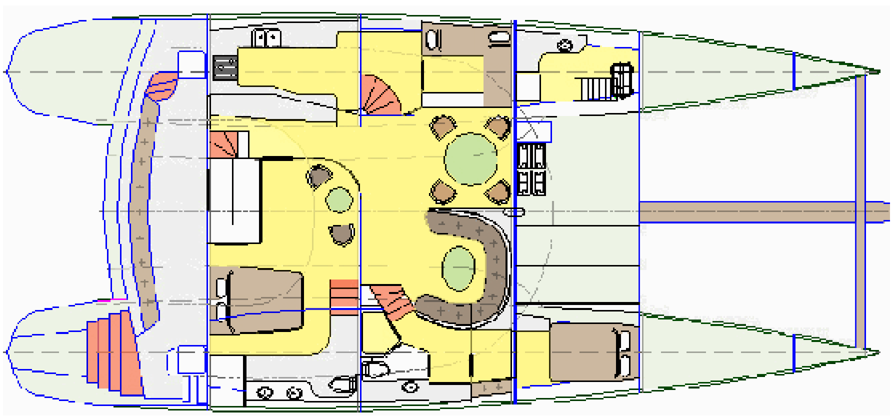
Note the spacious and airy Pilot House in this Roberts 64.

RIGHT:

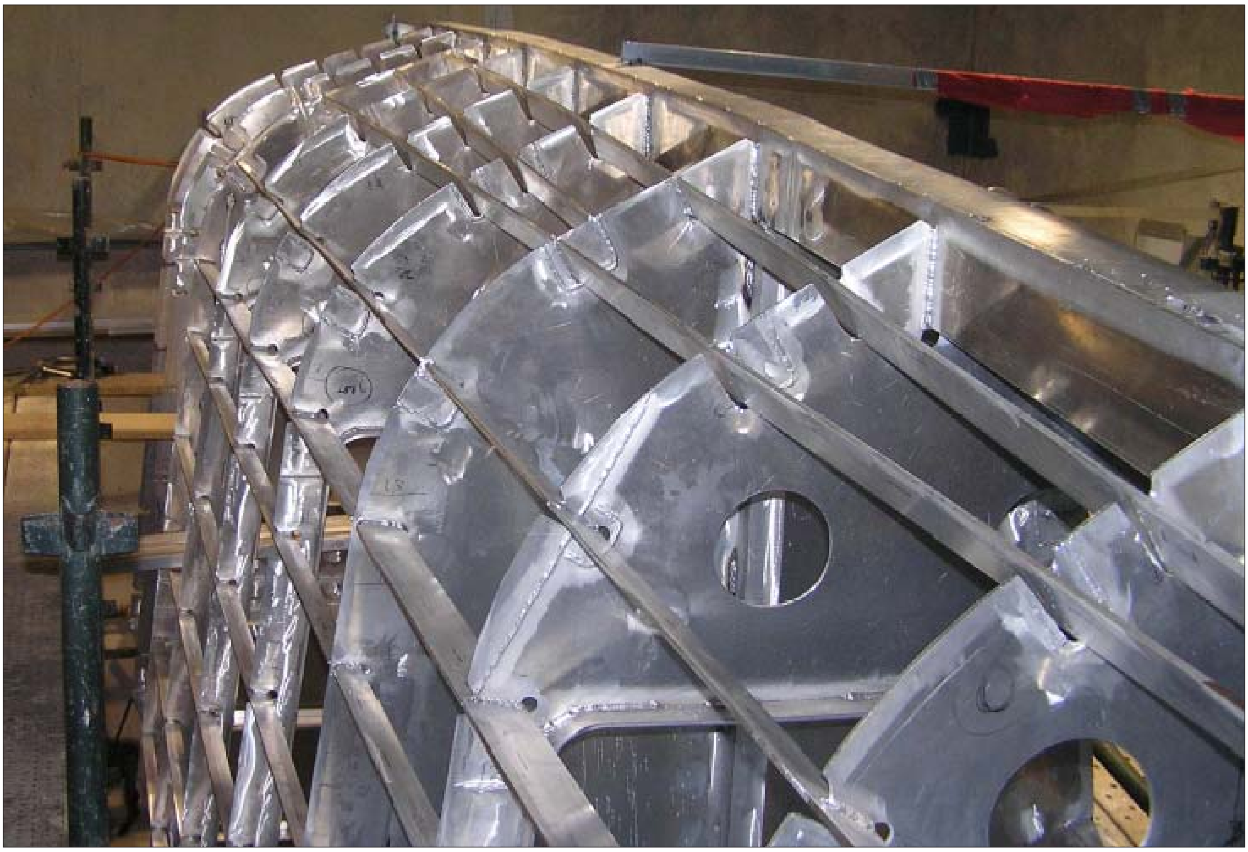
Now this is really a grand salon in this Roberts 64. There are many and varied accomodation arrangements that would work in this generious space.

Euro CAT 2000 - Aluminum

LOA...64'-11"   19.81m
LWL...62'-11   19.20 m
BEAM...29'-6" 9.00 m
DISLACEMENT.. 71,000 lbs 32,272 kg



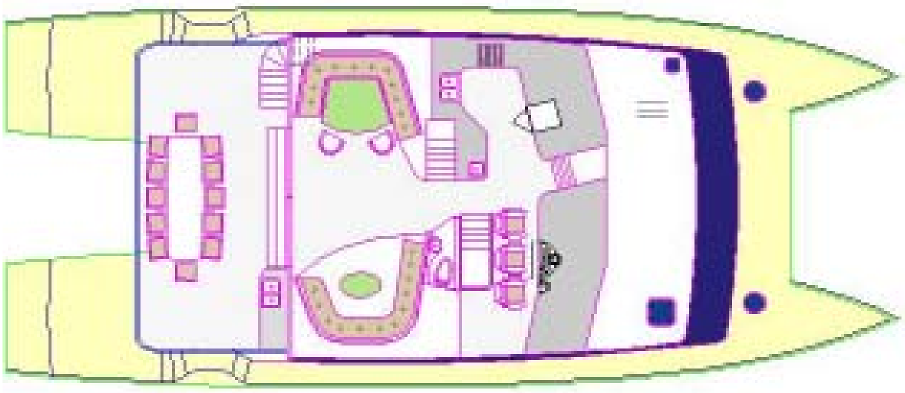
The Euro CAT 200 was custom designed for an experiance yachtsman who has cruised around the world in other large cats; he know what he wanted and between the client and the Bruce Roberts design team we believe we have created something really special !



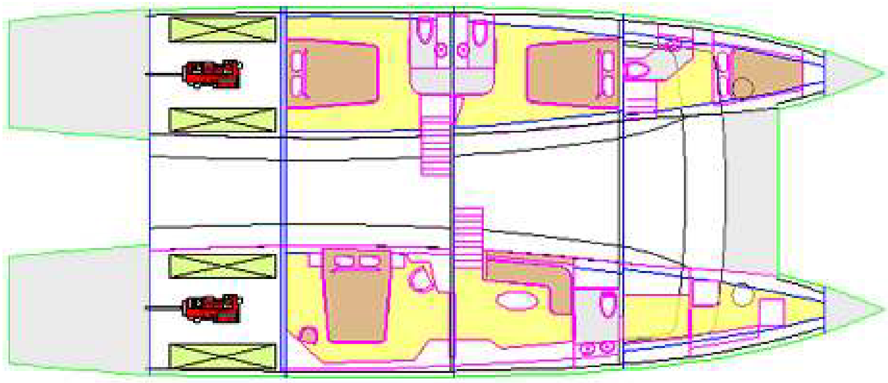
ABOVE: Here are the first construction photographs of the new Euro Cat 2000

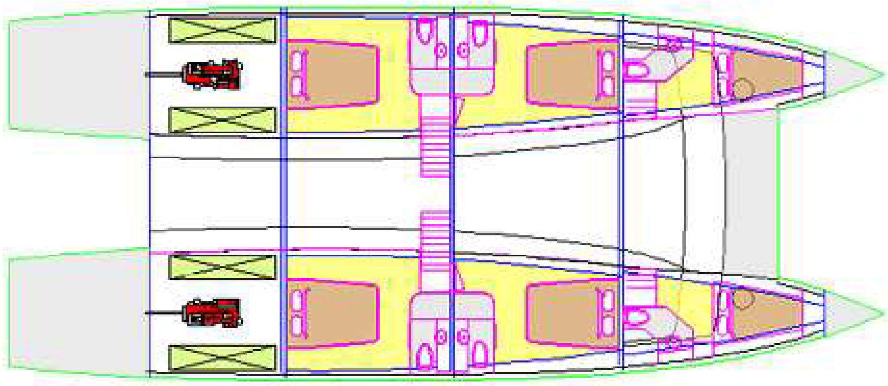
CAT MS 65 - STEEL . Aluminum

The first example of this design will be built in steel. We feel this the smallest cat where steel construction is practical so we are excited to prepare this new design. The first Cat 65 MS will be built in Europe as a family cruising boat.

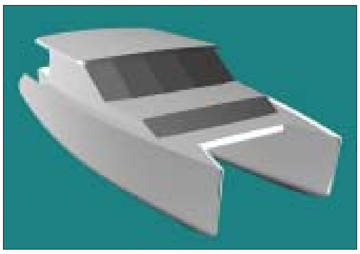


This catamaran was designed for personal use or charter work and the accommodation was laid out with that in mind. There will be two basic layouts - personal arrangement as shown here plus an arrangement more suitable for charter use. The building technique is well proven as Bruce Roberts has used similar techniques in building radius chine mono-hulled sail boats since the early 1980'S.





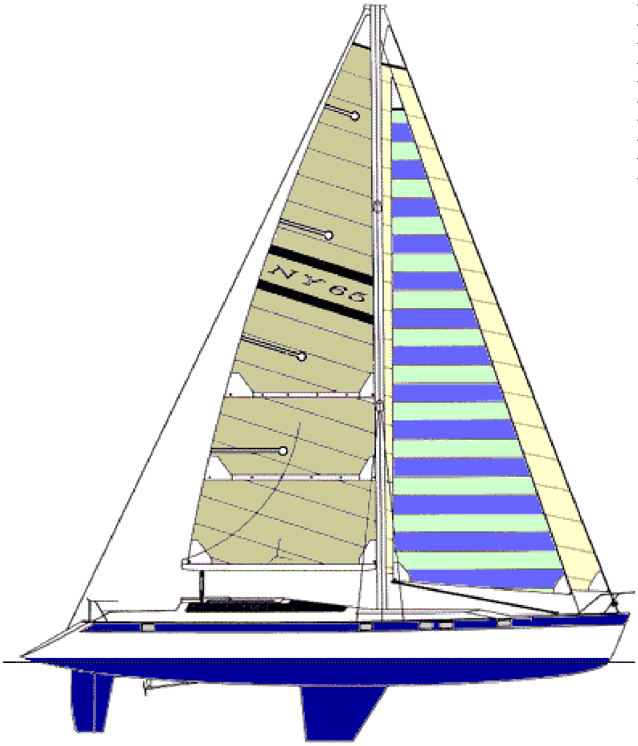
On the left are our suggested lay-outs for the sleeping accomodation - top shows the 'Owner' arrangement and the lower illustration is the suggested 'Charter' arrangement.



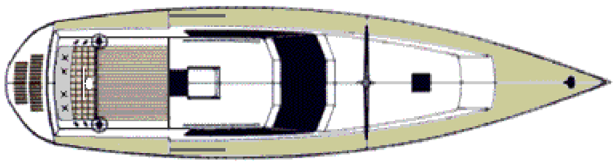
NEW YORK 65 STEEL . FIBERGLASS

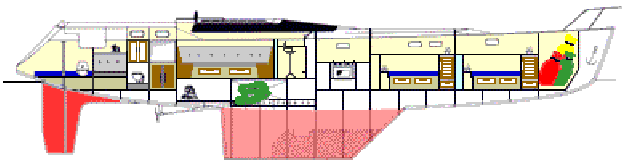
This is a sailboat that can be modified to suit a variety of sailing lifestyles. Both Slimline & regular beam versions are available as plans and frame patterns to be built in Steel or Fiberglass.

The New York 65 is ideal for luxury charter or fast family sailing and offers a variety of accommodation options and many accommodation layouts are possible. Each New York 65 version will vary depending on the building material, draft limitations and any client options and requirements. Construction methods include: Radius chine aluminum, Radius chine steel and any one of the fiberglass methods. There are several different accommodation arrangements available.



L.O.D...65'-0" 19.81 m
L.W.L...60'-8" 18.53 m
BEAM (Slimline)..............................12'-6" 3.81 m
BEAM (Widebody)......................... 16'-0" 4..88 m
DRAFT ....Various



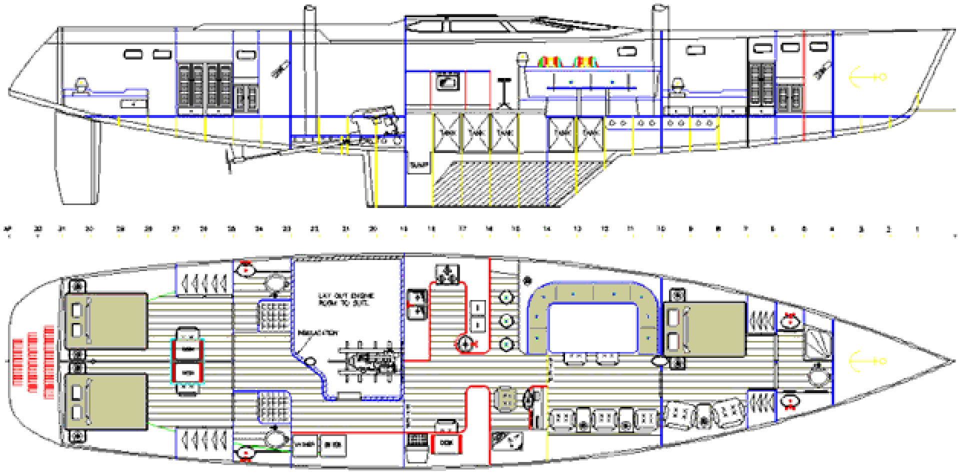


Dear Bruce,   I have constructed a beautiful NY 65 / Voyager 655 "Melon Eye. I would like to share info with you.   Paul & Melinda West of Ketchikan Alaska.

Hello, I wasn't sure if Paul responded to you letter or not. We have made a lot of progress with the Melon Eye. We managed to put her under Sail last year. The interior is almost done fewer stacks of lumber! We will get some pics ready for you by early summer and some pics of her out sailing! Thanks for the interest. She is really a beautiful boat. Paul has done a wonderful job. Paul & Melinda West

THIS PAGE:
Here we see a selection of views of the New York 65 which you can build in radius chine steel or fiberglass

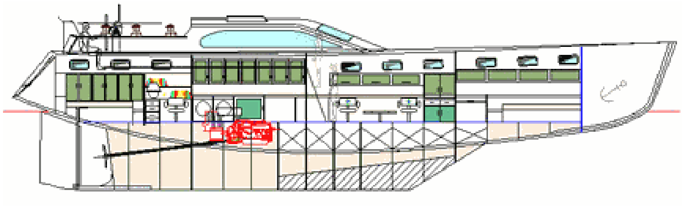
NEW YORK 73 STEEL

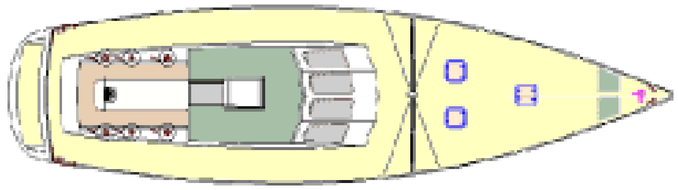


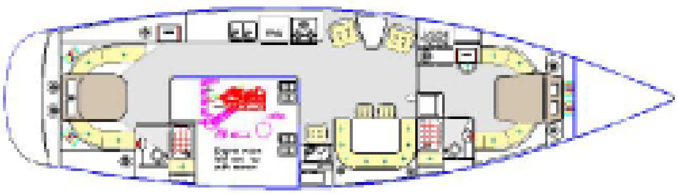
This is a sailboat that can be modified to suit a variety of sailing lifestyles. This boat is available as plans and frame patterns to be built in Steel or aluminum. The New York 73 is ideal for luxury charter or fast family sailing and offers a variety of accommodation options and many accommodation layouts are possible.

Voyager DS 655 WOOD EPOXY

L.O.D.	65'-10" 20.08 m
L.W.L.	56'-9" 17.30 m
BEAM	17'-6" 5.33 m
DRAFT	7'-3" 2.21 m
DISPLACEMENT	92,667 LBS 42,037 KG
BALLAST	30,889 LBS 14,071 KG



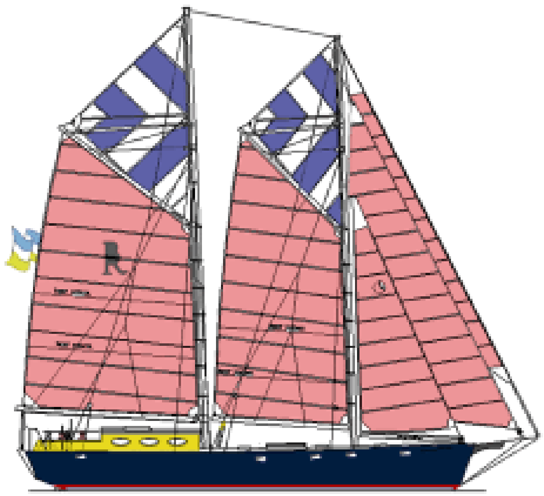




Hello Bruce, hope you had a pleasant holiday season. We have our VOYAGER DS 655 plans and they look great. John and I are both very pleased and excited to get moving. Thank-you Bruce for drawing our custom plans. We are excited to get moving and just waiting for the holiday stuff to be over with. I have built the lofting floor so we are poised to get going building the perfect boat, Daniel Boyko

Here we see another arrangement that would work in this boat.

This arrangement which we favour as will fit comfortably into this boat, see accomodation layout shown above left



This customized 69 ft / 21 m version of the Voyager and was designed for a client from Italy who will be having this boat built in Wood / Epoxy for his own use.

Voyager DS 655 WOOD EPOXY

Engine is under the dog house. Below is all one level sole (floor) the up the steps into the forward end of the dog house and into the cockpit. It is possible to have a variety of interior layouts for this design ... that is what the 'CUSTOM' is all about . YOU can have the layout that suits YOUR needs ! Contact Bruce to discuss your requirements and ideas for this boat. We can customize the interior to suit you!

TRADER 65 Radius chine steel

The first of this versatile design was prepared for Thomas and Linda Owens of North Carolina. Tom and Linda had been active in the charter business for many years and had very specific requirements when it came to their next boat. There are now over 20 of this design being built throughout the world so many other have agreed that this is a fine design for those who plan to earn their living while enjoying the cruising lifestyle. The Radius Chine Hull has beautiful lines and will please anyone who builds this design. are between 6 and 10 sheets of drawings in the typical study plan package.

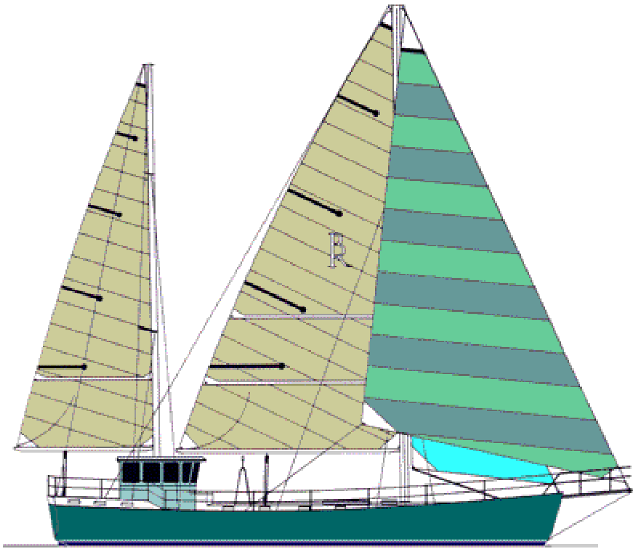
Hey Bruce,   It's Thomas Owens and Linda Maruna that worked with you on the design for the "Trader 65". Remember us?? She sails like dream. She is the fastest boat in the Abacos, Bahamas where we run our charter business. She has hit 12 knots....sailing like a freight train! She is stoutly rigged and heavily ballasted.

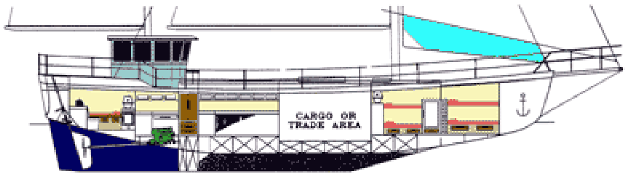
She lends herself so well as a live aboard in the charter business. We have enough of our own space in the aft cabin and our own head and shower that we don't mind having a heavy charter schedule. The galley is fantastic with plenty of space. We even put in a 6 burner stainless steel restaurant stove and oven.

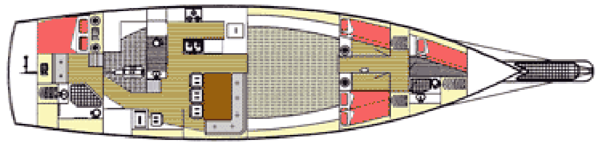
We LOVE the pilothouse! We have 20 windows and have a huge table that can seat 12 people. This is really where we "live" ourselves. We eat, read, do our computer work, and hang out all the time in the pilothouse. Has anyone else completed building this boat? Thomas did such a beautiful job on the whole project, doing it all by himself! You wouldn't believe how smooth the hull came out and we have never put any filler on the hull. The best compliment was when we were in a boat yard and we were down below. We heard this light tapping on the hull. We came up to see what it was. Two guys looking across the boat yard had made a bet. One said our hull was a fiberglass hull and the other said it was steel! So they had to tap on it to see who won the bet. We are extremely proud of our accomplishments with this project. And are happy having our home and business aboard "Ciganka"! Thought you would enjoy an update!

TRADER 65 Radius chine steel

L.O.A.......................................19.80 m 65' 0"
L.W.L.......................................17.90 m 58' 10'
BEAM.......................................5.10 m 16' 7"
DRAFT......................................1.80 m 6' 0"
DISPLACEMENT........45450 kg 100,000 lbs
BALLAST.......................13640 kg 30,000 lbs
SAIL AREA.....................204 sq m 2,036 sq ft







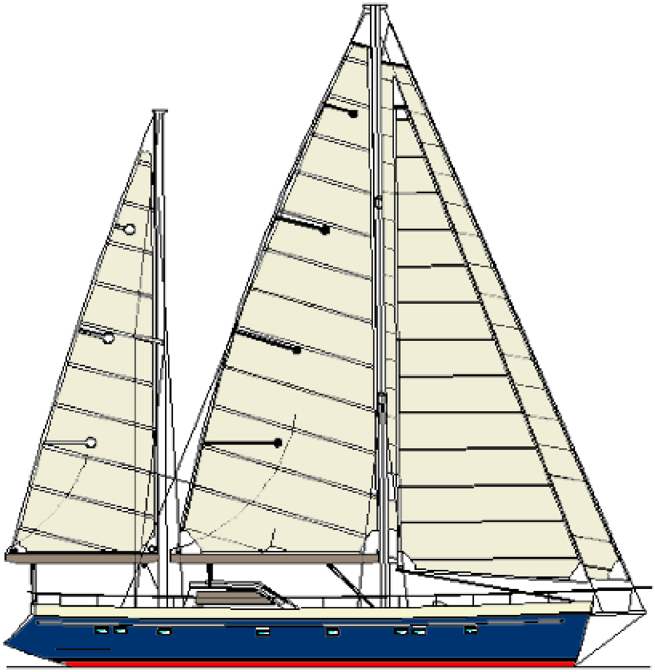
TRADER 65 Radius chine steel

TRADER 65 Radius chine steel

TRADER 65   Radius chine steel

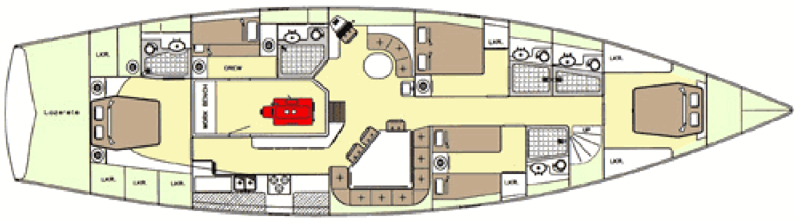
VOYAGER 765 CUTTING FILES OR STEEL KIT

This new robust go anywhere at any time - radius chine serious cruising sail boat is based on our New York 65 many of which are sailing the oceans of the world. This new design is available in KIT form or custom CUTTING FILES. We can design custom sail and accommodation plans to suit your particular requirements.



LOD.......................................76'-5" 23.31 m
LWL......................................65'-0" 19.81 m
BEAM....................................19'-6" 5.94 m
DRAFT...Various
SAIL AREA............2,800 SQ FT 260 SQ m

See STUDY PLANS ON CD for details on the plans and cutting files for this design.

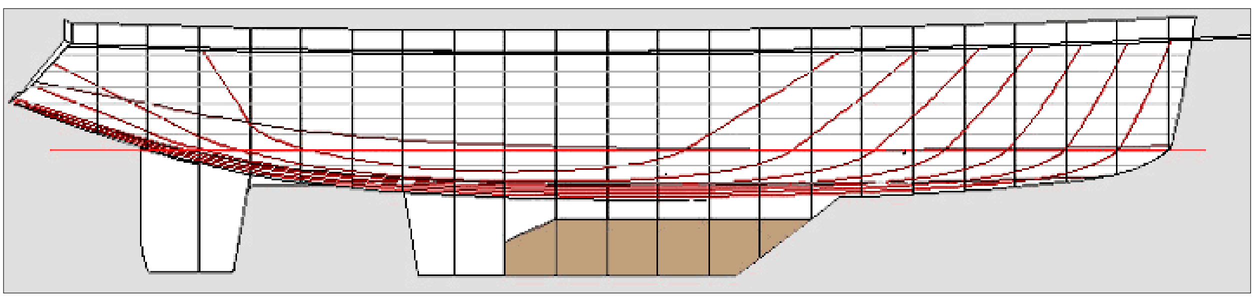


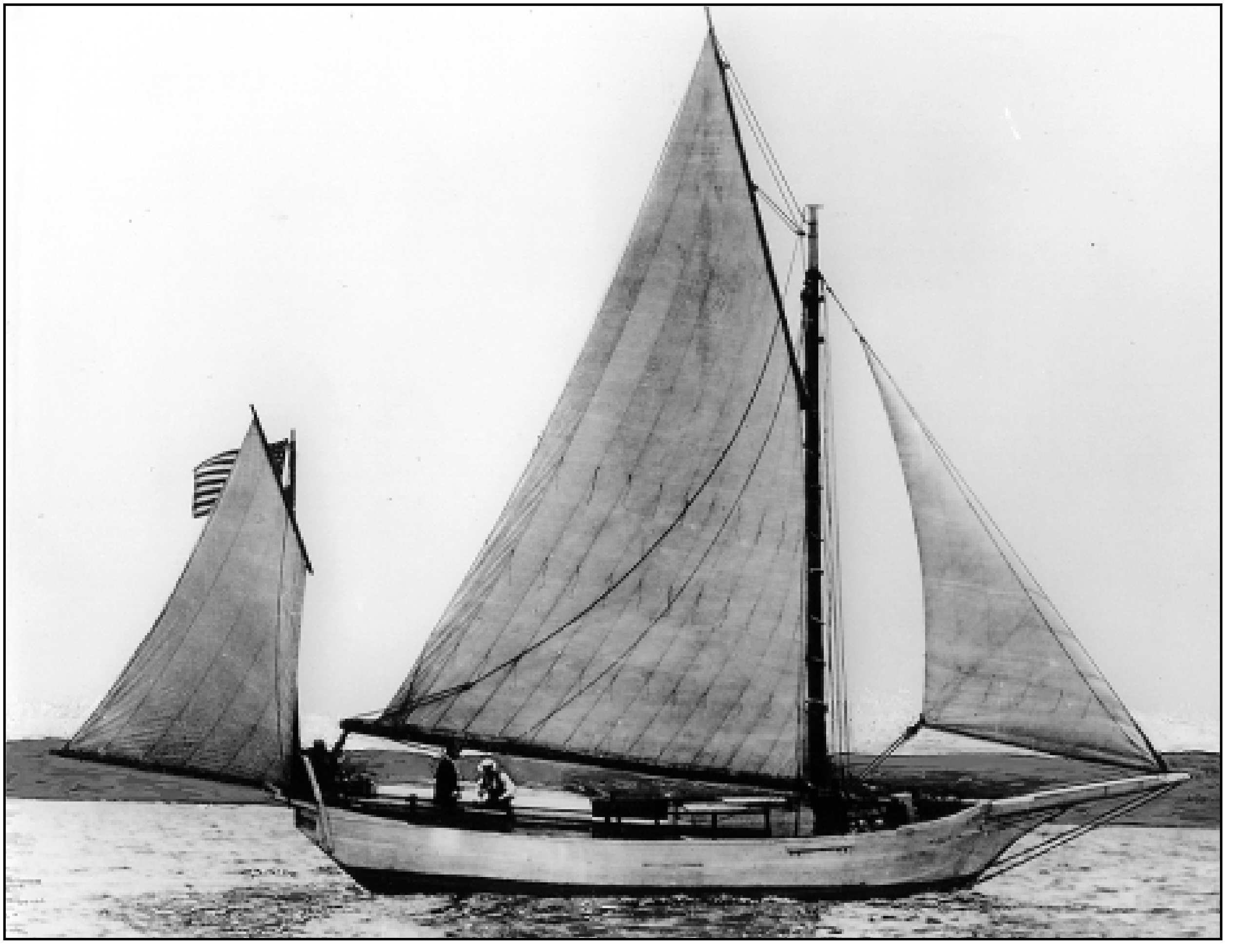
Bruce Roberts SAILBOAT KITS Pre cut boat kits are all the metal parts required to build a complete boat. These parts are computer generated and NC Plasma cut before they are packed and delivered ready for you to start assembling and welding into the finished boat. We design and nest the package using our specialized computer programs, then cut on a computerized plasma-oxygen cutter. For example, an 13m (43') yacht would comprise of around 470 parts! These kits are shipped world-wide, each in individual containers.

These cruising sailboats are designed in accordance with Lloyds for category 1 (unrestricted operating / sailing area), which is much better than the EU and other Classification Societies and the CE-A require. Complete stability calculations to USCG offshore requirements are included in the design package. All calculations are also cross referenced against ABS requirements to ensure that the design meets world-wide standards and specifications.

In the case of KITS, all plate parts belonging to the hull, deck and superstructure that are accurately cut to size are included. The parts are marked with the appropriate part number and engraved matching marking lines to assist in the assembly and location of the part in its position. Cutting method is Plasma / Oxygen, ensuring highest accuracy and smooth edges.

Plate parts are cut from Lloyds approved A Grade Shipbuilding quality STEEL that has been coated with factory applied Sigma weld MC welding primer. We use and recommend steel plate that has the official designation ISO standard 10474 or EN 10204 with 3.1.B certificate.





This rare photograph shows SPRAY off Sydney with Joshua Slocum and Sydney business man Mark Foy. They are trying out the new set of sails that Foy had presented to Slocum. Photo courtesy Dr Kenneth E Slack.

In 1892 at the age of 51, Joshua Slocum was given a decrepit sloop called *Spray.* and spent the next two years rebuilding this vessel. He removed the centreboard and replaced nearly every piece of timber in the hull, deck and superstructure. He sought to improve the seaworthiness by adding some freeboard, so that the boat would be better suited to the deep water sailing he obviously had in mind. All the materials used in the reconstruction were collected around Fairhaven, in Massachusetts, where *Spray* had lain in a field for several years. The boat's lineage is clear when one examines photographs of early examples of the North Sea fishing boats that have worked off the coasts of several countries bordering that area; and rumour has it that the *Spray* was over one hundred years old when she was given to Joshua Slocum. There was a story that she had worked as an oyster dragger off the New England coast. Joshua Slocum, a seaman with vast experience, must have recognised something of the potential of his new acquisition, for otherwise he would not have invested two years of his life in the total rebuilding of her. As it turned out, he could not have made a better choice.

Budgets and planning to build.

Initial planning and calculations of how much will it all cost. How to save money and keep within your budget. Budgets for acquiring your boat and for maintaining the cruising lifestyle. Earn as you cruise.Chartering your boat. Setting up a workshop. Boat size for cruising and crew requirements.

What a depressing subject budgeting is when you may be just starting to explore the possibilities of your (first or next) cruising boat. Unfortunately the subject of finance will be one of the foremost things you will need to consider. Everything to do with cruising has a price and some form of budget is required at every step from your first planning session through to enjoying your cruise. If you do not have a well planned budget, you are unlikely to have a successful cruise.

DEFINE YOUR CRUISING GOALS

What type of cruising do you have in mind? Occasional weekends and annual holidays; long term or full time cruising? The answer to this question will have a great bearing on your budget requirements. If you are planning the former your biggest expense will be the boat itself, whereas if you are considering long term voyaging your budget considerations will become more complex.

This much traveled Spray is owned by Ron and Joyce Macmillan of New Zealand

Once you have clearly defined your cruising objectives then preparing your budget can take shape. The last thing you will want is to end up with a mountain of debt when you come back ashore. All cruising experiences have a beginning (planning) middle (the cruise which may last for a number of years) and an end (the day you sell your boat and take on a shorebound existence).

LIFE AFTER CRUISING !

You should budget for all aspects of your future lifestyle. Most people ignore the last part of the exercise; they either think they will never return to a shoreside life, or they just ignore the subject altogether. You can plan and budget for all main stages of your cruising adventure including the end, and still not detract from the overall excitement. Choosing the right boat will go a long way towards the planning for the end of the cruise; a well chosen boat capable of holding or enhancing it's value, will help to provide you with a re-establishment fund when you move ashore. This is not to suggest that you necessarily put a limit on the length of your cruising experience; many cruising individuals, partners and couples like Eric and Susan Hiscock, the Pardy's and many other lesser known people, have managed to continue and enjoy a cruising lifestyle for many years. You should be aware that some time in the distant future, you may need to re-establish yourself ashore. Each individual or couple will have limits of one form or another. Lifetime partnerships often start when couples meet in foreign ports, children are born, and other factors may require a change to your plans during a cruise.

APPORTIONING AVAILABLE FUNDS

Now to get down to specifics. Let us assume you have a certain amount of money available and you have caught the cruising bug. As yet you do not have a vessel or perhaps the boat you currently own is unsuitable for the type of cruising you have in mind. For those planning a long distance cruise (as opposed to local weekend cruising) you will need to divide your available funds into at least two, main plus several smaller components. The first sizeable chunk of your budget will be for the acquisition of the boat. You will have several options including having a boat designed and built to your requirements, building your own from a suitable design, buying new, or finding a suitable secondhand craft. It would be difficult to set an accurate budget until you have investigated each of these options.

The second main budgetary consideration for those who plan either to cruise full time or continuously for several months each year, will be the expenses associated with day to day living. Items such as food and clothing, boat maintenance, mooring and haul out fees will have to be allowed for. Add to this, visas and other associated paperwork, which can often be more expensive than expected. There will be the cost of additional gear and equipment such as replacement of lost or worn out items, plus new charts, pilot books and the like.

Fiberglass Spray 40 - Tinimara *built by Jack Danneels in Belguim and sailed throughout Europe*

CRUISING FROM UK AND EUROPE

Cruising full time could involve leaving the UK in September and utilising the trade wind route to make the West Indies for Christmas, cruising in that area until Spring and then returning to the UK, taking about 12 months to accomplish the round trip. Thousands of cruising boats make this type of voyage each year including those who make detours to encompass the Atlantic islands and the Mediterranean. The step of heading into the Pacific takes a bigger commitment, one that you may wish to consider after you have explored areas nearer to home.

CRUISING FROM USA

US east coast based sail boats often restrict their cruising to the beautiful coastline, heading to Maine or down to Florida and the east coast of Mexico or out to the various islands of the Caribbean. For these sailors crossing the Atlantic is the big commitment. US west coast sailors usually cruise up to the San Juan Islands off Washington State and the Canadian Gulf islands and then possibly on to Alaska. Other west coast based boats' head for Mexico and always the big decision is to head out into the Pacific. West coast sailors have the option of an exploratory cruise to Hawaii; if they find long sea passages are not for them then they can simply return to the west coast and the thousands of miles of beautiful cruising.

CRUISING FROM AUSTRALIA

Australian yachtsmen also have many choices; with their huge coastline and the proximity of the Pacific islands, they have plenty of places to explore before taking off on a long cruise. East coast based sailors often head for Lord Howe Island and use this round trip as their shake-down cruise.

CRUISING FROM A FOREIGN PORT

For those committed to long distance and full time cruising and considering the above options, you may prefer to travel by conventional means to your chosen cruising location. You can acquire your boat in the area where you want to commence cruising. At many of these locations you will find boats for sale by people who have not planned their cruise as well as you have! For example if you live in the UK and you have in mind some Pacific cruising, you will find the market for used boats in Australia very much to your liking. The prices in Australian dollars, when converted into sterling, make the boats seem very inexpensive.

The same applies to UK residents with their eyes on the Caribbean; there is a good selection of used boats to be had in the USA especially in Florida. Other good places to look for a suitable boat are those areas which are the first major port of call for cruising boats. These early ports of call include Hawaii, Noumena, Fiji and the Azores, as well as places in and around the Mediterranean such as Gibraltar, Portugal, Spain, Greece and Turkey, where you can often find a bargain. Exchange rates fluctuate and the current value of your currency verses the currency in which you will be required to pay for the boat, may well be a deciding influence in deciding whether to purchase locally or abroad.

BUYING ABROAD

If you are shopping for a boat away from your home territory you will need to be very careful about the ownership rights of the person selling the boat. You would be wise to deal through a local broker with a good reputation; better still would be a broker who has affiliations in your home country. To buy a boat dockside from some unknown owner would be the height of folly as many have discovered to their cost.

This round bilge steel Centennial Spray 36 was built in UK and is now cruising in the Mediterranean

EUROPEAN RESIDENTS

You will also need to explore the VAT minefield. From January 1 1993 when the EU single fiscal area came into being, boats can be transferred and sold freely between residents of EU countries without duty being levied provided that evidence is produced that VAT has been paid on the particular vessel. The best proof of VAT paid status is the ‘green flimsy’ the EU standard document that is issued when VAT is paid on a new boat. For older boats where VAT was paid before the VAT rules were properly documented the next best thing is an original letter form the Customs office stating that in their opinion they are satisfied that VAT has been paid on the vessel. In the UK you should contact your local HM Customs office, where you can obtain up to date information on what is required for you to formalise the VAT paid status on your present vessel on a boat you are interested in purchasing.

A special exemption exists on boats built before January 1985 provided they were in European waters on 31 December 1992 and the owners can prove it, then they are VAT exempt. If the boat was built *after* this then VAT will sooner or later have to be or will already have been paid. Where the boat was located on 31 December 1992 is the deciding factor as to where VAT had to be paid. In my own case the UK built *K*I*S*S* was in Holland on the fateful date and that is where the VAT was paid before I consented to purchase the boat. My current boat was built in Holland in 1991 but was in the UK on the 31 December 1992 so the VAT was paid in the UK. As the green flimsy did not exist for this boat it was necessary for the seller to obtain a letter from the UK Customs that they accepted the proffered evidence that the VAT was paid. This original letter along with previous owners' bills of sale, builders' invoices and SSR certificate now forms part of the 'ship's papers.'

There is a quirk in the VAT laws the rule being that if you purchase a VAT paid boat outside the EU and then bring it back into EU waters then you will have to pay the VAT. If you are considering buying a VAT paid boat that is currently located outside EU waters, make sure it is returned to an EU country and check the VAT status before you make the purchase.

NON EUROPEAN VISITORS

For those USA, Australian, New Zealand and other non European residents who want to cruise the Mediterranean, and perhaps cruise through the French, Dutch and Belgian Canals (highly recommended), the idea of obtaining a boat in Europe has its attractions. For one thing the long ocean crossing can be avoided There is also the possibility of having the boat built in the low cost labour countries of the former Eastern block. The very reasonable building and labour costs of the UK (compared with Germany and certain other EU countries) make acquiring a suitable boat in this area worth serious consideration.

The recently enacted European Recreational Craft Directive (RCD) and the requirement to pay VAT on boats remaining in EU waters for over 6 months, make it a sensible alternative for non EU residents to buy their boat within the EU. Non EU residents who bring their boats into EU waters will need to pay the VAT or limit their stay to less than 6 months. The current rate varies between 15% and 20% depending in which EU country you are located when the tax is due and payable.

Cost saving is not the only reason (although it can be a very good one) for buying your boat abroad. In some cases time restrictions, unwillingness of your partner to undertake long ocean crossings, and numerous other circumstances may make the idea of starting from a distant port an attractive option.

Even the best equipped boat will require many additional items to meet your particular needs. My own Spray 28 *K*I*S*S* was 'well found' when I acquired her. She had been built by an American couple Hal and Dorothy Stufft and equipped for similar cruising to what I had in mind, at least for the following two or three seasons. On reviewing my last two years' expenses for her I note that the equipment added totaled some thousands of pounds. She did come *well* equipped but obviously not *totally* equipped, as my records revealed. The above examples illustrate the need for extra funds to be put aside for unexpected expenses including taxes and additional items of equipment that you may have overlooked but will require for one reason or another.

This brings us to the KISS factor, the initials being an acronym for 'keep it simple sailor' or less politely 'keep it simple stupid'. This saying which I am told originated in the engineering industry, it is well worth remembering when considering all things boating.

BUDGET FOR THE BEST

When budgeting for additional items to complete the fitting out of your cruising boat, always consider buying the best. Perhaps that will be the best you can afford, but nevertheless this should be the best. Most experienced cruising people can relate stories of their own regrets at cutting corners, when purchasing a particular item of boating gear. Naturally you will be looking for the best price; you had better be, or your cruising experience will be shortened due to over extending your budget. If you allow a known price for a particular item and then are able to obtain it at a better price, then you will be able to offset the cost overruns that will certainly occur.

BOAT JUMBLES

In my opinion one of the greatest British marine institutions is the 'Boat Jumble.' This wonderful source of inexpensive, often top quality equipment and boating gear, is unparalleled in most other countries. After attending the *Beaulieu Jumble,* the grand daddy of all boating jumbles, I am sold. Unless you have considerable boating experience, you should attend these Jumbles accompanied by a knowledgeable boating friend. Know what you are looking for and only part with your money if you are absolutely sure of the suitability of the item for your boat. Make sure you are confident of the quality and you should have checked the best prices available from more conventional sources. Assure yourself that the item was legally obtained by the vendor! When it comes to price, haggle like your life depended on it. Under no circumstances buy something 'that you think may come in handy', but for which you have no specific need; most boat owners homes and boats have a collection of such items; the smart ones sell them at the next available Jumble.

Spray 28 **KISS** *built by Hal Stufft in UK, sold to the author and currently owned by Ian Crosfield and shown here in the 'round lock' on the Canal du Midi.* **KISS** *has cruised extensively in Europe and Scandinavia .*

REPLENISHING THE COFFERS

So far we have only discussed the budgetary outgoings; many of you will have plans for replenishing your coffers during your cruising. If you are planning weekend and annual holiday cruises only then you will most likely have a regular shore-side income and the next few paragraphs may not apply to you.

For those of you who are planning to retire or take an extended break from your normal employment; you should consider how you can replenish your coffers as you cruise. Consider your skills and those of your partner. Do either or both of you have skills that can be utilised for earning extra income during your cruise?

One of the more obvious earners is chartering; although this is so obvious as to be over worked when it comes to expectations, it is surprising just how many cruising people make a success of *part time* charter. If you have the right boat and perhaps just as importantly, the right disposition to deal with charter parties or individuals, this possible money earner is worth your consideration. Referring to *part time* charter; this can mean a couple of weeks per year for some expense sharing friends or several short charters by strangers who come recommended to you in one way or another. Unless you are running a full time professional charter operation, you should choose carefully when deciding who will spend time as a paying guest aboard your boat.

EARN WHILE YOU CRUISE

Consider you and your partners personal skills. Again the obvious ones include boatbuilding experience in any material. You may have obtained your boatbuilding experience by building and or fitting out your own boat. This is a factor worth considering when you are deciding how you will acquire your boat. The actual building and fitting out of a reasonable sized cruising boat will certainly add to your marketable skills. Most useful when you are cruising.

Most tradesman have marketable skills, welders, metal workers, carpenters, plumbers and electricians will find part time employment not only ashore but among their less handy cruising contemporaries. If you have some experience with the maintenance and repair of electronic equipment you will be *very* much in demand.

Dentists, Doctors Chiropractors and other professionals can often earn worthwhile fees both ashore and among the cruising population. Some licensing requirements may interfere with your activities ashore but it is worth investigating in advance where you can legally practice. You may be able to obtain a license in those areas you plan to visit. Language skills can be turned into cash as can secretarial experience. Computer literacy is a definite skill and one that will always find a ready market. Writing articles and perhaps a book on your experiences is another possibility; be aware that these latter activities are in a crowded market and are not that well paid.

USING YOUR BOAT TO GENERATE INCOME

In the planning stage is when you should decide if the boat itself will play a part in earning income as you cruise. The prospect of chartering may cause you to select a certain type of layout to allow some separation between the hosts and guests. If you are planning to earn income from a trade or profession then you may wish to include a workshop or work space in the accommodation layout. You will have your own ideas of how important the work space is to your future cruising needs. Do not become carried away with this element; you will be advised to make the work area fit the boat rather than choose the boat to fit the work area!
What is all this talk of working when you are cruising? You may be fortunate enough to have a

reliable income to cover your costs. Perhaps you can lease out your house while you are away, you may even acquire a property with that eventual purpose in mind.

It is a wise cruising person who covers many sheets of paper with figures before starting to look for a suitable vessel. After you have what looks like a workable budget you can start to consider acquiring a suitable boat to be your cruising home for the future weeks, months or perhaps years ahead.

'HOW BIG', USUALLY REFERRED TO AS 'HOW LONG' ?

BIG ! This Spray 58 is a big boat and should only be considered if you are planning to charter or have some other commercial use for such a large boat. The first Spray 58 was built for a commercial fisherman who is operating in Alaska; this large Spray has proved most successful in this case.

Over the years my office has dealt with literally hundreds of thousands of enquiries from those who intend taking up the cruising lifestyle. One of the most asked questions is how big a boat should I choose. Our reply is always the same, *'choose the smallest boat that will satisfy your current requirements.'* Will your children want to accompany you when they are past the early teenage years? Do not expect to have a continual stream of friends and relatives who are clamoring to join you for various sections of your voyage. Unless you are very wealthy do not choose a size of boat that will require a crew to assist you in handling the vessel. As for the upper size range; well set up cruising Sail boats up to 55 ft (16.75 m) can be handled by a two person crew; this includes a husband and wife combination. How small is too small; one Canadian couple built and sailed a Roberts designed 18 ft (5.48 m) trailer sailer from Montreal to Australia; they even took their cat along. Please do not take this later example as a recommendation.

GUNKHOLING

This term will mean different things to different people. When I think of gunkholing it brings to mind lazy sailing and exploring in protected bays and estuaries and rivers. For this type of sailing your cruising boat can be as small as you wish; a considerable amount of this type of activity is undertaken in open boats. When it is time to anchor at night, a boom cover often serves as a shelter. Portable gas or primus stove and a bucket may be all of the ‘appliances’ carried on this cruising boat.

The right boat and an inquisitive mind are two important qualifications when considering gunkholing. Shallow draft is a major benefit when considering this type of cruising. Once the water gets really thin you will no longer be able to rely on your depth sounder so you will literally have to feel you way in many of these areas. Detailed charts of the area you are exploring are essential, if none are available then it may be fun to make your own thus enhancing the enjoyment of the current trip plus adding to the enjoyment of future visitors to the area.

Nature watching is one of the many attractions of gunkholes. You may also find unusual man made oddities; follies, abandoned fishing and other commercial operations, historical relics and occasionally a human eccentric. On reflection I can claim to have encountered all of the above and they all bring back pleasant memories.

TRAILER SAILING

The size of your trailer sailer will be restricted by the width limits placed on road vehicles by the authorities in various countries or individual states. In general the width limit is 8 ft (2.43 m) however in some places it is a little more generous but usually never exceeding 9 ft (2.74 m) without special permits. As far as the length is concerned, a boat with 8 ft (2.43 m) beam should not exceed 28 ft (8.53 m) in overall length. Before you restrict yourself to the local legal trailer width, you may want to consider just how often you really intend to move the boat by road. Many people find it is easier to leave their ‘trailer sailer’ in the water all season and just bring it home for winter storage; if this is your situation then it may be more useful to exceed

The Spray 22 - Fiberglass version was built in Brisbane and makes a fine pocket sized cruiser that you can tow to your favorite cruising area. The slightly longer Spray 27 can also be trailed.

the trailerable width limit by owning what is a ‘Pocket cruiser’ and obtain a permit to move the boat to and from the water twice a year.

If you intend to use your boat as a true cruising trailer sailer then you will need to check width limits and other requirements for the areas where you operate the boat. In the EU (European Union) these regulations are being harmonised so that you can trail your boat across borders using one set of rules. This agreement will make trailer sailing much more attractive; you can take your boat from the UK by ferry and trail it anywhere in Europe (using it as a camper or caravan along the way) and commence your cruising from some desirable location. You could even leave your boat and trailer safely tucked up in a boat yard ready for the following season. If you can not afford a large boat at this time or if you prefer some of the benefits of owning a smaller vessel including lower initial investment and less maintenance**,** then a trailer sailer or pocket cruiser may suit you best.

ACQUISITION CHOICES

In this area your choices lie between buying new, having a boat custom built, purchasing second hand or building from a hull and deck package or perhaps from plans and patterns. These choices are all effected by your particular requirements. You and your partners present age, financial situation, family considerations and perhaps the desire to get on with it, can influence your choice in this matter. Many people who will be retiring in a few years plan well ahead and have all the above options available. Those with foresight can have the boat ready for their retirement and enjoy uninterrupted cruising.

BUYING NEW

Buying new is an obvious option. If you buy a new stock boat, you will find that it will most likely need some modifications and a considerable amount of extra equipment before you are ready to start any serious cruising. New boats bought *off the shelf* are usually the least equipped of all; you will need a hefty budget allowance to outfit your new acquisition. You will have the gratification of instant ownership (very important to *Now* people) and of course if you choose well, your new boat and its existing equipment should serve you for several years. You should be able to avoid the large expenses of the replacement of major items such as mast(s), rigging, sails, engine and the other equipment that either comes with, or is added to the boat soon after the initial purchase.

CUSTOM BUILDING

Custom building is an exciting way to acquire your cruising boat. This term usually refers to having the boat built and/or mostly completed by a professional builder. For those with some boating experience and a patient disposition, this can be the best way of obtaining the cruising boat of your dreams. You will have the opportunity of being involved from conception to completion of you boat. Many of you may not have the time or the inclination to become so intensely involved, however it is a worthwhile exercise if you can arrange it.

If you can manage the project yourself there are considerable savings to be made. With some planning you can end up with a beautiful custom cruising boat for less than the cost of an *off the shelf* equivalent. You can choose an existing design or have a designer prepare custom plans and patterns. If you are able to source your own engine, mast, rigging, sails, deck hardware, engine and interior fittings, you can save many thousands off the cost of the finished boat. Any large chandler or marine hardware store will offer worthwhile discounts in return for the size of order that you will have at your disposal. It may even be worthwhile setting yourself up as a ‘boatbuilding enterprise’, this will give you access to trade Many of the cruising boats you will see in far off and exotic locations were completed from a ‘hull and deck kit.’.

BUYING A PRE-OWNED BOAT
Buying used is another option but the purchase of a second hand boat can be fraught with traps for the unwary. The term *buyer beware* is never more apt than with buying a used boat. If you are able to deal direct with the owner you may avoid some of the pit falls associated with this type of purchase. There are many honest and trustworthy yacht brokers and boat salesmen handling used boats, however there are also many who have received their sales training selling used cars and the like. You must make sure you are absolutely satisfied BEFORE you hand over your money. ALWAYS hire a qualified surveyor to check out your boat purchase before you part with *any substantial* amounts of cash.

In the USA boats are often documented which is a similar arrangement to the UK Part 1 Register. In the UK Part 1 certificate will be a good way start to proving ownership; make sure you call the Registrar Generals office in Cardiff to check that the document is current. The certificate issued by the Small Ships Register is not a proof of ownership but it will be a start. Another way to check ownership is to contact the yachts insurers and, the harbour master where the boat is kept.

BE SURE OF YOUR TITLE
It is well to remember that at least in the UK, if you buy a boat from a person who does not have legal title to the vessel and it is later reclaimed by its lawful owner, you will most likely be out of pocket and lose your boat and your money. The boat you are considering buying may be subject to a hire purchase agreement, it may form part of a legal dispute or there may be some other impediment in the title. Make sure you carefully check builders certificates, bills or sale and any other documentation that is offered to prove the current ownership.

SURVEYS ARE A MUST
You will often have to pay for the boat to be hauled out before it is in a position to allow for a full survey. To cut your potential costs, why not conduct a very detailed inspection of the interior, galley equipment, pumps, heating, batteries as well as mast(s), rigging, sails, dinghy and electronic equipment before you commit yourself to a full survey. Do not be rushed, do not be afraid of being a nuisance, take your time. If you have trusted and knowledgeable friends who have a *proven* knowledge of things boating, ask their help and advice at this early stage. Do not ignore advice because you have fallen in love with the boat. Assemble your facts and on no account part with your cash before you are in possession of all the information as to the boats condition.

CHAPTER 19. Spray 22 -Trailerable

Plans and frame patterns available for building the Spray 22 in round bilge fiberglass, multi chine steel or multi chine plywood.

In the late 1970s a customer approached our design office wanting to build a miniature version of the Spray, and asking we felt the boat could be built while still retaining most of the Spray's favourable characteristics. He wanted to build the boat in a garage, and had a limited period in which to build it. He made a deal with his wife: if he could build the hull during the summer and get it out of the garage before the first snow fall, he could use that space. She wanted her garage back come the winter, so he had to be sure that not only would the boat fit, but also that it would be built quickly enough to get it out in time!

Initially, plans were drawn up for fiberglass construction. However, some additional calculations revealed that provided the decks and superstructure were kept light, it would be possible to build the hull from steel. It was decided to include a steel version with the plans. Since that time, many Spray 22s have been built. This boat is easily trailerable and numerous examples have been cruised extensively around the coastal waters of various countries.

Pillsbury Spray

Harold Pillsbury of North Ridge, California, has built his Spray using the wood epoxy technique, and is planning to trail his boat across the USA from California to the east coast, and commence his cruising where there are cruising grounds ideally suited to the Spray 22. There are plenty of sheltered anchorages and islands to explore.

Ivey Spray

Some time ago, we heard from James Ivey of Oakley, Michigan, USA who said:

> 'I would like to be able to discuss the sailing ability of my Spray 24, but unfortunately the boat is still not finished. I built my Spray from your 22ft [6.7m] plans, which I stretched to 24ft [7.3m] LOD, by increasing the station spacing as you suggested, altering the bow a little, and adding 3in [75mm] to the freeboard.
>
> I added about 200 lb [91 kg] to the ballast, which consists of scrap lead, steel and steel punchings, solidified with polyester resin 'bog'. I also made some interior changes, including adding a head. I kept the mast support in the position on the 22ft [6.7m] plan, my reasoning being that I thought it might work well for a cutter rig. Maybe I should have consulted you on this. I feel it came together nicely. The mould was not difficult to construct, and the sheathing went better than I had anticipated.
>
> To cut the metal, I found - after trying a disc saw and an acetylene torch, that I could simply take the templates to a local metal fabricating shop where I was purchasing the steel, trace the template on the sheet, and have it cut out on large nibbler shears. If I was careful to trace with the template the proper side up, the slight stretch the nibbler produced would work to my favour, causing the panel almost to follow the contours of the hull. After tacking the hull together at 3in [75mm] intervals, I opted to weld it with MIG welder to keep the heat to a minimum, resulting in what I feel is a very fair hull without the need for fillers.

After grinding the weld smooth, I had the hull blasted to white metal and primed with Pettits Rustlok. I think if I were doing it again, I might opt to right the hull and then complete the welding inside before blasting and priming the outside, as the inside welding tended to affect the outside priming. I have enjoyed working on the project and have received many favourable comments from people who have seen it.'

Joshua Slocum

Joshua Slocum is one of the moulded Spray 22 hulls that were produced at Marine Park, Gumdale, Brisbane. This was in fact the first, so we were most interested to see how the boat would perform. Fortunately, Andrew Slorach took the boat out and gave it a good trial then sent us this report:

'It has been a long time coming! I am sure every builder knows the feeling. After months of slaving away on my Roberts Spray 22 fiberglass boat, the day had finally arrived; it was time for the sea trials.
My project started when I asked Bruce Roberts to prepare plans for a fiberglass version of the Spray 22. I was already familiar with the basic design as I had some experience with the steel and plywood versions of the same boat. I wanted a round- bilge version, and the best way to go was to build in fiberglass.

After careful consideration of all the available fiberglass building methods, I decided to build a foam sandwich hull with the hope of using this as a plug to build a female mould. Further conversation with Bruce Roberts seemed to suggest that there would be a market for this boat in Australia.

The building of the sandwich hull proceeded without any unforeseen hitches, and the plywood plug for the deck and cabin structure was built using the details from the plywood plan as a guide. Some minor changes were necessary in the area of the deck and cabin, for this was to be a plug and the mould would later have to release smoothly from the structure. No room for reverse outward leaning shapes here. A little extra time spent in planning the deck plug - paid off handsomely when the mould later released without a hitch.

The moulding of the first hull and deck went smoothly; the fitting out of the interior was accomplished quickly with the help of Peter McCoy, my long-time boatbuilding friend. Now here I was just a step away from the launching and sailing trials, but no, not so fast. Bruce Roberts suggested, that I show the boat at the Brisbane Boat Show. Indeed, why not?

The boat show exhibit went well. The comments on the boat, its overall finish and the roominess of the interior all combined to give Andrew a most successful boat show, resulting in two firm orders and many serious prospects.

A few days after the show finished Andrew was able to get the time to schedule the sailing trials. The season had now started of the strong south-Easters, which start at 15 knots and quickly go through the 25 knot range, so that Andrew's chances of getting a medium day of say 12 to 15 knots seemed unlikely.

He prefers to give boats their first trials in medium wind strengths, for there are always some things, no matter how small, that will go wrong. It is much better to have the time to deal with these small problems without half a gale of wind. No matter, it was time to get on with the trials.

Andrew was anxious to see how the Roberts Spray 22 would handle as a single-handed boat. Most of his sailing is done either alone or with his wife as crew, and generally he likes to handle the boat on his own. He invited Peter McCoy along to do the actual sailing, for that would give him the opportunity to study objectively the boat's handling in the conditions they expected to experience during this first sail.

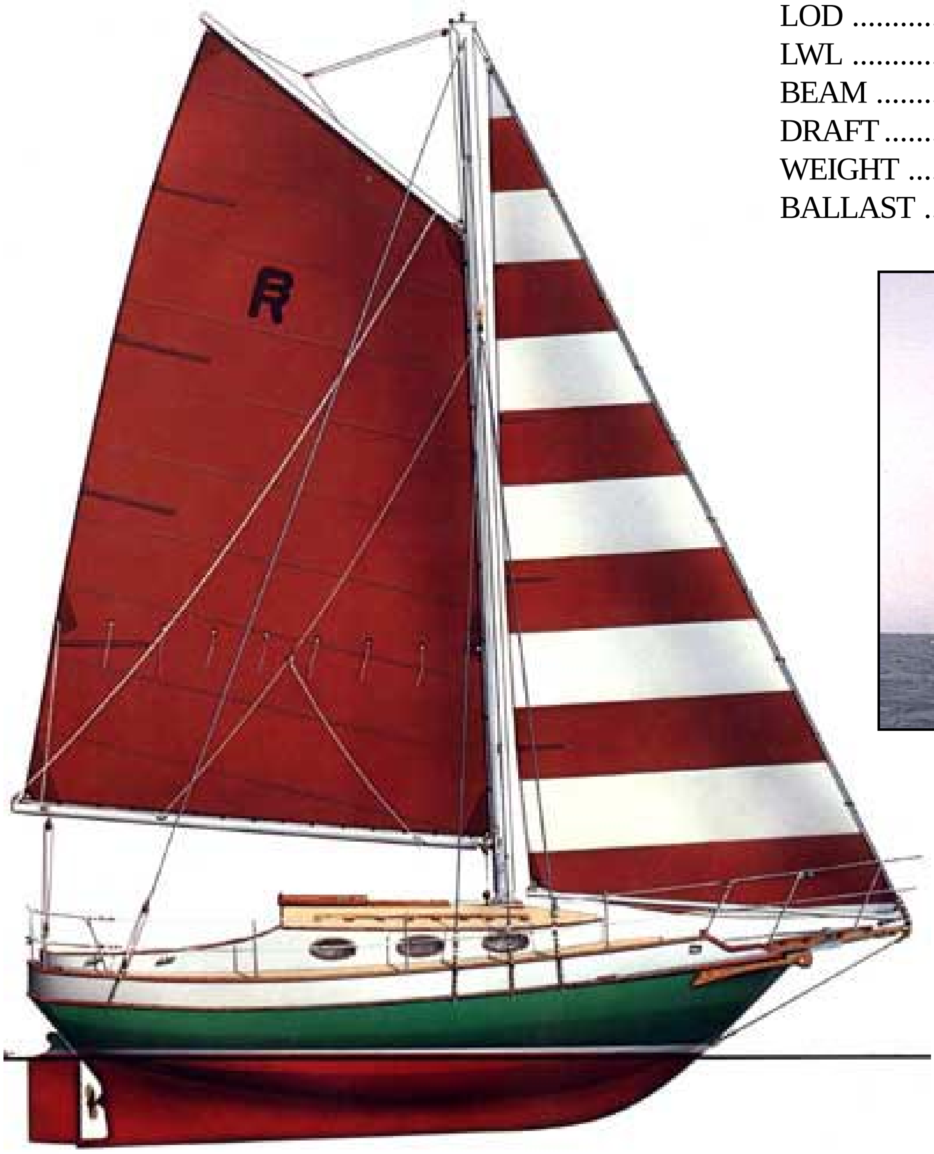
Andrew wrote:

'Well, we got our 25 knots all right, and then some. The day started off with the southeaster blowing at a steady 10 knots. At this wind speed, the Spray 22 carried her full gaff mainsail with ease - a great feeling as she sliced through the short chop.

Soon the wind piped up to 15 knots. We put the Spray through her paces, full sail was still carried and we tacked, and brought her hard on the wind. She sailed closer to the breeze than I had hoped. I guess the proportionally deeper keel was doing its job. OK, so far so good. The boat was most satisfactory upwind, and as I had some experience with the Roberts Spray 33 this did not come as a total surprise. I expected at least creditable upwind performance. By now, the wind had increased to 25 knots and it was time to take in a reef. With the jiffy reefing set-up we have, reefing the gaff mainsail could be handled by one person, again a nice thought for my single handing in the future. Sailing downwind and reaching were something of an anticlimax. Almost anything will perform well on these points of sailing. The Spray scooted along, feeling comfortable and secure at all times.

It is certainly a boat for the whole family to enjoy and a boat I will be most happy to single-hand at any time. For those who prefer it, a Bermudan sail plan is now available, which will appeal to those who want the simplest of rigs.

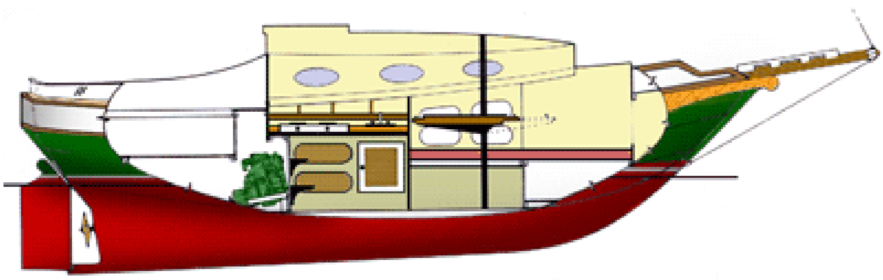
LOD .... 21'-4" 6.50 M
LWL .... 16'-11' 7.32 M
BEAM .... 7'-10 1/2" 2.39 M
DRAFT .... 2'-6" 0.76 M
WEIGHT .... 2,219 LB 1,007 Kg
BALLAST .... 700 LB 317 Kg

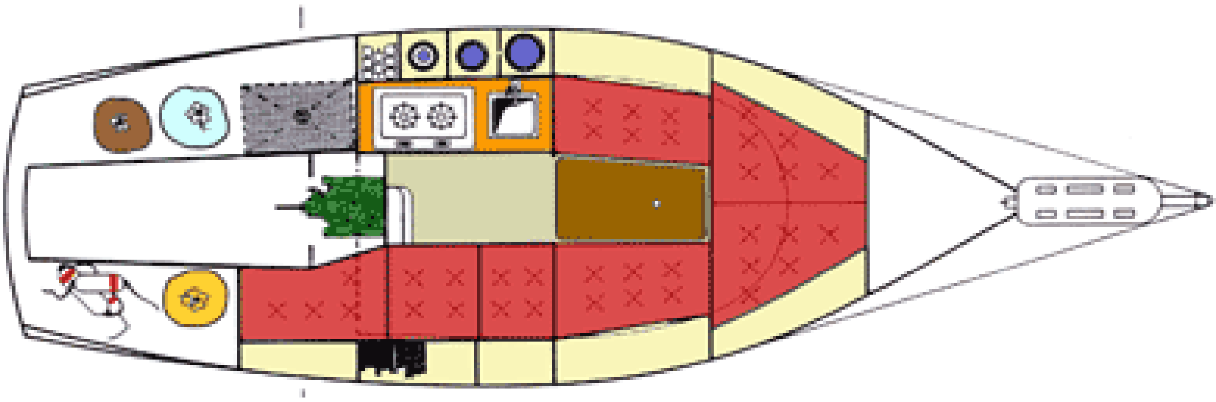


The Spray 22 has been built in Steel, Fiberglass and Wood/Epoxy Over 500 examples have been completed at this time. The rig options include Gaff or Bermudian sloop and the boat sails well with either rig. Junk rig is also available.

One advantage of this mini Spray is that is can be built in the garage and the hull can be assembled over one Summer thus liberating that area before winter sets in.

The many owners of this design who have contacted us over the past years have been most enthusiastic about the boat and its handling and performance.



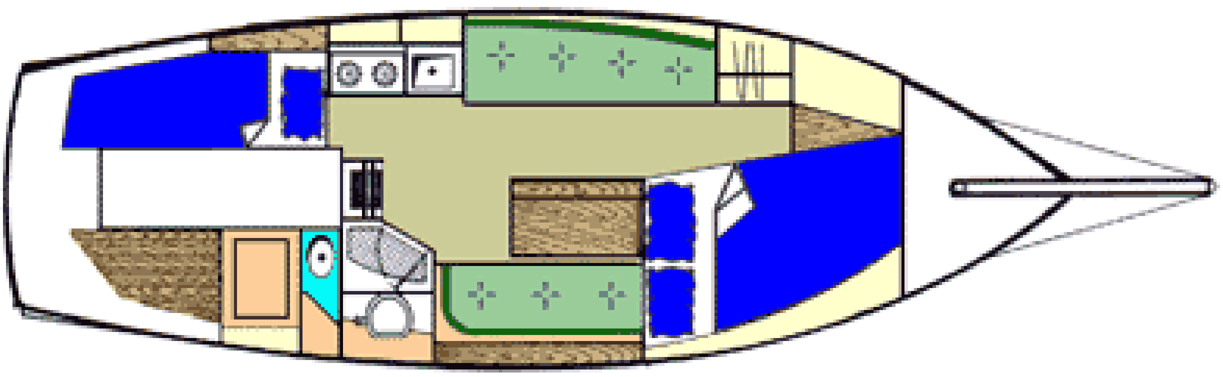


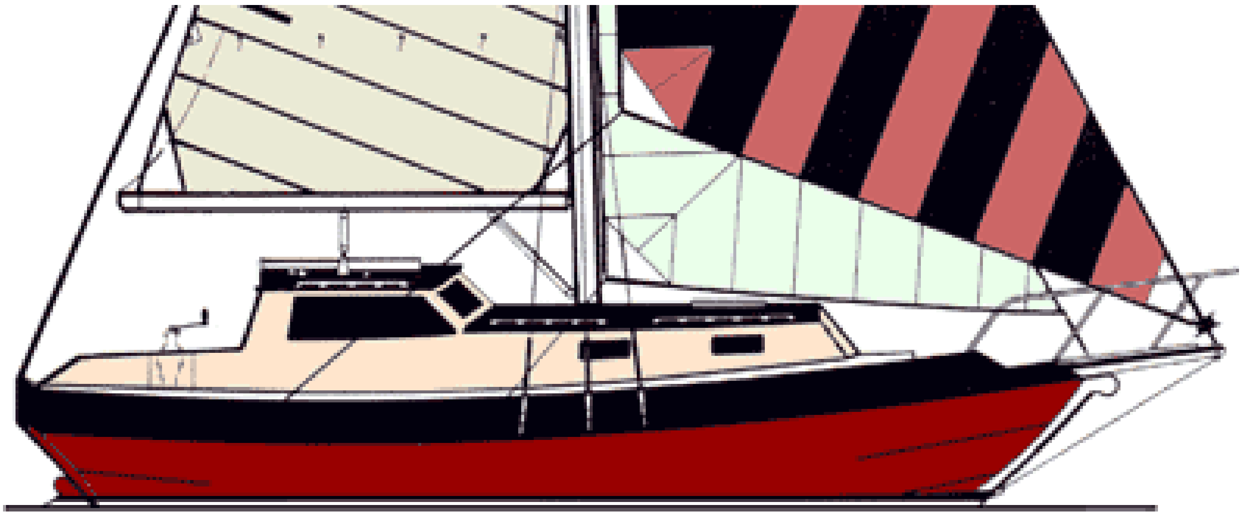
Spray 27 - Trailerable

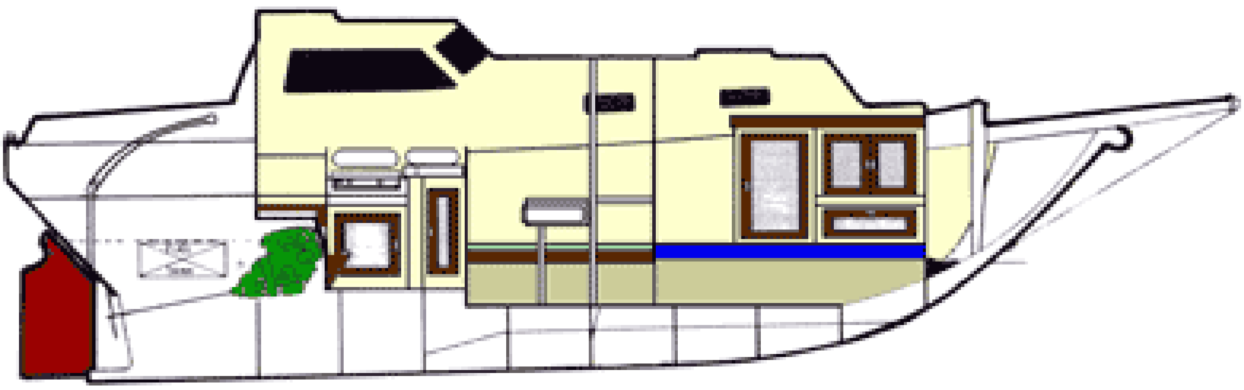
Plans and frame patterns available for building the Spray 27 in round bilge fiberglass, multi chine steel or multi chine plywood.

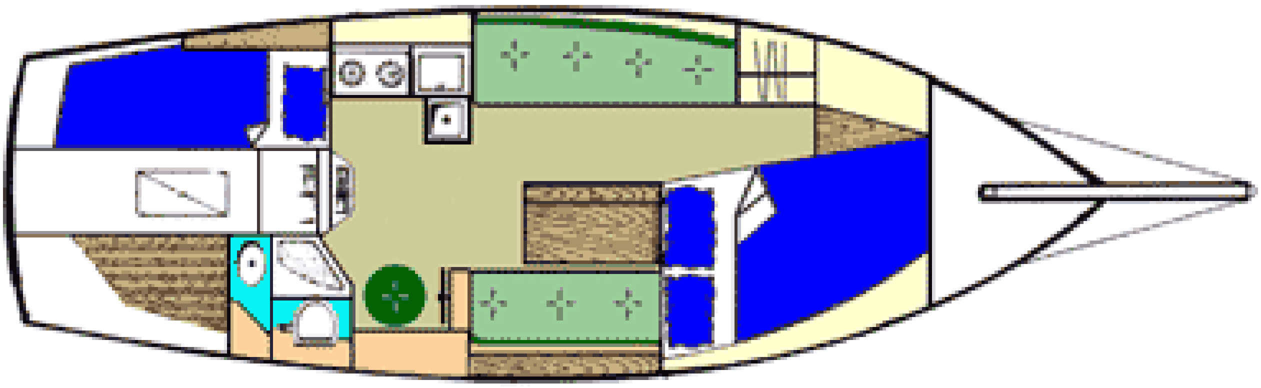
LOD .... 27’-0” 8.23 M
LWL .... 21’-6” 6.55 M
BEAM .... 8’-6” 2.59 M
DRAFT .... 2’-9” 0.84 M
DISPL. .... 4,885 LB 2,216 Kg
BALST .... 1,465 LB 665 Kg
AUX PWR .... 10 HP
FIBERGLASS, STEEL OR W/E

We designed the Spray 27 after many builders had requested a longer trailerable version of the Spray 22. Some builders made the change themselves and then came back to us for amended sailplans etc. By now the plans for the Spray 27 have been available for several years and over 300 of these boats have been built in Steel, Fiberglass and Wood/Epoxy. The trailer weight will vary depending on the material you choose to build this boat but the average weight would be around 3,250 lbs / 1,474 Kg.









Some years ago the builder of a Spray 27 who was adept at graphics sent us this representatioln of his own Spray 27.

SPRAY 27
TRAILERABLE

Malwine

This boat was built for Volker Wesenverg in Germany, and I quote from his letter:

In 1990 I ordered from you, plans for the Spray 27 in wood epoxy. Due to lack of time and building site I contracted out the hull and rig to a small East German shipyard. Fittings and equipment were built by myself. The rig was transformed into a gaff cutter and glued at the shipyard. The gaff remains underneath of the spreader. Both port berth and starboard seating bench in the saloon were increased in the width at expense of the foot space.

MS Voncille *Mr A J Culp of Santa Maria, California, provided the following information:*

> *'I received my Spray 27 plans at Christmas 1985 and immediately went to work building her in the backyard. Her name is* MS Voncille *and I launched her on my 65 th birthday, 12 January 1989. Her construction is all steel and I eliminated the cockpit and enlarged the pilot house and put two fishing chairs on the poop deck. I rigged her as a two-masted schooner to keep the mast short, so I can go under all bridges in Seattle without waiting for them to open. With hot and cold water, refrigeration, Loran, autopilot, inside and outside steering, electric anchor windlass, etc, she is the best-equipped boat I have ever owned.* MS Voncille *has cruised the west coast from Los Angeles to Friday Harbour in the San Juan Islands of Washington State. I usually sail singlehanded, since my wife's eye doctor told her to stay away from the ocean. I do a lot of powering up and down the coast, so the 20 hp Vetus diesel was really a wise investment. I enjoyed building the boat and have enjoyed sailing her.*

Mathematically minded readers will easily work out that by now Mr Culp is 70 years of age, so one is never too old to take up cruising providing you have 'the right boat' and enjoy good health.

Greetings, Bruce. My name is Igor. I - the Russian architect. Excuse for the bad text. It - electronic translation. I live in Siberia near to beautiful big lake Baikal. All life I am engaged in sports travel. Still I very much love yachts. Earlier I had small plastic yacht in length of 5.5 m. I very much wanted to construct the boat. 4 years ago I have found on the Internet the description of yours *Spray-27*. It was that that is necessary. You have sent me drawings by mail. I have a little changed the project. 2 years proceeded construction. The hull - metal, a cabin - wooden.
Weight of a boat of-3850 kg. Cost of construction - 30000 $. I have named her *Mobi Dick*. In August 2006 I and my wife of 2 weeks travelled across Baikal.
On travel the boat has very much liked me. She is reliable. It is not overloaded with sails. Allows to operate to one. Long Kiel it super. She goes against a wind! Many familiar have become interested in this project and now 3 more hulls are in work. Now, I want to do internal furnish and internal management. I want to thank you for the successful project. I have one request. Please, send me addresses of other owners and builders *Spray-27*. The best regards!
Igor V.Logvanov.


МОБИ ДИК

Copeland Spray -

Jack C Copeland of Defiance, Ohio, USA has almost completed his Spray 27. He wrote: 'I am building the decks, cabin and cockpit from aluminium which is 3/16/5086 marine grade. The superstructure inside is 6061-T6 1in x 2in x 1/8in [25mm x 50mm x 3mm] channel. The engine is a 20 hp Perkins diesel. I have built all the railings and fittings from 316 stainless steel; also, the rudder is made from stainless, with Teflon bearings to insulate it from the steel. The connection between deck and hull will have a gasket with neoprene sleeves to insulate it from the hull.

Pizza Spray

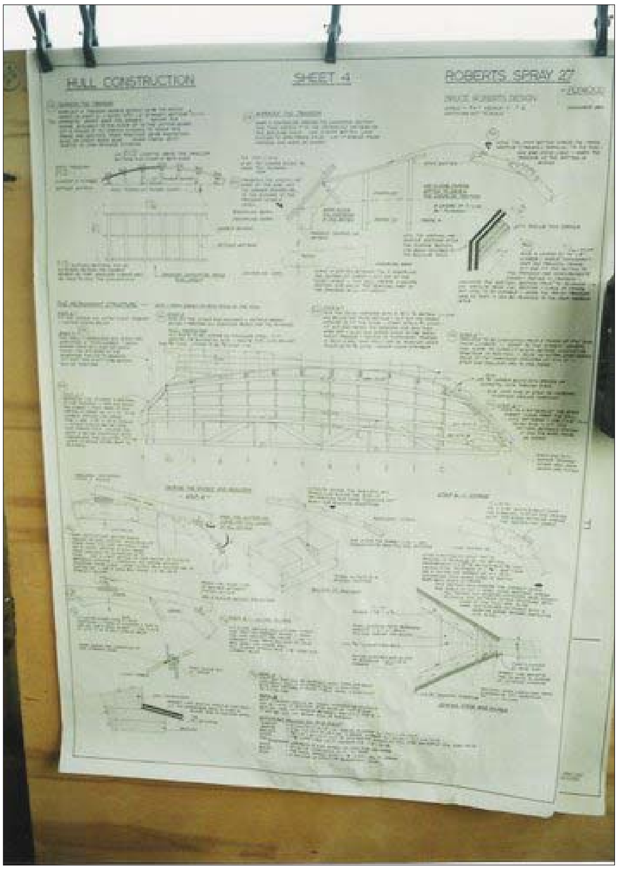
Sam Tasto, an American of Italian descent who is really something of a character, built this boat. He brought a photo to my office and explained that he had fitted her out as a mobile pizza parlour, because he was making pizzas on the boat and delivering them to all the yachts in his area. It seems that he had built up a good business, for he was considering building a larger boat. Quite a character, and quite a boat!

Above: Pizza Spray - *One of the most unusual Spray 27's ever built.*

Below: A steel Spray 27 shown heading dow the St Mary's River making for the Chesapeake Bay

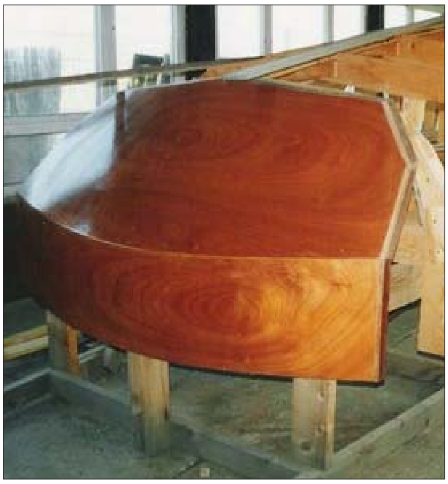
SPRAY 27 - WOOD EPOXY

The following sequence of photographs shows the building of a Spray 27 hull in wood epoxy by Dietmar in Ehrenhof.

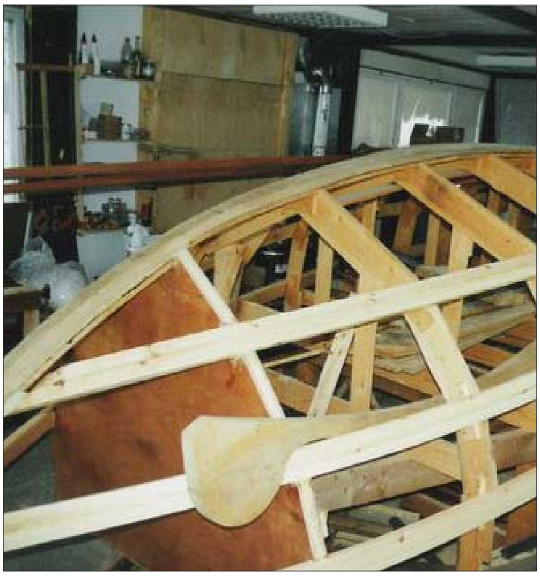


ABOVE:
Make sure to have the relevent plan sheets handy and well displayed. One advantage of receiving your plans on CD is that you can have sheets re-printed if they become damaged or too faint to read properly.

ABOVE and LEFT:
The frames and stem are assembled as per the full siz\e patterns and plans and then the frames and stem are installed on the strongback that has be pre-built again following the information on the plan.



THIS PAGE: *The frames are installed on the strongback and the transom has been pre-laminated and installed. Note that the chine log may need to be formed out of more than one length of timber laminated to form the correct thickness and or width; hence the large number of clamps required until the adhesive sets up properly.*




THIS PAGE:
Here we see some more details of setting up the framework and the steps required to fit and install the plywood planking. Again note that many clamps are required to ensure a good bond between the various components that go into the final hull structure.



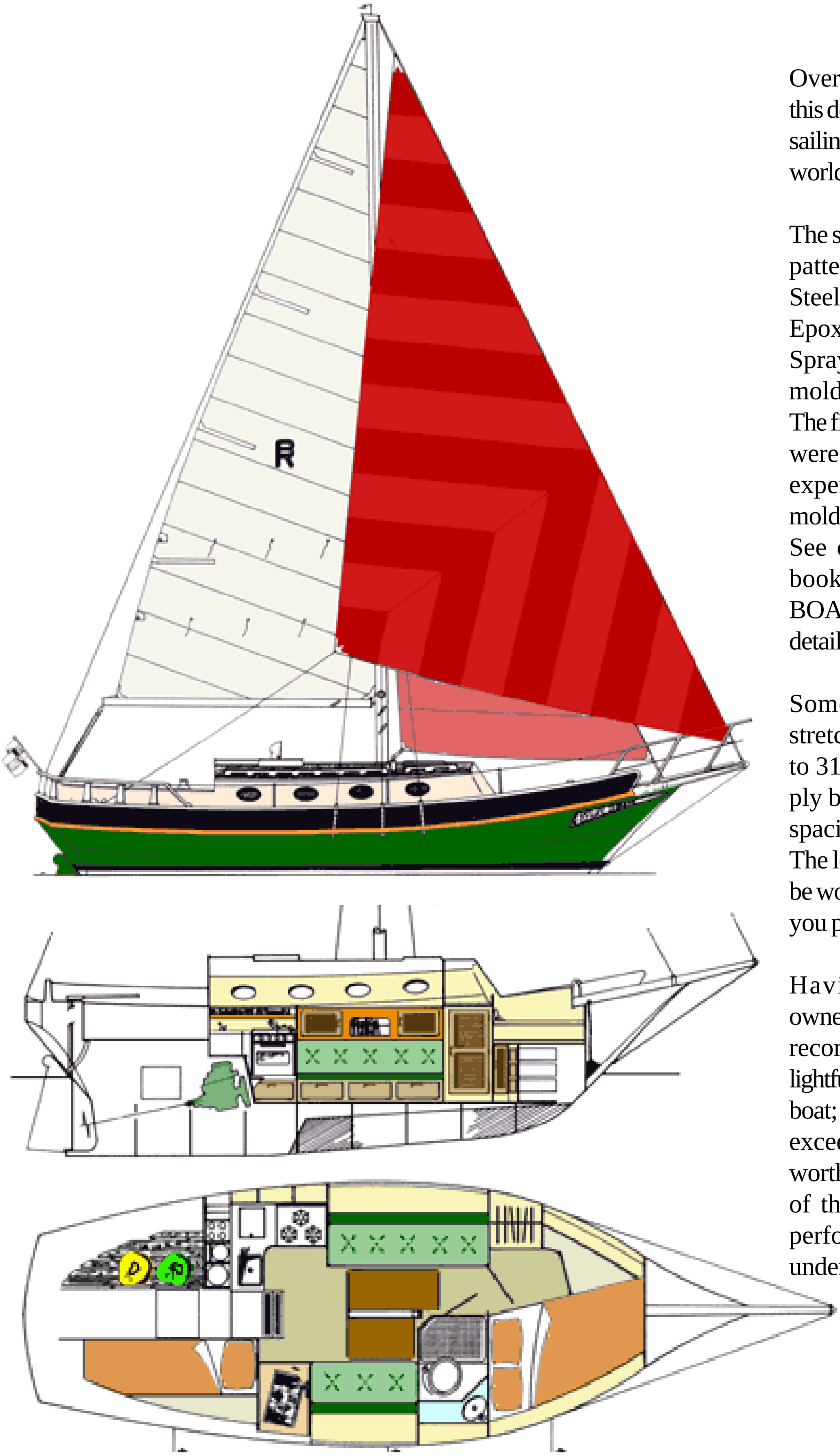






19/3/2008

SPRAY 28 - M/C STEEL. WOOD/ EPOXY



Over 500 examples of this design are currently sailing in all parts of the world.

The standard plans and patterns are for M/C Steel and M/C Wood/ Epoxy however many Spray 28s have been molded in fiberglass. The fiberglasss versions were built using an inexpensive hardboard mold to lay up the hull. See our forthcoming book FIBERGLASS BOATBUILDING for details.

Some builders have stretched this boat out to 31 ft / 9.44 M simply by increasing the spacing of the frames. The longer version can be worth considering if you plan a pilot house.

Having personally owned a Spray 28 I can recommend it as a delightful small family sailboat; it sails and motors exceedingly well. It is worth noting that ALL of the Spray designs perform equally well under sail or power.

The Spray 28 design was drawn when a client wanted to build a Spray, but found the Spray 33 too large for his needs. This a common story where prospective builders and/or owners want a boat, but the size available just doesn't suit them for one reason or another. Either it is too big, too small, too wide, too deep, too expensive, or too something. Consequently, we have tried to oblige by redesigning the Spray to various sizes and materials. In the case of the Spray 28, we originally designed this for steel construction and that has proved quite popular. However, the boat has now been built in fiberglass, as well as by using wood/epoxy construction technique. The wood/epoxy plans feature multi-chine hull, and virtually the same plans as for the steel or aluminum version. These same plans and patterns were used to build an inexpensive Masonite mould in which several fiberglass hulls have been constructed.

Spray 28 dimensions:

LOD	28ft 0in [8.53m]
LWL	22ft 11in [7.01m]
Beam	10ft 6in [3.20m]
Draft	3ft 6in [1.07m]
Headroom	6ft.4in [1.93m]
Displacement	13600lb [6169kg]
Ballast	Varies
Spars	Timber or aluminum
Auxiliary	20 to 33hp
Sail area	Varies
Sail plans	Sloop or cutter
Materials	Steel or Wood/Epoxy

K*I*S*S

This Spray 28 is fitted with an attractive pilot house, adapted by the original owner from another Roberts design. This vessel was built by Roger Apperley of Watercraft in Diglis Worcester, England. Roger has built several steel Sprays, including many Spray 28s, 38s, 33s and 40s. *K*I*S*S* was built for Hal and Dorothy Stufft of Imler, Pennsylvania, USA. They

K*I*S*S *shown in the 'Round Lock' on the Canal du Midi on her way out to the Mediterranean - Owner Ian Crosfield.*

purchased their plans from our US office and then, having heard of Roger Apperley's building skills, decided to have the boat built in the UK.

The hull was completed in 1987 by Watercraft, then the owner finished the interior and launched the boat in June 1989. This is a rugged go-anywhere vessel and, according to her owner, has been much complimented wherever she has been. when we saw her she was in Holland, having already cruised the River Seine and the canal system in France, as well as offshore trips to Ireland, Scotland, the Mediterranean and Scandinavia. When we discovered *K*I*S*S* was for sale we couldn't resist buying her for ourselves.

Although *K*I*S*S* has covered a wide area and visited many countries, much of her cruising has been on the inland waterways. The Spray is an ideal vessel for cruising the canals of Holland, France and Germany, as well as the canal that transits Sweden. Her shallow draft and generous accommodation make living aboard and cruising these areas a pleasure, and by the time this book is published we hope to have transited the Dutch, Belgian and French canals in her, ready for Mediterranean cruising. *K*I*S*S* is well fitted out and mahogany timber is featured in much of the joinery. The head is Formica lined with a custom fiberglass floor moulding and a shower, with additional storage behind the head. The pilot house seats four to five people and converts to a single or double berth. To sum up *K*I*S*S'*s qualities, she is a rugged, go-anywhere boat.

KILIFI
This is another Roger Apperley-built steel Spray 28. However, Roger stretched this boat to 31ft [9.45m]. Ian and Jenny Gorham wanted a boat a little bigger than the Spray 28, but not as big as the Spray 33. Often the beam is a governing factor. Some people may want a boat that is a little longer, but want to retain the same beam for a variety of reasons; that was exactly the case with the Gorhams.

The *Kilia* is currently in Spain, having been cruised from the UK to the Mediterranean and the Gorman's have had many pleasant months cruising around that area.

Spray
This particular Spray 28 was seen at Britton Ferry in South Wales, UK. The boat was built by Roger Apperley of Watercraft, and is fitted with bilge keels. The fitting of bilge keels is quite popular in the UK, as the tidal nature of many of the rivers and estuaries means that many vessels dry out in various harbours. The rise and fall of the tide is usually such that it is necessary to have some method of keeping the boat upright. Some boats bury themselves in the mud, and for a boat with a deep keel this can become quite a problem.

Although the basic part of the canoe body will make itself a nice easy impression, the keel tends to get sucked down in the mud -and this can be a nuisance if you are trying to get in or out of your berth at half tide. The Spray with her shoal draft makes an ideal boat for these conditions. However, some owners still find it advantageous to fit small bilge keels, which are usually just plates that keep the boat totally upright under all circumstances. Several owners have found the bilge plates unnecessary and, after removing these appendages, their boat speed has increased by 12 knots.

HARCLA
This is a multi chine-fiberglass Spray 28 that was moulded by Humber Boats in England. Sir Christopher Musgrave wrote to us as follows:

> 'My own boat, *Harcla* ,was built by Ron Atherton of the Humber Boat Company... I was originally looking for a boat to live on and cruise blue water with, around 30 - 35ft [9.1 - 10.6m]. When I saw Ron's advertisement... I went to see the yard to discuss my requirements with him. He had at that time just completed a Spray 28 that stood outside. I had a look around the hull and deck mouldings and took some measurements and photographs. I went home to dream.
>
> About four months later I took delivery, and started to fit out in Scunthorpe at Ron's yard. I had designed a gaff rig for her for several reasons. It looks more appropriate for the hull and I prefer to sail with it; and, most importantly for some of the places I

This is a multi chine-fiberglass Spray 28 that was moulded by Humber Boats in England.

intend to cruise in, in the years ahead it can be modified or repaired with low-tech resources. I redesigned the interior, apart from the forward cabin, and I find it very spacious and workable. I checked the Bermudan mast position in the sail plan and your centre of effort, which I find to be correct. It was quite interesting to compare how she sails with the more modern boats of equivalent size. In heavy weather, as one would expect, she has an easy, soft motion at sea, and stands up well to sail. Discounting the topsail, which I have yet to rig, the first reef goes in at the top of force 5. In a force 6, the second reef goes in and the jib comes off, leaving her with a slight weather helm, up to the point where the helm is totally neutral and can be left for ages.

As yet, the strongest she has sailed in is a force 7 from the Humber to Wales, which was done with two reefs and staysail all the way, averaging just over 5 knots, but reaching 6 knots at times. A few anxious moments, but they soon passed when we realized she wasn't going to do anything daft.

Sir Christopher wrote that:
The real surprise to him is in the light air with calmer seas, where the vessel just sails along at 2-3 knots with no apparent wind. He comments that it is quite amusing in these circumstances to see the others twitching with their sheets while *Harcla* glides majestically past them. He continued:

'I once took her out in the Humber in a force 6 with all plain sail up to see how she performed. Usually, the vessel tacks safely and predictably, but this day she was tacking like a dinghy with weather helm, so obviously that tends to increase in line with the wind, which is a good safety feature. *Harcla* has pitch pine laid decks with oak rubbing strips, and with the Douglas fir spars and cream sails, she looks very traditional. With her brown hull, she often confuses people as to her age, which causes me great amusement. Although she is rather overweight at 72 tons [6804kg], she imbibes a great feeling of solidarity and confidence in everyone who comes aboard.
Overall, I am well pleased with the design. Given my time again, I would do everything the same-maybe one or two alterations in constructional methods with the benefit of

hindsight, but the boat rig and accommodation are basically too good to change. I sometimes wonder if I should have built a larger version, particularly when I am trying to figure out where to stow something, but I know I can handle *Harcla* on my own at sea with ease, and having a proper cutter rig means I run my bowsprit in - in other words, a housing bowsprit, so marinas only charge me for the 28ft, [8.5m] much to their disgust!

Harcla ,the name of Sir Christopher's boat, is a family name. It is the name of a castle that still exists, built by one of Sir Christopher's ancestors when he came to England with William the Conqueror.

Hazebra Too
This Spray 28 motor sailer is another of the Sprays built by Jack Read, as mentioned elsewhere, he has built several Sprays, some in round bilge fiberglass, some in multi-chine fiberglass and others in steel. I know that he did cruise in this boat and sold her on before building his next Spray

Hazebra Too - fiberglass *one of seveal Spray's built by Jack Read.*

Longshot
This boat was built by Bob Phillips of Milbury, Massachusetts, who commented: The name *Longshot* is the result of many remarks of friends, who said I would never finish it. I not only finished it, but I built every inch of it alone. It sails brilliantly, and I didn't have one drop of leakage in all those welds. I am a retired 66-year-old and enjoying my summers on Narragansett and Buzzard's Bay areas. The boat never fails to turn heads and draw favourable comments.'

Webber Spray
This steel Spray 28 was built by Jacques R Webber of Cudahy, Wisconsin, USA. Many enjoyable family hours have been spent on her creation. She has taken on a life of her own and we look forward to giving her a rich and colourful history. She is the topic of the neighbourhood, friends and the local newspaper. Because of the low budget available, every component and fitting has a story of its own. Mr. Webber has put his budget to good use as there are some very attractive interior shots of the boat, and one can see by the general construction and the quality of the fitting out that he intends her to be a credit to both himself and to the design.

This is one of several multi-chine-fiberglass Spray 28's that was moulded by Humber Boats in England. The owner of this business built a several fiberglass Spray 28's plus other Roberts designed boats and then retired and sailed off into the sunset .. Literally!

Carter Spray

This beautiful Spray was built by Mr. B W Carter. The boat is multi-chine, and Mr. Carter has built the boat of plywood, and then heavily covered the exterior with fiberglass. The finish is magnificent - Mr. Carter and his sons have certainly produced a most attractive vessel.

Carter Spray 28 nears completion - Another one to add to the over 500 alrdeady sailing.

This Spray 28 was built in Spain and is now sailing in the Mediterranean

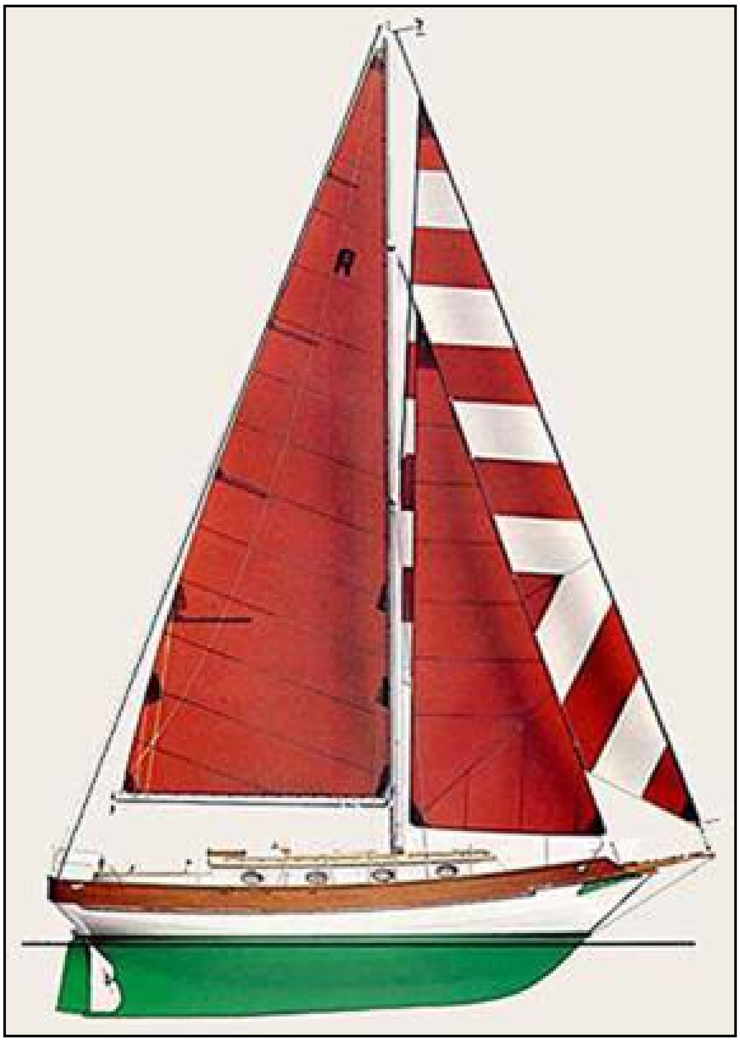
Spray 28 owner built and ready for turnover and adding deck and cabin.

Spray 28 ready for addition of windows and final fit-out. In my eyes this particular photo shows the attractive profile and clean lines of this Spray - always one of my favourites.

CHAPTER 20 Spray 33, 36, 38 & 40

M/C STEEL. FIBERGLASS WOOD/ EPOXY

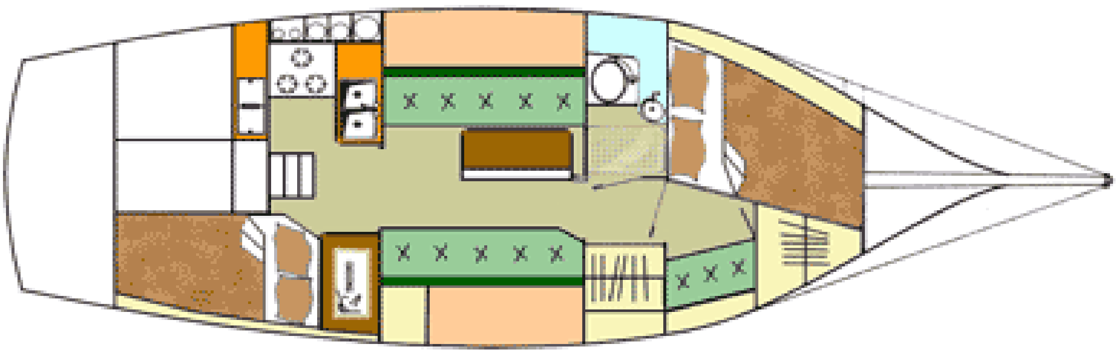
Spray 33 in round bilge fiberglass, multi chine steel or multi chine plywood.

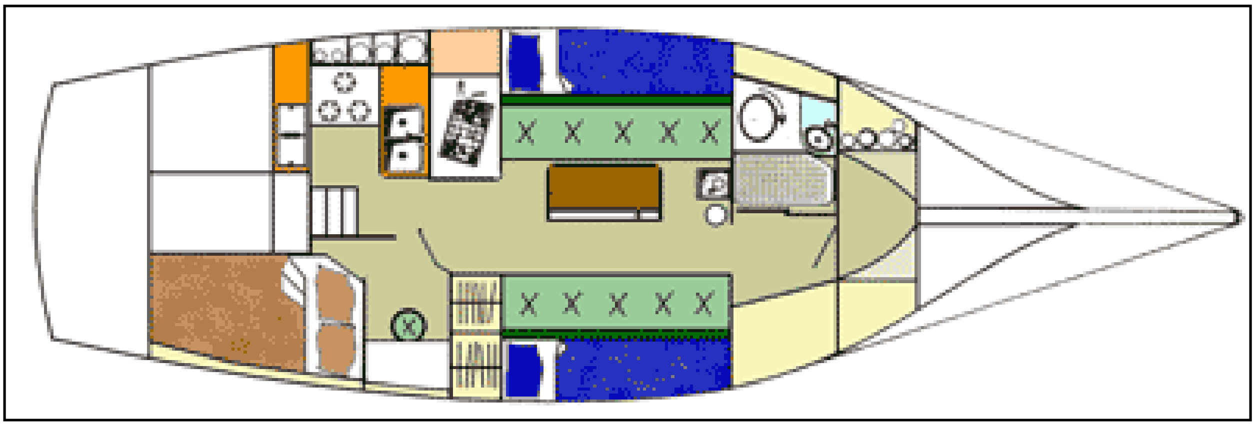


LOD .... 32'-11" 10.03 M
LWL .... 26'-7" 8.13 M
BEAM .... 12"-0" 3.66 M
DRAFT .... 4'-0" 1.22 M
DISPL ...... 22,000 LB 9,980 Kg
BALST .... 7,500 LB 3,400 Kg
AUX PWR .... 20-33 HP

There are over 1,000 examples already on the water and cruising throughout the world.

This design is a smaller version of the original Spray and shares many of the same features. Either can be built in Steel, Aluminum or Copper-nickel. These designs are available in double chine or round bilge hull form. A large variety of deck layouts including center cockpit, aft cockpit and pilot house versions are available for these boats.





SPRAY 33 - Alternate layout.

The Spray 33 is one of the few Spray designs that we prepared without any firm order from a particular client. Many of the designs offered by our company are the result of custom design orders that we feel will have a wide enough appeal to be offered as stock plans. The Spray 33, though, was a design we felt would be well accepted; and plans and patterns were prepared without a firm order being to hand. As with any business activity, you win some and lose some. Fortunately the Spray 33 has turned out to be a big winner.

Spray 33 dimensions:

LOD...32FT 11in [10.03m]
LWL...26ft 7in [8.13m]
Beam..12ft 0in [3.6m]
Draft...4ft 0in [1.2m]
Headroom..6ft 4in+ [1.9m]
Displacement..22000 lb [9972 kg]
Ballast..Varies
Spars..Timber or aluminum
Auxiliary..30 to 50hp
Sail area..Varies
Sail plans..Cutter, ketch or schooner
Construction materials................................Steel, fiberglass or wood/epoxy

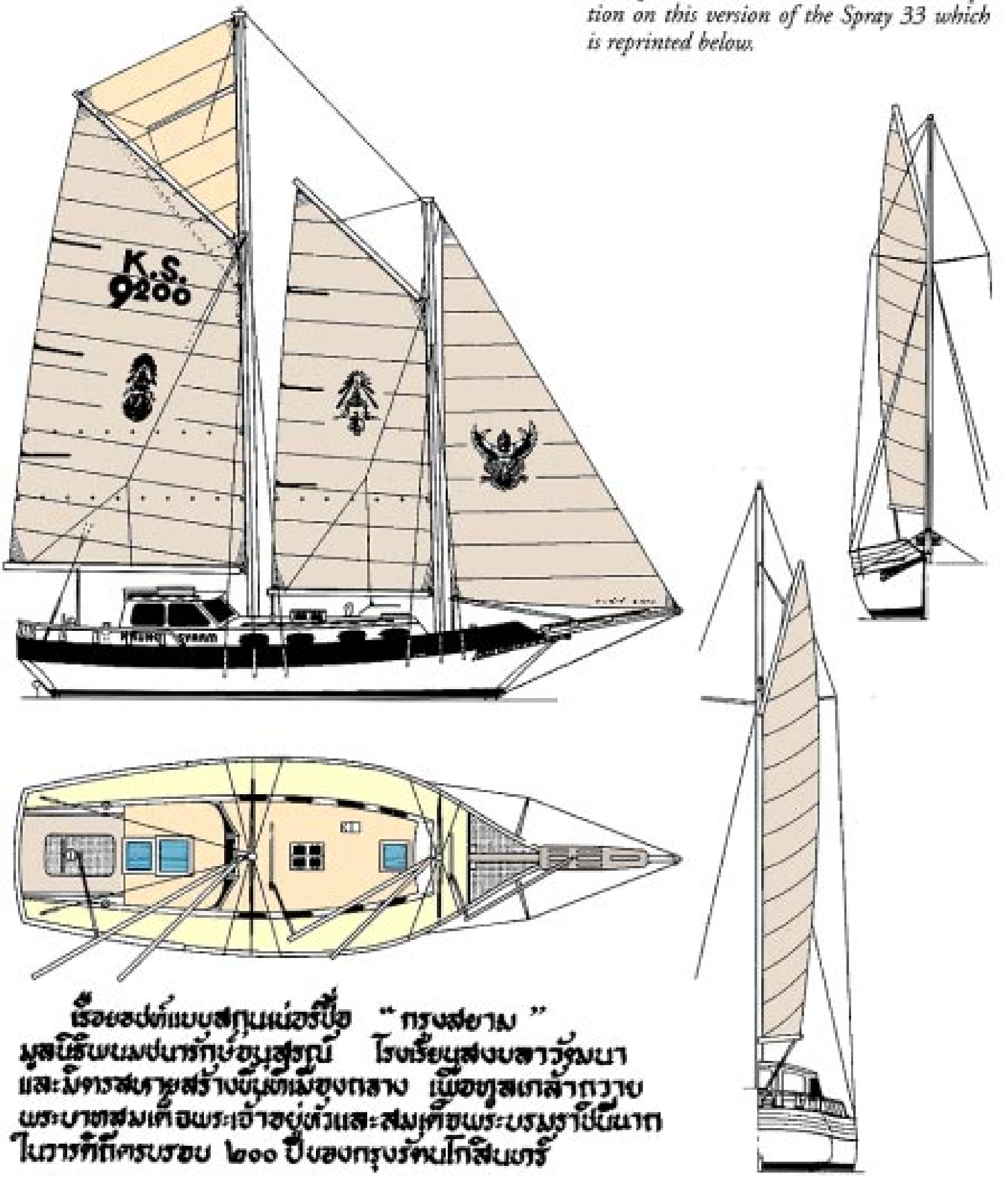
I have just received my plans for the Spray 33. I am overwhelmed by the number of drawings and the detail including deck fittings right down to the plans for the Roberts Dinghy. This is not my first boat building experience. I have built what my wife refers to as "toy" boats, a 14' wood /epoxy daysailer and a 20' cedar strip canoe.

This will be my first "serious" boat building experience and I am looking forward to getting started. Having looked them over I can see where the cost lies. The plans from other designers do not compare. I would not hesitate to recommend Bruce Roberts for boat building plans to anyone who might ask. Sincerely, Rick Deschenes"If you spend all your time trying to get even, you will never get ahead."

Royal Spray
One of the most unusual Spray 33s we designed was one for the King of Thailand. We were approached by the Boy Scouts' Association of Thailand, who wanted to build a boat as a gift for the King to celebrate the 200th anniversary of the dynasty. As my own grandfather had

ROYAL SPRAY

Perhaps someone will translate the inscription on this version of the Spray 33 which is reprinted below.



been a mining engineer who spent most of his life in the Far East and often dined with the present king's father, this project was of particular interest to me. We were sent a considerable amount of material written in Thai script, including three drawings, one of which represented the crest of the King, another the crest of the Queen, and the third was the crest for the nation. This last crest took the form of a sacred bird.

We faithfully copied all of the script to be included on the plans, which obviously were intended to be presented to the King along with the boat. Our associate designer Graham Williams also copied the crest of the King, Queen and the country on to the sail plan.

We had a lot of communication with the people who were handling the work. We received photographs showing the hull being built and then no more was heard from the principals concerned. We understand that th boat has now been completed

Cora

Palle Christoffersen built his steel Spray 33 *Cora* in Sweden, starting construction in 1988 and launching her in 1992. The recently received letter that accompanied an excellent set of photographs was written in Swedish so unfortunately I am unable to quote directly from Pelle's comments.

Fortunately the photographs speak for themselves; Pelle has made a beautiful job of not only building the hull; the quality of workmanship exhibited in the fitting out of the interior is first class. Solid mahogany timber was used extensively and the cabinet work is all of the highest professional standard.

The decks and cabin top are all sheathed with a laid teak deck and again the photographs reveal a well thought out arrangement and high standard of workmanship throughout. Pelle has fitted the Ketch rig and I notice he has chosen tan sails that always look attractive on a traditional boat like the Spray.

Southerly Buster *running in the Pacific.*

Southerly Buster

This Spray 33 was built at Ballina NSW Australia by John Page and launched in 1982. This boat was completed in the very creditable building time of under 8 months. This must be one of the most travelled Spray 33s ever built; John has successfully completed many single handed ocean voyages in *Southerly Buster* cruising to New Guinea, the Solomon Islands, and Thailand by way of Christmas Islands, the Philippines and Indonesia.

The most notable voyage, a complete circumnavigation, was undertaken with English born Carol Larkin as crew. Countries visited included, South Africa, Brazil, various Caribbean Islands, Panama, and back to Australia calling at Brisbane, before completing the voyage at Darwin Northern Territory Australia.

The worst weather encountered was 200 miles off Townsville, Queensland, when in 1989 *Southerly Buster* rode out Cyclone *Ivor.* John found himself 40 miles from the centre of the storm and considered himself lucky the avoid the worst of a very serious cyclone; he only experienced 80 knots, at the centre it was reliably reported that the wind speed reached well over 100 knots.

John reported his best passage was Cocos Keeling islands to Rodrigues a distance of 2000 M [5179 km] covered in 13 days. During this crossing the crew slept every night with winds of 25 to 35 knots on the quarter.

Southerly Buster *at a beautiful Pacific anchorage.*

Anna Lee

Joseph W Rohloff of Nunica, Michigan, bought plans for the Spray 33 and had the hull shell built in Canada. The Spray was extended 2ft [610mm] in length. This was before we designed the Spray 36, but Rohloff also made other important changes. He used a steel bowsprit and arranged the foredeck flush all the way to the bow. The bow was closed resulting in a large foredeck. The builder also raised the gunwhale 2 - 8in [50 - 200mm],a change that some others are also making. It makes sense, because high bulwarks mean safety at sea.

In December 1993 we heard from Jo Rohloff: '*Anna Lee* was launched on 4 June 1987. So far, she has been sailed on the Great Lakes. She has met or exceeded all my expectations and could certainly take me anywhere in the world'. Joe explained that Anna Lee is fitted with 6000 lb [2721 kg] of lead ballast. The cutter sail package for the Spray 36 was installed to suit the longer overall length. A section of the keel was closed and used for a closed-system engine cooling, which worked very well. A 20hp Humpah diesel provides adequate power through an 18in x 12in [457mm x 305mm] three-bladed prop.

Isambard

This boat is jointly owned by Reverend Richard Gregory, and Mr. G D Luton, both of Dorchester in Dorset, UK. Back in 1986, we heard from Reverend Gregory:

> 'It gives me great pleasure to write and tell you that the plans I bought for the steel Spray 33 at the latter end of 1979 have this season led to the launching of our centre-

Spray 33 - Anna Lee - *Nice to have a boat named after one ! My wife's name graced one of our boats too.*

Isambard - *The gaff rig shown is one of several sail plans that are included in the plans for the Spray 33.*

cockpit, gaff cutter, *Isambard,* which we named after the great engineer Isanmard Brunel. I extended the coach roof forward about 18in [457mm], and cut it off 2ft [610mm] aft, and added an after cabin, which is really spacious with an athwart ships double berth. The two cabins connect via the cockpit, and also by a passage down the starboard side under the cockpit seat. This gives excellent access to the engine, which I fitted further forward than shown in the plans. I raised the topsides by 7in [178mm] abaft the cockpit, but laid the afterdeck without the 4in [100mm] bulwarks, so I gained 11in [280mm] headroom for the after cabin and reduced the apparent height of the after coach roof. Under the stern there are four galleon windows, so that the after cabin is very light, and there is a nice view for those that occupy the after berth. Forward of the saloon, the forepeak is 5ft [1.52m] between bulkheads, and is fitted out with a workbench and a store.

After launching in July, they managed a five-day cruise in light winds and have since done a fair amount of day sailing. Although they have yet to experience any seriously testing conditions, their verdict is that *Isambard* is a most comfortable yacht, and excellently stiff and reassuring to live aboard. They say that she sails well in light winds and has impressed some very experienced sailors.
Reverend Gregory said:

> ‘It’s been a long slog building the boat, only one day a week and no evenings from my job as a parish priest, but I have enjoyed it all - except the grinding down and wire brushing. She does not leak a drop, either from above or below, and I have not had any condensation either, even though as yet the lining has not been done. I am, as you can gather, very pleased with the design and look forward to many happy seasons of good cruising.

He goes on to say that they have been restricted in their sailing to the English Channel and Brittany because of work commitments, but that their boat has ‘dug a groove in the sea’ between England and Normandy, and that they have found her very sea kindly whatever the weather. Reverend Gregory plans cruising on 52 to 6 knots, and though with a strong wind they have done 8 knots, 5.3/4 knots seems to be the hull speed. They have had a number of grounding experiences, and September gales parted the mooring chain and drove the vessel on to a rocky beach. The boat's underwater configuration, combined with the well-protected rudder and screw, and beaminess, all proved good insurance against damage, which did not take them long to repair. Reverend Gregory comments that many fiberglass boats did not survive nearly so well in these gales:

> 'Despite dire warnings that a boatbuilding project that becomes too protracted leads to loss of enthusiasm, I must say that for the six years we were building her, the project gave me tremendous satisfaction, and I have gained such useful skills, especially in metalworking, that I never could have imagined would be so valuable and in so many fields. At present they are being used in the sculpture class, for which the students need steel armatures. This winter my co-owner, Mr. Luton, has been building a large wood frame screen, and we are extending the Spray hood to cover the hull cockpit. It must be a sign of ageing!

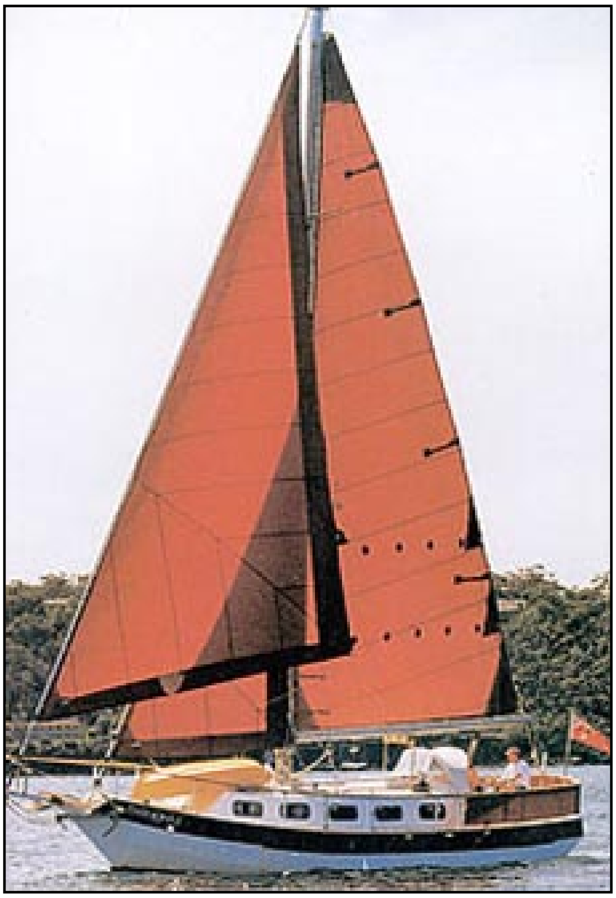
Oysterman Spray

This steel Spray 33 was built for Mr. and Mrs. Giddy of St Athan, South Glamorgan, and UK. Other than a photograph of the boat and a short note from Mrs. Giddy, I did not know much about this particular vessel. 'Enclosed, photographs of our Spray on the day of launching. At the moment we have none of her sailing, but hope we might have some soon as we know other members of the club have taken some photographs. However, as usual this is a view that we never seem to get ourselves. 'You may note that *Oysterman* is the same name as the Roberts Spray 40 which was built in fiberglass by Roger and Riva Palmer back in the late 60s. *Oysterman* is a natural name for any Spray because apparently the original Spray was used for oyster fishing before she came into Slocum's ownership. When I later spoke to Mr. Giddy *I* learned that *Oysterman* had been sold and cruised down to Malta in 1990 by her new owners,

The subsequent history of *Oysterman* came to me via a communication entitled *The Malta Un-connection*. Due to the death of the owner, *Oysterman* had been left in Terry Erskine's boatyard on the island of Gozo, Malta.

This Spray 33, built of steel some 12 years ago, had never been properly maintained and was left virtually abandoned for the previous four years. She was indeed a sorry sight when a prospective buyer Mr. Bob Stewart first saw her late in 1993. Bob was smitten with the boat and returned to the UK and negotiated the purchase and in early 1994 became the proud owner of a very tatty Spray 33.

Oysterman was sitting in a locked boat yard that had now ceased to trade and was caught up in the usual mess of third party properties. Terry Erskine, the only director of this business still remaining in Malta, was in limbo with all sorts of restraining orders forbidding him to leave the



This Spray 33 was built in Australia by Anthony Fountain - Anthony also was involved in forming the Spray Society in Australia.

Spray 33 JOSE *shown here sporting her full rig.*

islands while at the same time not allowing him to be there. Notwithstanding all of these problems, Terry agreed to help Bob liberate his new boat and also to assist on a quick 'tart up' and re-launch of the vessel, so it could be sailed back to the UK.

After a few days of working on the boat Terry Erskine knew that the 'tart up' was in reality a major refit. Almost everything on the boat was in need of attention and Terry worked long and hard to prepare it for sea. Bob Stewart arrived for his three week vacation and worked a 14 hour day alongside Terry, virtually rebuilding his recently acquired boat. At the end of his time off, Bob returned to his oil rig job and left Terry to complete the refit and re-launch the Spray 33 by the middle of May. After a Herculean last minute rush, common to all refit and building jobs, *Oysterman* was launched.

As Terry Erskine had an 'Impediment of departure' placed on his person by the Maltese government, it was with some trepidation that *Oysterman* was sailed out of the harbour under the watchful eye of a Maltese gunboat. After engine trials for an hour Bob then hoisted the sails, put aside his worries about clearance and set a northerly course for Sicily.

Bob continues, ' By the next morning we were motor sailing along the Sicilian coast when we received a buzz from an Italian patrol boat asking where we were bound. We replied, 'France', and they lost interest in us at that point, waving us on our way. After sailing through some thick fog, plus an encounter with a large section of hatch cover netting, we pressed on towards southern France.

Next morning, a German warship was on the RT asking for 'yacht in position so and so to identify', itself and of course it was us! We were informed that we had entered a 40 mile radius, war games area, where live missiles were being fired! They ordered us to leave the area on 110 degrees which was back the way we had just come. We tried a 60 degree course, to slip out of the area without losing too much ground, but very shortly a large bow wave was sighted, belonging to the destroyer, and we were told to clear out of the area immediately. We politely explained there was no wind and we were a sailing boat with very little fuel for our 33 hp diesel engine. After a pause the warship came alongside with the crew lining the rails and we were given a jerry can of fuel and they filled our two plastic containers as well. They waited for the return of the jerry can; it was the only one they had! It seems that the whole of the North Mediterranean was closed to all shipping, except for a narrow three mile channel at the top of the French coast.

At dusk we found ourselves in the three mile channel with all of the shipping of the Med. funnelling through it and by now the winds were up to force 5 and right on the nose. It was a very uncomfortable night with winds increasing to force 6 and 7, and by morning we were off St Tropez. We finally arrived at Toulon where we tied up at the hospitable Du Port De Saint Mandrier marina. We searched out the customs and were asked why we bothered, we had no drugs did we ? We were British were we not? So all was fine, no paper stamping or form filling needed here. Next day we headed off again, finally arriving at Sete. There was no room at the marina so we anchored in the commercial dock basin. We had covered 872 nautical sea miles, 7 nights at sea and an average of 4.98 knots; not bad for a Spray 33.

The next job was to un-rig the boat and prepare for the passage through France via the Canal Du Midi and Canal Lateral, from Sete to Bordeaux. Sete is a nice holiday town totally dominated by the port docks and canals. There are lifting and swing bridges dividing the town into areas of fishing boats plus docks for commercial and tourist activity. It is possible to spend considerable time in Sete without paying mooring fees. The bridges open at set times to allow ships and yachts to negotiate the various areas and passage into the large Etang De Thau. For the next month we spent time tied up in various locations taking advantage of the free moorings and sampling the local wine.

During this time we met many passage-making yachts and boats arriving and leaving the French canals so we were able to gain valuable information that would be useful on the next stage of our trip. Several tires were procured from local garages and carried back to the boat and strung around the sides of the hull as a canal ‘defence system’.

Bob returned for another stint of leave so we were able to proceed through the lifting bridge that would admit us to the canal system. We tied up in the dark near the first lock, ready for an early start the next day. At 0800 the lock opened for business and we paid the keeper a fixed fee that would cover us for the whole passage through the canals. Our first days run of 66 km ended at the junction of the Canal De La Robine, and having negotiated 16 locks, we felt that our target of seven days to Bordeaux was possible.

Now we were in amongst the hire boats, nicknamed by the locals as ‘bumper boats.’ These plastic boats are crewed and skippered by people of all nationalities and levels of proficiency. An example of this experience is the memory of one skipper who, when his lady crew fell overboard, immediately proceeded to reverse over her. He said he did not know how to find neutral! The lady had a lucky escape.

After a 52 km [32M], 20 lock, day’s run we were greeted with the news that the lock keepers throughout France were now on *STRIKE*! Tied up in the middle of nowhere with 85 degree heat, there was only one thing for it, we would declare a ‘Make and mend day’, and change to engine oil etc. Terry rowed back 3km [1.8 M] to the village of Trebes and secured a can of oil from the English owned hire boat company.

The strike only lasted one day and with the lock keepers back to work we were able to continue our passage along the Canal Du Midi. Our next day's run was 41km [24.4M] and 24 locks. Next day, we ran aground when the canal water dropped one foot! Within a minute of the lock keeper's start up time, a surge of lock water was released to float us off and allow us to continue on our way.

When we left the Canal Du Midi and entered the Canal Lateral we soon cleared our first automatic lock. The rest of the passage was uneventful and we arrived in Bordeaux having travelled 572km [355M] and 148 locks in the very respectable time of nine days.

The canals were a great experience and they can present some minor difficulties to yachts with masts laid on deck. They are a necessary part of moving around Europe and a boon for those of us who do not have unlimited time to sail around, rather than through France. At time of writing, *Oysterman* is in Bordeaux, re-rigged and ready for the next and final stage of her return to the UK.

Dragon Spray
This steel Spray 33 was built by Dragon Marine then located on Hayling Island near Southampton. Dave Folwell of Dragon Marine has built many Bruce Roberts-designed steel boats, and he built a Spray 33 for his own use. Often he would be out sailing and some of the so-called 'hot' keel boats would think his Spray was a pushover, and would come alongside wanting to show their superiority. However, in anything but a hard punch to windward, the Spray 33, which could carry full sail long after the other boats were reefed down, would surprise all concerned. Many of these impromptu challenges ended with the Spray 33 showing the other boats a clean pair of heels.

Columbine
I photographed this steel Spay 33 when I was visiting Minnisot Beach Marina in North Carolina. Dr Keith Wolfenbarger and his charming wife, Judy, carved out a 200-berth marina from swampland off the Noose River, and they had personally owned four Bruce Roberts-designed boats including Roberts 53s. There is always at least one Spray visiting the marina, including one that sailed over from South Africa. The couple that brought her over, worked in the marina for some time, hoping to remain in the USA. *Columbine* displayed as her home port the little town of Littleton, Colorado.

Colorado is more or less in the centre of the US, and a very mountainous state; it is famous for its skiing rather than its boating activities. However some people prefer to register their boats in their home town, no matter whether the town is miles from the ocean. Also, in the USA it was at one time an acceptable practice to register your boat in a state that had few boating facilities, and consequently no taxes aimed directly at the sailor.

By registering the vessel locally, one could thereafter escape the taxes of the state where the boat was kept. Of course, the authorities soon woke up to this ruse, and consequently any boat that appeared in a marina in their state could be slapped with a tax demand. This in turn lead to unfair situations in the extreme, as one could be visiting a marina or anchorage for just a few days and have the taxman knocking on your hull.

Northern Spray
This boat was built by John E Bushnell of St Paul, Minnesota. I remember well the day that John walked into my design office and said that while he found the Spray 33 an attractive

boat, he would really prefer to build something just a little longer, and would help in designing a stretched version of the Spray 33. At that time, I considered this to be a one-off request, so I consented to assist John with some additional sheets added to the Spray 33 plans which would enable him to build a slightly longer version of this boat. John chose fiberglass as his boatbuilding material, so we set about outlining the changes that would give him the space he required. At this time, there were no plans to design the boat that is now known as the Spray 36; this was simply a one-off exercise for a client who wanted something just a little different. John subsequently went ahead and built his Spray.
After a considerable amount of cruising around the Caribbean, John wrote:

> ‘It is now four years since 4 July 1979, which was when I started constructing *Northern Spray.* Suddenly the long task had become worthwhile. I cruised the Bahamas alone for several months. Alone? Not really. At every anchorage I met other boaters. At one of them in the Berri chain, my offer of a tray of ice cubes each evening from the plenty my refrigerator turned out provided me in return with surplus fish from their snorkelling expeditions.

John then goes on to chronicle all of the places he visited around the Caribbean and all the friends he made both afloat and ashore, and the chance meeting with boats that he had met up with several times, and all in one wonderful year of cruising. After that he went back home to Minnesota to spend a winter with his family, and his letter closed by saying, ‘When I resume cruising this spring, it will again be towards home, and then finally get to Lake Superior to taper off with short trips on the Great Lakes for parts of the summers.’
Shortly afterwards, in January 1985, I received another note from John. It read:

> ‘I have owed you a letter for a long time to inform you how *Northern Spray* has turned out. In essence, you in design, and I in execution, have both done a fine job on her. There is no detail of design and execution that was not suitable for the requirements of a fine, comfortable cruising boat. In the year and a half since I arrived in the Gulf, after a fine trip motoring down the Mississippi, I have been fortunate enough never to have been in any long-lasting heavy gale, but on quite a few occasions I have sailed in very fresh winds. At no time have I had any green water on deck, nor has *Northern Spray* heeled over far enough to put the deck under water. She has stood up well in the occasional heavy gusts of winds such as those that often precede a thunder shower. I have never had any failure concerning any of the rigging or operation of any part of *Northern Spray.*

Brass Loon

This boat, owned by Leuder L Kerr of Comox, British Colombia, Canada, is of aluminum construction, cutter rigged, and has a Perkins 4108 auxiliary engine. The hull was built in 1979 by a yard in Vancouver specializing in aluminum fishing vessels. It was then finished by the previous owner over a three-year period and launched in 1982. The main departure from the plans was the addition of a pilot house, which works very well, and the installation of a larger engine.

Leuder Kerr is currently living aboard and finds it very comfortable.; the pilot house allows him to sail in the Pacific north-west all the year round. It is not a fast boat but he particularly likes its stability, sea kindliness and the sense of security its massive strength gives him. He has run into floating logs, which are a local hazard - often at night and while at full speed - without the least worry or hull damage. Another plus is the keel configuration coupled with the wide beam. It lets him run ashore on a sand or mud beach at low tide to clean the bottom, heeling only about 25 degrees. On the next tide, he simply changes sides !

Aluminum Spray 33 **Brass Loon** *owned by Leuder L Kerr British Columbia.*

Hazebra Lady

This fiberglass Spray 33 was the first of several Sprays built by Jack Read, and we visited this boat when it was moored on the Norfolk Broads. *Hazebra Lady* is fitted with a Vetus 33hp diesel, and rigged as a Bermudan cutter. When Jack built this boat, he wrote the following; 'Since being launched in June we have spent a month cruising from Norfolk to Portsmouth and back, and hope to get over to Amsterdam next week. She took ten months full-time work to complete and cost ,12500. Timber is genuine teak, except for the mahogany cabin sides. I am well pleased, and she has been much admired at all ports of call.'

Jack Read eventually sold *Hazebra Lady* to Paul Francis, who owned her for three years and cruised for 5000 miles. Paul Francis has a most complimentary opinion of this boat, and only sold her to order a larger Spray 36, named *Hazebra Pride.*

Fiberglass Spray 33 **Hazebra Lady**

Hazebra Lady was sold to the present owner, Mike Ambrose, and he has since crossed the Atlantic in this Spray 33. The route was Walton-on-the-Naze, Ramsgate, Southampton, Falmouth, and Lisbon. Gibraltar, Canary Islands, Barbados, Trinidad, Honduras and Guatemala. Last report was that Mike was sailing *Hazebra Lady* north to Mexico and then on to the USA.

Molded Spray

Some years ago we received a call from Florida from someone who suggested he was going to build a mould for the Spray 33; his company would produce fiberglass hulls. We were pleasantly surprised when we received photographs of a beautiful moulded Spray 33. Also enclosed with the photographs was a picture of a well-built mould. Some time later I was in touch with the company, who informed me that so far they had only built the one hull, for pressure of other business had caused them to put the project to one side. The photographs reveal a hull, for that is incredibly fair, but I wonder where it is now.

Plucky Lady

This boat was built by Mr. and Mrs. Depreitere in France, and I first became aware of this particular Spray when I received the following communication headed 'In the Wake of an Obsession':

'It all began in 1987 when my husband fell in love: he saw the first picture of the Spray. After owning three other boats he had finally found his dream boat, so we bought the plans. The hull and deck were to be built by a professional, but two months before it was finished the company went bankrupt and we lost everything. In 1989 we decided to buy another boat. After visiting quite a few sailboats, my husband said that if we couldn't have a Spray to sail in, then he didn't want to sail. In August 1989 we rented a broken-down farmhouse with lots of land space. We did not have a lot of money, but the courage was there. My husband did not have any experience in welding, but that did not stop him. With the help of some friends, it was OK after a few weeks. It is now 1994 and we will be launching in the summer of 1995. My husband's dreams, which also became mine, were not lost. It was a beautiful dream come true. She is a real plucky lady, which of course is the name of our boat. See photo on previous page - *Plucky Lady* is a dream come true and she has now cruised many thousands of miles; the Depreitere's love her !

Scesney Spray

This Spray 33 will soon be launched by George A Scesney of Atlanta, Georgia, USA. George has written to inform us about his boat and to request information about the use of a solid spar for his mast. One of the few designs in which we would recommend the use of a solid spar is the Spray series. The Spray is so inherently stiff that the solid spar with its additional weight may even be of some advantage over an aluminum mast of similar strength

Hamblin Spray

In 1982 Doug Hamblin was already well advanced in the building of his steel Spray 33, and as Doug had a few ideas of his own, it is worth quoting him here:

> 'It has been necessary to deviate from the suggested building plan in several cases. I have chosen the upside down building method on a steel jig. The steel jig costs about the same as a wooden one, and I feel the steel is sturdier, longer lasting and does not change shape with the weather. I set the frames up on the jig with a transit to level the head stocks. I built a complete framework for the transom. I decided to use a hydraulic drive system; instead of putting in an angled propeller shaft, I have mounted the stern tube horizontally 16in [406mm] above the keel. The hydraulic motor is to be mounted deep in the keel. I plan to use a Mazda RX7 rotary engine because of its smoothness. It will drive a Rex-Roth variable displacement hydraulic pump. This unit should put about 50 hp at 3000 engine rpm and 900 propeller rpm.
> Even with limited space available, this boat is still easy to build. Thanks to the multi-chine design, the skin plates are kept to a reasonable size. I have had no problem whatsoever building this boat alone.

California Spray

This fiberglass Spray 33 was built in California. As our office at that time was located nearby in Newport Beach, we had quite a lot of contact with the builder of this boat. When the time came for launching, which was to take place near San Diego, I and another member of my design team were invited to the big event. Accompanied by my long-term Australian friend and associate designer, Graham Williams, we proceeded to San Diego in time to see the boat being trailed down to the marina. As is typical in California, the launching was undertaken using a travel lift, so there was none of the panic that is sometimes associated with these events. There was plenty of time for us to inspect the boat, which was beautifully built and finished - both inside and out. The boat was rigged as a gaff cutter, and all of the masts and equipment had been custom made. This was really a beautiful boat, and one that I would be proud to own.

After this very joyous occasion, it was surprising and somewhat disillusioning to receive a phone call a few months later from a doctor who lived in the area. The conversation went something like this.

'Have you read about my boat......? 'No,' I admitted, I had not heard anything. 'Well, the fellow who built it absconded with the boat' The doctor explained that the person who had built the boat, and who had been officiating at the launching, was only the builder and not the owner. This was certainly a very different impression from that obtained by all who were present at the launching party. It seems that the launching was held while the doctor, self-declared owner, was away. On his return, he found his boat missing; the person who built the boat had sailed off into the unknown. The doctor alerted the authorities and a full-blown helicopter and aircraft search was made for the vessel However they did not find the Spray 33.

Truly a beautiful Spray 33 - I wonder where she is now ?

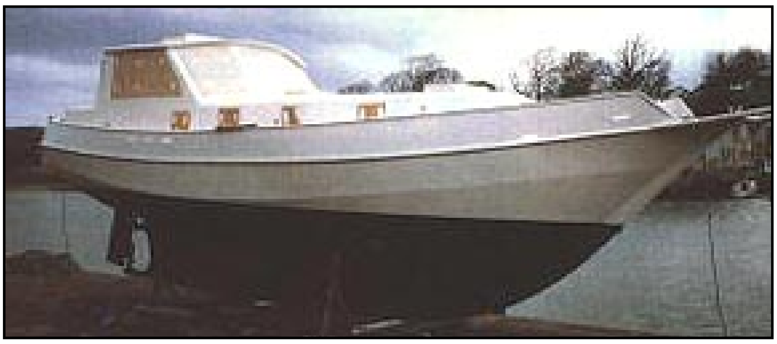
A few days later though she was sailed back into port voluntarily and the builder was arrested. The doctor now wanted to sell the boat, and unfortunately at the time I did not have the sense to buy it myself. I have to assume that the story told by the doctor was correct; the facts would have been easy to check.

Bellavia

This steel Spray 33 was built in England for an American client who took delivery of her and sailed down through the Mediterranean, and subsequently the boat was sailed across the Atlantic and now is in the United States. I did have the opportunity to see her being built and also be present at the launching and trials. This Spray 33 certainly sails well and she was beautifully built and fitted out by Wistocks of Woodbridge, Suffolk.

The foregoing was written several years ago and appeared in my earlier Spray book SPRAY The Ultimate Cruising Boat. Since that time *Bellavia* has had some interesting experiances. Firstly she was sailed around Europe including some canal crusing and the across the Atlantic to the USA and on to Bermuda where she was laid up by her somewhat elderly owner. A broker friend of mine in Annapolis sold her to an Irishman who operated a world wide salvage company. After enjoying *Bellavia* for two or three years she was again on the market. As with most of our boats that are for sale, I heard about this and put a prospective customer from Iceland in touch with the broker. She was purchased and after a few minor repairs, sailed to Iceland. Now as we know (I have been there) Iceland is has a cold climate so a pilot house was called for. So she is sporting her new addition!

This is Bellavia *a much travelled and modified Spray 33 - Her owner loves her and writes glowing reports of her handling and sea worthiness in the rough waters around Iceland.*



Pilot house Spray 33 built by Terry Erskine.

Pilot House Spray 33

This steel Spray was built by Terry Erskine when he was operating his boatyard in the UK.Terry later moved his operation to Malta to take advantage of the low taxes and other incentives being offered by that country. However, he found Malta too far removed from the marketplace; we now have him back in the UK building boats.

Rahmani
This boat was built by Major Pat Garnett MBE, who is attached to the Sultanate of Oman Ministry of Defence. There are a few British military officers who serve in the Sultan of Oman's Army, and Pat Garnett has served in this capacity for several years. During his stay in Oman, Pat built the Spray 33 called *Rahmani*, as well as the Roberts 434 radius chine steel *Omani,* which he sailed single-handed around the world in 218 days - a record in itself a record for the 27000 mile [43451km] voyage. Pat has also been involved in the construction of a Roberts Waverunner 44, which was built for the Fisheries Inspectorate in Oman. Pat is also planning to build a Roberts New York 65, which he will be sailing single-handed around the world and trying to establish a record. But here is Pat's Spray story:

> 'In November 1986 I sailed my Spray 33 *Rahmani'* single-handed from Muscat to Bombay. During the voyage I suffered from increasingly severe pain in the left buttock. By the time I reached Bombay, I was barely able to walk. The Breach Kandy Hospital diagnosed a prolapsed disc and recommended that I be admitted and put in traction.
>
> This posed a number of problems, so I repaired away to the five Star Oberoi Towers Hotel to consider the options. Should I leave the boat and fly home? (Unthinkable.) Should I accept the treatment? (Not attractive-it could be an indefinite period.) Could I find a crew, at least two, and pay the return fares? (Probably difficult, expensive, and what about visas?) Time was short, with only 14 days' leave remaining. Perhaps the pain would go away, but when?
> In a blinding flash of foolhardy inspiration, I resolved to let Rahmani take me home. When I informed the hotel doctor that I was going home, he said he would make the necessary arrangements with the airline. I told him I was going by sea. In that case, I must give the following instructions to my cabin steward. I explained as gently as I could what I had in mind. His manner changed rapidly from incredulity to alarm, and he insisted that I sign a note exonerating him from all responsibility. Doubtless, he still has it.
>
> The Tindal (head boatman) of the Royal Bombay Yacht Club rowed me out to where *Rahmani* was anchored off the Gateway of India. It took some time to persuade him to hoist the mainsail and the No.2 jib and to crank in the anchor. He was standing in the tender as I motored away in a flat calm, and the expression on his face was memorable.
>
> The sea breeze came up around noon and *Rahmani* put her shoulder into it and began that gentle pitching motion that is so characteristic of the Spray 33. In order to avoid the fickle winds of the Gulf Oman, I set a course for Oman's southern port of Salalah, a distance of about 1100 sea miles [1770km]; but I hoped to be able to go the whole way on an easy reach in the north east monsoon wind. I set up the Aries and lay down flat on the cockpit seat.
>
> Except for easing the sheets for the land breeze, I remained there all night.
> The pain was worse by the next day, but we were starting to feel the northerly wind so I extended the Aries control lines to run below, prepared a stock of food and water close at hand, and assumed a prone position on the lee berth. I was not to set foot in the cockpit again until we reached Salalah.


RAHMANI

heading by the position of the sun and the constellations sweeping past the open hatch. Each night I took the altitude of Polaris. No fancy corrections, altitude Polaris - latitude is good enough for government work. This was much less painful than hanging around waiting for a meridian passage.

I was in excruciating pain and great distress. The pills were gobbled up too quickly and I resorted to whisky. I read the Walker log with the camera telephoto lens and, when I felt able to do so, I took a morning sight draped on the ladder with elbows on the bridge deck. A position line worked up by the Haversine method gave me a pretty good check on longitude.
These navigational excursions presented an opportunity to dump my urine bottles and plastic-bag bedpans overboard. No navigation lights. The battery was flat and I was in no state to hand crank the engine. No lookout of any kind. It was a disgracefully un-seamanlike performance, but we reached Salalah in eight days; 130 miles [209km] a day virtually without touching a rope.

I anchored at about 2 knots in some disarray and then spent three months in traction in various hospitals.; ample time to reflect on the remarkable qualities of the Spray.

Not long after I had received the story from Pat about their experiences I heard from Sarah Wright, Pat's long-time friend and associate, who has made several cruises with him on his various boats. One trip was from Oman to Goa, India, and Sarah sent me the log of this trip; it runs to 40 pages, so could not be reproduced here. The sail from Oman to Goa takes about ten days and Sarah's log reveals a relatively uneventful sail. Sarah, who at this stage was a relatively inexperienced yachtswoman, found handling the Spray quite easy, and managed to carry out her watches without any problems. As *Rahmani* has the characteristics common to all Sprays - that is, she will steer herself for long periods - the log of the voyage to India has many passages that tell of nice easy cruising. No big crises, and good daily runs with the Spray looking after herself much of the time.

After a few days of rest and relaxation Sarah and Peter sailed the Spray back to Oman. Again it was a pleasant easy sail without any drama. Pat went on to build his Roberts 434 *Omani*, which he sailed single-handed around the world in only 218 days.

Lucia

This Spray 33 was built by Paul Fay, who also built Spray 36 called *Faizark,* details of which appear in Chapter 8. Paul is now a full-time professional boatbuilder and has made a wonderful job of building *Lucia* for Maureen Dawson of Westward Ho, Devon, UK. Maureen intends to sail this boat single-handed across the Atlantic, and will be sponsored by the Variety Club of Great Britain. Her purpose in making this single-handed transatlantic crossing is to raise funds for her favourite charity. She was hoping to leave England in April of 1995, to coincide with the date on which Slocum left the USA on his single-handed round-the-world voyage. Several other Spray owners are planning similar trips and hoping to leave on the same date.

I first met Maureen Fay (at that time Marueen Jenkins) at one of the UK Spray owners get togethers at the t ime we managed to organize a Spray Association in Europe ... Alas Spray owners are very individual in their ways so eventually our small band was absorbed by the Joshua Slocum Society in the USA. As you will see it all turned out well in the end.

Maureen, better known as Mo is a very attractiveand delightful lady. Mo was in the process of having her Spray 33 built at that time. Mo's boat was built by Paul Fay, his third Roberts boat, see Fays Ark in the Spray 36 chapter. Paul did a great job of building the Spray 33 for Mo and the next time I met Mo was at the Joshua Slocum / Spray centennial celebrations and rally in Newport RI USA. With almost no previous experiance Mo had sailed her Spray single handed from UK via the Azores to Newport. We all had a great time at that gathering, many Sprays had sailed from far and wide were on show with short trips available for those who wanted to sample the delights of the various boats.

Maureen Fay and her Spray 33 LUCIA

The Slocum Society is comprised of not only many the many Spray owning members but in addition admits anyone who is interested in Single handing. Many single circumnavigators were present at the Spray Centenary get together.

One person present who I greatly admire is David Sinnett-Jones, see details of Davids Spray 36 later in this chapter ... Anyway David built a near replica of the Liberdade, one of Slocums other boats I designed the hull based on drawings of Liberdade, for David and attempted a single handed trans-Atlantic crossing from UK to make it to the Centennial but alas the Liberdade replica hit an obstruction and bent her rudder and had to limp back to the Azores. David did make to Newport by air and was one of the featured speakers at the rally. David later sailed Liberdade from UK to Brazil and then sailed the same voyage as Slocum made from Brazil to Newport USA.

SPRAY 36A

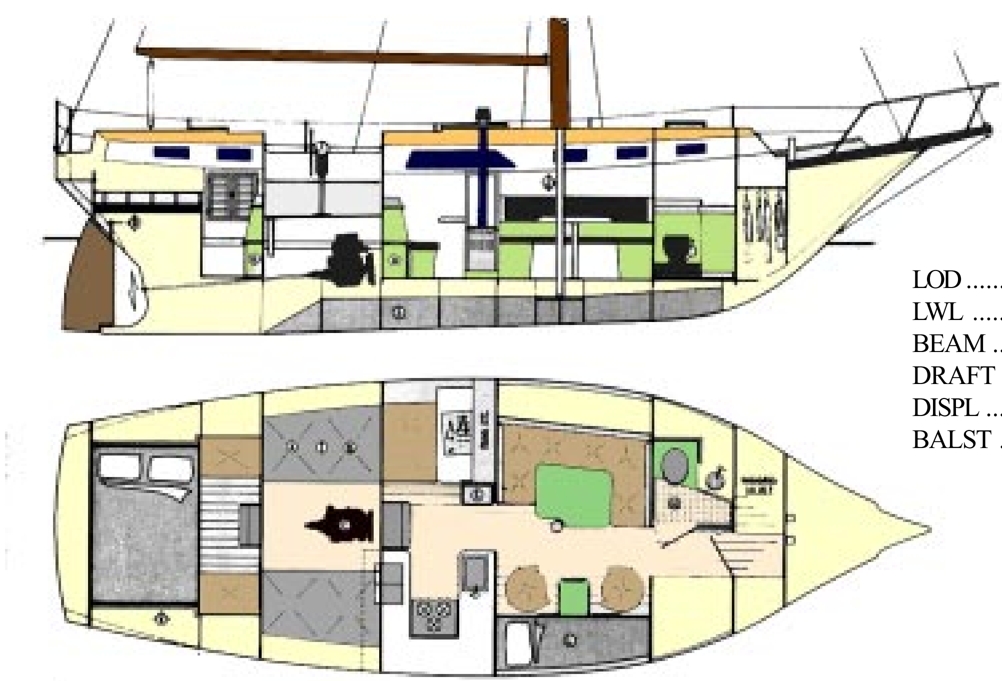
MULTI CHINE STEEL.
WOOD / EPOXY
FIBERGLASS

There are over 500 Spray 36s in service and as many again being built in Steel, Fiberglass and Wood/Epoxy.

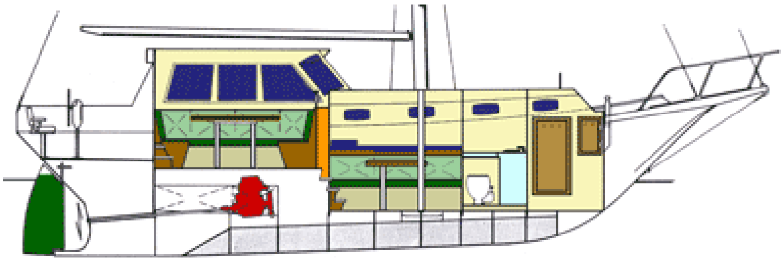
If you are looking for a medium sized family cruising sailboat then the Spray 36 could fulfill your requirements at minimum cost to your family budget.

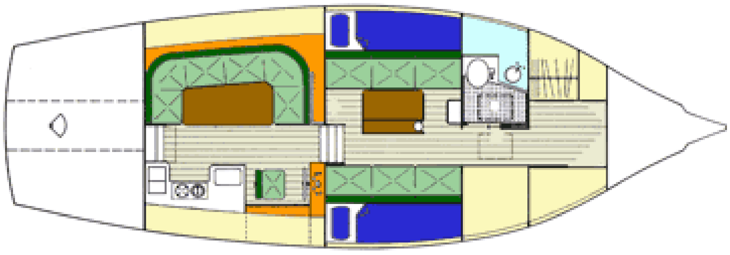
There are several versions of the Spray 36 and the accommodation can be rearranged to suit all types of family requirements for a crew of up to six persons.

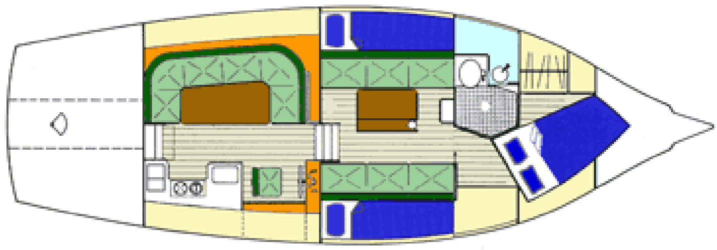
This design has also proven itself many times to make a highly successful single-hander so if you are expecting to sail on your own or with minimum crew, then we can recommend the Spray 36



LOD	36'-10"	11.23 M
LWL	30'-0"	9.14 M
BEAM	12'-0"	3.65 M
DRAFT	4'-0"	1.22 M
DISPL	24,400 LB	11,068 Kg
BALST	8,400 LB	3,810 Kg





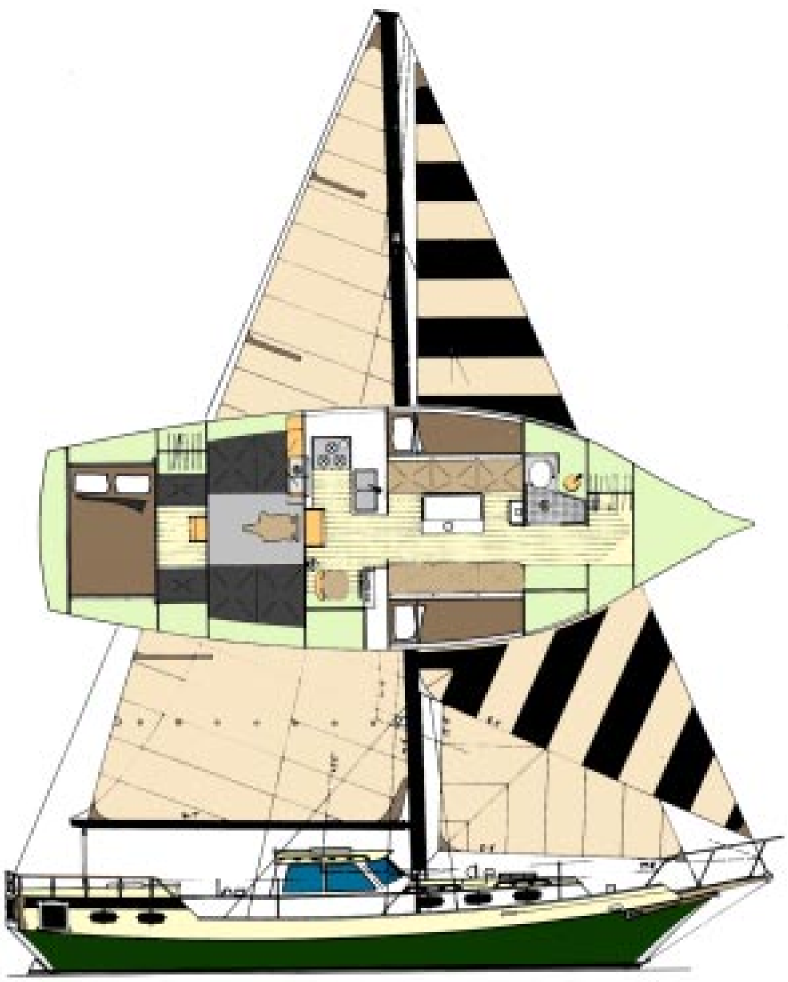


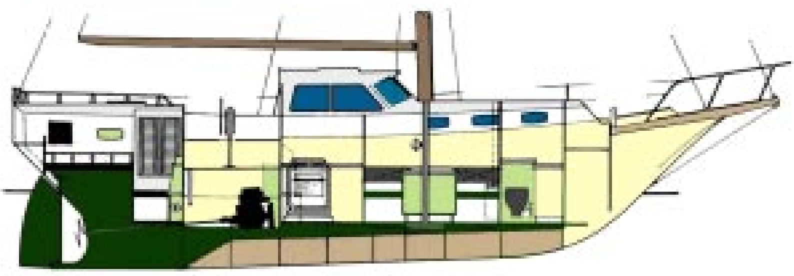
SPRAY 36 B

MULTI CHINE STEEL. WOOD / EPOXY FIBERGLASS

LOD	36'-10" 11.23 M
LWL	30'-0" 9.14 M
BEAM	12'-0" 3.65 M
DRAFT	4'-0" 1.22 M
DISPL	24,400 LB 11,068 Kg
BALST	8,400 LB 3,810 Kg

This aft cockpit version combined with a generous sized pilot house offers many alternate lay-out possibilities. Using the Super Study Plan package you can design your own interior accommodation.





SPRAY 36 C

MULTI CHINE STEEL. WOOD / EPOXY FIBERGLASS

LOD	36'-10" 11.23 M
LWL	30'-0" 9.14 M
BEAM	12'-0" 3.65 M
DRAFT	4'-0" 1.22 M
DISPL	24,400 LB 11,068 Kg
BALST	8,400 LB 3,810 Kg

Over 300 completed. The 'C' version of the Spray 40 has been so popular that we received many requests for a similar arrangement for the smaller Spray 36. There is a great photograph of David Sinnett-Jones 'Zane Spray' in the book *SPRAY The Ultimate Cruising Boat.* The same book details David's single handed **round the world voyage** as well as his Atlantic crossings in the SINGLE HANDED TRANS-ATLANTIC RACE.

If you are seeking the maximum family accommodation while retaining the excellent sailing qualities of the Spray then this version may be just for you.

Note the 4 ft / 1.22 M draft, this is one of the shallowest fixed keel cruising boats available that really sails!

Super Study plan packages include ALL VERSIONS A,B,C.

Originally, we prepared plans for this design because a few customers lengthened the Spray 33 to get extra room and in some cases desired a centre cockpit arrangement. After some of these stretched boats were completed we were able to determine that this design would work quite well, so we decided to prepare a complete set of plans for the Spray 36 for construction in either fiberglass, steel or wood/epoxy.

Swedish *Spray*

On one of my first visits to Europe, I went to Sweden and I stayed with Sven Pettersen who was my agent at that time; now retired. Many of our designs were and continue to be built in Sweden, including many Sprays of varying sizes. Some were built at Sven Pettersen's factory at Kelmar, and others were built by individuals and various professional boatbuilders throughout Sweden. One of the first boats I had the opportunity to see was the Spray that was being built by Christos Athanasopoulous, a Greek professional jazz piano player who lived in Stockholm. First, Christos built a model of the boat he intended to build. The pilot house followed the typical Scandinavian styling and he blended this in with other features of the Spray 36. The whole worked out very well and we later incorporated the arrangement into the standard plans. When I visited Christos Athanasopoulous' s boat, the hull, decks and superstructure were completed and work had just started on the interior. Christos was very proud of what he had achieved to date. About two years later a letter arrived from Christos:

Spray built by Christos Athanasopoulous, a Greek professional jazz piano player.

> 'You perhaps have been wondering if I will show up again. Well, here I am, after four years of building my Spray 36, and all in my spare time. I was able to launch her at the beginning of last summer. I named her *Spray* and have enjoyed cruising in the Archipelago around Stockholm. She is just a wonderful boat. She is still unfinished in some details, like the decorative painting, the teak trim on deck, etc. Inside, though, she is just about complete. I have altered the interior, as you can see in the photos; her great space inside gives a home-like feeling.
>
> Unfortunately, I cannot say much about her performance under sail, simply because I have not had her rigged until now. However, the spars are now ready, although there is

no chance of enjoying sailing as the boat is laid up for the winter. I can say a little about her motoring abilities, though. I have installed a Kabota 6 cylinder diesel, developing 58hp, and 2600 rpm. My first propeller, which was 19in x 13in [482 x 330mm] was giving 5 knots at an idle speed of 800 rpm. By that time, my optimistic waterline was disappearing under water as she was weighing 26455 lb [12000 kg], so I took her up on the land for a new antifouling job and changed the propeller to another that is 19in x 10in [482 x 305mm]. It was at that time I discovered the rudder was full of water due to bad welding, so repairs took place at that time. I managed also to fit a greaser to the rudder stock for easier turning of the wheel. Motoring now at 1400 rpm gives a good 6 knots and 7 knots at 1700 rpm, still having plenty of margin for adverse conditions. Maximum speed so far is 9 knots at 2400 rpm. I very much appreciate your time spent helping me, mostly for my peace of mind.

From the above, you can see how important it is to fit the correct propeller to your boat: 1in [25mm] in pitch can make a lot of difference, and even after having calculated and recommended hundreds of propeller sizes over the years, think trial and error seems to be the only way to get the perfect propeller combination. This can be expensive if the error is too great, as the propeller has to be changed rather than altered. Even with computer aided design, we still cannot guarantee a perfect match every time.

It was another two years before I heard from Christos Athanasopoulous again, the letter was from Athens: 'I arrived in the port of Athens at the end of last summer. *Spray* has proved to be a marvelous boat. She is now under Greek flag ready to be chartered. Finally, he wrote 'she is stable, like a rock, large and strong. She gave me many thousands of hours of pleasure in return for the time I took to build her. I have now sold *Spray* and I will miss her a lot.

Hopeful

See photo of Hopeful on left. This steel Spray 36 belongs to James and Joan Moysey, who purchased their plans when we were exhibiting at the Newport, Rhode Island, Boat Show. We heard nothing from them for two or three years, but then we received news that they were having the hull, deck and superstructure built by a professional builder. Shortly after this, we received regular progress reports:

'*Hopeful* has been launched and christened. The keel was laid in 1981 in Gulfport, Mississippi, by Ray Merrell and his sons. They constructed the hull including decks, engine formers, prop. tube, rudder, window and port light cut-outs. She was flame sprayed, zinc and primed when I received her by truck on 10 October 1981 at my residence in Grangeville, New York.

I was working full time, and during the next five years not much progress was made. I took early retirement, and in October 1988 I shipped her back to Ray Merrell, who was now located in Pass Christian, Mississippi. My wife Joan and I had put our home of 26 years on the market. We followed closely behind *Hopeful* and moved south to enter another phase of our lives. In Mississippi I worked full time on the boat, and received direction and encouragement from Ray and his sons.

Hopeful was launched on 29 June 1992 at Misc Marine in Gulfport, Mississippi. After a week of sea trials, James and John motored her over to Florida via the Intercoastal Waterway to Hernando Beach on the west coast of Florida. *Hopeful* was not rigged at that stage, but she was at their dock in their back/front yard. James said: 'If you thought I worked slowly up to this point, I really slowed down. Finally on 13 June 1993 the mast was raised with the help of four others plus myself. When it came to raising the mast, it went very smoothly and was completely uneventful. After a last-minute clean-up and some accessory additions, it seemed like time to have a christening.' This was held in October 1993. *Hopeful* has now been sailed, but not yet fully trialed. James is very pleased with the way his vessel has turned out and has received excellent reviews from everyone who has been aboard.

It is amazing how some builders can build a complete boat from scratch on their own in one year, when another builder will take up to ten years to fit out a hull. When I first became interested in boats some thirty years ago, I used to marvel at the various boatbuilding projects around Brisbane, which seemed to take for ever to complete. My own first boat, a 28ft [8.53m] sailboat, was built in under a year; however my neighbour Bill Haslet took about eight years to build a 30ft [9.14m] planked motor sailer. Bill has now had that boat for about twenty-two years.

ABOVE Hopeful - *some photos of this attractive Spray 36*

Hopeful - it is interesting to the difference a new color will make to any boat !

FAIZARK is a Spray 36 was built in steel by Paul Fay, who has gone on to become a professional boatbuilder. To quote Paul:

> ‘Before building our Roberts Spray 36 in steel, I read Jim Mellor’s articles in the English boating magazine *Practical Boat Owner.* I read these articles very carefully, and bought a copy of Mike Pratt’s *Own a Steel Boat.* I also read every book in the local library on boatbuilding, regardless of the type of material it was referring to. We found that useful information on general methods of building could be learned from all of them. We bought a copy of *Boat World,* which is a wonderful annual publication listing all of the manufacturers of marine parts in the UK. Over a period of about two months, we used it to find the makers of most of the items we would need to fit out our boat. We then wrote almost 300 letters (not all at once), asking for details and prices. Savings made here allowed us to spend more on other things. The best example of this were anchors and chain, which were bought at half the normal price. We also saved money by regularly visiting various second-hand dealers and going to marine auctions.

Paul and Fay his family and friends built the hull themselves, though they did need help in carrying the 5 tons [5080 kg] of steel from the delivery truck to the garden. The cost of the hull was ,4100, and this included the deck and cabin, and four steel bulkheads, two water tanks and a diesel fuel tank, as well as the welding rods, grinding discs and gas used for cutting. They bought several tools that the average handyman probably wouldn’t have, like a grinder, oxyacetylene cutter and some smaller hand tools. The price of ,4000 for the hull included the cost of grit blasting and painting. The paint scheme is epoxy tar for the inside and outside up to deck level, and then epoxy resin over the deck. Regarding the rig, they bought a Sitka spruce tree for the mast, which needed to be left to season and then planed down to shape. The rigging wire is completely galvanized, except for two forestays. These need to be stainless, otherwise the sail hanks would quickly wear away the galvanizing. They made all the mast fittings themselves, except for the blocks and rigging screws, and then had all the fittings galvanized. All the running rigging is 2in [12mm], which should be obtainable at a discount price if bought by the reel. (Regarding making your own fittings, if you are capable of welding up a steel boat, you are certainly capable of making all the fittings that are needed to complete the project, and it is worth remarking again that with a boat like the Spray, she looks best if the fittings have that slightly rugged commercial or handmade look. A Spray looks all wrong when she is glossily finished and fitted out with all off-the-shelf gear and equipment. It is best if some of the vessel's workboat heritage shows through.)

Paul Fay's original estimate of how much the boat would cost to build was ,9500, with only the cost of grit blasting and painting to be added. Nevertheless, they added ,3500 for luck to make a total of ,13000. In the event, the total cost will probably rise to nearly ,1000 above this because they have added to their original specification. For example, having bought a few windows from the auction, they decided that the overall appearance of the boat would be enhanced if the rest matched. They also bought a radio after being lectured by a coastguard friend.

FAIZARK *anchored off the wild Cornwall coast.*

Paul wrote:

'For anyone who would like to build a boat of this size, but cannot afford that sort of money, don't be put off. I am convinced that an amateur who is prepared to spend more time making things himself can build a strong, seaworthy boat about 35ft-40ft [10.6 -12.1m] for about ,10000, especially if he has bought a set of Bruce Roberts's plans, which are full of money saving ideas. We bought ours long before we were ready to build. After studying the plans thoroughly, we wrote to 20 steel stockholders asking for quotes 'to include delivery for the 5 tons [5080 kg] of steel we needed'. This is one area where great savings can be made, by buying as much as possible in one go. When we received all the quotes, we were amazed to find that they varied from ,1700 to ,2250. Our local stockholders were some of the most expensive, so our steel came all the way from the Midlands to the West Country and was still ,500 cheaper than we could buy it round the corner. As you may have realized, we don't have a bottomless pocket. Like most amateur boatbuilders, we have to watch the pennies very carefully, so for those of you thinking of doing something similar, we have quoted figures that are applicable to the early 1980s. Of course, prices will change, but if you just add in something for inflation, you should be able to come up with an estimate that is fairly close.

Faizark' s engine is a 4 cylinder, 42 hp Volvo Penta with a propeller bought from a second-hand dealer. They bought a new stern tube and shaft. They have three anchors, 240ft [73.1m] of chain, two anchor warps and a very pretty anchor winch, which Paul doesn't believe will last very long. There are six sheet winches, all of which were bought second-hand. The reason for the number of winches is because they believe that the weakest member of the crew should be able to handle the boat. Paul says that plenty of mechanical advantages are needed but that the rest of the deck fittings were made by them and then galvanized.' As you can see from this list the basic boat, in what can be called sail away trim, can be built quite cheaply,' he said.

Faizark was launched on 22 June 1983 into the river at Bideford, Devon, UK and despite the slight change I made to the design, she floated dead level, about 22in [60mm] higher than the design waterline (its always nice to have some waterline to spare !). Paul reports being extremely pleased with the way she handles and the speed achieved even in light winds. She is very stiff, and even though there is more ballast to add, she has proved very comfortable to sail in. Apparently she punches through the horrible Bristol Channel chop, like a dream. As the photo shows, the deck layout has been altered by taking the poop stern 5ft [1.5m] forward, and the deck used as cockpit seats, with simply a coaming around the cockpit. There is full headroom throughout the boat. She certainly has as much accommodation as most 45ft [13.7m] boats. The engine is under the cockpit well, there is plenty of room to move about.

Paul Fay and his family have extensively cruised their Spray 36 and some of their experiences were chronicled in letters and phone calls:

> 'We left Bideford on 5 September bound for Spain across Biscay. The first night going down the Cornish coast we averaged 5 knots, rounding the end of Cornwall next morning. Then we crossed the Western Approaches. The wind fell light until we were totally becalmed for the next night. The following day we moored for a while until a little wind came. After this, only the log can tell the story, as the wind increased to force 7, quickly going from south-west to north-west, causing a very confused sea that impeded our sailing. Later, the wind swung back to the south-west, and increased to a force 8 for a while, but this time the seas were more regular; and, under deep-reefed main and staysail *Faizark* worked up to windward magnificently, giving us great confidence if ever we get caught on a lee shore. During all of this, the only water we had on deck was when going to windward, when she occasionally scooped up a dollop along the bows. After this, we were again becalmed, eventually moping for 100 miles [161km]. The last night was really grand sailing, with winds of force 6 on the beam; we arrived at La Coruna on the 12th, which seems a long time for this distance, but speaking to others who crossed at the same time, it seems we did very well.

Since then, Paul and his family have taken a slow cruise down the coast of Spain and Portugal. At the moment they are in Lisbon, and the next stop is the Canaries. In every port they arrive at, *Faizark* causes quite a stir: 'There are always several people who come up to us with the expression "She's a Spray ,isn't she?" We have met a Norwegian who has a deep keel yacht in steel. He has problems with water coming into his boat, and when I took a look I found that his skeg was falling off, so between us we dried his boat out and did a major repair on the beach in Lisbon. After getting to know *Faizark* well, our Norwegian friend is interested in owning a Spray of his own, so perhaps you will send me some information that I can pass on.'

Paul’s comments about the Spray working to windward were later confirmed during several conversations. The addition of a slightly deeper keel on some Sprays makes a world of difference to their windward ability. This has also been backed up by comments of many other Spray owners including Charlie Jupp, who added about 1ft [305mm] to the draft of his Spray 40, and also by owners of some of the older Sprays that were built in the 1930s, 1940s and 1950s many of which also had slightly more draft than the original *Spray*. With our smaller Spray designs, that is, the ones smaller than the normal full-size Spray 40, we always design in a little more depth of keel. This seems to have greatly improved the windward performance of these boats.

Paul also has some other useful information to pass on:

> ‘After our recent crossing we decided to try a square sail, so we cut down a piece of parachute that we had used as a spinnaker and made it from that. It sits right at the top of the mast. So far, for downwind work we have set twin headsails and the square sail above them. I have been so impressed with it that any boat I have in the future will have to have a rig designed to carry one properly, i.e. swept-back crosstrees, etc. Although ours is only 180sq ft [16.7sq m] it is much more powerful than a jib at 250sq ft [23.2sq m]. Using it on the trip from St Barts to here, we averaged 5 knots, and the only boats that passed us were a couple of large Swan, and they were motoring.
> We well understand why the Spray is so popular, as we have found her to be fantastically comfortable in any type of sea, even running before a bad storm, which another yacht equipped with accurate wind instruments reported as force 10 for a while. I went to sleep on the cockpit floor. On top of all that she still punches up to windward when everyone else is hove-to.’

Paul Fay subsequently returned to Devon in the UK, where he built a steel Roberts 345 that was sold, and then, pleased with the success and profits he had made from previous boatbuilding ventures, decided to become a full-time steel boatbuilder. Paul has recently completed a steel Spray 33 that is mentioned later. As for *Faizark,* this Spray 36 was sold to an Australian, who sailed it home to Brisbane, Queensland, and this vessel is now happily cruising the Australian coast.

Hornicke Spray

Recently, a large package popped through my letter box from Hans-Jurgen Hornicke of Vasteras, Sweden. This package contained a beautifully presented set of photographs covering the entire building process of Hans’s fiberglass Spray 36. To quote Hans:

‘I started to build my Spray 36 at Christmas time in 1988. I started by making the frames in May 1989, and by 27 July I had completed all the fiberglass. I then began to fair the outside of the hull, and the turning over was a happy day because for the first time I can see the whole hull, and it is beautiful. The same time as I built the hull, I made many items, including blocks, mast fittings, rudder, pedestal steering and the wheel, and many other items. I work on the boat every Tuesday and Thursday after my ordinary work is complete. I am a glass blower for neon lights. I also work on the boat on Saturdays for a full day.

Another thing of interest was that I had to attach the foam myself without any assistance, so I used pipe cleaners that I bent into a U-shape and inserted through the foam so that each side of the U was each side of a batten. I then twitched the pipe cleaners together from inside the mould. The whole thing worked beautifully. The pipe cleaners are very kind to the polyurethane sheets, and there's very little risk of drawing them right through the foam. Finally, I hope you can understand most of this letter for my English is not good..

PHOTOS . On left, below and following pages of Hans Jurgen Hornicke's **Spray 36**

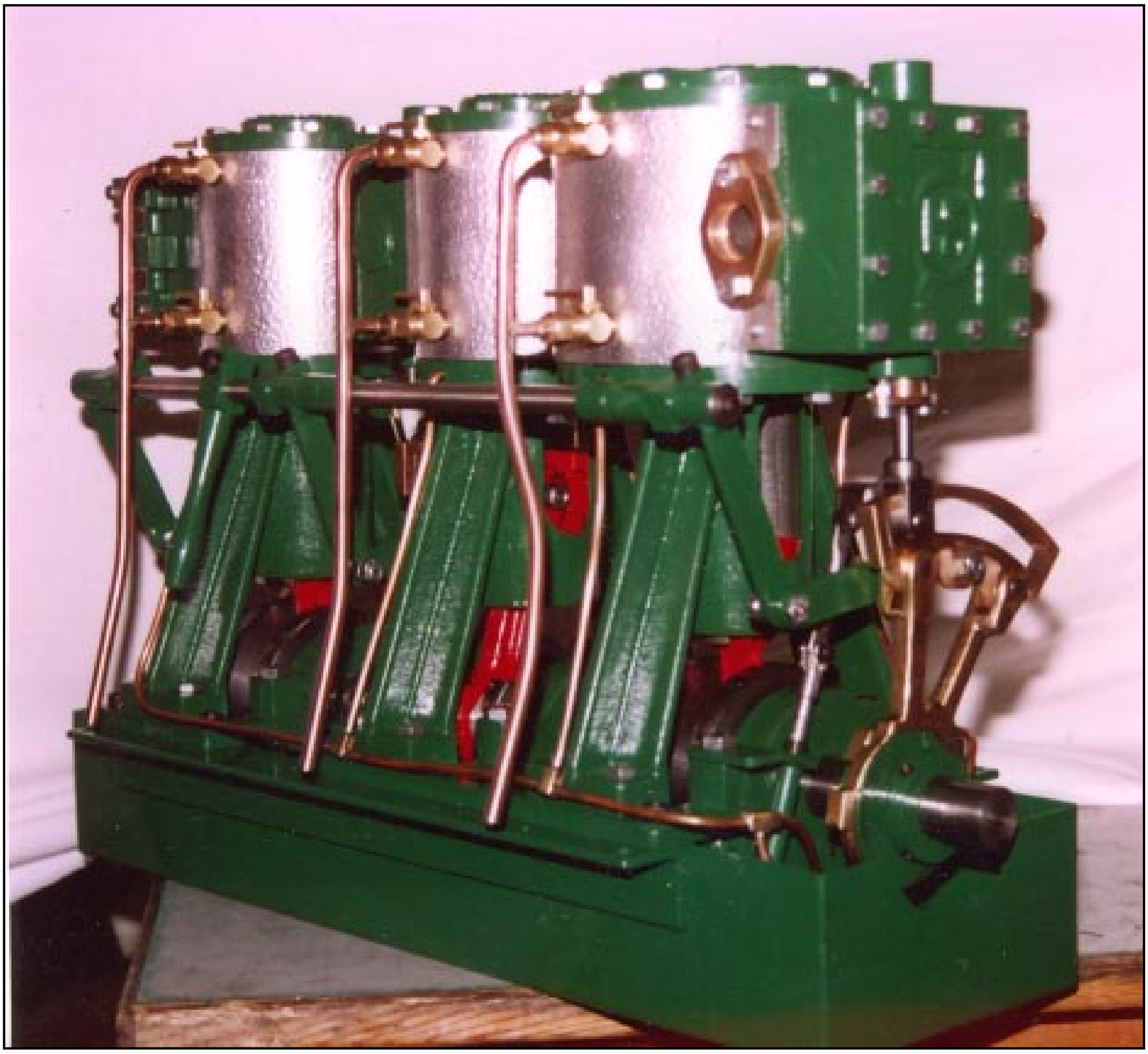
PHOTOS on above and below are of *Hans Jurgen Hornicke's* Spray 36

Steam Lady
For many years, Goran Kjerrman in Gavle, Sweden, thought about building a Spray. He had read Slocum's book, and he wanted to combine sails and steam power because his two big interests in life are sailing and steam engines. Of course, the combination of sails and steam is a very old idea; when Slocum decided to sail around the world, the steam engine was then very modern and also becoming very common. Goran decided to build a Spray 36, fitted with a steam engine auxiliary. He considered that this boat had all of the features to be a good sailor, and he thought the boat very beautiful. When people hear the words 'steam engine', it often conjures up thoughts about coal dust, soot and smoke, and a stoker shoveling coal in the front of a hot boiler.

However this is not necessary with a small, modern steam engine. In Nkyvarn in Sweden there is a small factory that specializes in building small steam engines; most of these are custom built. This factory, HF-Maskiner, was able to build Goran's steam engine just as he wanted it. It is a triple expansion engine working at a steam pressure of 426 lb/in 2 [30 kp/cm2] . The engine weight excluding the boiler, but including feed pump and lubricator is about 1322 lb [600 kg]. The engine develops 54hp, and the maximum number of revolutions is 400 rpm.

The diameter of the high-pressure cylinder is 3in [76mm] medium-pressure cylinder 5in [132mm], and the low-pressure cylinder, 9in [228mm]. Goran Kjerrman,is a licensed welder, and he made the boiler himself. He started with a water tube boiler, but this type took up a great deal of room and he soon changed his mind and made another one, a small fire tube one, very like the famous Scotch Steam Ship boiler.

Goran Kjerrman *and his partner resting after a good days work on* Steam Lady.



To this boiler he adapted a super heater, a feed water heater, a condenser and an evaporator for the production of drinking water from sea water. The boiler has a diesel oil burner, but it can also fire the boiler with coal or wood. The weight of the boiler and steam engine together is about 2645 lb [1200 kg]. Goran has insulated the boat for living aboard in all seasons, and the whole interior is fitted out with oak. The entire vessel is a masterpiece, and perhaps this *Steam Lady* is the only steam engine Spray in the world.

Lady Hawk

This Spray 36 was built by Paul and Pamela Hawkins of Palatine Bridge, New York:

> ‘Our Spray 36 took us eight summers of weekends to complete. We might have been able to build the entire boat in less than 16 months if we had worked on it full time. We enjoy the boat very much, and can’t believe just how much boat we have until we compare it to O’Days and Hunters of the same length owned by our friends. The overall performance of the boat is outstanding. She easily handles 20 knots of wind under full main, and 150 per cent Genoa. In 25 knots we routinely set the staysail and full main. On Lake Ontario we have 5ft [1.5m] waves and our friends are amazed at how well she handles these. The only changes that we would recommend are a larger diesel, around 45hp, a 6ft [.8m] cockpit, and a 3ft 6in [1.1m] wide cockpit sole, to give better clearance around the wheel.

Regarding cockpit sizes, it is always something of a decision as to what width your cockpit should be. If you have it too wide, then you cannot sit on one seat and rest your feet on the edge of the opposite seat, which is a common position for people sitting in a cockpit especially when there is any reasonable heel on the boat. Another thing is if the cockpit is too wide and too deep, it will hold too much water in the unlikely event that you ‘cop a big one’, either over the bow or stern. Generally speaking, we design our cockpits to be 2ft 6in wide [760mm] and about 1ft 6in [460mm] deep. If a cockpit is too deep, it can be uncomfortable to sit in. If you build a cockpit about 1ft 6in deep [460mm], then by the time you add a teak grating or other similar arrangement, it works out just fine. As far as making a cockpit wide enough to accommodate the wheel is concerned, quite often the seats are scooped out in the area where the wheel is actually located; in that way, there is room for the wheel to be located at the correct height and still clear the cockpit seats, and the temptation making the cockpit too wide is avoided. As far as cockpit length is concerned, the ideal is around 6ft 6in [2m] long. This allows the average person to stretch out full length on a cockpit seat, and this can have the added benefit that the seat can be used as a berth when in port in a very hot climate, thus allowing at least two of the crew to sleep comfortably on deck.

Silent Annie

This Spray 36 was built by Tony Nelson, who has made a particularly fine job of the interior; so much so, in fact that an English yachting magazine is expected to run an article on the fitting out of this boat. Some of the features of the interior include bulkhead doors fitted with stained glass panels showing east coast smacks, and a hand-carved rose on the seat end, the saloon table with 1/4in [6mm] beading and 15in [380mm] diameter compass rose inlaid in the surface. All of the galley posts and fiddle rails are hand turned, with beautiful hand-made mahogany cupboard doors and drawers. Other cupboards feature leaded doors, which gives the interior of the main saloon a beautiful hand crafted appearance.
Tony says:

> ‘What I am trying to do is to build a classic boat that will not die as so many yachts do in ten or so years, but one that will last for many, many years. Regarding the paint job, outside I have used two coats of zinc-enriched epoxy, plus two coats of primer. Inside, one coat of winter grade epoxy, plus three coats of Admer self-healing paint, plus of course the 2in [50mm] foam insulation. All interior cladding is coated with primer on the reverse side. The two stainless steel water tanks are 68 gallons each and situated under the saloon floor. The keel is filled with steel punching, plus a welded plate over the top, and then filled with cutting oil to stop rust. The engine is an 87 hp Ford diesel with a 2:1 reduction.

Hazebra Pride and Hazebra Lady.

Paul Francis first purchased *Hazebra Lady* a fiberglass Spray 33 built by Jack Read. After sailing this boat for some time, he decided he wanted a larger boat and commissioned Jack to build this steel Spray 36. Paul said: ‘I sold *Hazebra Lady* in 1989 to Mike Ambrose, who, although having only limited experience, bought it to sail to Chesapeake Bay, Maryland, USA. Details of Mike’s trip are given under the *Hazebra Lady* heading in Chapter 9. Paul wrote:

> ‘*Hazebra Lady* is extremely sea kindly, very gentle and predictable; she allows you to get away with mistakes. We sailed her for three years with many North Sea crossings covering approximately 5000 miles without a moment’s worry.
> Our second Spray, *Hazebra Pride* the 36ft [10.9m] aft cabin version that we have had since August 1989, is owned jointly by my son and myself. To date, we have covered

9000 miles [14483 km] exploring the Ijseelmeer, and Holland in general plus the Belgian and French coasts as well as the east coast of England.

Hazebra Pride is a lovely sea boat, again very safe and sea kindly; it is noticeable we are one of the last to reef down. Our most noteworthy trip was the return journey to the UK from Flushing in October 1990.(Paul related in detail this trip, where the weather forecast of force 4 to 5 turned into a storm with winds in excess of force 9) 'During the crossing in these extreme conditions, *Hazebra Pride* gave us not a moment's worry and all gear stood the strain. We have so much confidence in our Spray we would go anywhere in her.

Paul Francis was the founding Commodore of the Slocum Society (Europe), and took a very active part in the centenary celebrations and other activities associated with the furthering interest in the original *Spray* and her descendants.

Sally Belle

This steel Spray 36 was built by John Osborne, who decided to build her after he had been coerced into doing so by his friend David Sinnett-Jones. David, as you will read later, had decided to build his own Spray, so it seemed like a good idea for the two hulls to be built side by side. David Sinnett-Jones's first task was to persuade his wife, into accepting the idea of his building two steel hulls on the concrete yard outside their disused cowsheds, and much easier task was coercing his old friend John Osborne into building one of the hulls for himself while they helped each other in the construction. John Osborne completed his Spray 36 *Sally Belle,* and launched her, and she now sits snugly in Aberaeron harbour in Wales. John gets a lot of enjoyment from his boat and uses her for coastal cruising. He contacted me with the following comments:

> 'I enclose a photo of *Sally Belle* high and dry, but sitting nicely on her legs in the Cardigan estuary. I am very pleased with the way *Sally Belle* sails. On the way back from the Cardigan trip I sailed back with only the staysail set in a rolling sea, doing 52 to 62 knots. Smashing! On another trip last year we did it all to windward quite a crashing sail. But I also enjoy peaceful sails and I like the way *Sally Belle* keeps going in light airs down to about 2 knots.

Many Spray owners have remarked on their boat's ability to keep going in the lightest of airs. Not all sailing (fortunately) is done under gale conditions, so it is important to have a cruising boat that handles the light stuff as well as the roughest conditions.

Zane Spray

As mentioned above, *Zane Spray* was built in company with *Sally Belle* for it is quite common for two builders to get together and build boats side by side. In fact, we have seen several brothers build similar boats, father and son, or perhaps two friends or neighbours, or sometimes more than two people with shared interest who want to share the companionship of undertaking a similar project at the same time.

David Sinnett-Jones had a rather special reason to want to build his boat with some help, as he writes:

> 'I had been diagnosed as having advanced lung cancer and had to have urgent major surgery to remove one of my lungs and part of the wall of my heart. Luckily, a few months earlier I had taken up sub-aqua diving and my doctor had spotted the problem when I went for a medical check-up and X-ray. Twenty years before that, in my motor racing days, I was blinded in the right eye on being thrown through the windscreen of a car, and now -at the age of 53 -, was getting a bit stiff in the bones. Some of the worst things that have happened in my life have led the way to some of the most exciting ones. I would never have started sailing if I hadn't had cancer, nor farming if I hadn't been in and out of Sir Archibald McIndoe's guinea pig ward, having eye operations and 75 stitches in my face. McIndoe was a pioneer in skin grafting and plastic surgery during the Second World War, treating most of the Royal Air Force pilots who had severe burns; and when I was in there, the ward still had a very relaxed attitude towards the patients.

Right from the outset of building their boats, John Osborne and David Sinnett-Jones were looking to, build the boats for as little money as possible; and, with this end in mind, they used an old steel-framed harvest trailer on which to set up the frames. When the hulls were completed, they moved them down to a car park by the harbour. The idea was that they were going to have their yachts lifted into the water when the rest of the yachtsmen were having theirs lifted out at the end of the season -, another example of taking the most economical route. Regarding the masts, John and David found some clear knot free Douglas fir in a timber yard that was about to go bankrupt, and for ,350 they bought enough timber to build the masts and the booms as well. *Zane Spray* features a centre cockpit layout with a small pilot house and is cutter rigged. The auxiliary is a Massey Ferguson 165 tractor engine that David marinized using second-hand parts. His idea of using the Massey was that he figured that wherever he might go in the world, he would be bound to find one in the corner of a field. John and David made their own sails, and in all they made three sails for each boat, but no spares. However, David was to take a roll of cloth and an electric zig-zag sewing machine with him on his round-the-world voyage. He was fortunate in that John was a good friend and actually stopped work on his own boat so that he could help David for the six months before he was due to leave on his voyage. David comments on this by saying, 'This was a great sacrifice, as he wanted to see *Sally Bell*e sailing, but perhaps he knew that once I had gone, he would get a bit of peace and quiet'
When once *Zane Spray* was complete she was taken for a trial sail, and again I quote David's words:

> 'Once at sea, we stopped the engine and unfurled the staysail in easy stages and half the main. She picked up speed straight away in the stiff, south-west wind. We put out more sail until we had all 1000 sq ft [92.9 sq m] up, and she raced along, throwing spray into the air, and the lee scuppers in foaming water. We took turns at the wheel, each one of us hogging it as long as we could. As we trimmed the sail ,she got up to 7 knots and then 7.5. We were overjoyed with our work. The boat was good, fast and strong -, old Joshua would have been pleased with us!

Can you imagine the joy of these two friends out for a sail on the first of the two boats they were building, and to have the boat perform as they had hoped. Both would have been equally overjoyed. David Sinnett-Jones was fortunate. His friendly open-handed manner and his lifelong habit of easily making friends, including the period that he spent racing cars, came to fruition when many people offered to sponsor him and his boat. They offered various pieces of equipment that otherwise would have cost him a considerable amount of money. Not only did friends from the past act in this way, but often complete strangers would come up, introduce themselves to David, and take an interest in the project; this led to various sponsorships and donations of gear and equipment. David also had a friend called Eric Williams, who is a *HAM* radio operator and had also worked with him on previous voyages. He found David a very reasonably priced transceiver that would do nicely for the trip. Originally, David had not planned a single-handed voyage; however, one by one, the people who had planned to accompany him on various stages of the cruise became unavailable for one reason or another.

Another lucky break for David was when he met Phil Davies, known locally as 'Phil Photo'; Phil takes HTV news film and stills for the newspapers. As the media had previously given David good coverage, he thought that he would ask Phil if HTV might be interested in David sending back news reports on the voyage. The idea was to bring in some money. Phil suggested that David should go and see the opera singer Sir Geraint Evans, who lives in Aberaeron and is on the board of HTV. The upshot of all this was that HTV eventually worked out an excellent sponsorship arrangement with David, whereby David was to make a film of his voyage that would be sent back and screened on HTV. All of this worked out very well. HTV got some very interesting and exciting film, and David secured very worthwhile sponsorship.

On 17 September 1985, exactly three years to the day from the time David Sinnett-Jones had arrived home in his previous boat, *Zane* II, he motored out of the harbour and set sail on his great adventure. David completed his circumnavigation, and on his return to Wales he was feted. He received a considerable amount of press coverage, not only from HTV who had in part sponsored the trip, but also from the local newspapers.

David's single-handed voyage would have been a magnificent achievement for an able bodied person, but even more so for someone who has lost both a lung, and the sight of one eye. David has approached HTV to allow him to use the film in the form of a video, which will be available to other Spray enthusiasts. Sailing round the world single-handed is not a first for mankind, but an amazing achievement for someone with David's disabilities.

When asked to comment on the most memorable part of his trip, David chose Percy Island off Australia, a perfect tropical island that is kept by a former triathlon Englishman for the benefit of passing sailors. Well, one would think that was enough adventuring for one man -. Not so with David Sinnett-Jones.

In June 1992, at the age of 62, David took care of another ambition when he started in the single-handed Trans-Atlantic Race, currently known as the Europe One Star. *Zane Spray* has been given a new rig and suit of North headsails, and David was overjoyed to cross the line in Newport, Rhode Island, USA, in 40 days. This is the same time that Francis Chichester had taken to win the inaugural race in 1960. David is now living in a waterfront cottage in Aberaeron, Wales; and his book *Not All Plain Sailing* has been completed and published along with another book covering his voyages prior to building *Zane Spray.* According to David, says his sailing days are still not yet over.

Because David Sinnett-Jones is a very friendly and generous person, he has offered to pass on advice to those interested in learning more about the Spray and her sailing qualities, and other aspects of preparing for and executing world cruises. Some of this can of course be found in his book *Not All Plain Sailing;* however, he is more than happy to talk to anybody who is interested in the subject of the Spray and cruising in general.

John Henry

Mark J Tompkins of Tolono, Illinois, USA was building a steel Spray in 1991. He used the table of offsets to lay up full scale the frames for the hull, deck and cabin top. He also wanted an aft cockpit with a long and cosy cabin. He was planning to build the mast and boom from two flagpoles, one 35ft [10.6m] and one 30ft [9.1m] donated from two local McDonald's restaurants, I promised to take them sailing!

We know of many cases where various aluminum poles have been turned into masts. One was Tom Corkhill, who sailed his catamaran *Ninetails* around the world. *Ninetails* has covered many additional thousands of miles on trips between Australia, Indonesia and so forth. Tom built his catamaran at our Brisbane boatyard way back in 1967, and he is still sailing the same boat. He rigged his cat with a light pole mast, and to my knowledge it is still in service. People have used a complete assortment of items as masts, from cutting down a tree, through to light poles and flagpoles, and of course purchasing a complete ready-made, custom-built, aluminum spar with all the goodies.

Nascimento Spray

In July 1991 Edison Do Nascimento wrote:

> 'I bought a plan of your Spray 36 in 1987 when I was living in San Jose, California. I ordered the multi-chine plywood plan, but with the full-size patterns for fiberglass because I will build the boat in round-bilge, cold-moulded construction. Today I am living in Campinas, Brazil. I built a temporary shed and bought the necessary timber to build the boat. I am now starting to build a Spray model in the same scale of drawings as the plans, 2in = 1ft. [1=24].
>
> Here in Brazil the economic situation doesn't feel nice, and the boat construction is stopped for a while. Two years ago, a very hard storm destroyed my temporary shed just when I had started to put the frames on the strong back. The frames were saved, but I had to build the shed again. This time I'm trying to sell my powerboat to get back on the Spray construction. As you know, whoever buys a Spray plan is a dreamer, and as a dreamer we will never give up.

Gypsy Lady

In 1986 Mr. E Marvin Johnson of Salem, Oregon, wrote of his Spray 36: With 7000lb [3175kg] of lead poured into the keel, and a Vetus P 421 engine, she is beginning to show signs of wanting to go to sea, so thought it best to keep her tied up!' The photograph reveals a mooring line from the bollards, through the fairlead, and the boat is secured to a post in the shed. 'You don't have to be crazy to start a project like this, but it helps. She is a fine retirement project and I'm having a lot of fun working on her. I'll call her *Gypsy Lady.*

Sweet Ecstasy

Calvin Ayers of Boyne city, Michigan, USA described the building of his Roberts Spray 36 in steel:

> 'I've been sailing and building sailboats since I was a kid, and after going to sea in the Navy I was hooked. I conducted five years of research before choosing to build a Spray 36 in steel, with the centre cockpit layout, and decided to rig the boat as a cutter. Before I started building her I had maybe 15 minutes of welding experience. Needless to say, 125lb [57kg] of welding rod later, my welding skills have greatly improved. I used the method of building the hull upright, welding the keel to an 'I' beam

set in concrete. The reason for doing this is the cost of wood for framing. I am building this boat on a shoestring, so every dollar spent has to represent a tool or part of the finished boat. The only change in the design I am making is to add freshwater cooling by adding a welded-up box made from T-section about 6in [150mm] deep at its aft end, and when added to the bottom of the keel that will be used as a heat exchanger I am having a ball putting her together!

Alpenglow

Back in the late 1970s the newsletter called *The Steel Yacht* was edited and published in California by Bill Tapia. It was a three-or-four page photocopied publication, which after a few issues grew into something a little more substantial. Unfortunately, this could not be sustained and eventually it went out of business. Bill Tapia had some good ideas, and there was -, and still is - a need for publications of this kind which give the builder and/or cruising yachtsman good hard information. Because of the popularity of steel Spray replicas, they were often featured in the magazine. To quote from one contribution:

> 'Doug Knight of South Lake Tahoe, California, chose the Spray 36 design because he was concerned with having enough living space for long distance cruising. 'I never heard of that fellow called 'Slocum', said Doug, 'until my boat was well under construction. I must have lived a hundred years ago, because when I first saw the hull lines I knew right then and there that the Spray design would be my next boat. In changing the interior layout, Doug Knight moved the cockpit aft, containing the interior to one space. 'In having one main area there will be no problem in heating the cabin in the northern latitudes where my boat *Alpenglow* will spend much of her life. The freeboard on *Alpenglow* was raised 3in [75mm] above the stock plans, and Knight is still thinking about adding an additional 2in [50mm] that will give the bulwark a total height of 9in [230mm]. With the main cabin contained into one area, the bulkheads were changed to suit the rest of the interior. Doug Knight is very enthusiastic about his Spray 36: 'I've always kept privacy in mind, because I could never rule out the possibility of charter service. I plan on having a solid timber mast that will support an enlarged sail plan of the gaff rig. This working sail plan is just that, a working sail plan and not a show piece.

This attractive Spray 36 was recently photographed in the Mediterranean

PRAY 36 PHOTO GALLERY:
Top: Glass Spray 36 built in USA
Second: Spray 36 built by Mr Moss, his son also built one of our boats.

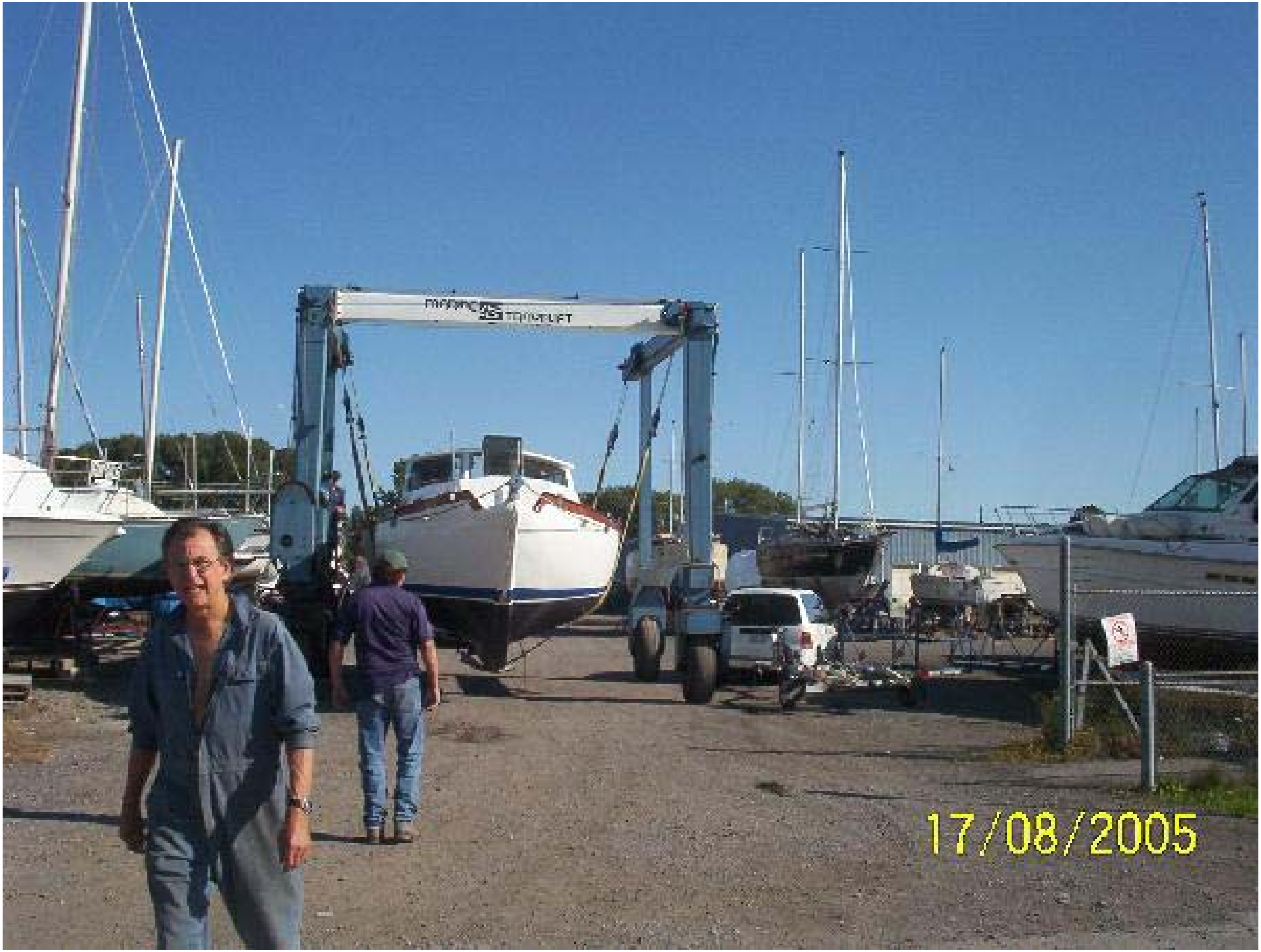
Above: Zane Spray ... David Sinnett-Jones much travelled Spray 36
Right above: German built Spray 36 that I saw in Paris when both of us were moored in the Arsenal Marina just off the Seine.
Right: "Uvea" ... This Spray 36 Seen here sailing off the Loyalties Islands

SEAGOAT

http://www.seagoatonline.com
adam@seagoatonline.com barbara@seagoatonline.com

Almighty God,
who guided Noah in the building of an Ark,
and calmed the raging sea,
we call upon you to bless those who have prepared this boat for service,
and to protect and preserve those who sail in her,
and surround them with your loving care.
I hereby christen this boat the "SeaGoat."

Wednesday the 17 of August 2005 9:20 AM – operation begins.
The SeaGoat is ready for the trip



The SeaGoat is traveling slowly forward the water.

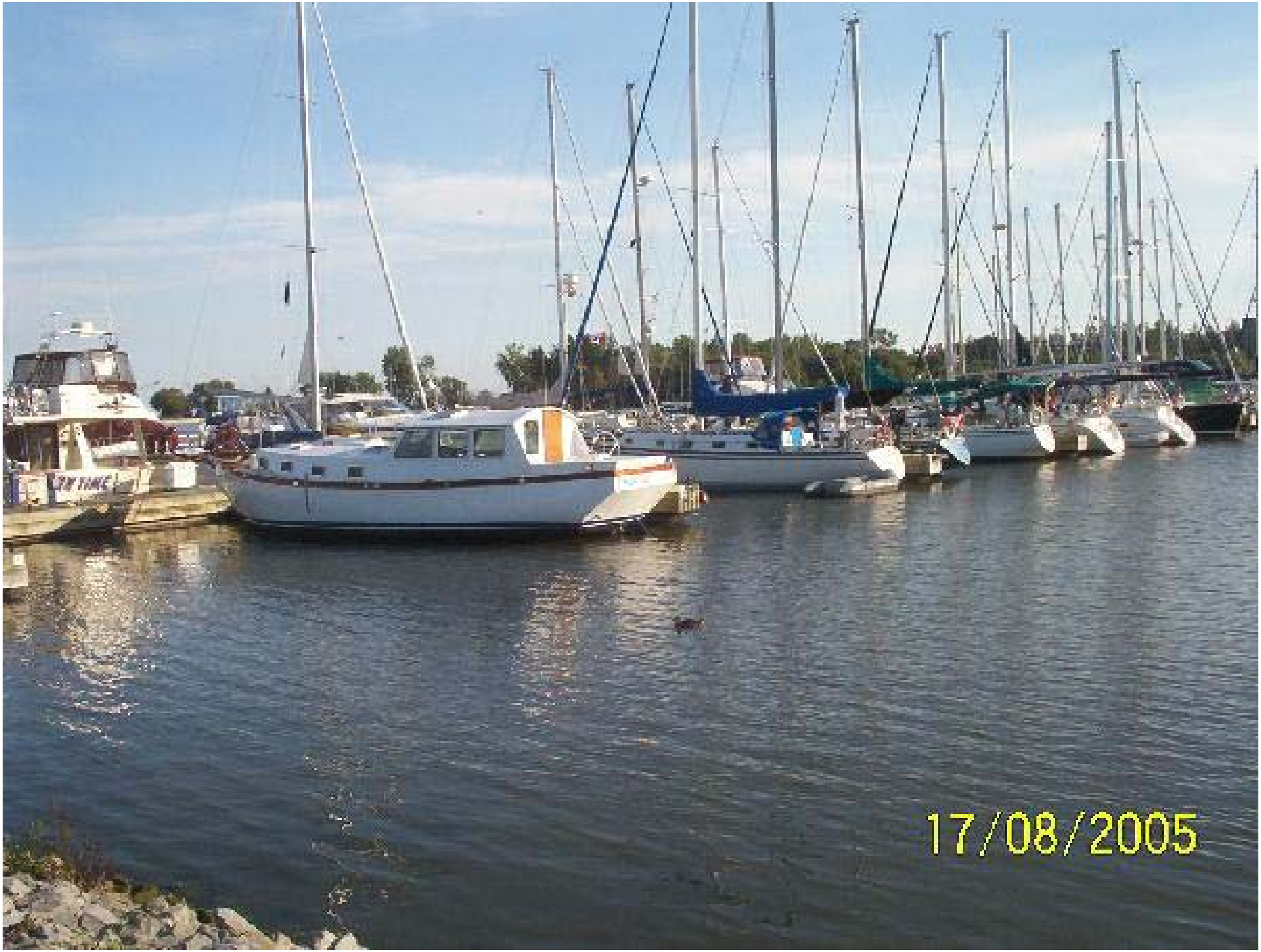
It is 9:55 AM – The SeaGoat is hanging over the water, and waiting for blessing.

Master of the Ceremony – Barbara – is praying- see first page for the text

The bottle of champagne was smashed – the champagne was all over the place – the bowsprit and the fore deck were wet the most.

For the first time the SeaGoat is touching the water – it is 10:05 AM now

Two SeaGoats ☺.



Already docked

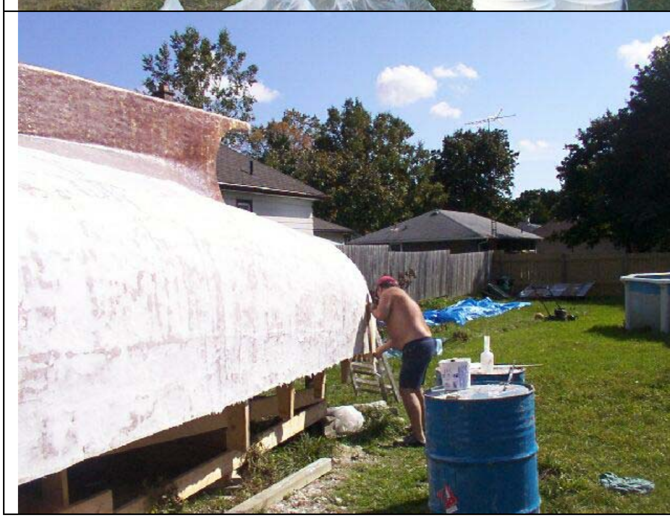
The SeaGoat TimeLine

2001	
November 2001 It is how it started. I've got the plans from Bruce Roberts. With Barbra we discussed what we liked and what we didn't like.	
December 2001 I started working on this project right away – after I got the plans. I started with frames for future mold. The job commenced in our basement.	
December 2001 After the biggest frame was done, we tried to fit ourselves inside. One single frame didn't look so big. I had to start working with half the frame, to manage the assembly out from the basement.	

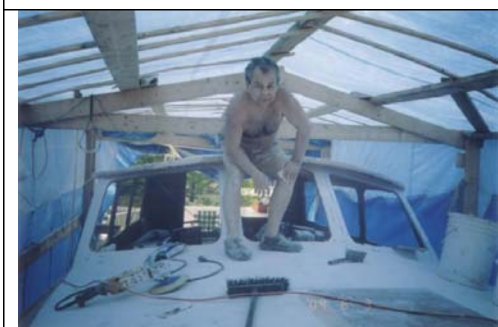
2002

	By the end of January 2002 all frames were done. I put all of them in the garage. I was waiting for Spring, to start building the mold.
	Finally in March I was able to start working with the mold. My shipyard was grounded.
	In April the skeleton was ready. The neighbor next door asked me what kind of green house I'm building.

	In May the mold was almost ready
	June – after working with mold we started working with real boat structures. First we put the Corecell foam. We were so excited, because we started working with serious tasks

	July – it was time to buy fiberglass and the resin, the major two components for the next step. I tried to put all heavy stuff to my van – it wasn't easy, but I did it.
	September – after almost two months the hull was ready. It was really hard time for us. Applying the fiberglass was an unbelievably messy job.
	October – still very hot. I started working with putty and fairing board – I didn't know at that time that it was going to be, a never-ending, very boring job. I didn't know that I would have done that for almost next two years.

2003	
January 2003 – My trip up North to buy the lead for ballast – 8400 lbs	
March 2003 – I started melting the lead – first brick is ready.	
April 2003 – the sanding begins ☹	
June 2003 – The hull was turned over.	

<table>
<tr><td>June 2003 – Now the hull is right side up and we can see how big she is</td><td></td></tr>
<tr><td>August 2003 – first bulkheads have been installed</td><td></td></tr>
<tr><td colspan="2" align="center"><u>2004</u></td></tr>
<tr><td></td><td>June 2004 – working with putty and with structure of the pilothouse.</td></tr>
<tr><td></td><td>July 2004 – the tarp has been removed and everybody can see The SeaGoat now.</td></tr>
</table>

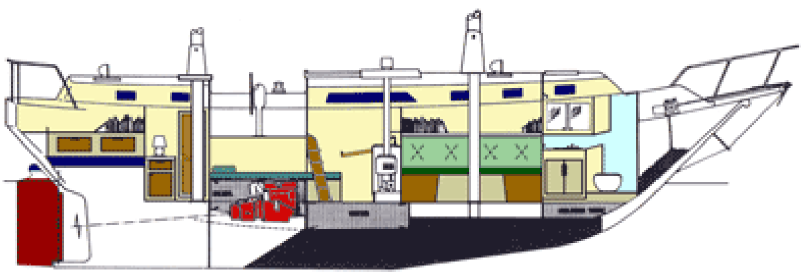
	August 2004 – The SeaGoat had been moved to marina – in one year and one day she is going to be launched.
	September 2004 – more sanding ☹
	December 2004 – Christmas.
<u>2005</u>	
February 2005 – Working in my basement – Barbara is holding a very heavy rudder.	

May 2005 – The SeaGoat has got a lot of hatches.	
June 2005 – new paint – now she looks much nicer. (Date on the picture is wrong – I forgot to change it)	
July 2005 – She got her name – now she is ready for launching.	

Spray 38

Plans and frame patterns are available to build this boat in multi chine steel.

L.O.D.	11.82 m	38' 10"
L.W.L.	9.65 m	31' 8"
BEAM	3.96 m	13' 0"
DRAFT	1.22 m to 1.52 m	4' 0" to 5' 0"
DISPLACEMENT	12946 kg	29,000 lb

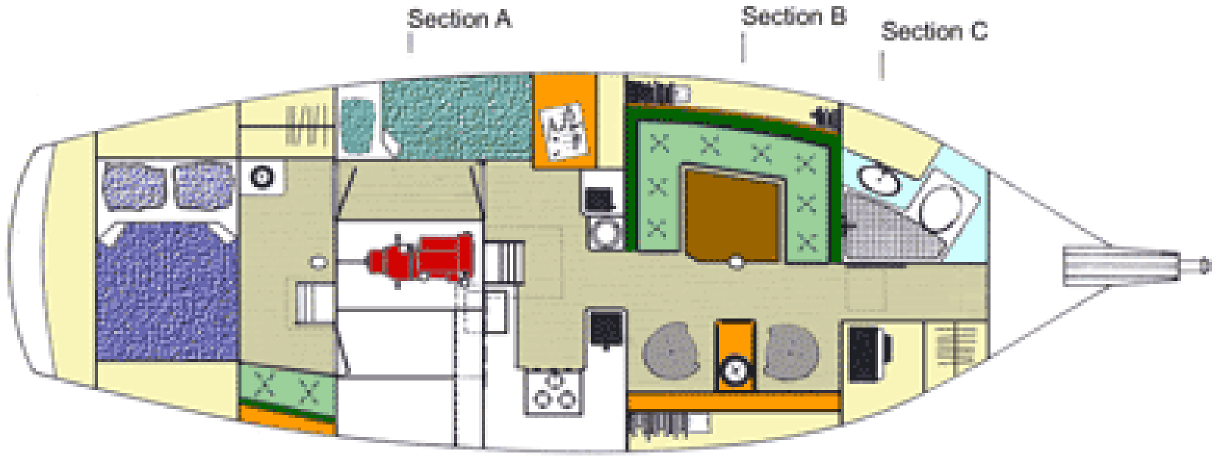


This design was prepared early in 1980 when one customer who had considered the plans for the Roberts Spray 36, felt he wanted a little more room in the aft cabin. In order to attain his wishes, we felt that a new design was called for, and hence the Spray 38 was the result. As this was originally a custom design, and as no other client has come forward requiring a boat to be built in any material other than steel, these plans were only made available in steel. Nevertheless, they have been quite popular, and seem to fill the gap between the Spray 36 and the full-size Spray 40. The Spray 38 also has a limited number of versions available. However, owner/builders have purchased the plans for this design and made their own changes.

RAVEN

This steel Roberts Spray 38 was built by Stuart J D'Arcy-Hyder, who commented:

'For your information, we cut the first steel in May 1988 and moved on board in March 1989. We had our first small cruise last year, 1990. The boat performs superbly. She is by and large true to the Roberts's drawings.



By altering the shape and size of the cockpit, we have a full headroom walk through-arrangement with pilot berth under one coaming. The galley is under the other coaming. We did put on the controversial bilge keels, but have never regretted the decision. The sail plan is altered, the area being increased. She is rigged as a Galios cutter-headed ketch, with square sail on the main. Much easier to handle than a spinnaker, and most attractive. The transom and poop deck shape have been slightly modified and the bow shape has the understated clipper line to it.

Machinery is a 72hp Ford by way of a 2:1 Borg Woerner, and a 23in x 16in [584mm] pitch propeller. Steering is by Servi hydraulic system. *Raven* is amazingly stiff, and in January when we sailed on the back of an easterly gale, my young son painted in the saloon, and not a drop of water was spilled. She is surprisingly fast and responsive. The finished boat cost something over ,25000 including absolutely everything, and was completed in under a year. The fact that I'm in the trade probably helped in both these respects, but none the less, it can be done.

We next heard from Stuart D'Arcy-Hyder in April 1991 when he said:

'I concur with Paul Fay's comments (Paul Fay built and sailed his own Spray 36, and details of his experiences appear in chapter 8) on the square sail being a lifting sail as opposed to the hard pressure of a spinnaker, and yes, keeping the yard tight into the stick is a problem that is still under development. The sheer efficiency of a square sail down wind is quite awe-inspiring to a man used to the more modern fore and aft arrangement. Basically, the route we are working on is as follows; we have aluminum spars, the sail yard is raised up a heavy genoa track fixed to the fore side of the main mast. The fixing of the yard to this track is by way of cannibalized stainless fittings, variously cut and welded together. There is no reefing. The sail is up or it is down. It is controlled by lines that open or close it like theatre curtains. The sail is currently 240sq ft [22.3sq m]. I was also concerned about the extra pressure on the mast, and have added an extra shroud. Our costs were low; for example, our aluminum spars and standing rigging cost only ,350, an insurance write-off. The main and mizzen masts were originally 10ft [3m] longer, keel stepped spars, a crane had driven over their heels, so we cut them off and deck stepped them. As a consequence, our main is 43ft [13m], our mizzen mast is 35ft [10.6m]. We lashed some wheels on the butt ends and towed them home. Why we didn't get stopped by the police still amazes me, we had to physically carry them around the roundabouts!

Our boat is called *Raven.* This year we only anticipate short voyages: the Scillies, Ireland and Brittany. Next year we hope to go to the east coast USA via the West

Indies. I live aboard *Raven,* and I have rigged her for easy single-handed sailing and find her quite manageable. We haven't as yet done any long passages, but we have sailed recently from here to mainland England and up the south coast and across to south Brittany in France.

Stuart supplied us with some details of modifications. He has increased draft to 5ft 6 in [1.6m] overall, and has twin bilge keels of 2in [12mm] plate. The bilge keels and the main keel have full-length sacrificial wooden shoes. The masts and bowsprit are somewhat larger than the original design recommended, thus the sail area is greater. The vessel carries 4 tons [4064kg] of ballast, 200 gal [909 lit] of water, and 120 gal [545 lit] of fuel. *Raven* is a cutter-headed ketch at the present time. This summer Stuart will continue to experiment with the square sail. He says he prefers it to the spinnaker for downwind sailing. He also carries a substantial mizzen staysail, which in the right conditions is a wonderful sail. Stuart told us that the boat balances wonderfully under almost any point of sail: stiff, comfortable and surprisingly fast.

It is our intention to make a centenary celebration circumnavigation, starting in 1995 via Panama. Is anyone else interested? It would be lovely to cruise in company with other Sprays. Our best run was from St Mary, Isles of Scilly, to Falmouth before a south-west force 7, average 8.4 knots, would have been faster but for the turning tide at the Lizard. If you ever get this way, welcome aboard! We are the only live-a boards on the Isles of Scilly, thus locally world famous, or infamous. You have to be slightly mad to live on a boat here in the winter.

Towards the end of March 1994 I again heard from Stuart, when he commented:

> 'You may wonder at the rig I have. This somewhat antiquated vessel actually sails an awful lot better than she looks, like she ought to. A friend built the jib furling sail. He cut it out of different weights of cloth, so that when almost fully furled it is a flying storm jib. This then becomes progressively lighter as it is unfurled for different sizes of jib/genoa. Finally, when fully unfurled a large balloon comes out of the top, giving me a sort of cruising chute/pseudo spinnaker. It is an enormously powerful sail. Whilst running before a gale of wind a couple of years ago, the poor old log kept bending the needle on the pin at 10 knots. We broke our bowsprit, a 6in x 6in [150mm x 150mm] section of Douglas fir. It was only a short thing too, and extended about 4ft 6in [1.3m] out from the stem head. The new one is a bit longer and made of 9in x 8in [230mm x 150mm] section. Originally I was going to have a nice modest gaff rig with tarred rigging and timber spars, all lagged. However things didn't happen that way. I got to hear about those damaged spars that I bought cheap. The engine, twice your recommended size, was another lucky find,17 year old, but had done less than 500 hours. Beautifully maintained too, it was an auxiliary generator engine at Treliske Hospital in case of power cuts. It was sold by tender, and as a 17-year-old generator' no one was interested in it so my silly offer was accepted. My main problem now was trying to convince people I am not an eccentric, wealthy man. They will just not believe that *Raven* was built in its entirety in a little over 12 months for something just over ,25000.

***Sea Pea* II**

Chris Parnham contacted us about his Roberts steel Spray 38, which was built in Kingswinford in the UK by master steel boatbuilder, Philip Grosvenor. Phil has built several of the Spray models, plus other steel powerboats designed by Bruce Roberts. This Spray 38 is fitted with bilge keels. *Sea Pea* II was fitted out over a 32 year period and was launched in August 1993 at Newark on the River Trent. After a week on the river, the mast was stepped and rigging installed, and the boat was sailed round to the mooring at Boston, Lincolnshire. Chris Parnham

is planning some blue water cruising, possibly a circumnavigation. The boat was built with blue water in mind and says it is a 'belt and braces' job with steel, watertight bulkheads, in mast roller reefing, oversize rigging, polycarbonate windows, Decca, GPS, SSB/VHF radios, bow thruster, power anchor winch, 300ft of 2in [12mm] chain, 35, 60 and 140 lb CQR anchors, bilge pumps, full burglar alarm, Ampair wind/water generators, Mase diesel generator, Whitlock 'Mamber', and cable steering, Cetrek Autochart Pilot, hydro vane/wind vane steering, keel cooling, 'Striver'/Aquadrive, etc, etc. All this has had an effect on the waterline; he reckons it will draw about 5ft. [1.5m]. It tips the scales at about 16 tons [16256kg].

Chris Parnham wrote recently, telling us that he plans to follow in Slocum's wake, one hundred years on exactly, and will be leaving from Boston, England, via Gibraltar etc, following his route, but calling in at a few additional places.

Geordie Lad

Mr. Lowther said that he spent a year deciding which design to build . He was only going to build one vessel so it had to be right. He chose the Spray because it looked right. The building of the *Geordie Lad* started in June 1986 and was finished in July 1992; The hull and fitting out was done by Mr. Lowther himself.

> 'The remainder of the season of '92, I spent in trials off the north east coast, and most of the '93 season we spent getting to know each other, then in August we went to the Ijsselmeer in Holland for a month. My only sailing prior to this was a two-week sail in the Western Isles. Going to Holland was quite an experience. I had two crew, one 71 years old and one 41 years old, neither of them experienced. The yacht handled beautifully and looked after us; never gave us a bad moment. This year I hope to lift her out and fit a bow thruster, and head for warmer climates. I am at the moment taking my Yacht Masters, so wish me luck'

I note from one of the photographs that Mr. Lowther sent, that he has painted the port side of his deck red, and the starboard side green. I imagine this was to assist some of his inexperienced crew in identifying port and starboard. This reminds me of an American yacht I once saw in Australia. This boat had every possible piece of gear fully labelled. The inside steering was clearly marked port and starboard, left and right, and all of the other equipment and fittings on the boat were clearly identified. Although this may sound a rather unnecessary arrangement, I am sure that it could have some benefits, especially in an emergency when sailing with inexperienced crew.

Eagle Spray

Recently I received a photograph of a completed Spray 38, together with a long letter from Alain Guichard:

> 'Many people have written about how the Spray stands up very well in rough waters, or how she seems to steer herself with a few minor sail adjustments no matter in which direction she is sailing, but nothing has been written about her aesthetics, and the following qualities are equally endearing. As an author and professional diver for three decades, it took me two years to decide on all the requirements for my ideal boat. A sailing boat is a bride. You marry her for better or worse, and it is important to know the qualities before you go ahead. I knew as soon as I studied your plan that the Spray would anticipate some of my minor distractions on a single-handed cruise, and at that time I hadn't yet read all the Slocum books. So what else made me choose the steel

Spray 38, apart from my budget, and an analysis of the future cost and maintenance?

What we call *l'assiette*, French for plate, describes how she sits in the water. I didn't want a racing boat. If you are going to spend a long period living on a boat, you must have a very large deck to give freedom of movement without knocking over your ship-mate while running around the side-decks. The Spray 38, with its 14ft [4.2m] beam which runs more or less the total length of the boat, gives tremendous space and comfort both inside and outside. Where, alas, would you find a sailing boat of this size where you can fit two toilets, one at each end with ample headroom. Ah, some people may say, what about the speed with such displacement? Well, who cares when you don't have to be in the office by 9.00 am each morning.!

Although Alain Guichard's Spray 38 is almost completed and about to be launched, he has as yet no experience of sailing a Spray. Once he reads the favourable remarks made about the Spray's performance, as voiced by so many owners of these boats, then he will no doubt add performance to his list of favourable points. Alain went on to say:

'For my personal use I wanted a very large rear platform on the deck above the aft cabin for diving, and had to be able to enjoy a good meal with friends, under a canopy, of course. The Spray gives me almost 100sq ft [9 sq m] of space. All Sprays are so well balanced and have such a low centre of gravity that they can be rigged as a ketch sloop or cutter. I have chosen a cutter because it facilitates a single-handed trip, gives me more room on the rear deck, and is much cheaper than a ketch to install. If you intend to sail around the Med or around the coast of Europe as I do, you must give some thought to the cost of mooring in these expensive marinas. A 38ft [11.5 m] boat, being under 12 m makes a lot of difference to the cost per night, believe me. So Bruce, if I cannot tell you right now how she will perform at sea, I can at least say at Ridge Wharf Yacht Centre, near Wareham in Dorset, there is no shortage of admirers for this beautiful boat, from both would-be and experienced seafaring folk.

Amanda Jane

Larry R Randall built his Spray 38 mostly in Oklahoma, which, as most of you will be aware, is a very much landlocked state in the centre of the US. Some of Larry's comments follow:

'Thank you for the chance to brag about my boat, *Amanda Jane.* We don't get enough opportunities to do that. As a former marine mechanic I had many bad experiences with what I refer to as production 'Tupperware' hulls. The keel of *Amanda Jane* was laid in Oklahoma in 1984 by a very good friend of mine by the name of Kendall Keeton. She was to be his retirement home on the water. She was trucked to Washington State, in 1984 for the fitting and commissioning, and she was finally launched at Point Roberts, Washington State in 1989. Kendall's intention was to sail to Alaska from Washington for the summer and then, like most sensible people, sail south in the winter. Unfortunately for him the sailing gods decide that it was not to be. While he was aboard her for the summer season in Alaska, fate changed his plans when his wife suffered a heart attack. Returning to Port Roberts he realized that his dreams of retirement as a live-aboard world sailor were not to be.

That is when I was blessed with the chance to acquire *Amanda Jane*. My wife and I are still attempting to get to know her. We are finding that she is a very forgiving lady, with the heart of a lion, a big steel lion.
As you can gather, I think she's a fine vessel and we are looking forward to many happy days aboard her with the wind in our faces. That's how you generally end up sailing in the north west.

Blair Spray
Jim Blair of Margate, Tasmania, Australia, wrote, My Spray 38 is under construction at present and steel work is 90 per cent complete. Regarding the sail area displacement ratio of the Spray 38; of course with the standard ketch rig, she has quite a low sail area displacement ratio and would take a larger sail plan. However, many people with families prefer to be slightly under-canvassed than over-canvassed, but it would not be a problem to design a larger rig for this boat; and as you see by the information supplied by some other builders, larger sail plans have been installed on the Spray 38 with considerable success.

Rosendaki Spray
Robert Rosendaki of Spring Field, Missouri, is building a Roberts Spray 38 in steel, and he commented as follows: 'On my Spray 38, the transom is done and most plating on. The pictures are 90 days old, and we are snowed in today. I have used a trolley developed from angle iron track and four roller skate wheels, about 400lb [181 kg] only, most helpful in frame erection, etc. I'm painting all new oiled steel with aluminized asphalt paint. Accepts welds, and sandblasts off easily, and prevents rust until I'm ready to blast and paint.'

Siaban
Sirius Yachts of Stourport-on-Severn in the UK built the hull and deck of this Spray 38 for Angus Mackinnon of Milford Haven. Angus told me that the name he has chosen for his Spray means 'Spray' in Gaelic.

Half Past
This boat is owned by Captain Harold Barbour who had the hull and deck built by Dragon Marine UK. Captain Barbour also informed me that he first picked up one of my design CATALOGS in Australia about thirty years ago and at that time he thought the Spray 40 too large for his needs; when the Spray 38 became available he decided to have a Spray for himself. This Spray was commenced in 1989 and completed in 1990. The hull is spar galvanized outside and the entire interior is epoxy coated. Spray on insulation was added to the interior. Captain Barber is 6ft 4in tall [1.93m] so on our advice, he increased the freeboard of the hull by 3in [75mm] and reports that he finds sailing with 4 to 6 people just about right.

Spray 40

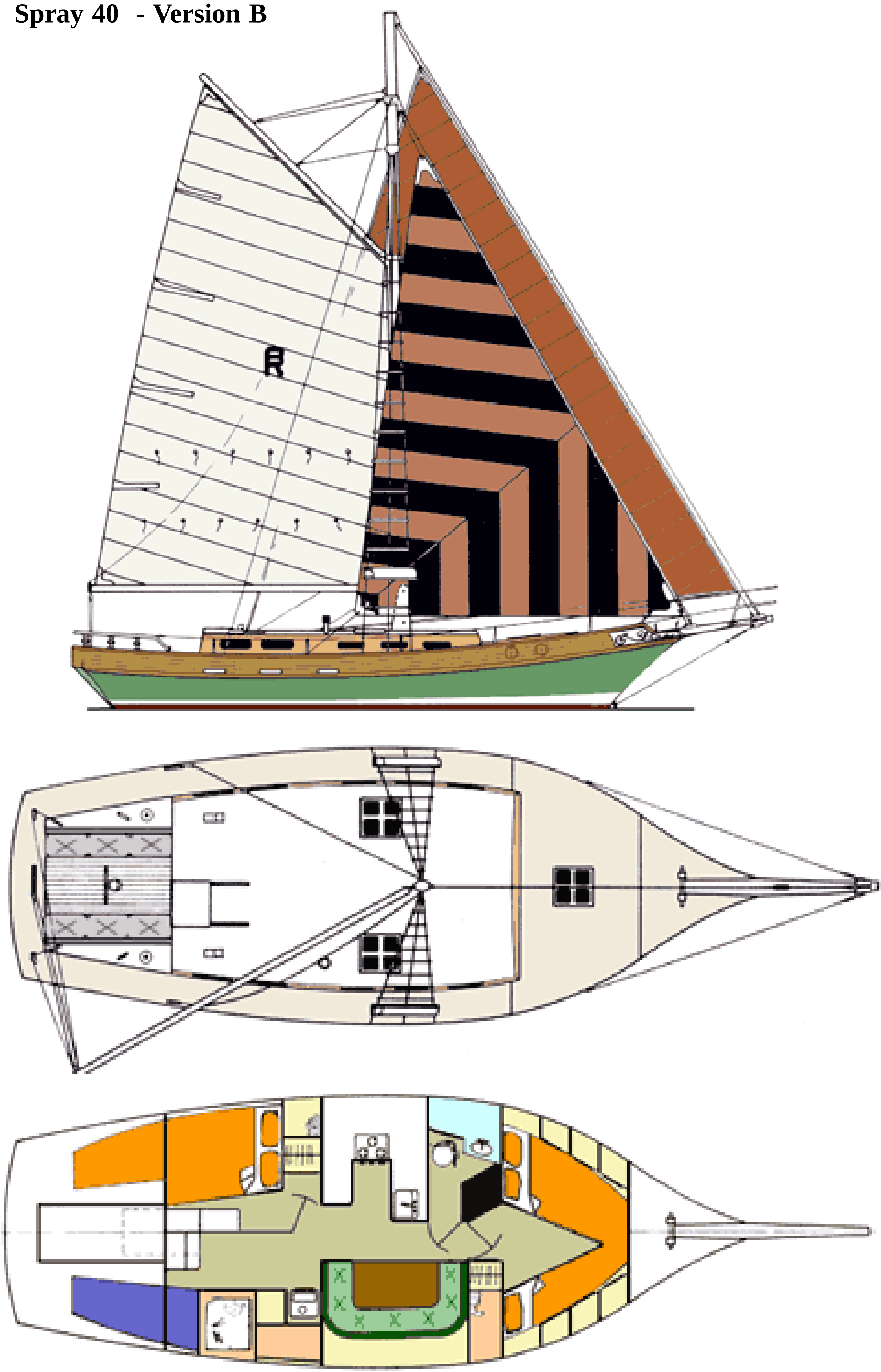
Plans & frame patterns, build the Spray 40 in round bilge fiberglass or multi chine steel.

L.O.D.	12.19 m	40' 0"
L.W.L.	9.73 m	31' 11"
BEAM	4.37 m	14' 4"
DRAFT	1.27 m	4' 2"
DISPLACEMENT.	16,257 kg	35,840 lb
BALLAST	6,804 kg	15,000 lb
AUX POWER		50 to 70 hp

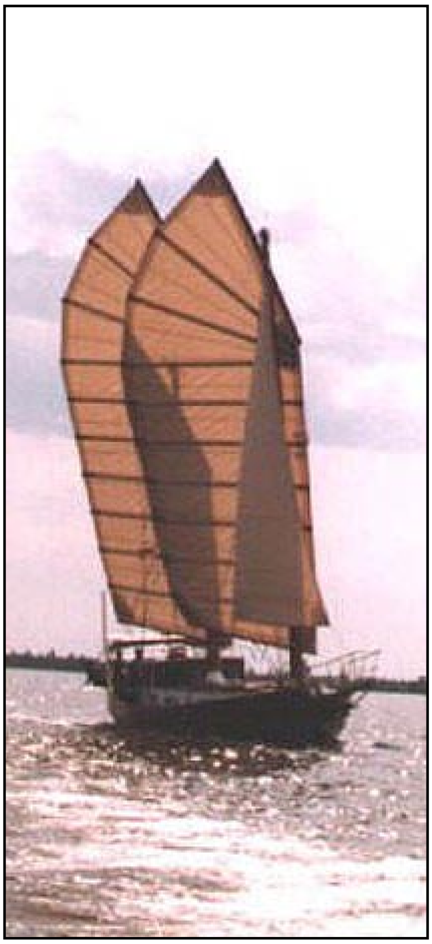
Spray 40 Version A

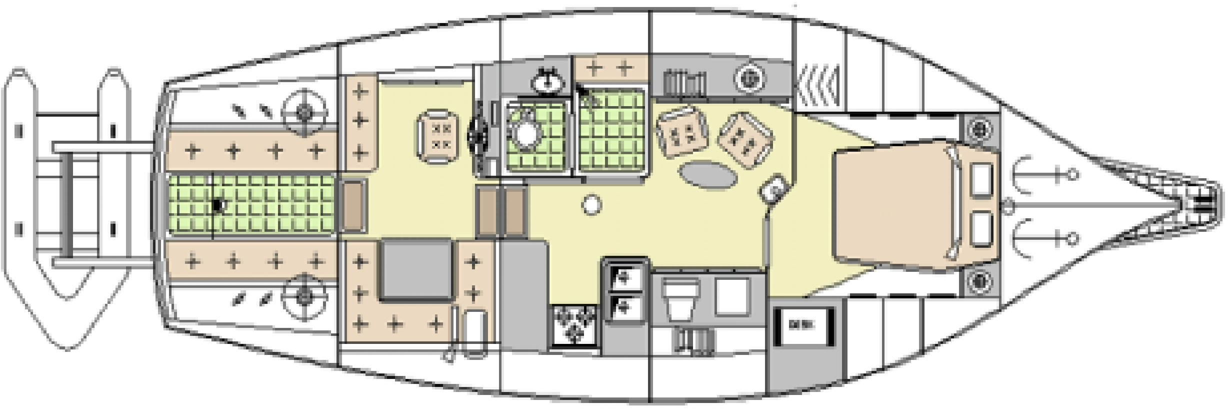
The *Spray* 40 was drawn by our design office in 1968 and was the first of the Spray series plans. The reason we called our design the *Spray* 40 was the way the boat was measured, rather than any difference in size between our Spray and the original as rebuilt by Slocum. Traditionally, a boat's length is denoted by the measurement between the transom and the deck line at the bow. There are many measurement systems, but leaving these aside, items such as bowsprits (and in the case of Spray, the cutwater) are normally not included, except when the measurement is quoted as length overall. This often causes confusion when comparing the length of any boat. Our Spray 40 is intended to be the same size as the original Spray. The dimensions shown below reflect the close similarity between the original vessel and our fiberglass version.

Spray 40 - Version B



Spray 40   version C





SPRAY 40 Pilot

The Spray 40 Pilot is proving to be one of the most popular versions of this design. The S40P can be built in multi chine steel from plans and frame patterns or from a steel KIT which will soon be available based on the already successful Spray 400 kit and cutting files.

Hi Bruce

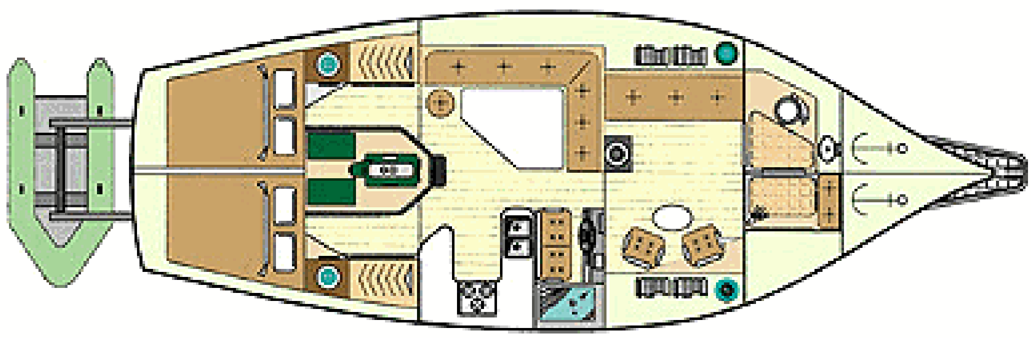
My wife and I have completed a Spray 38 in 2001. We bought the plans in 1996 from your UK rep. It took me 5 years to complete her and she is junk rig.

We sailed Ruffles Spray from UK to the Med and cruised there for 2 years. The boat looked after us magnificently. Even in 42 knots of wind sailing hard on the wind she behaved impeccably. The junk rig works well on a Spray and I can recommend it.

Next year we are heading to Turkey to continue our cruising.

Best regards Mike & Ann Ruffles
S/Y Ruffles Spray

These photos of Ruffles Spray were sent to us by Mike and Ann Ruffles - see letter above.



Spray 40 version D ... The Spray that has not happened yet ! My idea of an attractive Spray 40 that could be used for occasional charter or shared by two couples.

Jupp *Spray*

Charlie Jupp was a paying customer, and was ready to proceed, so it was decided that his would be the first hull to be produced. We had completed drawing and fairing the lines, and had prepared the table of offsets. Although we modified the bow by fairing the topsides into the large cutwater, in other aspects we followed the original design as closely as possible. The next job was to draw out the lines full size. Here George Love and Barry Long really showed their worth, and produced a beautiful fully faired set of full-size patterns that we transferred to Mylar plastic film.

These same patterns have been used to produce over two hundred Spray 40 replicas. Once we had the patterns for the frames, stem and keel, we were able to set up the male mould for the first foam sandwich fiberglass Spray 40. We next built a male mould, and laminated the first hull. What excitement there was when the hull was rolled upright, and we were able to inspect fully the Spray's beautiful form for the first time. One can study the lines and see the hull during construction in this case, upside down but the first time we saw in full detail the beautiful lines of the Spray was a moment to be remembered always.

Charlie Jupp took delivery of this first hull, which was finished outside with several coats of urethane paint. The hull was transported to Charlie's nearby home, where he proceeded to complete the interior and build the decks and superstructure according to the plans prepared for the fiberglass Spray 40. Charlie was working on his project full time, so I had my hands full keeping ahead and supplying the plan sheets in time for him. He actually got ahead of me at some stages, but this caused no problems, as Charlie was a trained carpenter and joiner,

It took Charlie about nine months to complete his Spray, and she was launched on our slipway with only two or three barrels of water as ballast. We knew that the original *Spray* was built and launched without any ballast at all, but since our Spray was much lighter we decided to use the barrels of water, this worked fine until we calculated the correct ballast amounts for this fiberglass Spray. Charlie even tried mineral sand from the nearby sand-dredging operation to see if he could have easily movable ballast. We decided this was not heavy enough so in the end the scrap steel set in resin putty method proved to be the most effective as ballast.

The masts were timber, and the rigging galvanized plough steel wire. Charlie wanted to use the traditional deadeyes and lanyards to adjust the rigging. Although I was skeptical at the time, believing that the rigging would require frequent adjustment, I have since become convinced that within certain sensible limits, a person should rig their boat as they see fit. After all, boats are supposed to be fun, and we each enjoy them in own way. We have a series of photos of Charlie Jupp's boat taken after he reached Lymington, England. The deadeyes and lanyards were still in place and Charlie reported that he had no problems with his rig. Charlie Jupp sailed from Brisbane, Australia early in 1976, and in November that year we received the first of several letters:

> 'I left for Mauritius, a voyage of 4500 miles and 2000 miles off the Australian coast I had trouble with my appendix. I lay in my bunk for five days with all sail up, with a rising wind; *Spray* steered herself. When the pain eased, I sailed for Mauritius, and on arrival I let the anchor go. The yachties saw I was in trouble, and came and took the sail off. I had an operation, but felt very weak so I stayed another two weeks, then sailed for Durban. Lousy trip, last two days were storms and lightning. Had a glow at the masthead, rigging was very hot. I went below; I thought the boat was on fire. As I was coming down the coast, a helicopter flew very close and took photos of the Spray, and last

This is Charlie Jupp’s fiberglass Spray 40 as she was built at our Marine Park in Brisbane Australia and sailed to and from the UK .. We had the pleasure of seeing her built plus meeting up with Charlie in the UK.

night she was on TV here.
I will be leaving here at the end of December. Most yachts are taking on extra crew as far as Cape Town; they think I am mad, but if I can't get a good crew, I'm better off on my own. I had no worry about my Spray in the storm. It blew 50-60 knots, gusting to 70. I will let you know how things go around the Cape.

Charlie Jupp's second letter came from St Helena:

'Thanks for your letter and all the help I received in South Africa. I am in St Helena there is no harbour, so it's a big job getting ashore. I met a lot of people building boats in South Africa, and over a hundred people came to see me off at Cape Town. My Spray sails very well, I sleep ten hours, and she stays on course all night. I hope to sail tomorrow; I will let you know how things go.

The next letter from Charlie was when he reached England, dated 3 July 1977:

'I have just arrived in Falmouth after leaving the Virgin Islands. I was 40 days crossing; I had calms, head winds, fog and storms. People who draw upwind charts should try sailing with them. They show west wind; I went looking for it and I nearly saw polar bears I was that far north. As I came up the Channel the weather was perfect, not a cloud in the sky; it was warm seas, flat and a full moon. What more could I ask?
When I left South America for Barbados, I was 300 miles from Barbados when a foreign fishing boat with 12 crew came alongside and forced me up into the wind. Two crew came over the side ready to drop on to my deck, when a freak wave threw us apart. The skipper pulled a revolver and fired. I got one in the leg, and a few in the deck, so I shot at the two crew and got one in the skipper's arm. He got on the radio to his mate, but a naval patrol picked up his message, came and fired across his bows, and gave me an escort for the day. So for a week after, every time I heard a noise at night I would go on deck, with rifle in hand.
While in the Virgin Islands I did have an offer to skipper one of the charter yachts, but I'd made up my mind I wanted to go to England first. The Spray stood up very well in all weather. I carried sail, when in other yachts I would have reefed down, so over a long distance I am not behind other yachts, sometimes I would be a day before them.

In January 1978 we received a further letter from Charlie:

'I got a letter from a yacht club meeting in London to ask if I would go along and give a talk on my trip, and also, my easy method of navigation. Everything was to be laid on, food, drink and pay, but I had to decline the offer as I had very few photos and material to talk on, and so many people are sailing round the world and writing books nowadays. I have decided to keep the Spray, and you may see me on the west coast of the States this coming year. I have sailed and delivered a few yachts for owners, and so far I haven't sailed on a yacht as comfortable as the Spray. I think if ever I built another, it would be on the same lines. On the River Hamble here there are over 3000 yachts, but there's very few I'd swap my Spray for. I thought with all the racing yachts here I would be able to buy second-hand jibs, but there's none available and new ones are expensive.
The plans of my Spray show the draft at 4ft 2in [1.2m]. I changed mine, and put 12in [305mm] on the keel before I left Brisbane. It sails close to the wind and turns very

nicely in the harbours, so I'm pleased I did it. I've met a number of people who are interested in building something they can take their families out sailing in. I'm sailing on a number of yachts, but they are very uncomfortable because there's a lump of ballast low down. However, if you spread the ballast the motion is much better. Other people may have different ideas. Two young fellows thought they would like to race against my Spray from Falmouth. It was blowing hard, so they had to reef down. I was in Southampton five hours before them, so a heavy boat is OK.

Here is Charlie Jupp's Spray 35 years later! Charlie eventually went back to the UK and later retired there after handing on Spray to a new owner who made several changes to the original. Spray is still going strong ... now back in Australian waters where she was born.

Charlie Jupp was a regular correspondent and we learned that he ballasted the hull with 9 tons of track pins taken from bulldozer tracks in a scrap yard, and screwed the floors down on top of them. He added a 12in [305mm] square wooden beam to the keel, and glassed it in without keel bolts. This altered the planned draft by 16in [406mm] which gave the boat a draft of 5ft 6in [1.6m]. He reckoned he could put a cup of coffee on his cabin table in a 30 knot wind, and it would stand without movement.

Like the original, this Spray will sail herself, although rigged as a Bermudan ketch she will hold a steady course for days on end unattended. In a storm the boat looks after herself better than the helmsman can with a storm jib to hold her steady. With a good trade wind blowing, Charlie set two jibs boomed out, with main and mizzen, and lashed the wheel, and left the ship to her own devices.

Also like the original vessel, Charlie has two separate cabins, with no cockpit; his wheel is amidships, sheltered by a canvas windscreen, and protected by ample bulwarks.' There is none of this sitting up in the cold and wet on this boat,' says Charlie. 'As soon as it gets dark, I go to bed. I sleep ten hours every night and wait for the sun to come up before I get out of my bunk.'

Charlie sailed like this across the Indian Ocean in 1976, some 4500 miles from Australia to Mauritius, with the ship holding her own course. He did not touch the helm until he was in sight of the harbour, being tied to his bunk sojourn by the attack of appendicitis.

Charlie Jupp enjoyed no special advantages over anyone else in making his dreams come true. Twenty-seven years ago he was working as a labourer building sea walls in Essex when he made the decision to emigrate, choosing Australia because of the sun. His subsequent efforts at sugar cane farming convinced him there was no profit in small crop husbandry, so he got a job as a builders' labourer. After three years, he was building houses himself, which he did for a decade or more until the credit squeeze forced him to lower his selling prices. Spread over the five houses he had on the market, he just about broke even.

Charlie is not married and has done most of his sailing single-handed. One of the reasons that many skippers are wary of taking on a crew came to Charlie's notice in Tahiti. Three men who had begged a passage from the West Indies then refused to go back to the yacht, saying they had enough of the sea. The immigration authorities held the skipper of the yacht responsible and ordered him to pay their air passages home, two to England and one to South Africa.

Charlie arrived safely back in Brisbane after transiting the Panama Canal and sailing on into the Pacific. With about 2000 miles still to go, Charlie had lost the use of his rudder. Crevice corrosion in the stainless steel rudder shaft had caused the rudder to become inoperable. He managed to sail the boat for some weeks without a rudder, and steered the Spray quite successfully by adjusting the sails. Charlie is now in Brisbane; he has sold the Spray and retired.

Trah

The second Spray to be built on the male mould that had been used to produce the Jupp Spray, was a hull for Spray model builder, John Haskins. This vessel was called *Trah*.
John Haskins was working for us at that time, and the agreement was that he would help with the construction of his own hull and would be paid for his services, and the money would go

towards the cost of his hull. John was a good worker, so everything was satisfactory to all concerned. It only took a few weeks to produce John's hull, and he elected to have his cored with end grain balsa rather than the foam core we had used for Charlie Jupp's hull. We were experimenting with different cores, and one of the first ones we tried was made of a PVC material, a similar product to Airex (tm). This core had properties that would make it suitable as a core for our fiberglass sandwich hulls. The manufacturers assured us that it would do the job, so we carried out some experiments making up test panels and subjecting these to various tests, some scientific and some not so scientific to establish the suitability of the material. I have had the opportunity to inspect some boats using this Australian PVC core and they have stood up well. Unfortunately, the company that was manufacturing this material has now stopped making it as they decided that there was not a large enough market for it in Australia.

The next core we tried was urethane-based foam. This material is made in a similar manner to Airex (tm) and other boatbuilding quality cores, but is not suitable as a structural core. However, it did prove to be quite satisfactory in providing a base on which to lay up the fiberglass hull. Later, when the hull is turned over and the mould removed, most of this foam is also taken out and stringers and other reinforcements are bonded in place. This foam material is really only used as a smooth former for laying up the outer fiberglass skin.

Another core material that was appearing in Australia for the first time was balsa core. This material consists of small blocks of balsa that are glued to netting backing (something like a mosquito net material), to which the balsa squares are glued. The arrangement comes in sheets of 1ft 6in [457mm] x 3ft [914mm], and these sheets are used in a similar way to the foam core; that is, they are either sewn or tacked on to a male mould and then the outer fiberglass laminate is laid up over the core.

One of the drawbacks with the balsa core was that it did not lie on the hull as fairly as foam sheeting. However, by putting extra cuts in the blocks and using other techniques that developed, we were able to use this material quite satisfactorily for hull construction. John Haskins opted for the balsa core in his hull, so that's the way his boat was laid up, and we actually developed the techniques of building balsa-cored hulls during this period. Balsa core is an excellent material for coring fiberglass decks, and has been widely used throughout the fiberglass boatbuilding industry for that purpose.

When John Haskins's hull was complete, he moved it into one of our boatbuilding sheds and proceeded to install the interior laminate and, as well as the bulkheads, web floors and other interior joinery. John then worked full time on his boat for some time while the cabin and decks were installed. He fitted a Lister diesel, which in its former life had been used to power a local dairy farmer's milking machine. The engine worked quite well until John replaced it some years later with a more modern marine diesel. John used his Spray as a family 'live-aboard', and his wife and three children lived happily on *Trah* while John worked the Marine Park boatyard.

John motored his Spray up to Cannes, a distance of about 1500 miles, where he cut down a tree and used this as his mast. He made a good job of converting the tree to a mast, and properly rigged the boat. John Haskins is certainly not the first person to go into the forest looking for a mast: many builders, not only of Sprays but of other vessels as well, have taken a similar route.

Terry *Spray*

Brian Terry was the third customer at Marine Park who decided to have a Spray built from the existing male mould. Brian wanted a quick start, so our staff laid up his hull which he then fitted out himself. Brian then equipped his Spray with a large settee and other furniture and lived aboard it.

Oysterman

The next Spray replica to be taken from our male mould was one built for Roger and Riva Palmer. This couple hired the mould and built their own fiberglass hull; they certainly built it well and we all made jokes about it being bullet proof and how it would knock down any reef that it encountered.

Roger and Riva also built a Spray dinghy. They took the lines of the Spray, and their scaled them down to create a set of lines for a boat of about 9ft [2.7m] length overall. Next they proceeded to build this mini-Spray as a dinghy. However although the dinghy looked fine, it was a bit too buoyant to be a good dinghy. Roger and Riva made a few changes to the rig of their Spray, one of which was to fit booms to both foresails. Charlie Jupp, on seeing this arrangement, commented (As most of us had already done), that he thought this was dangerous, especially if you needed to work on the bowsprit. Also, by having the outer jib on a boom, it meant that the amount of sail area that could be carried with this particular headsail was limited.

Roger and Riva have since sold their Spray replica, and I assume that the new owners have changed the arrangement for the headsails. The rigging chosen by the Palmer's was more than oversize, so no doubt this very well-built, heavily rigged Spray is still happily cruising today.

After the completion of these first four Spray replicas from the mould we built at Marine Park, there was such a rush of plan sales that it is impossible to list all of the boats built in chronological order. Consequently, I will select some of the Spray replicas at random, detailing the experiences of the owners, and commenting on the individual boats.

It is necessary to sort the various Sprays into sizes, because after the success of the Spray 40 design we then proceeded to prepare plans of other sizes for the Spray. These other boats which came to make up the Spray Series were scaled up and down from the original plans. Generally speaking, we tried to keep as close to the proportions of the original boat as possible, but of course there were always customers who decided that they would purchase a plan for one size, and then stretch it one way or another to suit their own needs. Some of these boats are very successful, praising that the Spray is an incredibly versatile design. No matter what criticisms have been levelled at the original *Spray*, and some of the replicas, I feel that most of these criticisms cannot possibly be justified in the light of the comments and experiences of owners with whom we have been in contact.

Salty Spray

We all well remember the day that Howie Franklin walked into our office in Vancouver, Canada. The design office had not long been moved from Gabriola Island, and Howie came to see us and saying that he would like to build a Spray. Howie had seen a boat that featured an unusual poop arrangement, and he decided that this would fit nicely on the Spray hull. He asked us to prepare plans for a semi-custom Spray design incorporating his own ideas of the poop stern and a small pilot house. So shortly after this, we started making plans to meet Howie's requirements.

At the time, we considered Howie's ideas 'a bit much', and we displayed our feelings when drawing up the sail plan by putting a pirate flag at the top of the mast! As events turned out, we had nothing to complain about when it came to Howie Franklin's *Salty Spray*. Not only has Howie kept in touch with us over the years, relating the various experiences he has had with his boat, but also he has proved that there are a lot of people out there who want

something just a little different, because the Spray Version C, (as it became known), proved to be a very popular arrangement for the Spray 40, and indeed for some of the smaller versions as well.

Salty Spray was one of the first steel Sprays built from the plans that we drew up for building this steel multi-chine version of the Spray. We simply took the original lines of Spray and redrew them to a multi-chine configuration. This retained the design parameters of the original, but made it possible to build the boat in sheet steel. There had already been round-bilge Spray hulls built in steel; however, round-bilge steel construction is beyond the ability of most amateur builders. For this reason we decided to produce plans for a multi-chine steel version.

We drew up the plans for the steel Spray at about the same time as we were drawing plans for several other new steel designs. This was in 1974, and anyone involved in the marine industry, (or any other industry then where fiberglass resins and other petroleum-based materials were required), will remember that it was a time when anything manufactured from petroleum was in short supply. Consequently, we found that we had many successful designs that could be built in fiberglass, but unfortunately the fiberglass, or at least the resin components, was almost impossible to obtain. In a way, this situation did us a favour, because it forced us to design boats that could be built in other materials. As it has turned out, steel now represents just over half of the boats built from our plans.

Howie Franklin took his plans back to Toronto, where he had the hull and deck professionally built; he then proceeded to fit out the boat himself. All the while he was in touch with us, and sent photographs of the boat at all stages of the construction process. We received one letter from Howie that reads as follows:

> ‘On 14 August 1978, we were out sailing on Lake Simcoe, which is just north of Toronto. It was a warm and pleasant day, but I was concerned about the possibility of thunderstorms. About 1630 and on our way home, the sky darkened and it was obvious we were going to be hit by a storm. Since there was little wind, I had decided to sail on jib-staysail and mizzen. The main was down and stowed. Soon the rain became heavy, and visibility was down to 50ft [15.25m]. Things were still OK, until all of a sudden the wind velocity increased from 10 knots to about 80 knots in less than 15 seconds, and *Salty Spray* was knocked down. The storm was part thunderstorm, part tornado, and we didn’t have the time to release sheets. It all happened so quickly.
> I am telling you this story because I want you and your customers to know of the incredible integrity of the Spray. In our knockdown, I think the masthead touched the sea, and yet she rolled back up with no damage done, except to the captain’s pride. She had

water inboard, but that was later discovered to have come from the freshwater tank, had siphoned up through the galley tap. It was an unfortunate incident, which could have been much more serious if not for the incredible integrity of the Spray design; I had 12 souls on board that day, and we all went out again the next day because of the faith we all have (even stronger now) in the design of Salty *Spray.* Although it frightened us at the time, the incident did not deter us from proceeding with our plans for the future with the Spray. I just wanted you to know how proud we are of our boat.

Howie is a former airline captain so is used to dealing with crisis situations.
Some years ago he sailed *Salty Spray* from Canada down the east coast of the USA to Florida, and we lost track of him for some time. However in December 1993 we received another letter that read as follows; 'Do you remember one of the first Spray 40s that you featured in your catalogue way back in 1980? Well, Salty *Spray* is still going and has just finished a total refit job with new rigging, new bowsprit, new bow rail, new wheelhouse and new engine. I fitted an 85 hp Perkins diesel. She is in very good shape at this time. We are still enjoying the boat, but would consider selling her at about $70000. Further correspondence with Howie produced the following comments:

> 'What I can do is tell you of all the good things we like about *Salty Spray*, starting with that nasty double knockdown we had in August 1978 when she was maybe only half finished and half ballasted. Her survival was a fine display of her great integral stability. Since then we have had many good times, including a trip down the Mississippi river to New Orleans, then over to Florida where she now resides at Key Largo. What I like about the Spray is that most other people like her too. Spray seems to be like a story book dreamboat, yet here she is for real.
> She is a great live-a-board and when we get together with friends with their boats, someone always says, 'Bring your boat; we need the poop deck for dancing.' Although *Salty Spray* is not the boat for winning races, she is certainly comfortable, stable, likeable and a lot of fun. There is one other Spray owner here in Key Largo. He bought it from the builder when it was a schooner, then he changed it to a sloop.'

Lynch *Spray*

Virgil Lynch operated an engineering business in the mid-west: and, like many people who live far from the water, he had a strong desire to own a boat and go cruising. Unlike so many people who never realize their dreams, Virgil decided to do something about it, and came to see us when we were located in California. Virgil purchased two sets of plans because he had a friend who also wanted to build a Spray 40 in steel. Over the years we received several letters and pictures from Virgil, mainly showing construction details and how he was looking to improve the methods of fabrication that we had shown in the plans. I must confess that we have learned as much from the builders of our boats as they have learned from us. We are forever indebted to the many builders who have shared their ideas with us, especially when we were constantly developing the building techniques. Virgil Lynch subsequently completed his steel Spray 40 and rigged her as a schooner. In fact, I remember he engaged us to custom design the schooner rig for his Spray.

I assume that the Spray that is moored next to Howie Franklin's *Salty Spray* is the same one that was built by Virgil Lynch, so obviously this Spray has been re-sold and re-rigged as described in the letter from Howie Franklin.

Jumbly Girl

Recently, in response to my notices in various yachting magazines, the following letter arrived. Before going into detail concerning the contents, one must speculate about the name of this particular Spray. This boat was built by Michael S Rigg, and although he does not say in his letter what inspired the name for his boat, we all suspect it might be the fact that in Britain sales of used and surplus marine fittings and equipment are generally known as boat jumbles. Here is what Mr. Rigg has to say about his vessel:

'I own a Spray 40, version C, Bermudan ketch built to your plans. I bought the bare hull in 1983 and spent nine years of my spare time fitting her out. She is built of steel, 3/16in [5mm] hull, 1/8in [3mm] decks and superstructure, and has hollow wooden masts and galvanized rigging. I have installed quite an old, but reliable, Ford 57 hp diesel engine, which drives the boat at 8 knots. The hull was built by an amateur boatbuilder near Manchester, and I did much of the fitting out in Whitby, which is where I lived before moving to Ipswich. The furthest I have been so far was a trip last summer across to Denmark. We went through the Limfjorden south through the Baltic, and back to Ipswich through the Kiel Canal. It has always been my intention eventually to depart on a long voyage, and we have finally decided to leave the UK this September.

Concerning the boat, she sails with a very small angle of heel, and has a very easily driven hull for a heavy boat. I have only three tons of ballast in her, and even then she is over her design draft of 4ft 2in [1.28m], due I think to her heavy construction. However I don't think of this as a detriment.

The photographs of *Jumbly Girl* show that she looks like a coaster. I use this term in its most complimentary manner, because one often sees small chunky vessels, trading around the coasts of Europe that give the appearance of no-nonsense, go-anywhere boats. This of course is in keeping with the heritage of Slocum's *Spray.* As we know, the original vessel was a commercial vessel, not only before Slocum rebuilt her, but also during her trip around the world with Slocum as her skipper. Quite often, he used *Spray* to carry cargo and for other money-making ventures, so when I see a Spray that has commercial overtones, that the boat is in the spirit of the original.

Shindera

This fiberglass Spray 40 was built by Larry and Karen Mahoney of Grand Rapids, Michigan; Mr. and Mrs. Mahoney who have sent me a fine selection of construction photos, plus a couple of photographs of their boat under sail. The Mahoney's have made a great job of building their Spray, and have been regularly cruising Lake Michigan. Although they do not elaborate on their future plans for the boat, the construction photos reveal that the boat is intended for long-distance cruising.

Mile High

One of the many interesting customers who walked into my office during the period we were living in Newport Beach, California, was James Kirby. Jim was a real- estate broker who lived in Valyermo, California, and operated the Mile High ranch, which (as its name suggests), was up in the mountains of California. Jim is an interesting person, and one with whom I enjoyed working. He had the hull professionally built, then finished it in a boatyard in Costa Mesa as this yard was close to my office. Thus I was able to visit the yard frequently to keep an eye on Jim's project. He did a fine job of fitting out the boat, and made his own mast from solid timber. It was interesting to watch as he started off with a square balk and taking advantage of the modern electric tools, gradually transformed this into a main mast for his Spray.

Jim kept in touch with us after his boat was launched:

‘Just a quick note to let you know how she handles; we launched 28 July 1981, and had her sailing within two weeks. Last weekend we came back from the Ismus in 15 - 18 knot winds, and she averaged 62 knots under drifter, main and mizzen. I am extremely happy with the boat. It is much better than I expected. As people sail by us on our mooring, which is two blocks east of the Pavilion in Newport Harbour, we get nothing but compliments. Come out and see us’

On 1 November 1981 Jim got in touch again:

‘With our big drifter in medium air she does really well. We averaged 7 knots on one of our return trips from the west end of Catalina in 20 -22 knot winds, and on a return leg from Dana Point we averaged 62 knots to windward with the main mizzen and jib in 28 knot winds and 6ft seas [1.8m]. Caught many fish with four poles trailing off the stern. The boat seems to steer herself no matter in what direction we are sailing, with a few minor sail adjustments. I just want to thank you again for all your help during construction, and if I had it to do all over again, I would not change a thing.’

On 2 February 1982 Jim wrote again, telling us of all the compliments the boat was still receiving. He also told us he had added polyurethane to all the topside teak. It is becoming a real show boat. He then continued:

‘Saw another Spray in Catalina made out of wood. The builder was from Long Beach, California. He stretched the boat out to 46ft [14m] with a 16ft [4.8m] beam. I tried to tell everybody not to mess with the original lines, but many people change them around. We are still outfitting, and plan to leave for Mexico in November 1982 and then jump off for the South Pacific in May of 1983.'

The 46ft [14m] long and 16ft [4.8m] boat that Jim Kirby mentioned was the first Spray that we designed for strip plank construction. The builder had some ideas of his own, so he asked me if it was OK to lengthen the boat to 46ft [14m] and also he suggested that as he was going to be building in strip plank it would not be too much of a problem to slightly alter the mould formers to make the boat a little beamier, and thus maintain the proportions. We have not heard any more about that particular strip plank Spray, except for the mention in Jim Kirby's letter.

Spiritwind

The following report was sent to us by Earl Maupin Sr.

'We would like to update you on our progress and send you some pictures. We have been building our Spray 40 foot steel Version C for eight years this July. To give you a brief history of our boat, *Spiritwind,* we received your plans and laid the keel and then began the framework in the fall of 1987. We rented some farm property in a small rural community of Washington State called Kingston, which is just west of Seattle. At this time, we joined the newly founded Metal Boat Society, and for the next 22 years, with the help of your material and boatbuilding books, we laboured on. In the spring of 1990, *Spiritwind* was shipped by truck to San Diego, California, and hit the water for the first time. We moved aboard and began finishing the inside. During this time, we were raising a family (two children), boatbuilding, and finishing a naval career. Since that time, the boat has been back to the Puget Sound area, where we continued to live aboard for three years, and our live-aboard home became a sailboat for the first time. *Spiritwind,* though built on a shoestring budget, has turned into a comfortable and seaworthy vessel. She was a participant in last fall's annual Metal Boat festival, and received excellent comments from all who boarded her.

Earl told us that the inside of the hull was sandblasted and painted with coal tar epoxy. The outside received coats of zinc-enriched epoxy, epoxy high-build and enamel, and has caused no problems. Inside the boat, they welded 300 2in x 3in [50mm x 75mm] steel tabs to which

they attached 2in x 2in [50 mm x 50mm] cedar strips, and then they installed rigid foam, sealing the backs and sides. This has worked quite well for them. The bulkheads are constructed of plywood, cedar, and mahogany. They did not install the after-cabin hatch. Instead, they have only one hatch entering the boat, and by bringing the sides of the cabin and coach roof back flush with frame number 18, they created a walk-through on the port side to the aft cabin.

On the starboard side, they stopped the coach roof and sides at frame number 17, giving them a walk-through to the cockpit on the main deck into their enclosed pilot house. For ballast, they used concrete and steel, giving them 15000lb [6804kg].Their mast and rigging are made from aluminum street lighting poles, originally from the highway Interstate 5. The main mast is 40ft [12.1m] and the mizzen is 30ft [9.1m]. The rigging is 7/16in [11mm] galvanized wire eye-looped with stainless steel 50 ton pressed fasteners. The total estimated cost of their rigging is $1500 [,1000 approx]. They chose the Marconi rig and have two after running backstays. Their bowsprit is made of 22 in [35mm] diameter schedule 80 pipe which they heated and bent around a tree into a loop. It is welded to the hull, on which they welded deck plate and chain link fence rollers for anchor rollers. The engine is a 75hp GM diesel with Borg-Woerner velvet drive transmission.

The boat has three staterooms, and a large enclosed horseshoe galley. The main salon has an L-shaped couch and table for eating, and a wood stove. Earl chose to eliminate the head in the aft stateroom, opting instead for a long closet on the port side and a full-sized bed on the starboard. This also gives them room for a love seat aft, and a sit-down make-up vanity area forward on frame number 18.
Earl continued:

> ‘*Spiritwind* was built on a shoestring budget. We estimate that over the last seven years we have spent approximately $35000 [,23333] to this point. Our cruising plans are to sail the boat south after our retirement from the Navy in the fall of 1995.

We are always excited to see and hear from other Spray owners. To our knowledge, during the time we spent in Washington State, we know of five Sprays and have made friends with their owners. One wood and the rest were made of steel. We have also met a Spray owner in San Francisco at the Alameda Air Station. His wooden Spray looks like Slocum's boat. Here in San Diego I only know of three, all steel; and, to our surprise, a new arrival at the marina where we live is the new owner of the 40ft [12.1m] version 'C' steel Spray, *Mile High,* which is featured in your publication. We have not seen another version 'C' Spray 40 on the west coast so were delighted to meet the very excited new owners, who were also delighted to meet us.

In closing, after nearly eight years of boat building and blood, sweat and tears, we are still content with our choice of the Spray design and the help you have given us. We would do it all over again.

Ara-A-Kiwa

Ron and Joyce Macmillan commented:

'Our Spray, was built in Wellington (New Zealand) by Stain, Ward and Jones, launched and registered in 1980, and brought to Auckland, sold to a Mr. M C Hornsby who fitted her out, and sailed to Fiji and Vanuatu and New Caledonia in 1982. Then she was virtually unused until we acquired her in 1991, when a major refit was necessary. Our voyages include the North Islands, and in 1992 we sailed to Tonga, the Heiapaignvavau Groups, then to Vitulevu in Fiji for the Suva regatta on the Vitulevu and Musatt Cove at Malololailai Islands for the Fiji regatta and the Fiji-Vila race. Then reluctantly we went back to New Zealand ahead of the hurricane season.

In the last year we have worked towards early retirement, and we are fitting out *Ara-A-Kiwa* as a long-term live-aboard. The vessel is what we expect of her no ocean greyhound, but comfy as old armchairs. She sails well, and we have added a bit to the rudder to track better. The multi-chine steel hull is 42ft [12.8m] on deck, 14ft 6in [4.4m] beam and 4ft 6in [1.3m] draft. Overall length is 48ft 6in [14.7m]. We have added the wood capped rail on steel stanchions, and recently the afterdeck canopy that performs as shade, water collection, solar panels on top and easy furling for the mizzen. We have seen three other Sprays. One from Canada, *Spray Venture,* and *Blue Beard* and *Susan II* on the New Zealand coast, though I believe at least another four are around here somewhere. Our interpretation of *Ara-A-Kiwa* is 'Wake of the Navigator' in Polynesian.

Recently, we were 'shaking down' after an almost complete refit, and *Ara-A-Kiwa* was behaving great. Our new GPS and radar were the latest toys; the new mainsail set really well. On top of this, both of us were feeling really smug, having passed the Yacht Master coastal exams together.

We visited Mayor Islands, and then decided to head north for the Great Barrier Islands. The weather was good and the wind fair. A night's anchorage at Slipper Islands was planned and a short cut to the bay between the south end of the island and Penguin Island was there narrow, but there. Our cruising guide indicated 12ft [3.6m] of water in the gap, not a problem for the Spray.

The following breeze pushed us along at about 5 knots, but as we approached the gap I started the engine just in case. Joyce went forward to the bowsprit to see if the bottom became visible, and I watched the depth sounder as it rapidly decreased: 15, 12, 10, 5 , 3, 2 fathoms, then 1 fathom (1 fathom equals 6ft or 1.83m). Joyce began gesturing, she had spotted large boulders that were getting closer; we had misjudged and were about to pay the price.

The engine roared in reverse, but Ara-*A-Kiwa* is almost 20 tons and the sails were still pulling well; we were stuck with a grating and sickening crunch and came to a halt. The following swell was about 3ft [less than 1m], but it began to pick the ship and force her further on to the rocks. The lifting and dropping could be likened to a pile driver. The incredible jarring had the booms jumping and the timber dinghy in the davits was attempting to turn itself over.

The tide is ebbing, it's a beautiful day, and we are having a terrible experience! We handed the sails as quickly as we could and took stock. The following swell meant that efforts to reverse off were negated, and the rudder was being knocked around a bit. There remained only one way off that I thought we could try. I gave the helm hard over and pushed the throttle further than it had ever been before or after.

The Leyland's 130 horse's roared smoke poured, the engine temperature soared, and Ara-*A-Kiwa* began to shudder forwards and to turn! Gradually and almost painfully, the ship made her way, grinding over the stones until her bows again pointed seawards. After what seemed a punishingly long interval, we broke free. Hurriedly, Joyce took over the helm while I searched the bilges, surely we would be taking water; there must be a broken weld, there ought to be, but there wasn't. Good old Spray, I do not know of any other boat I have owned or sailed that could take that amount of punishment and survive.

There was some damage; the lower edge of the rudder was mangled and punctured, the shoe bent, and the 2in [50 mm] stainless shaft was 'screwed' at the tiller bar. Our 'shake-down' cruise had become a 'shake-up' cruise. We rigged the emergency tiller and continued with our intended voyage, even crossing the Hanahe Gulf on a beam reach with the remnants of Cyclone Betsy still blowing 28 to 30 knots. We did over 8.1/2 knots and were comfy and proud.

Lowrey Spray

The following was an article in the New Zealand magazine, called *Sea Spray*:
Wellington fireman Chris Lowrey says,

'If you are prepared to rummage through scrap bins and put in a day's work in exchange for materials, you could get the boat you want at a price you can afford.' And to

> prove it, he picked up his hull plating for nothing, made his blocks from old bedroom furniture, sewed his own sails, had a brother-in-law make one SSB radio out of two DSB rejects, and sheathed his cabin top with 35ft [11m] of brown striped nylon dress material. The result... A 16 METRE CRUISER FOR NZ $20000 [,7000]. One of the greatest hassles of building boats is paying for them, but Chris Lowrey has found a way around the crippling costs. Over the past four years he has created a magnificent ocean-going cruising yacht, a 40ft [16m] Roberts Spray design, for just NZ $20000. The way he went about it was a simple process, and one he would like to pass on to anyone with big dreams and small pockets. To this end, he is writing a book as construction takes place.

The article went on to explain that four years before, Chris, a Stokes Valley fireman, had been dreaming of an ocean cruising yacht. He and his wife Sue had reached the dangerous age of discontent when the family became self-sufficient, and the mortgage was manageable. Chris has been a sailor since schooldays. As a small boy, he joined the sea cadets, the merchant navy at 15, and was never far from something afloat. Six years previously, as owner of a Silhouette, a 16ft [5m] dinghy with a lid, he crossed Cook Strait single-handed one afternoon on an impulse. There he tied up alongside a race finish of Wellington keel boats. 'That was it for me,' he recalls. Chris just had to have a 'real yacht'.

Chris had always loved traditional boats, and his initial thoughts were for something in timber, and about 36ft [11m] long. He made sketches, and took them to a Petone boatyard.' How much to build this?' he asked. 'One hundred and ten thousand dollars,' came the reply. That poured cold reality all over his dreams, but Chris is not a man to give up easily, he had once conducted a five-day vigil on Wellington harbour to protest against a nuclear ship's visit. For a cost of NZ $600
[,300] he bought a set of plans from two men who had decided against building a Ferro-cement Spray.
The article continued:

> 'Then, through consultation with designer Bruce Roberts, he exchanged the Ferro lines for steel. 'All I could do for six months was study the drawings,' he says. 'I didn't have any money, but decided there had to be ways of doing it. To Chris, that meant picking up materials at the right price and building the boat himself. Soon after, his first deal transpired. As payment for spray-painting a demolition yard owner's car, Chris accepted two truckloads of Kauri, Oregon, pipe, iron and valves. One piece of Oregon, 46ft [14m] long, 8in [203mm] octagonal, is now his mast. It was a magnificent piece of timber, not one knot in it. He set to work with a timber jack plane, bought a drum of linseed oil, and for 25 nights swabbed it down. Now 42 ft [12.8mm] long, it will carry the gaff topsail rig. 'It has to be the most expensive mast in the country, counting the hours I've spent on it,' says Chris. 'But it's some mast, my pride and joy; if it ever breaks, I will just put in a bigger engine.'

The article explained that the steel for the hull plating came from a diesel storage tank at Miramar. The twenty lumps of steel, all corten low carbon content, steel cost nothing. 'It looked dreadful,' said Chris. But once the hull was constructed, he and friends sandblasted it inside and out, submerging the Lowrey household and surrounding neighbourhood in a fine-dust cloud for five days. 'One thing you need for this boatbuilding lark,' said Chris 'is heaps of cheek. Never be afraid to walk into an engineering firm with a bin outside, and ask to have a rummage. It is amazing what is thrown out.'

Chris scored 1640ft [500m] of tongue and groove flooring this way, at a quarter of the price. For ballast, Chris worked for three days lifting 4900ft [1500m] of railway lines. He weighed the ballast into 50lb [23kg] lots, and divided the weight across the bottom of each keel section. Even the engine had a history: a Thorneycroft, it originally belonged to the New Zealand Navy. Chris came by it in the hands of one of the men he bought the Spray plans from. It was completely rebuilt, and Chris only had to tidy it up. It took six off-duty firemen to lift it, but it puts out 40hp, has an oil controlled gearbox, and two to one reduction. The big plus is that it can be hand cranked if necessary.

A tool making apprenticeship served years ago came to Chris's aid. With the help of a forge, made with the vacuum cleaner reversed, and a drum full of firebricks, he cast and made all his own fittings. He also made hatches from teak, dorade vents from mahogany and kauri laminated, and he made himself a lathe for the taff-rail. From old oak bedroom furniture came 52 wooden blocks, and he even turned his own axle pins and sheaves. The majority of hardwood on the boat is African iroko. Deck cleats at a cost of $1.50 each and jaws for the boom were from a selected jarrah railway sleeper.

Sticking fairly rigidly to tradition, there are no winches on deck. Sail handling is with tackles. The staysail is self-tending. He has one big headsail, though, to pull the boat along in light weather, so he may relent later and have a couple of single-action winches. He is looking out for a second-hand anchor winch, but is prepared to make one of those too. From lengthy discussions with similar-minded alternative-lifestyle cruising folk, Chris had deduced that when one closes the door on jobs and regular pay cheques, replacing worn-out gear such as sails becomes an impossible task. So, for the sails, which can be expected to last at best about five years, he has picked up an old sewing machine from a farm, borrowed a work table, and is negotiating with an Auckland importer to supply him with tanbark sailcloth. Sail making holds no mysteries for Chris. 'You just mount the machine on the table with a motor and clutch, and buy lots of books. I figure if you can't make it in the workshop, there is no way you'll afford an expert when you are cruising.'
Obviously there are certain things one must buy, but the single sideband radio was not one of them. From two acquired double sideband rejects, a 'radio nut' brother-in-law made one single sideband pretty cheaply.

The 118sq ft [11sq m] of glass sheathing for the deck and cabin top, at $45 a meter, was a difficult one, but Chris found out what the cloth was made from and bought the equivalent in brown-striped nylon dress material for less than NZ $1.00 a meter. He glued a test piece on to ply, boiled it, hammered it, and once convinced it was as good as you would get, down it went. 'It was harder to wet-out,' says Chris, 'but I defy anyone to knock it. You don't have to fill it, just paint over the top.' Chris emphasizes, though, that you cannot build a boat for nothing. 'You can't make welding rods, silicon brass nails, paint. You have to buy the stuff and it costs.' Chris also believes that a would-be builder need not be as fancy as he has been ornately carved dolphins either side of the pushpit, and three bullet-proof work-of-art hatches.

Below decks the accommodation sleeps seven, and has a private owner's cabin aft, and another to forward. There is provision for a potbelly between the galley and the main saloon. Naturally enough, Chris is making the stove. 'I was not keen on gas [firemen are all safety first], and it's not easy to get fills in some parts of the Pacific.' A kerosene cooker with an oven (Chris is into baking bread) would have meant parting with NZ $1200. So, from an old gas range, he made patterns, salvaging the racks and panels. Chris has installed a ring circuit around the interior. He salvaged four brass lamps from an old railway carriage to provide electric power over strategic spots such as chart table and galley, but the balance will come from kerosene lanterns.

Senta

Kenneth P Latham Jr of Rockport Maine arranged to have his steel Spray 40 hull and deck professionally built in Canada. The frame spacing was increased from 1ft 6in [457mm] to 1ft 8in [508mm] effectively increasing the hull length to 43 ft [13.11m]. Kenneth chose the gaff schooner rig and the photographs reveal a well proportioned sail plan; the main carries a topmast that often carries the topsail in lighter weather.

The pilot house was designer by the owner and provides extra comfort when the north east coast weather turns nasty. The auxiliary engine is a 3QM30 Yanmar fitted with a 3:1 reduction transmission and gives 6 knots. (Designers comment: Normally I would recommend a larger engine than the one fitted here, however the 3:1 reduction somewhat compensates for the lower horsepower rating.) The fuel tanks are integral (they use hull skin as one side of the tank) and provide 150 US gal [567 lit] plus the water tanks hold 400 US gal [1514 lit] divided between four tanks.

When the steel work was completed in Port Credit Ontario Canada, Kenneth motored the bare hull, down the Erie Canal to Boston Massachusetts where he finished off the fitting out over a two year period. Kenneth stated:

> ‘I think the hardest part was building the rig. The Spars are aluminum tubes, painted with Allgrip (with a brush!) and I recommend the finish which has lasted well over several years. The rig is that of a 19th Centaury Coaster with a single jib. All the blocks are rope stropped, the standing rigging is galvanized, hand spliced and tarred. The running rigging runs to pin rails in the shrouds. The steering is by rope and drum. Nothing fancy, but cheap, reliable and easy to repair.
>
> The extended cruising has not happened; although we did live aboard for four years, cruising New England coastline as time permitted. We are now settled in Maine and I am modifying the interior to suit her use as a coastal cruiser. For example what had been a workshop in the forepeak is now a two berth cabin for guests.

Walpurga

Mike and Christine Platzer wrote to us as follows:

> ‘It may please you to hear of another Spray that turned out well. She is built to your steel Spray 40 design, with slight modifications. My wife and I built her; we always wanted a floating home that was more of a cruising yacht, rather than one developed from a racing design. After reading Slocum’s book, Pete Culler’s *Building and Sailing a Spray*, and Kenneth Slack’s *In the Wake of the Spray*, the decision was quite easy, and we don’t regret it. Our Spray is called *Walpurga*, which was a Bavarian witch in ancient times, and we have lived on her now for more than three years.

After a season of trials in the German Bite, Mike and Christine left their home of Port Wilhelmshaven in the summer of 1991 and cruised the Baltic Sea until November. They then wintered in Hamburg and worked there on land. They left Hamburg in spring 1992 and visited

many ports in Holland, the south coast of England, Brittany and the whole north coast of Spain, where in November they found a little fishing port near Coruna to spend another winter and work on the land again. Mike and Christine left in the spring and sailed comfortably along the west coast of Spain and Portugal, and crossed from Lisbon to Lanzarote in the Canary Islands in 52 days.
They continued:

> 'Here our boat, for the first time, could really stand up to her reputation. She steered herself all the way, sometimes in strong winds, in exactly the same manner that Slocum's *Spray* and all the famous replicas did. She did it of course on other occasions, but only for hours at a time, on this occasion she had the opportunity to show her paces for a longer period. She does it on all courses and also under different sails.
> We want to stay in the Canaries for at least a year, and do a bit of charter work in the winter.

Chez Moi

This Spray replica is currently owned by John Guimont, who sent us the following account:

> '*Chez Moi*, currently at the Oyster Point marina in south San Francisco, California, is a Spray based on your design. I am the second owner. She is constructed in steel with some modifications. Don Lefler was the builder. Don is a retired custom home builder, who began construction of the Spray in 1981 in Oregon. He contracted the hull and deck welding project, and then moved her into his back yard where he spent several years completing the project. She was completed in Richmond, California, in 1987, and christened *Shibumi,* and sailed to Mexico, Hawaii, and then returned to California. The interior was photographed by Steve Dashu en route. (Steve Dashu is a famous American yachtsman who designs, builds and sails fast cruising boats, and is a prolific yachting journalist and well-known figure on the American cruising/yachting scene.) She was sold to me in 1991. The plan is to finish some upgrading in the next few years and retire for an extended cruise.

Chez Moi has a steel hull, a staysail ketch rig, and the interior is fitted out with Honduras mahogany. She was finished by a custom home builder, who did a wonderful job; this kind of interior is effectively unavailable from any commercial builder. Don made a number of design changes. She is powered by a 20 hp China diesel, which is marginal. The raised portion of her cabin was extended forward for additional headroom. The masts were raised 6ft [1.8m], and 6in [152mm] were added to the keel. John bought *Chez Moi* for the safety and comfort of the design, and the steel for long-distance offshore ventures. To date this experience has been in San Francisco Bay and the surrounding coast. John feels that the only drawback of such a heavy, stiff design is that the genoa will blow out before she feels overpowered enough to reef. This was his learning experience on a trip to Drake's Bay.

Instead of a conventional V berth forward, Don, the original owner and builder, built one on the starboard side, and then installed a complete head and sail stowage area on the port. In the main cabin there is a U-shaped settee to port and two swivel chairs to starboard near the heater and bookshelves. The galley is to starboard, and the navigational station to port. The aft cabin has an athwart ships berth, which is usable under almost any conditions. Don built pilot berths into both sides of the main cabin but John says there's been a need for them. He plans to remove the one on the port side to use it for an entertainments centre TV, VCR tape storage, etc. The overall design concept was to set up for extended offshore work by a couple with the option of having a single crew member in separate quarters forward for long passages. John's plans are essentially the same.

Fuel capacity is 2 x 45 gal [2 x 204lit] tanks with a 10 gal [45 lit] day tank mounted above the engine. There are four water tanks totalling 150 gal, [682 lit] and there is another 45 gal [204lit] tank that has never been used. Don was not sure which fluid he would run out of first, so he kept the last tank in reserve to be adapted to water or diesel as needed. He never came up short on either one. John plans to carry water, maker so he expects to increase the diesel capacity.

Don kept the construction simple and cheap, no refrigeration, but there are two huge ice boxes that are very well insulated. It is basically a no-frills construction. Don had Loran, HAM, VHF, and Satnav, supported by three batteries in two banks. John has added radar, and plans to add GPS, two of them, electric windlass, three more batteries as a third bank, inverters, scuba compressor, and salt water wash down.' That's more than enough complication

for me', he says.
John continued:

> 'When I bought *Chez Moi* I was single and planned to cruise alone. If I had known I would marry again, I would have named her *Chez Nous*. I will probably change the name when we repaint the entire boat prior to departure.

The Spray is a comfortable cruising boat, and one that can carry a lot of extra gear and equipment without adversely affecting the performance. When fitted with the slightly deeper keel that some owners have opted to install on their Spray replicas, then the boat does go to windward better than one would expect. Also, the rig is an important factor; and, as the reader will observe, many owners have opted for gaff ketches, gaff schooners and the like, so you cannot expect impeccable windward performance using these rigs. Various owners go into some detail about the rigs they have chosen, and try to assess the value of each in relation to the Spray design.

Florissant

Last year when visiting Australia, my attention was drawn to a publication called *Trade a Boat*, which contains hundreds of boats for sale. I decided to write to all of the brokers who had Spray replicas on their books; the first reply was from John Latchford at Whitsunday Marine Brokerage of Airlie Beach, Queensland:

> 'We regularly see Sprays here in our marina, particularly during the cruising season, and we are always interested to see how different boats of the same design can be. They certainly are boats designed for the individual! The *Florissant* is a Roberts Spray 40, built of solid fiberglass. The owners live on *Florissant* permanently and also run their business on board. She is cutter rigged with two furling headsails. The main has Dutchman reefing plus a storm sail is fitted and a 2200 sq ft [204 sq m] MPS, which I assume is a cruising spinnaker. The engine is a Ford 85 hp diesel, and the boat cruises at 8 knots. This particular Spray is well fitted out with Auto-helm, wind speed indicators, depth indicators, log and radar. She is also well fitted out with navigation equipment, including a GPS Navstar. Safety equipment includes dry chemical fire extinguishers, and a good selection of anchor gear, chain etc. Subsequently, a letter arrived from the owners of Florissant which stated:

> 'We were very excited regarding your plans for the forthcoming book about the beautiful Spray, and to know that our own yacht *Florissant* will take part.
> We bought Auntie, as we now affectionately call her, in the beautiful Whitsunday's, Airlie Beach to be

precise, which is part of the magnificent Barrier Reef on north-eastern Australia. It was an instant love affair; and after an inspection and a test sail a deposit was placed, and the arrangements made for a survey. In shock from our unexpectedly rash decision, we raced back to Sydney to finalize the sale of our home, which was to finance the purchase.

As nature would have it, we commenced our delivery voyage from Airlie Beach to our boats new home in Sydney, a voyage of approximately 1100 nautical miles, at the worst possible time of the year for the prevailing winds. The wind was on the nose at regular forces of 25 to 40 knots. Rain squalls and large swells, possibly 16ft [5m] on occasions, added to our time of about three weeks for the trip, which normally takes about ten days.

Their greatest problem was of the manmade variety. About 15 miles off the coast opposite the sleepy little village of Ballina, on one very stormy night, a huge container ship mistook their yacht as a rendezvous vessel for, they suspect, illegal drug trading or illegal migrants. Their radar screen picked him up about 6 miles away heading north to south, but instead of continuing on his way after passing them, he turned and circled *Florissant* in ever-decreasing circles until he was no further away than about 100 yd [92 m]
The letter continued:

'Repeatedly, we called on the VHF for the ship to recognize us and signal his intentions, but we were met with only the chilling response 'We have no course', which was spoken in such a cold and cruel tone that we will never forget it. Eventually our local volunteer Coast Guard came to the rescue via the VHF, and as soon as the ship knew he was monitored by the authorities he sped off at a great rate in a southerly direction. Naturally, reports were made to the Customs and other authorities.
On our arrival back home in Sydney, we had time to reflect upon our adventures and to realize what a wonderful yacht *Florissant* truly is, that is, a magnificently strong, stable and sea kindly lady. We would have no hesitation in sailing her in anything Mother Nature cares to conjure up, and to recommend her design to anyone contemplating purchasing a Spray.

Arnak
The owner writes:

'My wife, Linda, and I have now been living on board our Spray *Arnak* for the past 14 years, and, after a shake-down cruise around New Zealand in 1980, have cruised the south-west Pacific including Fiji, New Caledonia, Vanuatu, Solomons, Papua New Guinea and Australia.
We departed Australia in 1987 bound west across the Indian Ocean, visiting Christmas Island, Cocos Keeling Islands, Chagos Archipelago, Sri Lanka, India, Oman, South Yemen, Djibouti, Sudan and Egypt, then through the Suez Canal in May of 1988 to visit Israel, Cyprus, Lebanon, Turkey, Greece, Italy, Malta, Tunisia, Spain, Gibraltar and Morocco. We visited many ports on the Algarve coast of Spain and Portugal, then sailed to Madeira and the Canary Islands, thence to Senegal and Gambia on the West African coast where we sailed up the Gambia and Casamance rivers, perhaps the first Spray and New Zealand vessel to do so.

Their next stop was the Cape Verde Islands off the African coast and then across the 'pond' to Barbados, Bequia, and south through the Grenadines to Trinidad and Venezuela, where they explored as far as they could up the San Juan river in the Gulf of Paria. Next they went west to Bonair and Curcao, and on to the Bay Islands of Honduras. Their next stop was the Rio Dulce in Guatemala, where they explored far inland, then Belieze, Mexico and the USA, which is where they are at present. .

They called their Spray a 'Spray type', as a replica would indicate an exact copy, which theirs is not. The owner says he has heard the term 'Spray class' used, which may be relevant.

The letter continued:

> 'We bought your plans to the fiberglass Spray 40 and a copy of Ken Slack's book *In the Wake of the Spray* in 1975. After making some minor modifications and designing the cabin and interior layout to our liking, we built our Spray, completing the project in 1980. This is a rather sad time for us as we have decided to sell *Arnak* and live ashore for a while, during which time I will build another Spray. Tomorrow, *Arnak* will have a new owner, who will retain the old name and be using the vessel in his marine biology studies around New Zealand, so she will complete her circumnavigation and be an ideal platform and home for him and his wife. People often ask me what I think of the Spray, and my answer is, 'I am building another one.'

After cruising and working in many countries, Arnak's owner believes that Spray is the ideal vessel. To start with, a well-proven working boat type, modified slightly for ocean sailing, is a great compromise. The stability and balance of the Spray are legendary. What a lot of people don't realize is that there is no perfect boat, only boats most suited to the work you put them to. You can't have 14ft 4in [4.4m] beam and 4ft [1.2m] draft, and go to windward like a witch, just as you can't have 10ft [3m] beam and 7ft [2.1m] draft and have initial stability and live aboard comfortably on a small vessel around 40ft [12.1m].

The letter said:

> 'Looking back over the last 14 years in black and white, we have spent 80 per cent of our time at anchor or in port, 19 per cent sailing off the wind and 1 per cent on the wind. How much compromise should you make for windward performance? Of course, this is only the use we put our vessel to, which is, live-aboard ocean cruising. We have

spent a lot of time exploring rivers and creeks as well as coral atolls and islands, a lot of which are uncharted, and our 4ft [1.2m] draft was of great value. In the open ocean, again our draft has been of benefit, giving to the seas rather than being held when a large wave hits. Running dead downwind with our great beam has been very comfortable with no rolling from gunwale to gunwale.

This is a point of sail most cruising sailors hate, but one generally found on ocean passages in the tropics. I believe there are basically three items that should be addressed when choosing a sailing vessel: seaworthiness: a proven design or type. windward performance: look at where you will be cruising or sailing; comfort: look at how long you want to live on board, initial stability/stiffness, roominess and displacement. The *Spray* is exceptionally well balanced, and *Arnak* is no exception.

Arnak' s hull is built in solid fiberglass using C-Flex (tm) as the base material with alternating chopped strand mat and woven roving lay up. The hull laminate tapers from 13 in [31mm] keel to the 14in [355mm] high bulwarks which are 3/4in [20mm] thick. The hull is divided up into 6ft [1.8m] square sections using hollow fiberglass frames and stringers to give an extremely strong and stiff hull. Ballast is 42 tons [4572kg] of cast iron securely glassed in.

All full and partial bulkheads land on frames, and are locked and keyed in place with a substantial glass laminate. Below the waterline there are four thick layers of epoxy tar to prevent osmosis, followed by a waterproof barrier coat, then three coats of copper antifouling. The coamings, cockpit and cabin top are finished in epoxy saturated, laminated plywood, covered with a 6 ounce [170g] glass cloth and epoxy resin followed by a two-pot polyurethane paint system for very low maintenance.

The deck shelf is laminated New Zealand Kauri epoxy glued and through-bolted with 3/8in [9mm] bronze bolts, which pass through the hull and the rubbing strake. The deck beams are 4in [100mm] and 2in [50mm] kauri, checked into the deck shelf and carline, which is again laminated kauri. The decks are constructed using 2in [12mm] epoxy-saturated ply with 2in x 1in [50 x 25mm] teak over.

The cabin sides are 12in [37mm] laminated ply, and the cabin top is 1in [25mm] laminated ply over laminated beams. The king plank is 10in x 12in [250 mm x 37mm] in kauri, through which the anchor winch and large bronze bollard are bolted. There are six dorade vents on the cabin top, giving excellent ventilation in hot weather. All deck hardware, including portholes, winches, cleats, bollards and turn-buckles are bronze. There are no plastic fittings, and even the sail slides are stainless steel.

The sails are all triple-stitched Dacron, made by Lidgard Rudling Sails of New Zealand. All working sails are tan in colour; the large cruising spinnaker and mizzen staysail are gold. These sails are still in very good condition. The rigging is hand spliced and swaged 7 x 7 stainless steel, oversized, and supporting a large section double-spreader mainmast and single-spreader mizzen; a track holds the permanently mounted spinnaker pole. The headsail is rolled around a furling gear that is strong and reliable and can be reefed from the cockpit. All other sails are hoisted using double braid Terylene, all rope halyards leading on to New Zealand made bronze Murray bottom action winches.

The davits are a heavy section 2in [50mm] pipe and carry the 10ft [3m] aluminum dinghy. The outboard motor locks on to a pushpit bracket, and there are strong hardwood grab rails on the cabin top. The spray dodger, which covers half the cockpit, has zipped windows for extra ventilation. There are two large cockpit lockers. A large awning also doubles as an efficient rain water catcher with flexible down pipes. The bronze steering wheel is attached to the tiller arm with a 12 in [37mm] shaft, chain, cable and steering box, which is next to a robust autopilot motor. This gives a very positive and strong steering system without the loss of feel. The emergency steering drops straight on to the top of the flanged 2 inch rudder shaft for tiller steering. Spare steering cables are only part of the extensive spares carried to make this yacht self-sufficient. Under the cockpit floor is the main engine, a Ford 4 cylinder 60 hp engine (diesel), completely rebuilt with new cylinder liners, pistons, rings, bearings etc in June/ July 1992, it is a slow revving and reliable motor, which has always started at first turn of the key. *Arnak*'s owner has maintained this engine in top condition and kept a full log of all maintenance. Coupled to this engine is a large, two to one Paragon mechanical gearbox driving double universals and stainless steel shaft, which is held solid by a heavy thrust bearing. The stern gland is bronze and the stern bearing is of the rubber cutlass type. The three-blade propeller gives a cruising speed of 6 knots, with 8 knots maximum. At cruising revs, 1500 rpm, the fuel consumption is about 1 gallon per hour, giving a cruising range of about 600 M [965km]. Fuel is carried in two separate integral tanks of approximately 60 gal [270 lit] each with spare containers on deck. Situated in the engine room is a 12 gal [54 lit] hot water cylinder, which heats off the engine or via the AC system to which it is wired directly.

A lay shaft alongside the engine drives a 75 amp alternator and the compressor for the 4cu ft [.36 cu m] freezer and the 2cu ft [.18 cu m] fridge. There are spare pulleys fitted to take any other equipment that could be fitted at a later date. The freshwater pressure system is also mounted here, along with the automatic and manual bilge pumps. There is good access to the engine, and all regular maintenance areas can be easily reached. Two BCF fire extinguishers are fitted close to the engine room. Outboard of the engine on either side is the fuel and water tanks, with sight gauges and good access for cleaning.

We water tank in a dry and easily serviced area. The switch panel fronts the main saloon over the chart table, which hinges up for access to the fridge/freezer. The navigation equipment is also in this area, including autopilot, VHF, Satnav, RDF, depth sounder and instruments. The sounder swings out for easy helmsman's viewing.

All the bulkheads are 1in [25mm] laminated ply, faced with New Zealand honeysuckle and sapele mahogany. The cabin sides are fitted with polished brass grab rails and the main saloon table is mahogany with a unique cork inlay, and seats six. Cupboards and under seats provide plenty of storage space, and cupboard doors are fitted with rattan/cane for ventilation. The floors are ply with cork overlay, easy to keep clean, and warm. Forward of the forward cabin is a chain and rope locker with plenty of room for spare chain and rope, etc. The forward cabin has two V berths with separate reading lights and storage under and alongside. The galley is fitted with a stainless steel sink and tiled bench and up stand with a New Zealand-made stainless steel, three-burner stove, and efficient oven. There is also a DC to AC inverter fitted to run normal domestic appliances. There is excellent storage space for food and crockery, etc in cupboards and drawers. In the aft section of the boat on the starboard side is the master cabin, with a comfortable double bed and vanity unit with hanging locker and plenty of drawers. On the port side is the roomy shower and toilet area, with shower curtain and hot-and-cold pressure water. Forward of this is the sail locker with storage under. *Arnak*'s owner said:

> 'In 14 years of live- aboard cruising, during which she has carried us effortlessly three-quarters of the way around the world, *Arnak* has proved herself especially comfortable at sea, rarely heeling more than 10 degrees, and easy to sail for two persons in all weathers. Had we not decided to have a break ashore for a few years, *Arnak* would not be for sale. In fact, that period ashore will be spent building a new vessel, identical to *Arnak*. but slightly bigger.

Capt J Slocum

Kjell Zetterstrom of Norway has told us his experiences of building and sailing his steel Spray 40 Version C:

> 'Way back in 1980 I received the boatbuilding package and starting building shortly afterwards. I decided to weld the hull, since I had done some amateur work in the field and had access to left over 5mm steel plates from a shipyard. Your specification was 4mm (these two mm sizes fall one each side of 3/16 inch), but I estimated the extra weight not to represent a problem.
> Bearing in mind that I live in a cold and rainy country, I changed the upper decks and cabin and cockpit. The cabin and cockpit were 1/8in [3mm] steel plated, on which 3in [6mm] plywood was glued with polyurethane. In turn, 2in [12mm] teak was glued to the plywood with epoxy. Next change was the rig. Several old sailors advised me not to use the wooden gaff rig, and I'm glad I didn't, even though it would look more classical in appearance. I installed a new 6 cylinder Ford diesel that I was able to obtain very cheaply, and also installed hydraulic steering and aft deck mechanical steering. Also, I installed a 3 KW diesel-powered generator, electric bow steering, and a 1500 Watt winch. Also included are two 132 gal [500 lit] stainless steel water tanks. The hull was completely foamed

internally with polyurethane foam, and all of the interior was fitted out with teak; it is heated using a diesel heater and an electric oven. You can probably imagine that it has become 1, 2 tons too heavy. On the other hand, less ballast was required, so the total weight is approximately 18 tons.

Since I mostly sail alone, in moderate winds though, I saw the necessity of handling the boat from the aft deck. The solution was a roller sail system, and a genoa foresail using profurl. This gave effect that gave me more weather helm than I would like, so I found the obvious answer, and that was to extend the bowsprit. Now she sails beautifully. I don't mind challenges, and I believe problems are there to be solved, and the satisfaction in solving them justifies all the headaches. I will not hesitate to tell you that my Spray is admired wherever we go, and I can only guess how many hundreds of photographs have been taken of her by admirers. It probably does not surprise you when I say that she was christened *Capt J Slocum,* and that I am very proud of my Spray'

Mirounga

Ulrich Kronberg contacted me by fax to say he was the owner of a Spray 40, and that he was building it from early 1985 until 1990. He said that he had two friends with Sprays, *Cornchri* and *Walpurga, Cornchri* was standing in Wilhelmshaven and *Walpurga* was in the Grand Canaries.

Naturally, I was most excited at receiving Ulrich Kronberg's fax. Not only had I discovered one more Spray in Germany, but another three boats had come to light. Shortly after this, the postman delivered a large envelope, which contained a copy of the magazine *Palstek*, which specializes in the practical needs of sailing people.

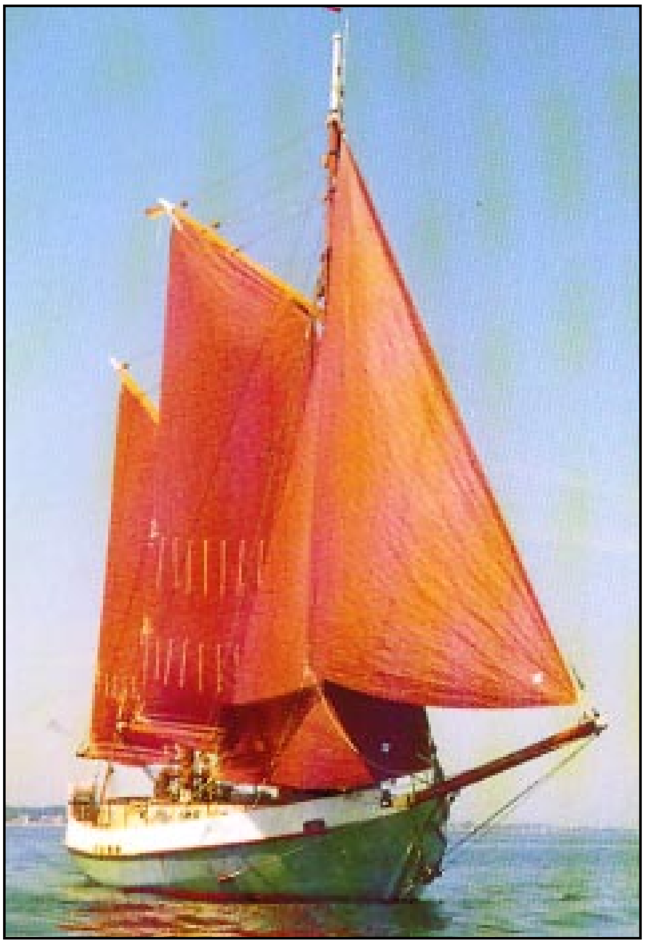
There are lots of 'Do It Yourself articles', and stories of the cruises undertaken by the readers of the magazine. Ulrich Kronberg is the editor of *Palstek* and has written several building and cruising articles that feature his Spray called *Mirounga.* In one of the articles Ulrich talks about the early days of building the Spray hull and points out that everyone has to make sacrifices if they are going to build a boat successfully. He says, 'You yourself will have to take a long period of deprivation. It is usually even worse for the family. No more visits to Granny's. The dog will be chased instead of walked. The theatre is a thing of the past, and conversations are just boring breaks that disrupt work, unless of course, they are about your own boat.

Ulrich Kronberg's article goes on to lay out step by step how he built the boat, and some of his comments are worth noting: 'With all purchases, the best advice is to have barbed wire in your pocket.' On building a steel boat, Ulrich says, 'The building site should not be too close to a residential area, for most of the work is done at weekends, when other people, believe it or not, want peace and quiet.' On working under cover, Ulrich says, 'The minimum covering is a tent roof. We were very happy with our "Scottish" tent. In Germany, 10 per cent of the building value is due in fees; the "Scottish" tent is most suitable.'

When discussing obtaining some of the materials for the setting up and the strong back, Ulrich says, 'You can get all the beams from the scrap heap. New ones would be too expensive and would not carry out their function any better. They will land up on the scrap heap again anyway. Prices are according to market conditions, sympathies and moods. Here you need to use the international boat construction currency: beer for small change, brandy for banknotes.' On buying the materials to build the boat, Ulrich says:

‘A sad chapter is the purchasing of materials and the acquisition of tools. It is sensible to order large quantities, because small orders are usually over-priced. Things that are used up like welding wire, grinding disks, etc, should never be bought individually, but you should try to negotiate prices for a large quantity to be delivered. Do not forget that high-quality tools are the only ones that last. Cheap DIY items seem enticing, but are only suitable for DIY home handyman use. We are not putting together a hobby room, but building a boat. A service network is important, although this can give you grey hair too. Good planning is especially important, because shops are of course closed at the weekend (at least in many countries!), when you do most of your work.’

On safety, Ulrich says, ‘Be careful with your eyes. Think of accident prevention. My two visits to the eye clinic have strengthened my conviction that you cannot make savings here.’



Alan Sendell

Peggotty

As is evident from the text, most of the Sprays are scattered far and wide around the world. There are Sprays in almost every country; and, as we wanted to include the details of as many of these boats as possible, we did not stint in our efforts to track down individual examples of the Spray design.

The story of *Peggotty* originally appeared in the *Eastern Daily Press*, a newspaper that covers Norfolk and Suffolk. Via a phone call to the newspaper, I obtained the original photographs that appeared with the article; shortly after filing the information away, a letter arrived from Alan Sendell, totally independently of the information via the newspaper article. Alan and his wife are the owners of *Peggotty*. Alan wrote:

'It was obvious to us that *Peggotty* was well suited to strong winds, and handled rough conditions very well. While I was building *Peggotty* I tried to imagine her in the worst seas and wind, and how she would fare if rolled or pitch-poled, and I tried to design all her fittings and fixtures accordingly. Always in the back of my mind I had the idea of sailing the Southern Ocean to round Cape Horn. Another desire of mine was to some day see the Antarctic continent, and it seemed logical to do that at the same time, seeing as we would be so close; and now in Sydney we started to prepare for the long trek across the Southern Ocean. We had new sails made, and incorporated a trysail into the main so that we would have a gaff-headed trysail, which I hoped would cause her to heave-to better. The new staysail had one reef which was probably a waste of time; we have only used it reefed a few times, preferring to use the storm jib.

A year after arriving in Australia, they left and crossed the Tasman Sea to Nelson, New Zealand, which gave them a chance to test their new systems and the new sails. Heaving-to now with the new mainsail was much improved; they lay 50-60 degrees off the wind, 'very comfortable' and it was so much quicker than setting the trysail. The next months in New Zealand were spent in preparation and waiting for November, the time they had chosen to leave. Alan commented that another advantage of a Spray is the ability to stow 12 months' food and all the spares and tools needed for such a voyage.
Alan said:

'We left New Zealand on 11 November 1992, and during the next 12 months we sailed 24000 miles. We sailed over 5000 miles direct to the Antarctic and cruised there for three to four weeks before heading north to the Falkland Island's where we stayed for

another four weeks before heading to the UK via Brazil and Granada. We left England in October 1993 and sailed to Antigua via the Canaries. During all these miles *Peggotty* took good care of us, and we had no really anxious moments (except for a few close calls with ships in the English Channel), whether it was beating clear of Elephant and Clarence Islands in the icy waters of the Antarctic, or drifting along in the Inter costal Waterway. In the big following seas of the Southern Ocean, we lay below reading. With the storm jib poled out and her long keel, there was little enough for the steering gear to do. The only breakage we had was a gaff fitting that broke 300 miles south of Port Stanley.'

This attractive Spray 40 - Pilot house version was built in Severna Park Maryland USA and later sold to a young couple who sailed her north to New York.

Harry B

Roland Latina of Illinois, USA, built his boat using some unusual boatbuilding techniques, which seem to have worked out well in practice. Bob's Spray 40 is not the first boat to be built using the multi-chine steel patterns as the basis for building a fiberglass boat, but some of the techniques Bob has used are a little unusual. He purchased the patterns for the 40 ft [12.1m] multi-chine hull Spray replica sometime in 1978, choosing the multi-chine patterns so that he could use the material that was available for frames.

He worked for the Rawlings Sporting Goods Company, and when they dropped their hockey line, he made them an offer for all the left-over hockey sticks. He used the ash handles, four in a bundle epoxy glued and bolted, for his frames. Roland was very pleased with results. He then planked the hull, deck and cabin using C-Flex (tm) fiberglass planking, which was Monel stapled to the frames, and inside the hull he backed this up by using epoxy fillets and additional fiberglass to attach and bond the frames into the hull structure. He discovered in order to keep costs down; you had to be a great scrounger. Roland used just about every type of wood available for the interior. He laminated his cabin and deck beams, mast, boom and gaff from clear Douglas fir and epoxy.

Roland made his mast and boom hollow, but had a tough time getting the wood to give him an 8in [203mm] round mast and a 6in [150mm] round boom. Roland filled the hollow parts of the mast with crushed aluminum foil, to ensure that he would be picked up on radar. He used railroad tie plates for his ballast and bedded them in epoxy. His vessel has a 50 hp Perkins diesel, an auxiliary engine and a three-bladed prop. When all this work was finished, Roland had the boat hauled on a hydraulic trailer from Belleville, Indiana, to Berkeley Lake, Kentucky.

After a shake-down, Roland and his wife left Berkeley and headed south through Kentucky Lake, Tennessee River, Pickwick Dam and Lake Cistlok, and then down the Ten-Tom Waterway to the coast. The last two years they has been cruising the Gulf Coast from Biloxi, Mississippi, and also around Ocean Springs, Pennecola, Pestin, and now at a marina in Niceville, Florida. They love the boat! lots of room down below and they live aboard quite a bit. Roland and his wife can easily handle the *Spray* (they are aged 69 and 66 years) and she stays stable under sail. The boat is rigged as a gaff cutter with the foresail on a boom.

Ospray

Jim Mellor, the builder of the steel Spray 40 *Ospray*, wrote in March 1982 providing considerable detail about the building of his boat. Jim also wrote several articles for the UK boating magazine *Practical Boat Owner*, which were run in the January, February and March 1981 issues. The articles and letters that Jim sent to me reveal that he was a very resourceful builder and thought through each stage of the building programme, and developed some useful building techniques as well as ways to save on the costs.

For instance, when it came to obtaining the timber for his mast, Jim researched the matter thoroughly and found that there was a stand of suitable timber up on the Welsh mountainside only 30 [48km] miles from his home. He said that for some reason or other this particular stand of timber had not been thinned out and the trunks of the trees grew straight and tall. Jim and another builder, who was also looking for mast timber, went off to inspect these trees. Accompanied by a forester, he was advised that providing he was willing to pay a little over the commercial price, he would be able to purchase one of these trees for himself. In effect, when the time came to choose the trees, he and his companion chose three for the two masts they needed, the idea being that if one proved unsuitable then they would have a spare.

The cost was ,80 for three splendid masts. The trees were felled without delay, and by good fortune a timber merchant working in the area agreed to haul the timber home for ,35. The same person had a 100 hp Ford diesel engine available, and Jim was able to purchase this for ,50. As he says, 'Thus by one stroke of luck did we acquire the basis of two forms of motive power.' Jim launched *Ospray*, and was in touch with us during the sailing trials and later reported:

> 'I am glad to say that *Ospray* has fulfilled all our hopes and expectations! After several grand little cruises to the Hebrides, West of Scotland and Ireland Else and I took a year off and did a round trip to the West Indies, going via the Scillies, Northern Spain, Madeira, the Canaries, Cape Verde Islands and then across to Else's birthplace - Trinidad, where I can tell you, there was a great reception from the family. We sailed in through the 'Dragons Mouth' just as dawn was breaking to the weird screams of the Howler monkeys and the rich steamy smells of the jungle only a few hundred yards away. An osprey swooped down and flew over his namesake which we took to be a good omen.
>
> After enjoying Christmas with the family we spent the next six months cruising the tropical paradise of the Grenadines, the Windward and Leeward Islands and then on to the British Virgins. The snorkelling was terrific and the variety and colour of the fish has to be seen to be believed. We swam and dived in the 'champagne' off Parumica where strings of bubbles trickle upwards from the sea bed as a result of volcanic activity beneath the sea.
>
> We had some close encounters with sperm whales who grabbed our attention by throwing their great flukes in the air only a few yards from the boat. The hand of god was what the old whalers called it. Mostly throughout the islands we anchored close in with a stern line tied to a palm tree. Talk about idyllic! Boat boys would swarm alongside, sometimes too many, bringing hands of bananas and other provisions. *Osprey* was the centre of attention where ever we went and we made many friends along the way.
>
> Having built my Spray with the help of my sons I was very proud that two of them were able to join us. All too soon it was time to make sail for old England via Bermuda, The Azores and Ireland. The twenty day crossing from Bermuda to Horta was a rough one, three gales and of the seventeen vessels that arrived in the Azores from Bermuda during that period, *Osprey* was one of only two that arrived undamaged she looked after us wonderfully well and in the big following seas she was brilliant; no yawing or corkscrewing as I have struck in other boats.
>
> On the way back we were guided by 'Herb' a radio ham and meteorologist from Bermuda. Each night Herb would call his 'ducklings' in listed order and give and receive weather information, telling us which way to head to avoid the worst of the weather. Over the years Herb must have saved many lives with is selfless all for nothing service, God bless him.
>
> We saw whales almost every day and one day a trio of fin whales which we estimated to be nearly 70ft [21.3m] long, against Osprey's 40ft [12.2m], swam up to us, one swimming under the boat while we looked on with some apprehension, truly a magnificent sight.'

Tanimara
This fiberglass Spray 40 was built in Belgium by Jack Danneels, who supplied the following information:

> 'Regards your calling all Sprays, I built *Tanimara*, (the name is Comanche for Northern Wind, Lonesome Wind,) in Antwerp in Belgium after work and during weekends and holidays. I started in 1978 with a companion called Frank Nys. Preliminary study of the subject via your booklet *Build for Less*, and the Spray, study plans plus Ken Slack's book *In the Wake of the Spray* finally set our minds on the idea.

The detailed construction plans and full-size patterns were received in the summer of 1978. They were to build one mould and two balsa sandwich hulls together, sharing all costs. When the first hull was finished and turned over in 1981, Jack's partner Frank lost heart. Realizing that the project was going to take up all of his free time and disrupt family life, he decided to give up. So Jack was on his own. He decided to use the hull as a mould for the second hull after he won the toss for the first hull. With the help of his wife, this second hull was completed in 1982.

Jack slightly modified the bow, starting at station one-half, to give *Tanimara* an increase in the clipper bow, making her LOA 44ft [13.4m]; the keel line was lowered by 5in [127mm] to accept 6.5 tons [6604kg] of lead ballast and to allow for the slightly higher masts. Jack goes on to list all of the equipment aboard his boat and then states, 'The boat was built as a "live-a-board" for four in great comfort, with room for another two occasionally.'

Tanimara - *Small section of the beautiful interior.*

Tanimara was finally launched in September 1991 and did not need trim ballast at all; she sailed her maiden trip on the North Sea in 1992. Although Jack and his wife do not have long-distance cruising experience, this is for them in the near future; they are hoping to circumnavigate - they can already confirm some virtues of apparently all of the Sprays: excellent balance on all points of sail, very sea kindly, and safe motion even in very chaotic seas. *Tanimara* is easy on the rudder, but needs a lot of practice tomaneuver out of the small, crowded and confined harbours of Belgium.

Jack's partner Frank found a courageous buyer for his hull in 1987, and since then the boat has been completed and Jack saw her sailing on the River Schelde on a return trip to his home port of Antwerp. This Spray is called *Jan Wandelaar* (Johnny Walker). Jack says he is convinced that all proud builders and owners of the Bruce Roberts Sprays will give 'equally enthusiastic experiences in reply to your call.'

Canores

My initial information about this Spray replica was obtained from the passage notes column that appeared in a recent edition of the American boating magazine, *Cruising World* I quote from the report:

> '*Canores*, a 40ft [12.1m] Bruce Roberts version of Joshua Slocum's Spray, with Floridians Julia and Jim Pensioner aboard, called at Barbados last spring, bound for the Grenadines and Venezuela. Jim and Julia have lived aboard Canores since she was launched in 1989, and have cruised the US east coast, Gulf coast and Bahamas with her. The Pensioners, who built their dream ship in eight years, prefer steel construction for its strength in comparison with other materials. They recycled some 5000 lead wheel counterweights for ballast and used masts resurrected from another boat.

Jim and Julia provided the US Bruce Roberts office with a brochure that details some of the features of *Canores*. Obviously they plan some chartering, as this brochure details all of the attractive features of the yacht that would appeal to would-be charterers. On deck they detail that the boat is equipped with two anchors that are housed on the bow with bow rollers, and an anchor windlass, for each. Some 200ft [61m] of anchor chain comes through the deck at the windlass and the second anchor has a 50ft [15m] chain and 200ft [61m] nylon rode. Teak anchor chocks are provided for on-deck storage for the two main CQR and Danforth anchors. A deck box behind the bowsprit contains mooring lines and anchor floats. The bulwarks of this Spray are 18in [457mm] high and these are topped off with stanchions and lifelines. The good-sized, comfortable, midship cockpit is covered with a permanent, but removable, sunbrella awning with roll-up acrylic windows all round. This of course is a very 'Floridian' type of arrangement, as most of the boats that operate around Florida and the Caribbean make plenty of provision for protection from the sun, and often the cockpit areas are capable of being temporarily fully enclosed, so as to afford protection from the numerous insects that prevail at certain times of the year in that area.

Spray of Dell Quay

Built from 1985 to 1987, using Bruce Roberts plans, by Trinity House pilot Brian Reed of Liverpool, this steel Spray 40 is currently owned by John Corello of Chichester. The Spray is fitted with a 80hp Watermota diesel. The sails and rigging were made by James Lawrence of Brightlingsea; the mast and spars by Collar of Oxford.

All the above detail was supplied by the current owner, and looking at the photos of the boat

I can see why he has gone to some trouble to give credit to the various suppliers. This is a beautiful example of the Spray 40, as an excerpt from a recent survey report conducted for an insurance company reads: 'Workmanship throughout the vessel is all of good standard, with every care being given to all aspects of construction to give a strongly built craft with scantlings in excess of normal yacht construction. The fitting of the plating is reflected in the fact that no filling of the topsides has been necessary.'

Owing to the frequent difficulty of obtaining crew, John Corello has mostly sailed the boat mostly single-handed. Poole, Portland and the areas around the Solent have been John's cruising grounds. John stated:

> 'She is a magnificent sea boat under sail or power (I've owned or built a total of 37 craft), and I am very happy sailing her on my own, but now long for a companion. For some years I sailed the famous *Gold Belt,* a coasting barge carrying foodstuffs around the coast; she likewise has great seagoing properties, riding out many storms.'

Delphinae

This is one of several fiberglass Spray 40s built by Peter D Norman from a female mould he constructed in Vancouver in Canada in 1974. During the period when I was I opening the Bruce Roberts design office in Vancouver, Peter occupied an adjoining office, where he carried on his practice as an insurance adjuster. I remember Peter was well respected in his profession and was always in demand, flying here and there to inspect the latest major disaster.

Peter approached our design office and purchased a set of Spray 40 fiberglass plans and patterns. A female mould was to be built, and it was hoped several hulls could be sold. To my knowledge, about a dozen hulls were built from this mould - and maybe many more. A photo taken back in 1976 reveals several hulls being fitted out at that time. Hearsay leads me to believe that the moulds were still in use until recent times. We would like to hear about some of the other Sprays whose hulls were laid up in the same female fiberglass mould.

Drifter Way

Frank Thiessen, an airline pilot/training captain who is stationed in Taiwan, writes:

> 'I leased a mould from Peter Norman in British Columbia Canada in 1979 and we laid up a Spray 40 hull. Subsequently, I finished the ketch design with centre cockpit. The boat was finished beside my house in Whistler in British Columbia, and we named boat the Drifter Way. My wife completed the interior fabric work and like every sailor's wife, was a terrific support person throughout the project. *Drifter Way* is presently located at Mosquito Creek Marina in North Vancouver. Our plans are that as soon as Taiwan allows private yacht ownership, we shall park the boat here for a while.'

Derwent Endeavour

This is another Australian-based fiberglass Roberts Spray 40, which took Ronald Moss four and a half years' part-time work to complete. Derwent Endeavour was built in Tasmania close to the banks of the Derwent River, hence the name. As the boat was intended for the Queensland charter trade, she was built to the strict survey requirements required by the Queensland authorities. The hull was constructed using C-Flex (tm) fiberglass as the basis for a hand-laid-up all-solid fiberglass hull. In May 1982 *Derwent Endeavour* set sail from Hobart with her first planned port of call, Port Macquarie, which is on the New South Wales coast. After the several hundred mile uneventful trip, *Derwent Endeavour* tied up at the marina in Port Macquarie. Ronald was very pleased with his new boat, for she had behaved very well when the boat was struck by heavy winds, just north of Newcastle.

The Australian east coast is famous for the dangerous sand bars that attempt to deny entrance to the safe harbours in this area. Many boats have come to grief when attempting to traverse these bars, which can present a boiling caldron to any yachtsman daring to cross in the wrong wind and sea conditions. Ronald discovered that if he opened up the engine, he could surf in over these bars. He stated, 'I realize I should have reversed the engine and cleared the broken water as quickly as possible, but the Spray seemed to delight in this surfing; no doubt the hull design, long straight keel and an 80hp diesel contributed to the success of this action.'

Ronald felt that the craft had still not as yet proved herself, but on a trip to Lord Howe Island the boat was to remove any doubts as to her ability. Ronald and his son, together with two friends, sailed out of Port Macquarie. At first the weather conditions were reasonable, as had been forecast; however, about 60 miles out, the wind veered and blew up. This caused a confused sea condition, and the Spray was indeed in the middle of a sizeable storm. The storm lasted all through the five days it took to reach Lord Howe Island, and the local met office on Lord Howe recorded wind speeds of 60 knots. 'As can be imagined, Ronald reported conditions on board were pretty hectic, but the boat behaved beautifully, the only damage was a torn mainsail.'

After an uneventful sail back to Port Macquarie, the next trip planned for *Derwent Endeavour* was from Port Macquarie to Southport. Owing to business commitments, the crew who took the boat to Lord Howe was not available, so Ronald signed one young totally inexperienced crew (he refers to this young man as a 'hairdresser') and another older person with some offshore powerboat experience as crew. In June 1983 the Spray was sailed out over the turbulent river bar at Port Macquarie and headed north. The weather forecast was not particularly favourable, but as Ronald's son and one of the crew had a tight time schedule, it was decided to make for Southport in one hop.

With a 20 knot easterly, the boat was making good progress; but as the weather looked threatening and as a seam in the jib looked suspect, it was lowered. It was decided to go into Coffs Harbour to get the sail repaired. The next day it poured with rain as *Derwent Endeavour* left Coffs Harbour. The weather forecast was for more rain, and north-east winds of 15, 20 knots. Soon after leaving harbour, the winds freshened and backed to the north. Under all plain sail, the Spray handled the conditions well. Mr. Moss reported:

> 'At 4 pm I awoke, the craft was being thrown around; I put my head through the hatch and the 'hairdresser' who had been on watch said, 'She has been going off the clock', and promptly put his head over the side to be sick. The log read up to 12 knots, the sea was menacing, and I remember thinking, 'I hope it does not get worse.' Well, as later reported by all of the crew, it did get worse, a lot worse. Although a lot of spray was coming over the cockpit, no sea was coming on board. After checking the Satnav to assure there was plenty of sea room, everything was battened down and all of the crew took to their bunks, only stirring to take it in turns to be sick.

By this time it was pitch black outside, the wind shrieked as only it can, and the waves appeared to be massive. Ronald was wedged in his bunk in the stern cabin when he heard a strange noise, loud enough to be heard above the din of the storm. On looking through the yacht had been sitting out the storm for two days and the crew had about all they could take. With two inexperienced crew and all on board seasick, they wanted to attempt the entrance in the hope of getting some relief from the awful conditions outside. The Coastguard advised against them making the run over the bar; however, the skipper of *Derwent Endeavour* insisted, so the Coastguard officer gave all the help and advice that he could. The skipper sounded confident, knowing of the Spray's log keel and a 80 hp diesel. Appalled at the thought of any boat attempting that entrance in these conditions, the club bar emptied, and, along with half the town's population, headed for the breakwater to watch the saga unfold. The bar was a mass of boiling and breaking waves, line after line of breakers, surely no one would be mad enough to attempt to make the harbour in these conditions?

> It seemed as though every house in Ballina had a 27 meg. radio, for the word spread so quickly. Cars from all directions converged on the breakwater. This is a fishing town, and all the locals are very much aware of the bar entrance to their harbour and its well-earned reputation.
>
> As *Derwent Endeavour* approached the bar, she began to be picked up by the breaking waves that thrust her forward at accelerated speed before sliding off the back of the wave. Closer to the bar as the seas got steeper, the onlookers expected to see her broach, but it seemed that the long keel kept her heading in the right direction. The flat transom caused her stern to lift, and the waves were lifting her as she surged forward on each succeeding breaker.
>
> An exceptionally large wave picked her up, right at the start of the breakwater and at that moment the watching crowd could hear the helmsman give her full throttle. The Spray took off like a surfboat, disappearing in a sea of foam, and she surfed in at what was reliably estimated by the many experienced onlookers at an incredible 15 knots. During the entry, her fiberglass dinghy was mounted on the stern in davits, filled with water, tearing the stern out of the dinghy. *Derwent Endeavour* herself suffered no damage, and a spontaneous cheer and applause showed the relief of the watching crowd.

Anne Clode completes her record of the events with the comments, 'Anyone who watched *Derwent Endeavour* can hold no doubts as to her seaworthiness and the skill of her captain. Her full bow would not allow her to bury her nose, and the stern lifted exceptionally well in the following sea. My mind balks at the thought of what would have happened to a fine fin-keeler. The enthusiasm of one fellow watcher knew no bounds; he had recently launched his own Spray in Sydney, and boy! Would he have something to tell the "knockers" back home'

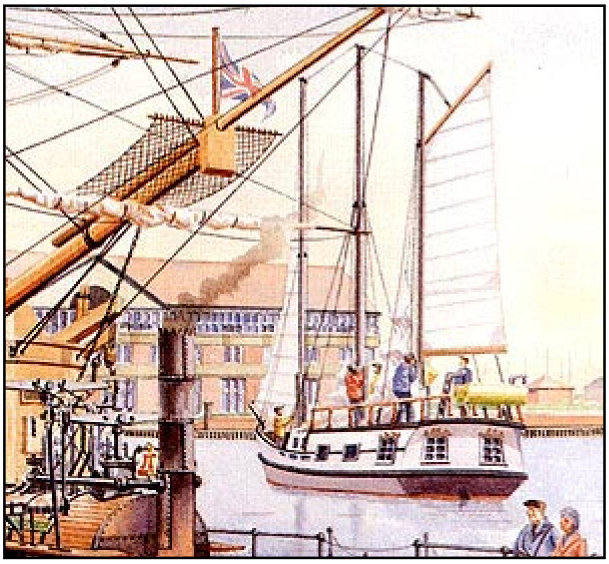
Wagonga

In Cruising *Helmsman* magazine, the headline for the article by Bob Reynolds that described the building of a Roberts Spray was *'Wagonga, The Boat* from the *Bush'.* Bob Bettini used a set of Roberts Spray 40 fiberglass plans as the basis for building his Spray replica. Thus the wheel had turned a full circle. Plans had been up drawn to build fiberglass Spray's from the original timber *Spray,* and now these fiberglass plans had been used to build a timber Spray. It is interesting to note that Bob retained the Roberts Spray bow, and several other updated features of the Spray 40 design. As we have said before, Slocum improved the original *Spray* when he rebuilt her, and we in our own way tried to improve the boat without losing the many features of the original *Spray.* It is for the owners and crew of the many Spray replicas to decide if we have succeeded.

Resolve
Rick and Mary Smith are completing this steel Spray 40 at Mariners Farm Boatyard in Rainham, Kent, in the UK. Rick's steel work and attention to detail are superb examples of what can be achieved by a careful builder.

Baggins
This Ferro Spray is owned by Wayne Marshall; the plastering was undertaken by Colin Brooks. Wayne obtained his plans from our Australian office some years ago, after we had designed the Spray *Variant,* for which plans were available for Ferro construction. At present, *Baggins* is kept on the Medway in Kent in the UK.

Castelgate Spray
Many Spray replicas have been used for worthy purposes and none more so than this steel, three-masted, schooner-rigged, Roberts Spray 40. This boat was built for the Castlegate Quay Heritage Centre, which forms part of the 'Vision 2000'. The Castlegate Quay is situated in Stockton-on-Tees, Cleveland, England in the UK. This project consists of a large wharf side development that includes a floating, full- size replica of Captain Cook's *Endeavour*, plus the *Castlegate Spray* youth sail training schooner and a number of other vessels and associated co-ordinated facilities.



Throughout the UK there are many waterfront redevelopment schemes and the Vision 2000 Castlegate Quay water activities centre has made the Maritime Youth Training Centre one of the centre points. The first project to get started was the Roberts Spray 40 youth training schooner, and after the recent crop of modern sail boats and powerboats that my office has recently designed, it was refreshing to be asked to draw a special version of the Roberts Spray 40 for use as a sail training vessel. The object was to provide a sailboat suitable for maritime youth activities; the boat had to be capable of accommodating ten young people for training cruises up to several days long.

It was important to provide for handicapped youngsters, as well as make sure there were 'plenty of strings to pull', so as many youngsters as possible could become involved at one time. Another requirement was that the boat had to be capable of being short-handed in the event of seriously adverse weather conditions that made some of the young crew inoperative due to severe sickness, or for some other reason. The sail plan was designed to fulfill the foregoing requirements. The boat also had to be suitable for accommodating disabled persons, and allowing them to share fully in the activities.

The Spray sail training schooner is currently nearing completion, and we are looking forward to seeing her fulfilling her designed role of offering a seagoing experience to the youth of Stockton-on-Tees.

MOULDED SPRAYS
Allan Roper of Box Hill, in New South Wales in Australia, informed me that he has a female moulded fiberglass Roberts Spray 40. From the plans and full-size patterns a strip plank male mould plug was built and a split mould was built on this plug.

The basic dimensions of the finished hulls are as follows: length of hull including bow fairing, 42ft 72in [12.9m] waterline length, 33ft 12in [10m], and beam
14ft 6in [4.4m]. Five solid fiberglass hulls were built from the mould. According to Allan, ‘I have sailed on several of these completed boats and they are quite impressive and enjoyable,

Gallery of Spray 40's

Fiberglass Spray 40 built in Australia - shown here with two different paint schemes.

Pilot house Spray 40 built in central Australia and transported to the coast for launching.

Spray 40 built in USA

Traditionally rigged Spray 40 **Senta** *built by Keneth Latham*

Traditionally planked timber Spray 40 built in Burma

Above: Typical Spray 40 beating to windward - note small angle of heel !

Left: Unknown Spray 40 photographed in Newport Harbor USA

Top: Chez Moi - Photographed ashore in France
Above left: Spray 40 built by Jim Gladstone in USA
Above right: One of my favourite Spray 40 photo.

Spray 40 CORSAIRE
built in Australia

Homeward Bound

This fiberglass foam sandwich Spray 40 was built by Richard White of Cincinnati, Ohio, who sent a sketch of his boat and his ballasting arrangements:

> ‘Enclosed find a sketch of my Spray 40 showing the location of the major weight items and the ballast that is already installed. The ballast is lead pigs cast to fit the sections between the solid floors, bonded in with resin and glassed over. Each section was weighed as it went in. The hull is glass with 2in [12mm] balsa core and 10 ounces [283gr] of fab-mat on the inside. The lay-up on the outside is pretty much as specified on the plans. As my sketch shows, the keel is extended adding some weight in glass, but is all enclosed, and not an outside bolt-on arrangement. The deck and cabins are timber, as shown in your plans for wood. The aft end of the cabin has been shortened 6in [150mm] and the cockpit shortened to make room for a 12in [300mm] bridge deck.

Pleiades II

This Spray 40 was built using fiberglass by Thomas R Scott (Bob) of Columbia, South Carolina, USA who has made a nice job of it. Bob Scott recalls that as a youngster in Galveston, Texas, he once went down to the beach and built boats out of sand. With the help of his five-year-old imagination, Bob sailed his make- believe boats around the world, stopping along the way to improve and enlarge his vessels with sand from exotic beaches and distant shores.

Almost half a century and half a continent removed from that scene on Galveston Bay, Scott has built a real boat in his Columbia backyard, and he still dreams of sailing around the world. His childhood fantasy has materialized as the 41ft [12.5m] fiberglass hull of an ocean-going cruiser *Pleiades II.* ‘When I remembered that incident on the beach, it gave me a sort of spooky feeling,’ said Scott, ‘because a fiberglass boat is made of sand too; sand and oil.’

Bob Scott’s boat became a reality when he launched *Pleiades II* in July of 1987. Since then Bob has lived aboard for the past seven years and cruised the east coast of the US and the Caribbean. Ports of call have included Bermuda, Abaco, Eteuthera, Berry Islands, New Providence Island and Bimini, to name just a few.
To quote Bob:

> ‘I had something of an adventure between Dry Tortugas and Havana when at around two in the morning I ran head on into the biggest wave I have ever seen. The green water came over the bow and filled the cockpit in a second. It felt like I ran into a brick wall; I guess when you run into a huge wave like that it is pretty solid; thank goodness I had installed four large drains in the cockpit.
> Due to various circumstances, including my crew having the need to return to work to top up their finances, I have done a lot of single handing in my boat. The amazing directional stability of the Spray made my single handed passages considerably easier since I was able to put her on ‘automatic pilot’. My automatic pilot consists of two lines led from the tiller to cleats at the side of the cockpit; I just set up the sails to suit the conditions and let her rip.

When Bob built *Pleiades II*, he added 10in [254mm] to the depth of the keel; he credits this change for much of the exceptional windward ability of his boat. As for stability, Bob regularly sails right through thunderstorms and 40 knot winds, he does not need to shorten sail; the rail goes almost under but water never makes on to the decks.

Hale Spray

This steel Spray 40 is being built by Art Hale, of Brenerton, Washington State, USA. In 1991 he sent some photos: 'Here are some pictures of one of your 40ft [12m] Sprays in steel. I am building Version C, and I am not really big on all this high-tech rigging bull; I would like to go a little more old-fashioned on the sail rig to complement the particular version of this fine vessel, say a schooner rig or maybe a 1901 Amundsen's sloop. I would like to use 2in [12mm] steel cable, greased and sewn over with canvas the way it was done in yesteryear. Here is a picture of what I want for the sail plan. Would you please look this over and let me know if it will fly.' But alas, the sail plan is now separated from the photos and the letter, and I'm not sure if it would have flown or not.

Burma *Spray*

Bo Colomby reported from Myanmar (Burma) about a recently launched Roberts Spray 40. Bo's Company South Asian Nautical Explorations Ltd builds boats in Burmese hardwoods, using quarter sawn teak above the waterline and for decks, cabin tops and interiors.

Burmese forestry practices are very sound; there is no strip cutting and logging is still done by elephant and ox cart. The felled trees have to be dragged to the river and then have to wait for the monsoons so there is enough water to tow them down to the places where they can be collected or trucked out for cutting or shipping. The wood that is not used for boatbuilding is used for framing sheds; what is left over is then used by the workers for cooking their meals. The sawdust and shavings fire the primitive heating system used for applying direct heat to the planks when bending them on the frames. There is no waste in this operation.

Weise *Spray*

Several builders have stretched the Roberts Spray 40 to various lengths, including 45ft [13.7m], 47ft [14.3m] and 50ft [15.2m]. Many of these boats have been redesigned after the builders have contacted us for suggestions, and to obtain our approval for the design changes they propose to make to the Spray 40 design. We have provided additional sheets of drawings to some of these builders. In some cases we have designated the design as the Spray 45, Spray 47 and Spray 50, and so forth.

One stretched boat was built by Mr. Weise, who requested plans for increasing the length of the fiberglass Spray 40 to 47ft. [14.3m]. At the same time, he asked us to design a larger sail plan. The Spray 47 was a great boat, tons of room, wide side decks with adequate, confidence-inspiring bulwarks.

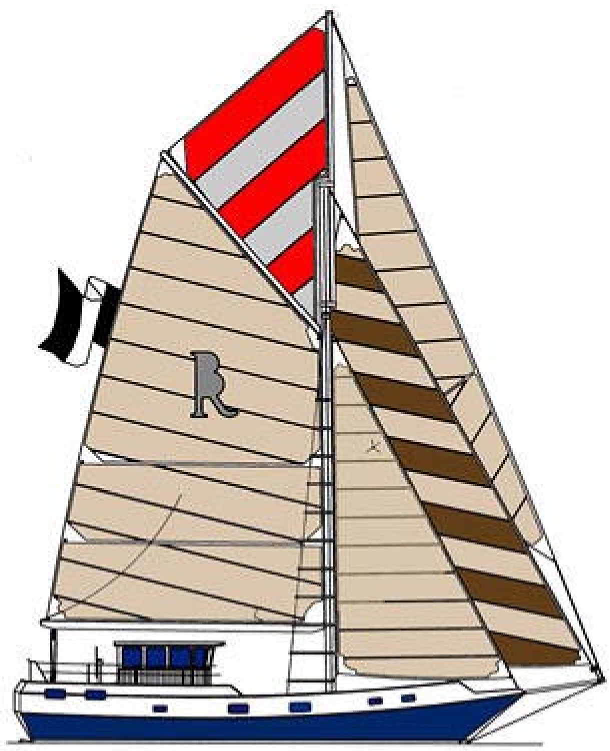
Spray 55

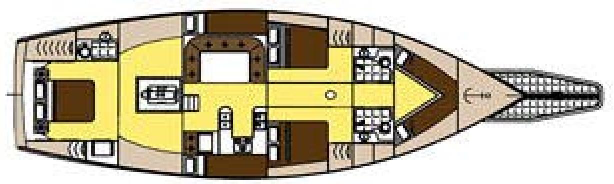
Plans and frame patterns available for building the Spray 55 multi chine steel.

his version was created as a custom design for Robert T (Bob) Murkland, a civilian employee of the US military in Kuwait, this steel Spray will prove popular with anyone looking for a larger Spray type for either charter or cargo use. As several stock plans have already been pre-sold for this design, we can assume there will be several Spray 55s around in a few years time.

Spray 55 Dimensions

LOD	55'-0"	16.70 M
LWL	46'-6"	14.17 M
BEAM	18'-0"	5.48 M
DISPL	75,000 LB	34,020 K

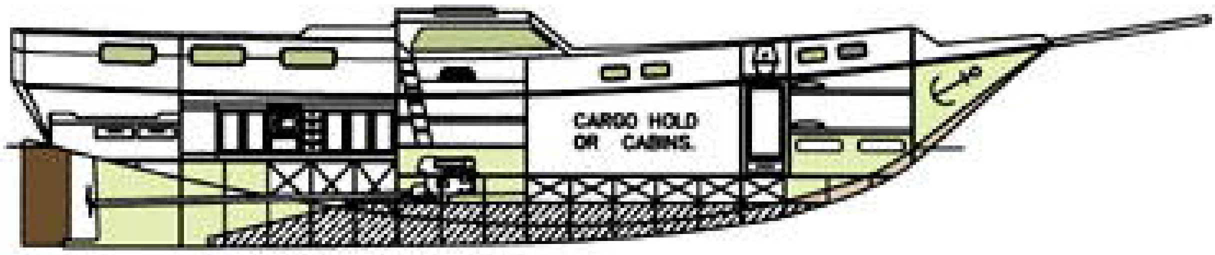


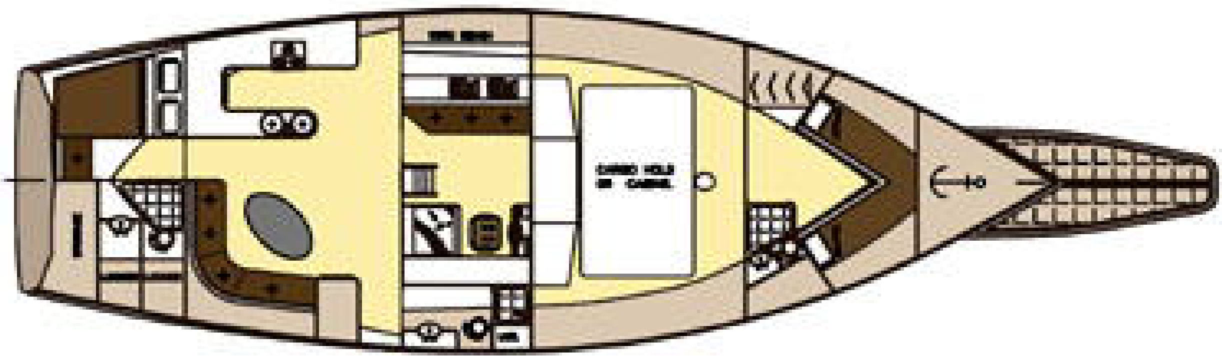


SPRAY 55 STEEL

We have been willing to listen to every combination of idea's about this wonderful boat and several layouts have been drawn. Many of these features are interchangeable between the various versions.

CONSTRUCTION MATERIAL Multi Chine STEEL This is a VERY large Spray and the accommodation arrangements are endless. You may have your own ideas about the perfect Spray. We are always willing to comment on any thoughts you may have regarding your next boat. A custom version of this well-proven vessel could be your dream ship. You can choose to build this design in multi chine steel or aluminium and the boat can be rigged as a Bermudan or Gaff Cutter as well as a Ketch or Gaff Ketch.

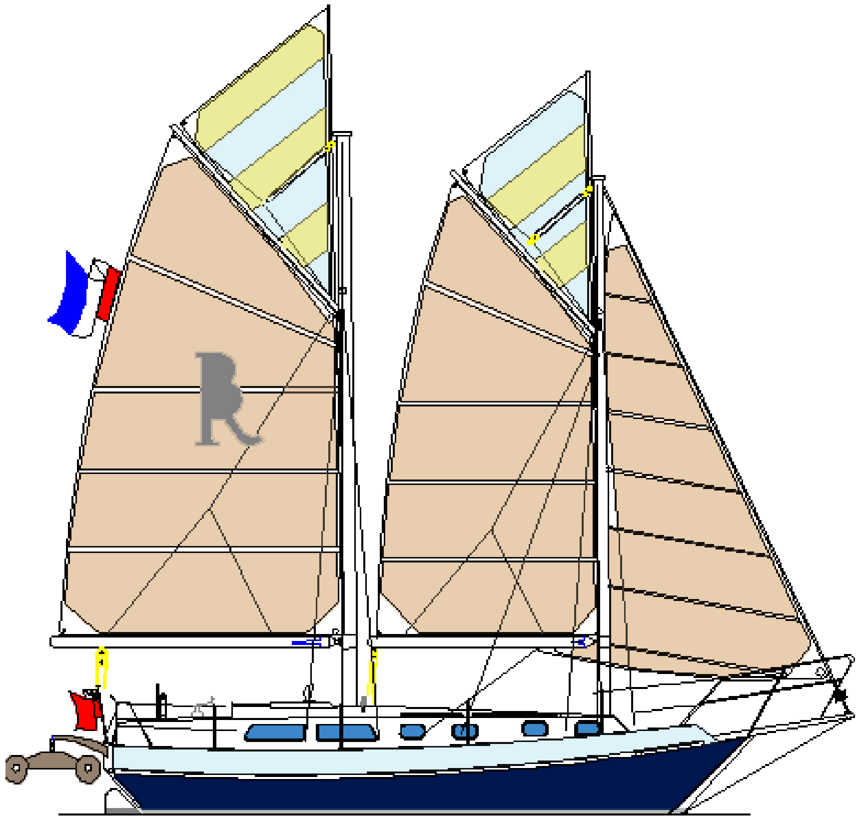


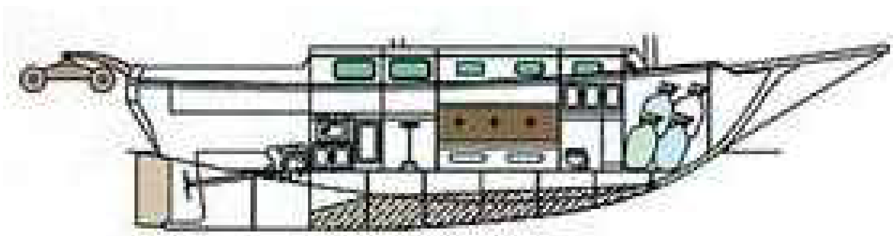


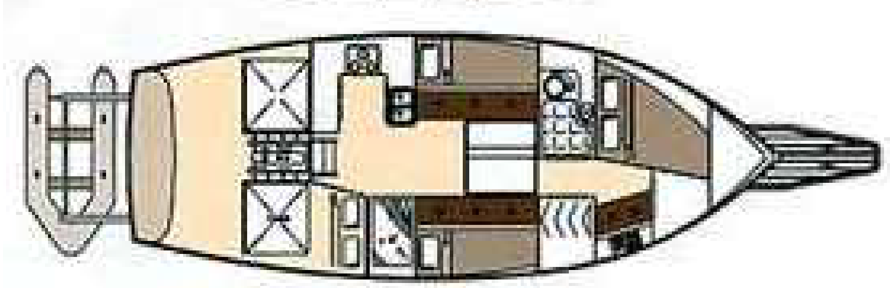
Spray Trawler Yacht built by Vejini Ltd Riga Latvia

Centennial Spray 34

Boat building plans for Round Bilge Steel or Wood / Epoxy



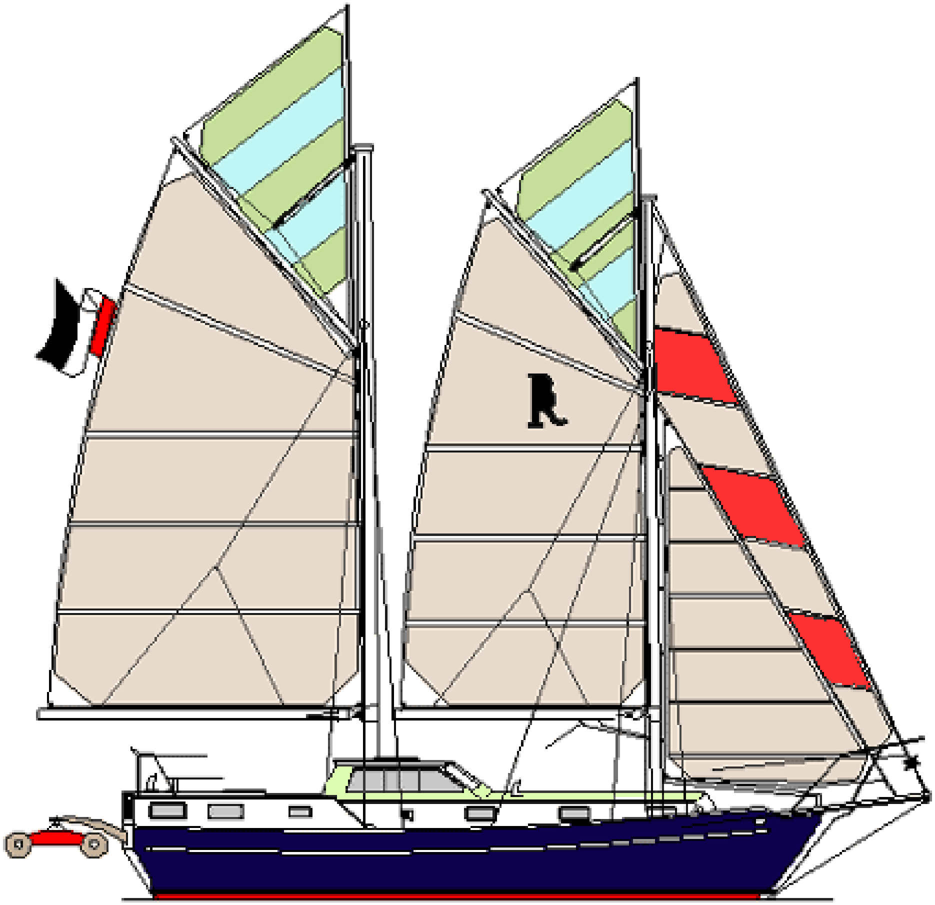




Centennial Spray 36

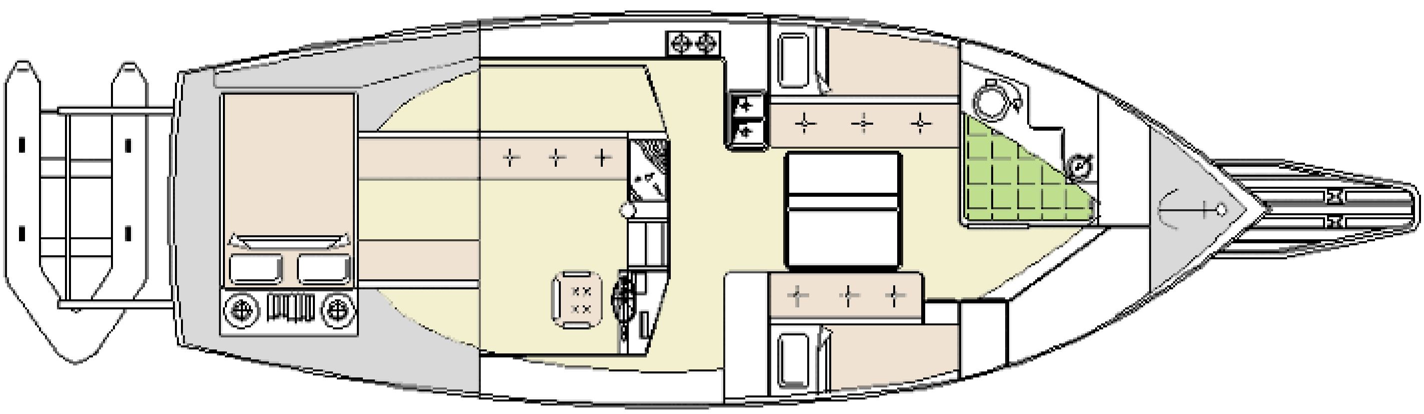
Plans and frame patterns available for building the Centennial Spray 36 in round bilge steel or wood / epoxy.

L.O.D. (HULL)	11.05 m	36' 4"
L.W.L.	9.85 m	32' 4"
BEAM	3.96 m	13' 0"
DRAFT	1.30 m	4' 3"
DISPLACEMENT	12,700 kg	28,000 lb



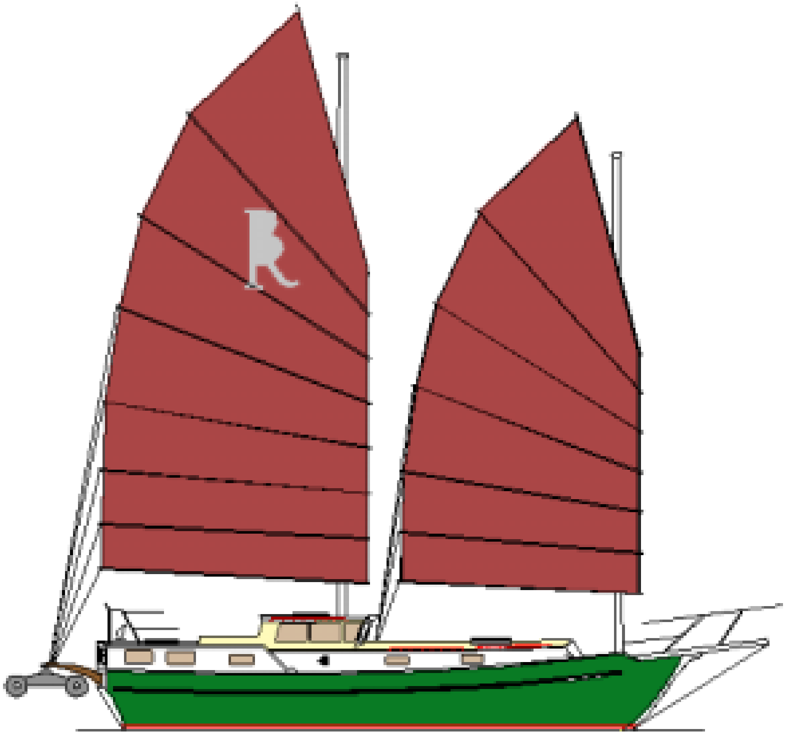
The Centennial Spray is designed for Round bilge steel or Strip plank Wood/Epoxy boat building, and can be rigged with a variety of sail plans including a gaff schooner, Bmu cutter, junk rig etc. Custom sail plans and accommodation layouts may be drawn to suit your requirements for a reasonable fee.

Gaff Schooner shown above is part of the standard plans.



Centennial Spray 36

Boat building plans for Round Bilge Steel or Wood / Epoxy



Alternate Pilot house shown - Junk rig is also included with plans & study plans.

This is part the interior of the beautiful Centennial Spray shown on left. We have received word from the owner who is very pleased with the all round performance of his Centennial Spray 36

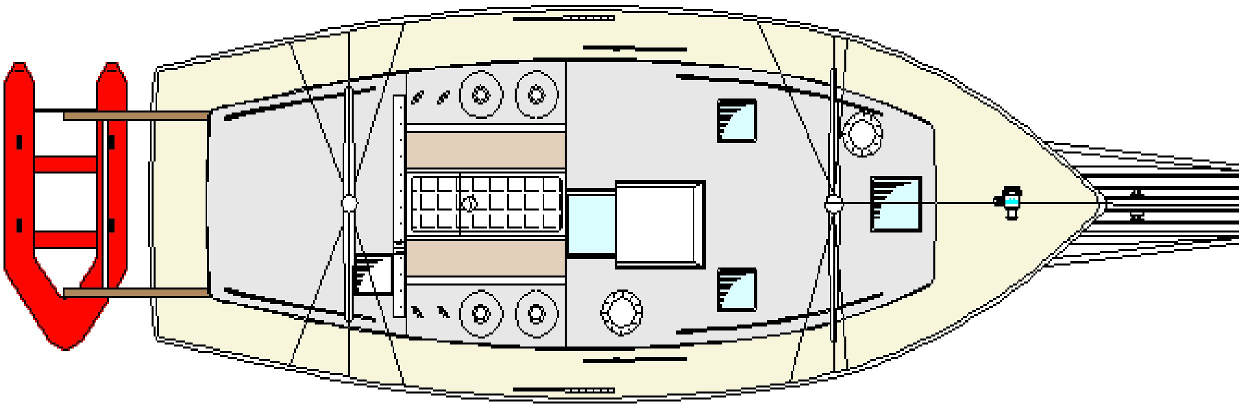
Another view of the interior of the Centennial Spray 36 featured on the previous page.

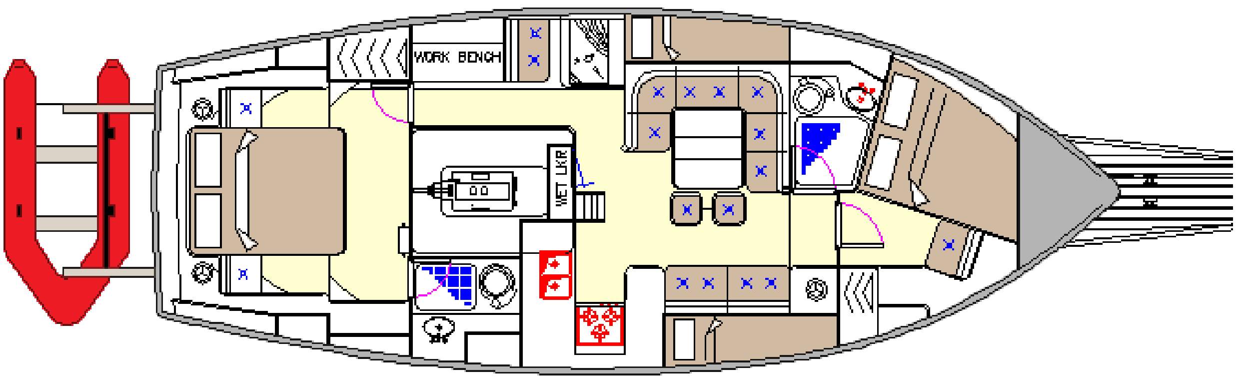
Centennial Spray 38

Plans and frame patterns available for building the Centennial Spray 36 in round bilge steel or wood / epoxy.

L.O.D. (HULL)	11.73 m	38' 6"
L.W.L.	10.08 m	33' 1"
BEAM	4.29 m	14' 1"
DRAFT	1.47 m	4' 10"
DISPLACEMENT	16,174 kg	35,638 lb

The Centennial Spray is designed for Round bilge steel or Strip plank Wood/ Epoxy boat building, and can be rigged with a variety of sail plans including a gaff schooner, Bmu cutter, junk rig etc. Custom sail plans and accommodation layouts may be drawn to suit your requirements for a reasonable fee.





The round bilge steel Centennial Spray 38 shown here was built in Sweden.

Centennial Spray 38 ready to receive antifouling prior to launching and final fitting out

Centennial Spray 38 stern view - note heel and propeller tube - makes for clean water flow and efficient powering.

Centennial Spray 38 - here we see the walk-thru between main and aft cabins.

The Birth of a 'Centennial Spray' in New Zealand!

These photos will record the construction of our Bruce Roberts 'Centennial Spray 38'. .
Photos and text by permission of Rob McGill and Nina Morissette.

We began in late March 2001 by laying out the full-size plans and making up the temporary frames...

Once all of the frames had been constructed, they were stood on a stable floor, strongly ramsetted down to solid 'grounds'. They were placed at the station intervals specified in the plans, and accurately plumbed and levelled.

All of the frames in place. Small temporary battens were fastened between the frames, along the turn of the bilge, in order to keep them plumb and stable. The laminated transom can be seen in the left foreground (it has yet to be trimmed to shape).

In the process of laminating the inner stem.

All frames in place, with the finished but unbevelled stem in situ. The rather untidy battens tacked fore and aft will only be necessary until the Keelson, gunwales and other fore-and-aft bracing are checked into the frames prior to planking.

In this photo, the three 75x20mm layers of Kauri for the gunwale (deckshelf) have been laminated up in situ on the frames. Once dry, the complete units were removed, excess epoxy was cleaned off, and both sides were run through a thicknesser. Using a standard deck camber, bevels were calculated at each station, and the gunwale was beveled to suit before final refitting in the frames.

The completed transom, showing the Kauri 'grounds' epoxied onto the inner edges. All of the edges have been bevelled to accept the planking, and the inner, lower side has been checked out to receive the keelson. The upper edge (the sheer) has not been trimmed: this will be done once the boat has been completely planked and a final deck camber has been marked. The transom was fitted into the frame matrix at the appropriate 40 degree angle specified in the plans. Planks have since been glued over and past the edges of the transom.

Fitting 75x20mm planks to the temporary frames. Each plank is epoxied to the plank below, and the planks are glued to the stem at the forward end, and to the transom at the aft end of the boat. Each plank is temorarily screwed to the frame, and the scarphs (joins) between the planks are glued in place across the frames. The small blocks on the planks are used to align each plank with its neighbour.

Yet FURTHER into planking. As we progressed up the hull, there was increasing 'edge set' in the planks, meaning that each piece of timber was curving down to the bow, and around to the stem and over to the transom more with each level. The twist was going to become unmanageable, so a 'stealer' plank was fitted above the completed planking: we then planked DOWN from that stealer plank, scarphing as we progressed.

Early May 2001, and planking below the stealer has been finished, and we've started to progress UP the hull towards the keel again. As the height increased we had to fit scaffolding to the boat so that we could continue to work up the hull. As we planked over the turn of the bilge, the curve required narrowed planks, so we began to use 45x20mm stock. When we reach the flatter areas of the bilge we will go back to using the larger planks.

Mid-may 2001, and we've had to fit a second 'stealer' plank past the turn of the bilge. Again, we planked down from the stealer to the planking that had been fitted previously. There is a lot of shape in the bow of a spray, and bending fore-and-aft planks can be difficult!

Late May 2001, and planking has been completed on the first layer. Only fairing to do before the second, diagonal layer of planking can be started. The stem and keelson have been planed off to the correct widths, and the planking has been trimmed off the transom.

First week of June, and we are well into getting the second skin of hull planking underway. Both this and the next diagonal layer will be composed of New Zealand Kaihikatea planks, 100mm wide and 4mm think. To hold them in place until the epoxy has cured, we are using air driven 12mm long plastic nails. The hull frames on the very left of the photo are for another yacht (a 64'er, also of wood-epoxy construction).

Early June 2001, and the second skin is completed! Planking of this layer took about 6 days (including the fairing). The dark line amidships is some filler used to fair a plank that was between 0.5mm and 1mm too thin on one edge.

A close-up shot of the hull on the port side, showing the curve and angle of the planking

At this stage we were halfway through planking the starboard side with the third layer (the second diagonal layer). Some of the planks on the forward half of the boat have been dry-fitted to check that they align with each other, and planks glued on previous days have been trimmed back to the sheer line (those in the centre of the hull)

This is a closer view of the planking process. We had to spile (or shape) some of the planks so that they would lie against the hull and each other without tending to buckle (note the variation in plank widths as a result). This necessitated dry fitting of every plank: the lighter planks in the photo have been dry fitted, and the darker ones have been glued. Once the glue had dried, the planks were trimmed off to the sheer line.

The 22nd of June 2001 and the third and final layer of planking is completed! The planks have been faired, and many of the small nail holes have been filled. We used long boards to fair the areas above the waterline, but the final fairing and filling will be done after glass sheathing of the hull.

The end of June 2001, and we've started to build up the keel deadwood. The hole has been bored through the hull to accept the shaft tube, and the first two pieces of keel have been glued into place (note the taper towards the aft edge). Parts of the next two keel layers can be seen on the right. These have been shaped and dry fitted.

Early July 2001, and we have the stern tube glued in place in the hull. The plywood and bracing will be removed when the epoxy has cured. The rest of the keel deadwood will be built up around the tube.

As was the case with the inner stem, we laminated the outer stem on the floor. This provided for easier cleaning and dressing of the final structure, prior to permanent fitting onto the hull .

With the stern tube in place, we've started to build up the keel deadwood. Each layer is shaped as required prior to lamination onto the hull.

The keel deadwood has been built up to the level of the ballast keel, and the small wedge forward of the lead position has also been attached. The dark area of the hull is a layer of fairing filler (epoxy resin and microballoons) applied over the glass sheath.

With the deadwood laminated up over the stern tube, the remaining layers could be assembled off the boat for ease of shaping. Once completed, this structure will be laminated onto the boat aft of the ballast keel position.

The next run of glass cloth has been applied. As with the sheathing already completed, a layer of fairing filler will be applied over the glass, as an aid in final surfacing, and to prevent "print-through".

The last remaining deadwood has been laminated into position on the keel of the hull. The deadwood will still require fairing and fibreglassing prior to painting. The heel, (which will support the rudder) will also require modification to accept a sturdy bronze casting. The position and size of the lead ballast keel can now be seen. Also, surfacing filler has been applied over the last run of fibreglass cloth. As most of this area will be below the waterline, a Microlite compound has been used (the lighter coloured filler) instead of Microballoons (the darker coloured filler). The final area of hull will be fibreglassed and faired when the keel deadwood has been completed to its final shape.

Mid September 2001. The hull has been primed with 2 coats of epoxy Everdure, and all of the laminated ringframes and keel floors have been bonded to the interior. The Everdured hull was abraded prior to fastening the framing down, and all of the frames have been constructed from *Sapele*. The next task will be to start fitting bulkheads and engine beds.

Early August 2001, and the hull has been completely glass sheathed. A laminated hardwood (White Gum) rubbing strip has been fixed to the hull. The last layers of filler have been applied to the hull and deadwood, but a final fairing will be required before an epoxy high build surfacing primer is applied.

With all of the major fairing completed, a coat of epoxy high build primer has been applied. This is a thick coating designed to assist further fairing of the hull. A temporary block has been fixed to the outer stem, just ahead of the forward face of the ballast keel rebate, to assist in levelling the hull after it has been rolled upright.

The completed template for the lead ballast keel. This has been shaped out of foam, glass and epoxy.

After the coat of High Build primer had cured, it was board sanded. A coat of "Interprotect" primer was then applied, and this was also board sanded after curing. The result has been an increasingly fair hull. We have applied a cove of filler along the base of the keel and along the rubbing strip. This will be sanded to a paint finish prior to rolling the hull upright in the next few days.

The "rolling day"! The hull has been jacked up, using large steel spigots attached to the stem and transom (the arrangement on the bow can just be seen). All of the frames have been trimmed off at the sheer line, to give better clearance during the rolling process. Two chain blocks have been attached to the beam between frames 6 and 7 (one on each side). One of these blocks will pull the hull over while the other block will check the hull's progress.

Hull halfway over. The large beam of the spray hull is VERY obvious!

The hull, now completely upright, has been initially blocked and cradled. Once finally levelled, and after the temporary frames have been removed, the inside of the hull can be cleaned up, and work on the interior can commence.

All of the temporary frames have been removed from the hull (note the heavy temporary cross braces to assist in stabilising the hull shape until the permanent internal structure has been installed). After several days of sanding, all of the planking on the inside of the hull has been cleaned up, and the first permanent ringframe (laminated *Sapele*) has been dry-fitted in place. Neither the transom nor the stem have yet been trimmed to length.

Early October 2001, and the side deck carlins are in place. The bulkheads have been trimmed down to the height of the side decks, but are yet to be trimmed down to the height of the coach house. The engine beds are in place (hidden forward of the aft-most bulkhead), and the framing for most fuel and water tanks is in place. The latter will all be integral, of ply, epoxy and fibreglass construction.

Work has continued on the structure of the side decks, and all of the side deck beams are now completed. Construction of the fuel, water and holding tanks has also been progressing. The latter has proved to be very time-consuming, as each join between a tank wall/tank baffle and the hull has been strengthened with a cove of epoxy filler and 2 layers of 600g/sqm double bias glass tape. Approximately 200m of glass tape will be used in the tanks for reinforcement!

We have now finished the coating of the fo'c'sle. The entire surface has been finished with a 2-pot polyurethane lacquer (including the deck beams). The deck beams through the rest of the yacht will be finished bright. Note the very sturdy sampson posts, which run right to the inner stem, and are fastened to the forward side of the chainlocker. These are fashioned from Jarrah, an Australian hardwood. The ply panels resting on top of the posts are the cabin side combings, which have been scarphed and fitted. These will be permanently fixed after the sidedecks are in place, and the motor has been installed. The next step will be to fix the foredeck into place: the underside of the deck panels have already been finish painted, after masking out the deck beams, deck clamp and breast hook. The ballast keel has been dry-fitted to the keel deadwood, and only awaits the arrival of the bronze keel bolts before it can be permanently fitted.

All of the side deck beams have been completely varnished, in preparation for the fitting of the sidedeck panels. As is the case with the foredeck, all of these panels have already been painted, after first masking out the location of side deck framing. Note that the bulkheads have now been trimmed down to final coachhouse height. The cabin doorways have yet to be trimmed to final size and shape.

Our two whisker chainplates have been polished in preparation for drilling and final fitting. As with most of the castings for our yacht (including all of the chainplates, bow fittings, rail fittings etc), these have been cast in Aluminium Bronze from our own patterns by a local foundry, and polished in house.

The foredeck, sidedecks and aft deck have now been permanently fitted. All of these areas will have laid teak as a finish surface, while the cabin top will be painted. Note the starboard cabin top carlin, which has been dry fitted. The port cabin top carlin is lying on top of the bulkheads, along with the cabin side combings. All of these will be finally fitted once the motors have been installed.

The underside of the sidedecks is an illustration of the final finish of the cabin top. All of the Silky Oak deck and cabin beams will be finished bright in this way, with several coats of epoxy timber preserver and 4-5 coats of high quality single-pack polyurethane. The underside of the decks has been sprayed with a satin finish two-pack polyurethane. The beams and ply were finished separately, and the gluing process was completed very carefully, to provide for a very crisp finish. The prefinishing process will simplify the process of painting and varnishing later! Note the provision for a deck prism: this opening will be routed to size and the prism fitted later in the building process.

We have started to finish the fo'c'sle, as this process is more easily accomplished before the foredeck has been fitted. This space will be used to store spare sails, and lighter items such as fenders etc. Note the chain locker (the smaller opening) just forward of the bulkhead. A large deck hatch on the port side of the foredeck will be used to store mooring lines, fenders and anchor when on passages.

The rudder has been completed with a coat of epoxy undercoat. This will be fitted into the rudder bearing housing and rudder shoe on the boat, once the engine and prop shaft have been fitted.

The tops have finally been fitted to the tanks. All but the water tanks were fitted in December, but the tanks used for drinking water were left unsealed for an additional 3 weeks to aid in solvent evaporation. Each tank lid was glassed and painted, then carefully pre-dilled (so the screws could be aligned onto cleats on the tank baffles). Each lid was glued and screwed into place, and then 2 layers of 600 gm/sqm glass tape were laid over each tank edge and seam. All tank fills, delivery and vent fittings were in place before the lids were fitted. This photo shows the diesel tank on the starboard side of the boat, under the saloon. Fuel will be stored in 2 tanks, each of around 450 Litres.

The beginning of cabinet work in the aft cabin. Each corner of the stern has a deck hatch, and a small locker has been constructed beneath each in the cabin below. Note the reinforcing of the small bulkhead in the centre of the photo: this is to accept additional loading of a chainplate. The rudder bearing housing can be seen at the aft end of the keelson on the right (under a carefully positioned cloth!).

The rudder has been constructed over the stainless steel rudder stock using Western Red Cedar blocks. It has been shaped to appropriate dimensions, and 2 layers of heavy glass have been applied to the top and bottom surfaces (this gives added protection for the timber end grain). The pale strip on the trailing edge is a fine glue edge to harden the surface and help protect against damage. The entire rudder will now be glassed using 2 layers of 810 gm/sqm triaxial glass cloth, and will be carefully faired prior to painting.

The laminated kauri bowsprit has been cleaned up and the end had been rebated to accept the crance iron. While perspective in the photo makes the spar appear larger at the forward end, the aft end is 150mm in diameter, while the forward end tapers to 90mm. The spar is hollow, with solid blocking at either end and where it will pass over the stem and stemhead fitting. The 'F' cramp is holding a pattern for the stemhead fitting in place. This fitting, like the crance iron, will be cast in bronze to our pattern.

A photo that does little justice to the amount of labour involved! All of the fuel, water and holding tanks have been completely coated, and all tank plumbing has been fitted. The inner surface of each tank was glassed, and then coated with 2 coats of epoxy resin and 3 coats of epoxy tank lining paint. The tank tops (composed of glassed, 12mm ply) are now ready to be fastened into place, and the rest of the interior can be commenced. Note the channels through the tanks at the right and left to allow for the running of plumbing, electrical and electronic lines. This form of tankage adds much strength to the boat, as most of the lower area of the hull is now braced with a sturdy "I" beam structure.

The foredeck framing has been completed, as has the framing for the anchor locker. The bulkhead to the aft of the anchor locker will remain as a watertight "collision bulkhead", and passage through it will be via a dogged-down hatch. The deck beams and carlins are constructed of laminated silky oak (an Australian timber).

A "warts and all" view of the early stages of construction of the integral fuel and water tanks. The hull inside the tanks and all of the panels have been glassed, and all seams have been taped with 2 layers of 600gm/sqm double bias tape. Timber cleats will be fastened to the top of all baffles and tank sides, to increase the glue surface area available for bonding the tank lids in place.

The starboard upper carlin and combing have been fitted, and most of the internal doorways have been trimmed to their correct size and shape. The upper carlin and combing for the port side are resting on top of the bulkheads. These have already been dry fitted, and will be permanently fixed in place once the motors (the main motor and a diesel DC generator) are installed.

The lead ballast keel has been fastened to the keel deadwood. This was mated to the keelson using a bond of epoxy to ensure a water tight join, and has been fastened using 3/4" bronze keel bolts.

Once the ballast keel was fixed on place, a layer of epoxy filler was applied over the surface to fair the level of the lead into the lines of the hull. This has yet to be finally sanded to a finished surface. It will then be undercoated prior to finishing with a bottom paint system.

The rudder has been fitted into place, together with the cast aluminium bronze rudder shoe. The shoe was fixed to the deadwood using 3/4" copper bolts (rivetted over), bronze screws and epoxy.

The saloon seat backs are in the process of being glued into place. Note the large holes cut into the backs. These are to facilitate ventilation, and to enable electrical cabling to be run through the cavity in the seat backs. The silky oak corner post has been wrapped in plywood to protect its corners during construction. Note the starboard pilot berth behind the saloon, and the freezer under the aft end of the berth (centre right of the photo).

All of the seat backs have been glued into place. The ventilation holes in the backs have been taped to keep dust out of the seat back cavities. The small square opening in the face of one of the seats is for a cabin heater vent.

Much of the plumbing has been finalised under the sinks (the forward bench). The face mounted waste pump and diverter valves have been removed to allow for painting. The refrigerator is under the bench to aft of the stove tray (outboard of the three pivoting drawers). The end of the aft bench has been given a curved face to provide greater access through to the aft cabin down the port side. For this reason, pivoting drawers were the best use of under bench space.

Much of the navigatorium has been completed, including the instrument cut-outs. The chart table has been constructed, but will only be fitted after final painting. The three drawers under the chart table have yet to be painted.

The chart table has been built with solid Silky Oak sides and trim, with laminated Kauri top.

The oval leg for the saloon table has been constructed from wide boards of Tawa (a New Zealand timber) and narrow boards of Silky Oak. This will match the final timber overlay that will be applied to the cabin sole (in contrast to the more traditional Teak and Holly sole). The arms are solid Kauri, and the foot is solid Silky Oak. The saloon table will be a feature piece crafted by a local "timber artist", with a background of Kauri and an intricate inlay using a variety of figured timbers.

The sampson posts on the bow have been glassed with 600 gm/sqm cloth to prevent deterioration and enhance durability. Robust aluminium bronze caps have been cast from our patterns, and fitted to the tops of the posts to protect the end grain. The posts have been wasted on their corners, above where the bowsprit will be placed, to give a fair surface for

A close-up shot of the cockpit dorade-type ventilator, that will feed cool air into the engine room under the cockpit. An integral, long flap can be used to stop air flow through the dorade. This flap can be seen at the back (outboard edge) of the dorade, and is operated from inside the boat beside the companionway. An additional 100mm wide overhang is yet to be fitted to the edge of the cockpit seat, and this will further protect the air intake openings. The cockpit sole is of a ply/foam/ply construction, to maximise rigidity and minimise the number of framing members required under the sole inside the engine room.

The forward vanity bench and locker have been completed, but not yet fully painted inside. The bench top is made from solid 50mm thick Kauri with a 10mm wide Silky Oak trim. A porcelain basin will be fixed into the bench on completion of finish work. The doorway to the left (aft) leads into the shower, while the locker to the right (forward) will be used as hanging space. The small light-coloured disk at the bottom of the vanity locker face will house an LED footlight. These will be distributed around the boat for night-time passage lighting.

The exhaust lines from both the main propulsion motor and the smaller diesel DC genset are first run through water separators in the engine room, and then the resultant dry exhausts are routed under the berth in the aft cabin to exit the transom. A water separator system was chosen.

The berth in the aft cabin has been framed up, and cabinet work has been constructed on either side. The small cabinet on the starboard side of the berth will house a diesel cabin heater, and this unit's exhaust will be conducted through the transom behind the cabinet face. A matching cabinet on the port side will conduct ventilation air from the house battery bank, that will be housed in sealed battery boxes under the forward end of the berth. Both transom vents will be run through baffled openings which prevent the ingress of water. Other equipment, such as the main battery charger and inverter, will also be contained under this berth.

The port side cabin combing and upper carlin have been fitted, completing the shape of the topsides. As with the starboard side, the combing was constructed of 12mm plywood, with an additional 9mm of plywood laminated over the outside *in situ*.

A photo from the bow, showing the shape of the coach house and main cabin structure. The starboard side of the cockpit has been framed up, and most of the interior doors and doorways have been trimmed to their final shape and size. The cabin top beams have all been laminated on a jig to the appropriate curve, but we will not fit these until much later, as this will make finishing the interior fit-out easier. Most of the interior cabinet work through the saloon and athwarts the cockpit has now been constructed, but has been dismantled to allow for finish coating.

Both the main engine (a 90HP Perkins diesel) and the auxiliary (an 18HP Kubota diesel, rigged with a high output water pump, dive compressor and desalinator pumps) have been placed into position under the cockpit. The exhaust systems are next to be installed: the waterlock for the small motor is in temporary position at the bottom of the frame. The propshaft will be driven through an Aquadrive™, to minimise vibration and alignment problems.

A photo of the engine room from the port side.

The rudder stop has been solidly constructed out of epoxy and glass, integrally mounted onto the transom. The hydraulic steering ram will be mounted on the large timber block to port of the rudder shaft. Note the copper bonding strap running along the keelson. This has been covered with double bias glass tape and epoxy, in order to prevent corrosion.

The desk in the aft cabin has been framed up. This will contain a laptop computer, printer and scanner. Like the top of the chart table, this desk has a laminated kauri and plywood top with solid silky oak edge and face trim. A cable way has been constructed along the back of the desk (and outboard of the drawer on the right hand side of the desk). This will take computer and power cabling. The silky oak panel on the cabin combing above the desk is a backing doubler for one of the mizzen D1's (lower shrouds).

The main companionway steps have been constructed from laminated silky oak, and the companionway opening has been cut from the plywood bulkhead. The panel at the back of the steps will be painted before permanent fitting. These steps will be removable to allow for access to the front of the main engine. A tall locker on the left (starboard) side of the steps will contain the yacht's isolation transformer and emergency grab bag, while the tall, angled locker on the right (port) side of the steps will conceal cabling and main engine switches.

With much of the larger panel work constructed in the interior of the yacht, the main cabin top beams have been checked into the upper carlins. These have only been dry fitted, and will not be glued into place until all of the remaining fore-and-aft beams, and partners for hatches and deck hardware have also been fitted. The cambered beams have been laminated from silky oak.

A 12mm thick cabin sole overlay has been laid in the forward and aft cabins and half of the saloon. As can be seen in the aft cabin, the overlay style is slightly unconventional, as we have used narrow boards of darker timber (Australian Silky Oak) and wider boards of lighter timber (New Zealand Tawa). This is in contrast to more traditional Teak and Holly soles, but will result in a lighter "feel". When the overlay has been completed throughout the boat, it will be sanded smooth, and finished with a hard varnish. The cabin sole will match the [leg of our saloon table](#).

The cabin top has been sprayed with a high-build "microsurfacer" epoxy paint. This is a fairing coating, that allows the cabin top to be easily board sanded to a fair finish. Note that the paint has been sanded through in areas of the cabin top that are slightly higher than others.

Following the microsurfacer, the cabin top has been sprayed with an "Interprotect" epoxy paint. This also allows for additional fairing, and acts as a complete base coat for the undercoat.

The trailboards will be laminated on each side of the bow. There will be 5 laminations: the first fore-and-aft layer will be 8mm Kauri, the middle 3 (slightly diagonal) layers will be 4mm Kaihikatea, and the final, outer fore-and-aft layer will be 8mm Kauri. The first layer will be screwed and glued to temporary battens that have been spot-glued onto the hull. The screws through the first layer will be removed before the second layer is laminated on top.

The final layer of Kaihikatea has been laminated, and only the final fore-and-aft Kauri lamination has yet to be applied.

With the laminations complete, the trailboards were removed from the hull, together with the temporary battens. The boards were then faired up and shaped to their final form. They will now be given to a professional carver/artist for completion. Note the substantial aluminium bronze head stay fitting that has now been permanently fastened to the stem.

Construction of the main companionway sliding hatch and drop-boards has been completed, and bases for the four primary sheet winches have been bonded to the deck. Four teak dorade boxes (2 forward of the cockpit screen and 2 just visible aft of the cockpit) have been temporarily placed into position. The main mast collar, temporarily placed so that the positions of clutches and winches can be determined, is just visible on the deck forward of the main hatch garage.

The helm seat has also been completed. This will have 2 hinged lids: the smaller lid on the starboard side will cover the cockpit bilge pump and shore power inlet, and the longer lid to port will cover an inflatable dingy. Note the mizzen mast base, which has been temporarily placed in order to start positioning other sailing hardware. The raised panel just aft of the cockpit will support the main sheet traveller, and the similar panel at the after end of the coach house will support the mizzen sheet traveller. The round block just forward of the mizzen traveller on the centre line is a port for our emergency tiller.

The teak deck and teak cap rail have been completed, and 4 deck prisms (2 on each side deck) have been dry fitted into place. One of the main mast cap-shroud chainplates can be seen on the side deck. The holes on the side of the coach house are for fastening one of the the main mast lower shroud chainplates. These chainplates will not be finally fastened to the boat until after exterior painting is completed.

In this photo of the aft deck, note the open fairleads on the stern quarter and the closed fairlead in the middle of the transom. Hinges and latches have not yet been fitted to any of the deck hatches (the end of one hatch can be seen as a thin line on the deck in the foreground).

An "aluminium-bronze mine" on the foredeck. All of the bronze castings in this photo have been cast by local foundries, but patterned and finished in our workshop. Rollers have yet to be fitted to the large "spareman" on the starboard bow and the smaller fitting on the port side. The taped teak block in the lower foreground is the base for our windlass.

Our deck organisers have been made in-house using Harken sheaves and silicon bronze plate. They are designed to be bonded down to the deck, while still allowing the sheaves to be removed for cleaning or replacement.

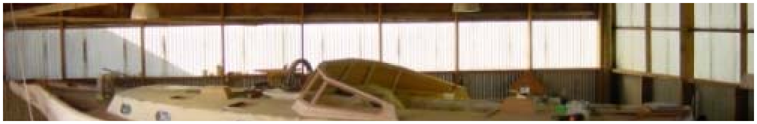
All of the bilges through the saloon and forward cabin have been completely painted out, and now await installation of electrical, plumbing and electronic systems. The base for the keel-stepped main mast, visible in the centre of the photo, will shortly be bonded into position on the mast step

A 2 metre long solid copper strap has been fixed onto the lead ballast keel, using bronze machine screws tapped directly into the lead. This will primarily act as a lightning ground plate, but also serves to improve the single sideband ground, and provide an AC and DC electrical earth. The yacht will be fitted with an isolation transformer for its AC systems.

The cutwater has been fitted to the bow, and the bowsprit has been shaped to sit over cutwater and between the sampson posts (a photo of the bowsprit will be published after it has been varnished!). Note the teak cap rail that has been fastened to the top of the bulwark, and the bronze open fairlead just visible on the port side. The latter has been taped to protect its polished surface. The teak decking has been primed in preparation for caulking. The lid of the deck hatch (along with two smaller deck hatch lids from the port and starboard aft quarters) will be caulked separately.

Caulking of the teak deck has been completed, using [Detco] 2-part polysulfide deck caulking. Note that the seams were not masked out prior to caulking, as this is a new teak deck that will still require finish sanding. The teak cap rail has been masked with plastic to prevent marking by caulking compound.

The cockpit screen has been constructed from solid Kauri, and glassed over to ensure the timber is well protected. A canvas dodger will be fitted into



With the cabin top completely glassed, all of the hatches have been trimmed out. The main companionway has also been framed in, along with the main hatch "garage" which has been pre-painted and is now ready to be fastened down (the lid of the garage is lying upside down forward of the sliding hatch).

The cockpit seat edges have been fabricated in a mould from 6 layers of double-bias glass cloth and epoxy, strengthened by several perpendicular glass "webs". Note the indent in each side, which is to allow the helm to be removed from the pedestal. The port side seat overhang protects the engine air intake dorade.

The early stages of laying the teak decking. All of the bulwark, fore, side and aft decks have been glassed with 600gm double bias glass cloth to ensure water tightness and teak covering boards have been glued around the margins of the coach house and

Almost half of the teak has been laid onto the each sidedeck. Temporary fastenings are only being used where absolutely necessary to hold the planking in position while the epoxy cures. No fastenings are placed through the planks, and EVERY hole is carefully filled with resin after the fastenings have been removed in order to maintain the water tightness of the deck.

The teak has been completed on the fore deck, and now just requires caulking and sanding. The check-out in the bulwark on the starboard bow will accommodate a sturdy bronze "spareman", and the check-out on the port side (next to the bowsprit position) is for a smaller bow roller.

The aft deck teak has also been laid and awaits caulking and sanding....

and the side decks have also been fully laid with teak. All of the holes used to fasten the planks into position have been meticulously filled with resin.

Teak has been laid onto the cockpit sole as well. Note the mounting base for the steering pedestal. The helm seat has yet to been installed. This will be positioned aft of the existing seats, along the bottom of this photograph.

The cabin top beams have been varnished in preparation for fitting the pre-painted cabin top panels (looking aft towards the main companionway hatch).

With the deck beams completed, the holes for been cut. There will be a total of 15 oval bronz each side of the combing, and one in the sterr bronze ports (1 on each side of the cockpit an the cockpit). The ply panels for the cabin top h and the location of the cabin top beams marke These have then been finish-coated, and will l into place to negate the need for a tiresome m curvature of the beams is now supported from from the cabin sole.

The first layer of the cabin top has been glued into position. This layer is 12mm plywood, and was fastened into place with temporary screws that had been dipped into a release agent. Once the screws had been removed, the plywood surface was faired to remove major surface blemishes and excess glue, and the edges were all trimmed to size.

The second and third layers of plywood on the layer of 6mm and then a layer of 4mm plywoo in one operation (half the boat at a time). This accomplished using the vacuum-bagging tech glued plywood is laid under a heavy plastic sh down at the edges. The air space beneath the evacuated using a vacuum pump, which comp onto the substrate. The vacuum is maintained cured. This method allows the operation to be greater speed, and the minimum use of faster are required to locate the sheets, and to hold

Here the surface of the cabin top has been gla
double bias cloth, and a coating of epoxy fairi
the glass before the resin had cured. The surf
using long boards, and the surface checked w
eliminate any high or low areas. Note that the
have been cut out of the cabin top, one forwa
Another 4 smaller hatches have yet to be inst

With the pre-painted cabin top fitted to the boat, a better impression of the ultimate interior style of our yacht can be gained. Hours spent meticulously cleaning epoxy from paint and varnish after the cabin top panels were glued down has resulted in an exceptionally crisp line between paint and varnish. Notice the small channel running down the underside of some of the central deck partners and some of the beams: this will allow us to run electrical wiring though the beams, while still retaining access to cables. The channels will be covered by polished brass flat strip, rebated flush into the surface of each beam.

All of the cabin top beams have been glued into place, and given three coats of epoxy Everdure. Once these beams have been sanded, we will coat them with an additional 4 coats of polyurethane varnish. Note the six 100mm x 45mm timbers fastened to the tops of the beams. These are temporary braces to maintain the correct curvature in each beam. Although the cabin beams were laminated on a curved jig, the timber "sprang" when released from the jig (as wood does!). When fully varnished, the beams will be braced from below, and a 24mm thick cabin top will be laminated from 3 layers of plywood.

The "snug" engine room, looking aft. Most of the sound insulation has been installed on the sides of the compartment. Access to all sides of both the main engine and the auxiliary will be possible from all sides of the engine enclosure.

On the outside of the boat, painting has continued with the gloss borders being sprayed on the cabin top. Note that the boat has been tented to reduce dust during spraying. The paint used is a 2-part polyurethane.

We are extremely privileged to call this masterpiece of marquetry our saloon table. This will be fastened down to the table leg. Crafted by a New Zealand timber artist, this table is composed of over 1200 pieces. The border and fiddle are fashioned from Australian Silky Oak, the main background from New Zealand Kauri, and the design from Puhutakawa, Mairie, Puriri, Kahikatea, Matai, Kanuka (all New Zealand trees), Teak, Iroko and Ebony. Unfortunately, no photograph can do this work justice, but if you click the image to the left a slightly higher resolution image can be seen.

A detail shot of one corner of the table, showing the precise rendering of the lei border, and the manner in which the grain is used to give depth and life to the dolphins. Again, a higher resolution photo can be seen if the image to the right is clicked.

All of the deck hardware has now been installed. In this photo taken from the aft deck, the mizzen mast base, the mainsheet track and the arrangement of cockpit winches and clutches can be seen. The modified bronze "mushroom vents" on either side of the mizzen mast will be underneath teak dorade boxes, topped with bronze cowl vents.

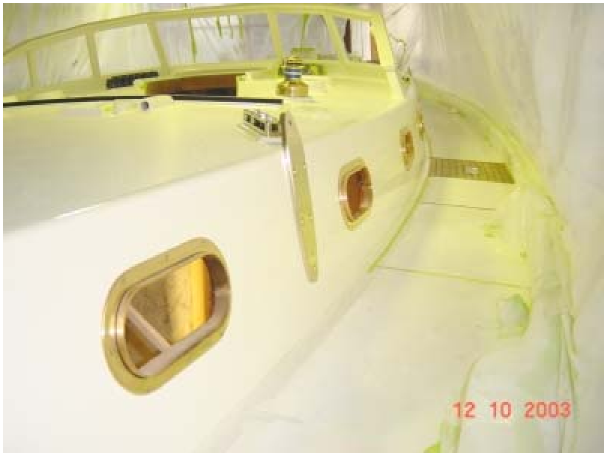
A photo from the foredeck showing the deck layout. Note the main mast collar, staysail track (on the edge of the cabin top between the lower shroud chainplates) and the windlass behind the starboard sampson post.

On the sidedecks we have completed installation of the deck prisms (two on each side of the boat), deck fills, stanchion bases, and genoa and gennaker turning blocks. Note the two bronze strips on the edge of the cabintop to protect against sheet wear.

With the exterior of the boat complete and weatherproof, it has been moved from it's cradle in the shed onto a specialised boat transport truck.

The boat on site at the marina, ready to be hardstanded while the interior is painted and all systems are installed.

With the cabin top completely painted, the deck hardware is able to be installed. All of the ports and most of the deck hatches have been fixed into place, along with some of the sailing hardware. The mizzen lower shroud chainplate, mizzen line organiser, mainsail track, main mast line clutches and a mizzen sheet/halyard winch can be seen in this photo.



Another photo showing the progress of deck equipment installation. Note that the mizzen mast base and main mast collar have also been fitted. We have used both conventional bedding/sealing and more 'modern' epoxy bonding installation techniques, depending on the type and location of each hardware item.

The hull topsides have now been finish painted. As with the cabin top, this paint is a sprayed 2-pack polyurethane. Once again, a plastic "tent" was used to minimise dust settlement during paint application. With the entire outside of the boat now painted, the remaining hardware can now be installed.

One of the first tasks was to run all of the electrical cable. Only fully tinned marine cable has been used. This photo shows cables that will be terminated at the main AC and DC distribution boards.

The same bunch of cables, but after MANY hours of work organising and terminating. The AC circuits are on the left, the DC circuits are on the right.

This photo shows the back of the DC board. Note that each cable has been labeled where it

The back of the AC board is similar in appearance to the DC board, except that there are fewer breakers. Note the small pneumatic tubes leading to the back of the Tank Tender head unit. This one unit can measure the levels in all of our fuel and water tanks from the one location. The other small panels under the AC breakers are the Start/Stop panel for the auxiliary motor and the remote panel for the solar regulator.

This is the front of the main AC/DC distribution board.

The carving on the trailboards has been completed. While the carving is not very clear in this photo, one of the boards is shown here being trial-fitted prior to drilling of mounting holes and final painting.

WET but NOT launched! It was easier to step the rig (using the gantry in the background) with the boat in the water. With the deck lower than the dock it allowed all of the bottom terminations to be completed without having to remove and replace the stays and shrouds from the masts. Notice that the bowsprit platform has not yet been fitted. The boat is floating to its lines in the bow, but is high in the stern: however, we have a lot of equipment to install in the aft third of the boat (including the house battery bank).

Back on the hardstand with the rig in place. The main and mizzen booms have not yet been fitted, as is the case with all of the mast collar/base halyard turning blocks. Although the stanchion bases are in place (and temporary stanchions are fitted), all of the railwork such as pulpit, pushpit and dodger frame will be completed later. Teak dorade boxes topped with bronze cowl vents will complete the majority of the deck hardware.

The bowsprit platform has been fitted using bronze studs bonded into the bowsprit brackets and custom made bronze nuts. The bow rollers have also been manufactured to fit the bronze castings. The small mushroom vent on the foredeck can be replaced with a deck plate during a passage.

The high build undercoat has been completely sanded, and is now ready for the second undercoat.

The aft rail and stanchions have been completed and mounted. The tops of the stanchions are topped with an aluminium bronze cap that is pinned and welded to the tube. All of the railwork has been electropolished and then hand polished.

The second (and FINAL) undercoat has been applied. Now we get to sand it all

All of the panels inside the boat that will be painted have been well resinned, sanded, filled and scrutinised for imperfections. Any exposed timber that will be varnished has also been masked out in preparation for painting.

The same area of the interior (looking forward into the saloon) after a high-build epoxy undercoat has been sprayed. The dark, mottled surface is due to a "guide coat" that has been applied on top of the undercoat as an aid to sanding.

Does this need a comment?

One portion of the fuel distribution system. From this point we can choose which tank is used to supply fuel to the motors, and we can use the fuel transfer pump at the bottom of the photo to circulate fuel through the Racor fuel filter/separators.

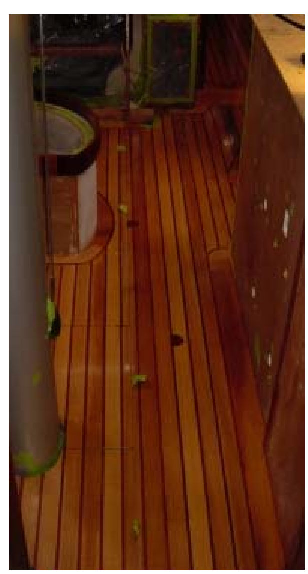
A photo of one of the bilges in the saloon. Note the high level bilge alarm float switch, the large diameter bilge pump hoses and the insulated heating system pipes

The space underneath the aft berth has been allocated largely to electrical, electronic, hydraulic and plumbing systems. The large white boxes will contain the house batteries. The small stainless steel tank in the transom cavity behind the berth is the cabin heater header tank (the heater itself is contained in the sealed locker to

A closer shot of the main DC fuse board.

With the systems installed we have started to complete the interior sanding and coating. The surfaces to be varnished will be first sealed with Everdure epoxy primer, and in most cases may not be finish varnished until after the bulkheads have been finish painted. Here the cabin sole in the forward cabin has been sanded and Everdured.

The saloon sole has also been sanded and Everdured.



The Perfection Undercoat has now been completely sanded, and the interior has been remasked in preparation for the final topcoat.

Finally, the topcoat has been completed! the paint is a ser polyurethane reaction lacquer (except in the head and the has been used). With the exception of the cabin top beam timber trim work (including the cabin sole, which is still cov in this photo) is still only coated with Everdure. We will fini the boat after we have launched.

The bootstripe has now been applied. We have also completed the installation of the bow pulpit rail.

The first coat of antifouling is a "signal coat". This is a har
colour to indicate the condition of the bottom paint over tin
has a slight flair towards the bow. The fasteners for the tra
on the bow.

Two coats of a soft, ablative antifouling have been applied over the signal coat. The colour will lighten after immersion.

Our variable pitch Max Prop has been fitted to the shaft, a
New Zealand product called Prop Speed before launching

The trailboards, which started out in [June 2003] have been gold-leafed and finish painted. These can now be fitted into place on the bow.

The interior has now been largely unmasked after painting, and a better idea of the interior style can be gained. This photo has been taken from the galley, looking aft down the port side.

Another photo of the unmasked interior, taken from the port pilot berth, looking forward into the galley, saloon and forward cabin. Everything LOOKS finished, but we still have much of the interior timber work to finish varnish (the coating on the door trims, fiddles and sole is Everdure epoxy primer. This will be overcoated with a single-component varnish). We also have seat and berth infills and locker doors to paint and install. These jobs will be completed once we have launched.

The big launch day! Even though the interior is not completely finished we have finally hit the water. Note that the trailboards, bow rail and

A closer shot of the bow and trailboards.

A photo from forward really illustrates the great beam and power of the spray bow! Now it's time for a holiday before completion of the last jobs, and THEN time for a sail!

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The trailboards, which started out in [June 2003](#) have been gold-leafed and finish painted. These can now be fitted into place on the bow.

The dodger and frame have now been comple
panels can all be removed, creating a cockpit
reminiscent of a bimini awning and allowing m
ventilation while still providing sun protection.
canvas work our "dodgimini"!

The cockpit showing pedestal and lines. The helm has been removed to provide more space in the cockpit. We still have to sort our stowage for the halyards, sheets and traveller lines, but we'll go sailing first!

We have run the headsail furler control line ar
sidedeck along the stanchions. The clutch hac
on a bronze bridge to match the height of the
block.

We have continued to varnish the interior trim work. Here, the hull in the starboard pilot berth has been finished, and kauri sealing strips have been fitted between the ringframes.

Finally, we have taken time off doing the interi
sailing sea trial! A sedate and gentle sail of ar
over 2 days, and our yacht performed wonder
steady 15 knots, we didn't bother to run the m
even partly furled the main, just to "get a feel"
handles. Just off the breeze we were easily ab
knots, even making 7 knots and better at time
sail next time, we will be more balanced (with
hoisted we had a little lee helm).

The superb work of Simon Willis Sails can be seen in the shape of the genoa. We had the full main set for an hour or so, and our yacht was well balanced and sailing with very little heel just off the breeze.

Looking far more comfortable in a bay after a marina!

Another step towards completion of the dream! We still have work to finish though, so it's out of the "lets go sailing" mode again for a while now.... ☹

This is same Centennial Spray 38 that is extensively featured in the timber construction chapter.

Photographs on this page by permission of Rob McGill and Nina Morissette

Photographs on this page by permission of Rob McGill and Nina Morissette

Centennial Spray 45

Plans and frame patterns available for building the Centennial Spray 45 in round bilge steel or wood / epoxy.

L.O.A. (HULL)	13.87 m	45' 6"
L.W.L.	12.42 m	40' 9"
BEAM	4.72 m	15' 6"
DRAFT	1.53 m	5' 0"
DISPLACEMENT	22,226 kg	49,000 lb

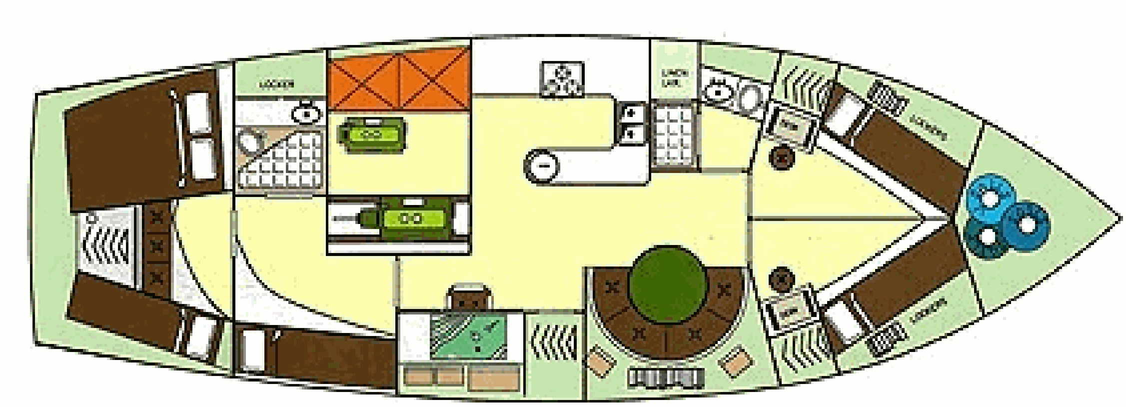
ABOVE: Centennial Spray 45 **Mother of Perl**

RIGHT: One builder took our wood epoxy plans and used these as the basis to build this fiberglass Centennial Spray 45

Hi Bruce, Yesterday our CS45 Spray was launched for the first time. Every thing went well we only need a small amount of trim ballast in the stern.
I guess its the first CS45 in fibreglass? We named her Corinne
Cheers, Johan and Lise Levin

One of several CS45's being built by Put Veini for in Riga Latvia.

Dear Bruce, "I can tell you my own impression of sailing the Centennial Spray 45. I made a trip cross the Baltic sea. She steering herself really, just need to carefully put sails on right position. I did not touch the steering wheel for more than 20 minutes, just look at compass. Excellent performance, just nice. Thank you very much for smart design. " Best Regards, Victor V. Tchaburko



The best way to see some of the alternative lay-outs for this and other Sprays is to order the study plans on CD which give you a wealth of information about the designs in question.

"Bruce, I and two Estonian master mariners motored Mother of Perl to Vastervik, Sweden for sails and rigging and sailed her back to Tallinn in the end of October. A truly great hull in every respect. We also barely touched the steering and this was going straight downwind under sail. With a little experience, I know that I could balance this boat on any point of sail. Fantastic! I'll let you know more about our adventures with Mother of Perl as we travel this next few years on both sides of the Atlantic and hopefully Pacific.... Regards Ben Smith"

CHAPTER 22. SPRAY KITS

Drawings, illustrations, construction photos and general information about these Spray designs that you can build from a KIT or Cutting files and plans.

The original Spray 33 has been slightly enlarged to create this new kit. With several hundred S33's in service worldwide, we felt NOW was the time to update this sailboat. Since starting work on this project we have realized the huge potential of this boat design. The new versions in the Spray 340 series offer something for all.
During the conversion from the Spray 33 to the Spray 340 Kit we have made subtle changes to the bow; this allowed for easier fitting of the forward plates plus an increase of space in the internal accommodation areas.
From a Spray Owner in Iceland:

I took the Kangaroo (ex Bellavia) for a test sail today. Simply pure joy. The pilot house hasn't changed anything. My wife came along (her first time on a sailboat) she loved the boat. I will send you some pictures soon of her with the sails up in a good breeze. I want to be on your Spray Website. Best regards Asi

FROM A SPRAY OWNER IN TURKEY

We arrived at Park Kemer Marina/Turkey in July 2004 after our return trip across the Atlantic from Florida/USA. My wife is Turkish, and, being one of the few Turkish girls to sail the Atlantic twice, is attracting a lot of media attention here, needless to say so is the boat.

Our Spray was featured on national TV in august and created enough interest to warrant a repeat showing. Since then we have been featured in four Yachting Magazines- the Antalya Regional Magazine- and a video of Blue-Belle crossing the Atlantic was shown at the Antalya Boat Show to a very enthusiastic audience. The Turkish Chamber of Shipping has also conducted an interview to be featured in their commercial publication 'Turkish Shipping World'.

We have a constant stream of visitors and Suat Zeybek of the Dive Centre is one of our regulars. He is keen to build a Spray 36 and I believe he has already purchased the plans.

Anyway, so much for the present, let me give you a brief history of Blue-Belle to date. In 1987 I was looking for a long distance load carrier, big enough to cross an ocean comfortably, but small enough to be easily maintained. I purchased the plans of your Spray 33 and began building on the south coast of England.

Due to working abroad, I didn't launch her until 1992; I would probably estimate that as a full time build project to high standard of finish, she would take two years for one man to complete. She is built in 4 mm steel and is hot metal sprayed with aluminum both inside and out. She is as per your version B plans apart from lengthening her to 34 feet on deck, in order to incorporate a double self stowing anchor roller assembly. (Designers note – this makes her the same size as the new kit version - Spray 340) Upon completion she was then stored ashore for a further four years while I was away earning the cruising fund. Her maiden voyage was in the autumn of 1996 London to Antalya/Turkey aprx. 3500 miles single handed. I hadn't fitted any self steering as yet, so this first long passage was a good test of the Spray's legendary self steering qualities. If you take care to balance the sails she will steer herself for amazingly long periods of time.

In Antalya my Wife and I were married and we moved on board to begin our full time cruising life style. Now I really did begin to appreciate the Spray's load carrying capability, I have never seen so much stuff poured into just one boat. We spent two full seasons cruising the Med and in September 2000 departed Portugal for the Cape Verde Islands via the Canary Islands. December the 1st found us leaving Mindelo/Cabo Verde and bound for Barbados. We still didn't have any self steering fitted, but then again neither did Slocum.

No problems, Blue-Belle took 16 days to make the 2037 mile crossing, that's an average of 127 miles per day. Her best days run being 147 miles. For a heavily laden cruising boat with a 28 ft water line she could certainly turn in a decent passage time. We were delighted with her. We also found that running downwind she didn't roll as much as other boats I'd sailed under similar conditions. Maybe the chines have something to do with this. We spent the next two and a half years cruising the Caribbean, Bahamas and the US Intracoastal Waterways. The Spray's shoal draft was paying dividends.

June 2003 and we were on our way back across the Atlantic. We did purchase wind wane steering gear in the states, but were so busy being tourists, we didn't have time to fit it. I think that only the crew of a Spray would contemplate carrying their self steering gear as deck cargo prior to an Atlantic crossing.

Our North Atlantic Passage was the usual mix of gales, calms, and occasionally some decent sailing. However we ate well, slept well and apart from blowing out the genoa suffered no damage. In Spain my wife had to fly home to cover a family emergency. So once again I single handed to Turkey, finally arriving to the fabulous reception mentioned earlier. This winter we intend to haul out and I will finally get round to fitting the Wind vane and steering gear. For as my wife says "It will look so much nicer dear, hanging on the transom".

In conclusion we find the Spray to be a wonderful sea boat, and Blue-Belle is a lot faster than she looks. When running in gale force conditions we find that our heavy weather staysail, sheeted flat amidships (a technique used by Slocum in his book) works well. The bow showing no tendency to dig in despite all the weight we carry up forward. One mistake we made in the early years was in reefing her down too early; the boat is very stiff and sails well in heavy weather. In storm conditions when it is more prudent to stop and we either heave to or lie to a parachute anchor streamed from the bow and attached to a bridle led back to a cockpit winch. In this manner we feel safe and secure.

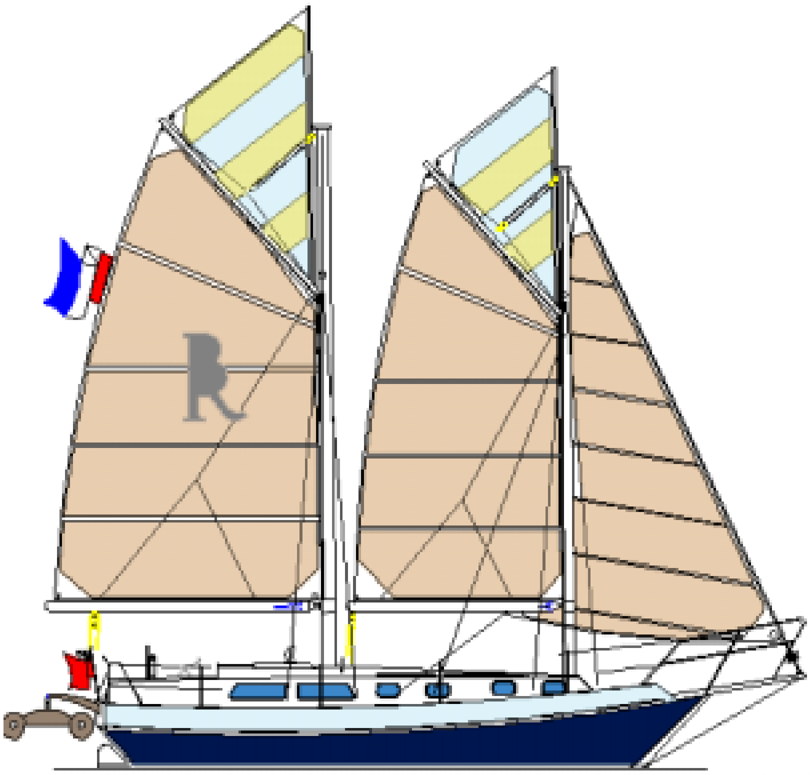
So, would we part with our Spray? Would we change her for something else? No - not ever. After 8 years and 35.000 miles we finally have our ultimate cruiser. Thanks Bruce, you gave us a great boat.

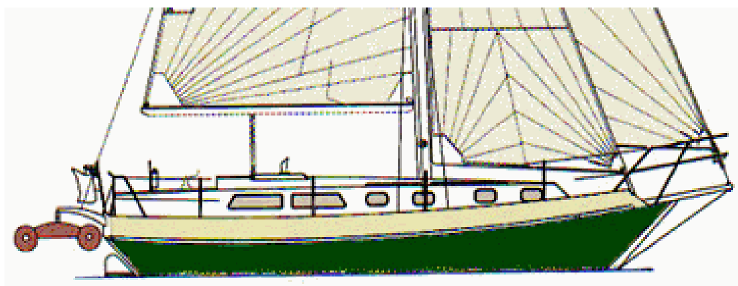
Kindest regards, Derek & Hulya
S/Y Blue-Belle Park Kemer Marina Kemer Antalya/Turkey

SPRAY 340 A

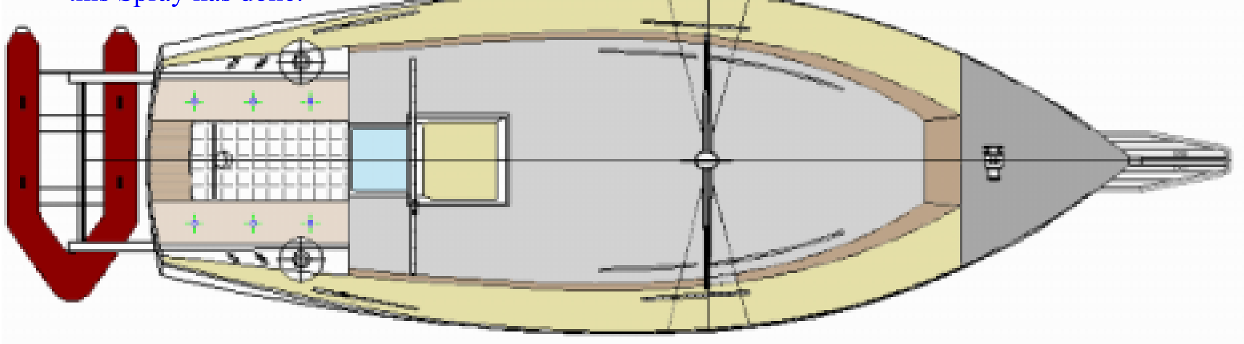
Length on Deck.	10.36 m	34' 0"
L.W.L.	8.53 m	28' 0"
BEAM	3.96 m	13' 1"
DRAFT	1.22 m	4' 0"
DISPL.	9,525kg	21,400 lb
BALLAST	3,0841 kg	6,800 lb
AUX PWR		20 - 33 hp

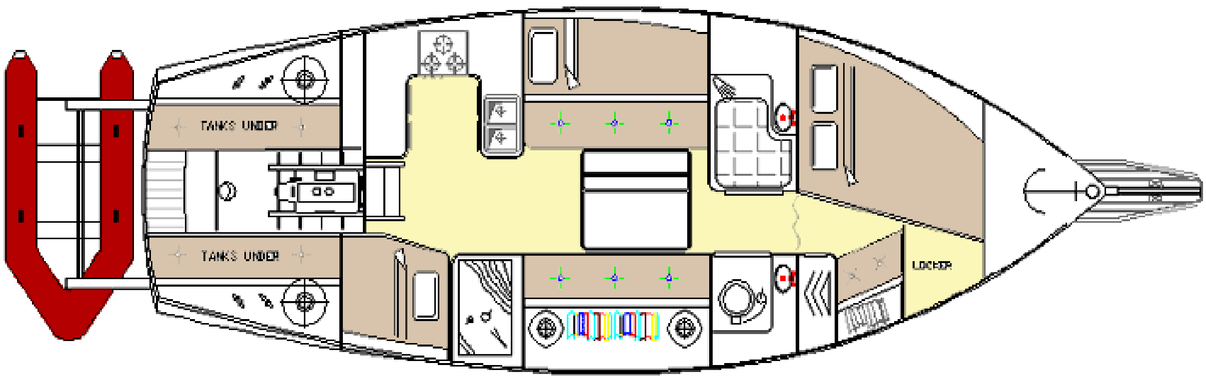
The original Spray 33 has been enlarged to create this new kit. The new versions in the Spray 340 series offer something for all. Several alternate sail plans available including Junk Schooner Gaf cutter, Gaf schooner & Berm. Cutter. Study plans are available.





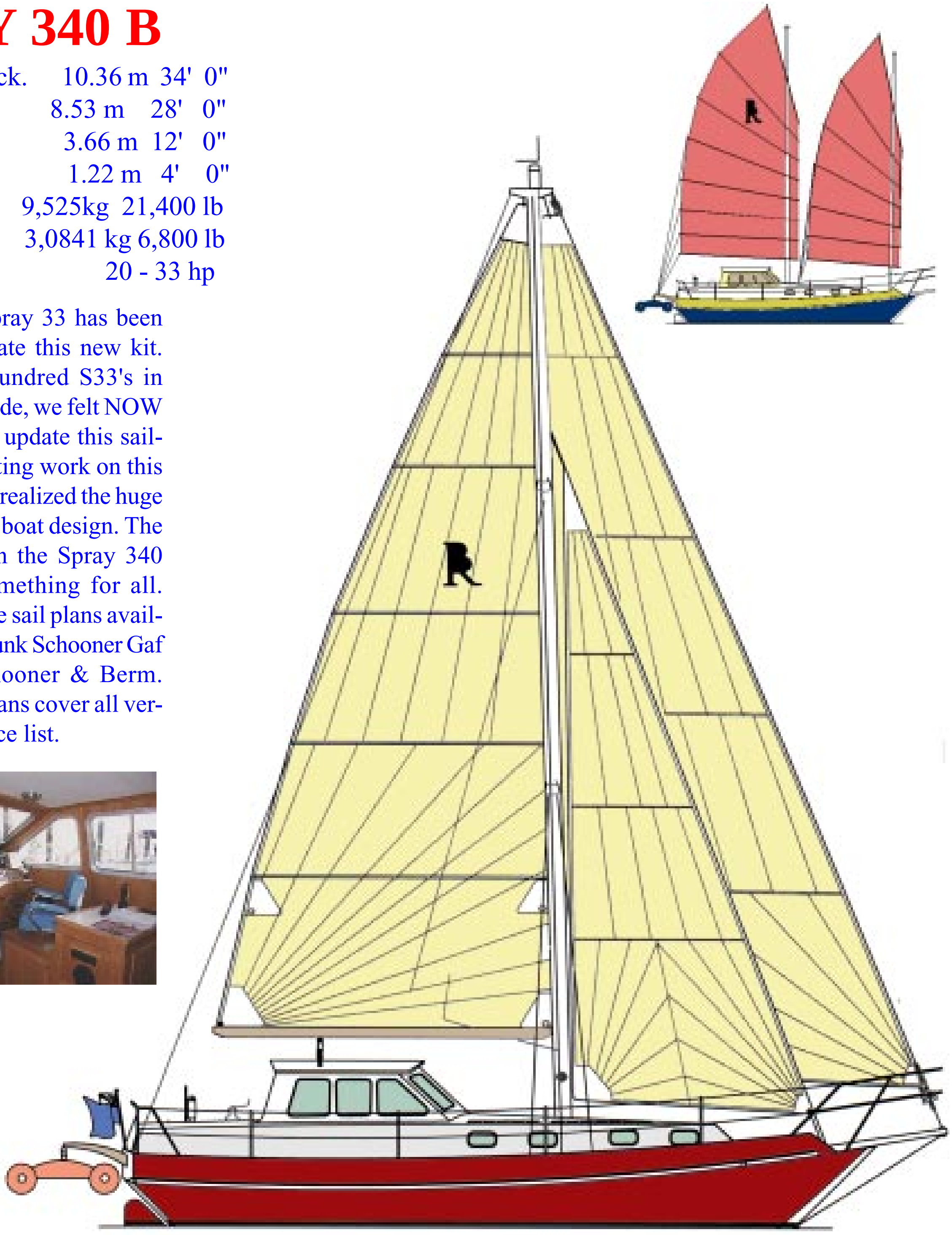
You may want to customize your interior as the owner of this Spray has done.



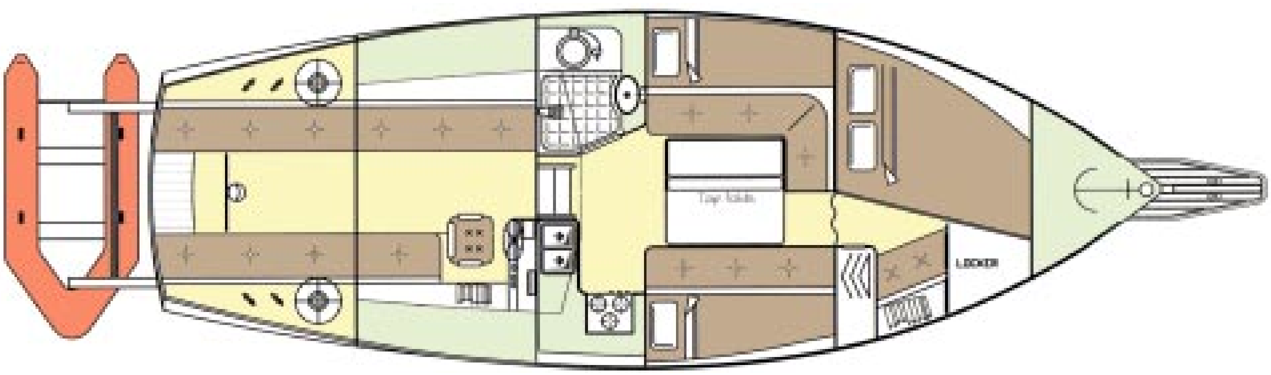


SPRAY 340 B

Length on Deck.	10.36 m	34' 0"
L.W.L.	8.53 m	28' 0"
BEAM	3.66 m	12' 0"
DRAFT	1.22 m	4' 0"
DISPL.	9,525kg	21,400 lb
BALLAST	3,0841 kg	6,800 lb
AUX PWR		20 - 33 hp



The original Spray 33 has been enlarged to create this new kit. With several hundred S33's in service worldwide, we felt NOW was the time to update this sailboat. Since starting work on this project we have realized the huge potential of this boat design. The new versions in the Spray 340 series offer something for all. Several alternate sail plans available including Junk Schooner Gaf cutter, Gaf schooner & Berm. Cutter. Study plans cover all versions ... See price list.



Spray 370 KIT

Drawings, illustrations, construction photos and general information about this Spray design that you can build from a KIT or Cutting files and plans.

S370A accommodation plan. At last we have managed a true “Walk-thru” in this size Spray. The fore and aft double in the aft cabin. A dinette could replace the settee & berth on the Port side. The table folds down on both sides.

The original Spray 36 was a stretched Spray 33 and with several hundred of the S36 in service worldwide, we felt NOW was the time to update this sail boat. Since starting work on this project we have realized the huge potential of this boat design. The large range of versions in the Spray 370 series offers something for all. Please check out the various general arrangements and see if one of these can be the basis of YOUR boat.

During the conversion from the Spray 36 to the Spray 370 Kit we increased the beam by 8 inches. We made subtle changes to the bow; this allowed for easier fitting of the forward plates plus an increase of space in the internal accommodation areas.

Hi Bruce,
Things are going OK. The attached photos are a little out of date now as the most recent ones are still in the camera. I’ll get them to you as I get them. Currently I’m working on the superstructure with the bow deck and the two main saloon decks in place. The saloon sides are also in place held with quite literally a couple of welds on the No 7 frame / bulkhead.

The welder is inside the boat so I’ve decided to tack weld working from the bow. I’ll then move the welder through to the cockpit, and then aft cabin and then seam weld in reverse order - inside - i.e... Aft cabin, cockpit, saloon then move to the outside, thus reducing the need to keep moving the welder through unnecessarily. It’s going OK. I hope to make some headway in a couple of weeks when I’m at home for 8 days.

I’ve got 8 weeks off in the summer (July & August! No holiday - just more boatbuilding!) At the moment it’s back to just the odd hour in the evenings and occasional weekends. *She’s a wonderful shape. I love her already! Thanks to you both for the design and cutting.* I’m working on my own since the Easter Holidays so getting plates aloft is quite a challenge - but I like challenges! I got three up today! Anyway I hope the photos are OK....
Regards Andy

SPRAY 370A

MULTI CHINE STEEL.

LOD	37'-00" 11.28 M
LWL	30'-4" 9.24 M
BEAM	13'-0" 3.96 M
DRAFT	4'-0" 1.22 M
DISPL	24,400 LB 11,521 Kg
BALST	8,800 LB 3,991 Kg

This new Spray 370 is developed from the original Spray 36 ... longer with one foot more beam this is a fantastic world cruiser.

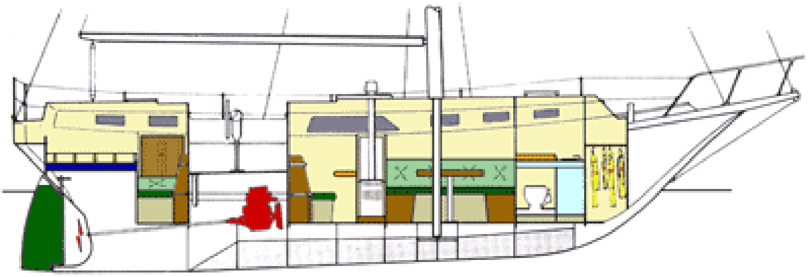
There are 500 of the original Spray 36s in service and as many again being built in Steel, Fiberglass and Wood/Epoxy.

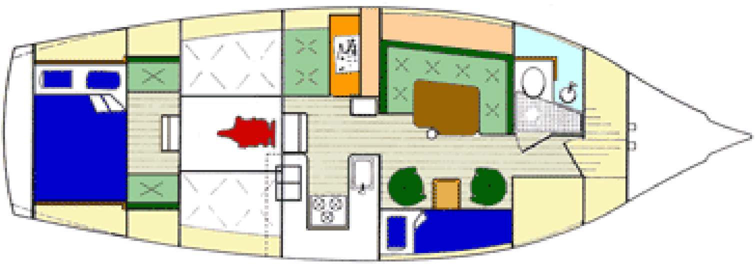
The **Spray book** details the exploits of many Spray 36s that have made circumnavigations, long ocean crossings and interesting and unusual cruises.

If you are looking for a medium sized family cruising sailboat then the Spray 370 could fulfill your requirements at minimum cost to your family budget.

This design has also proven iteself many times to make a highly successfull single-hander so if you are expecting to sail on your own or with minimum crew, then we can recommend the Spray 36.

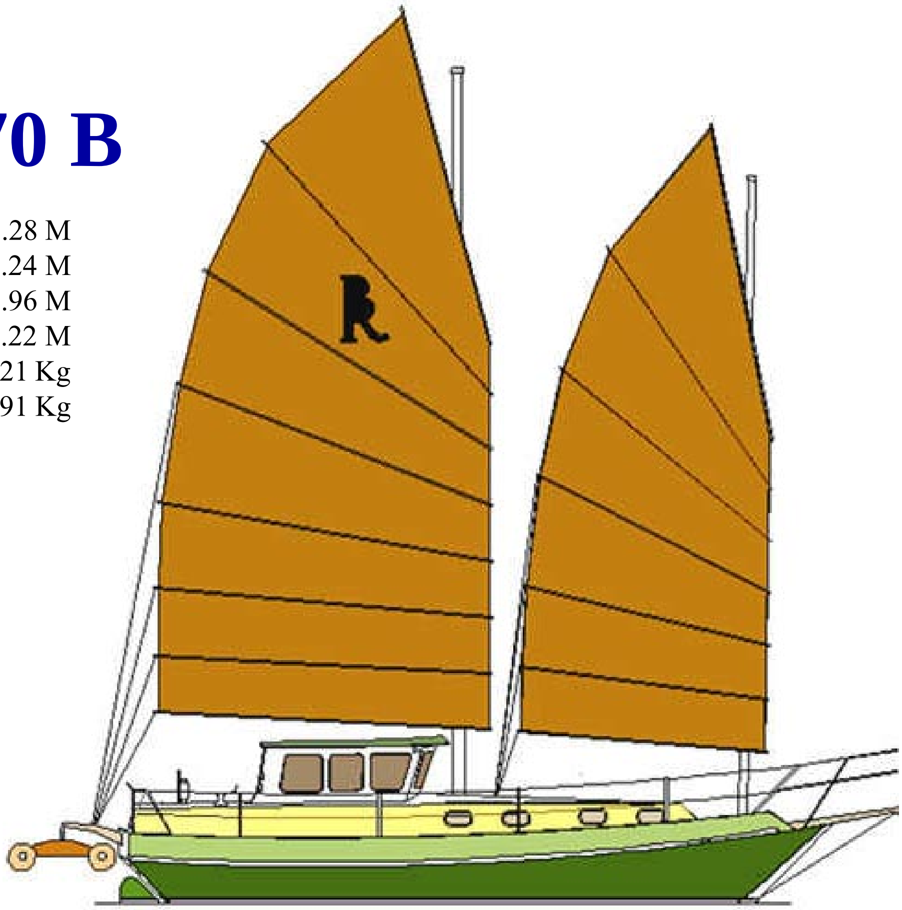
Complete KIT Study Plan Packages covering all versions with some construction sheets and material lists included.





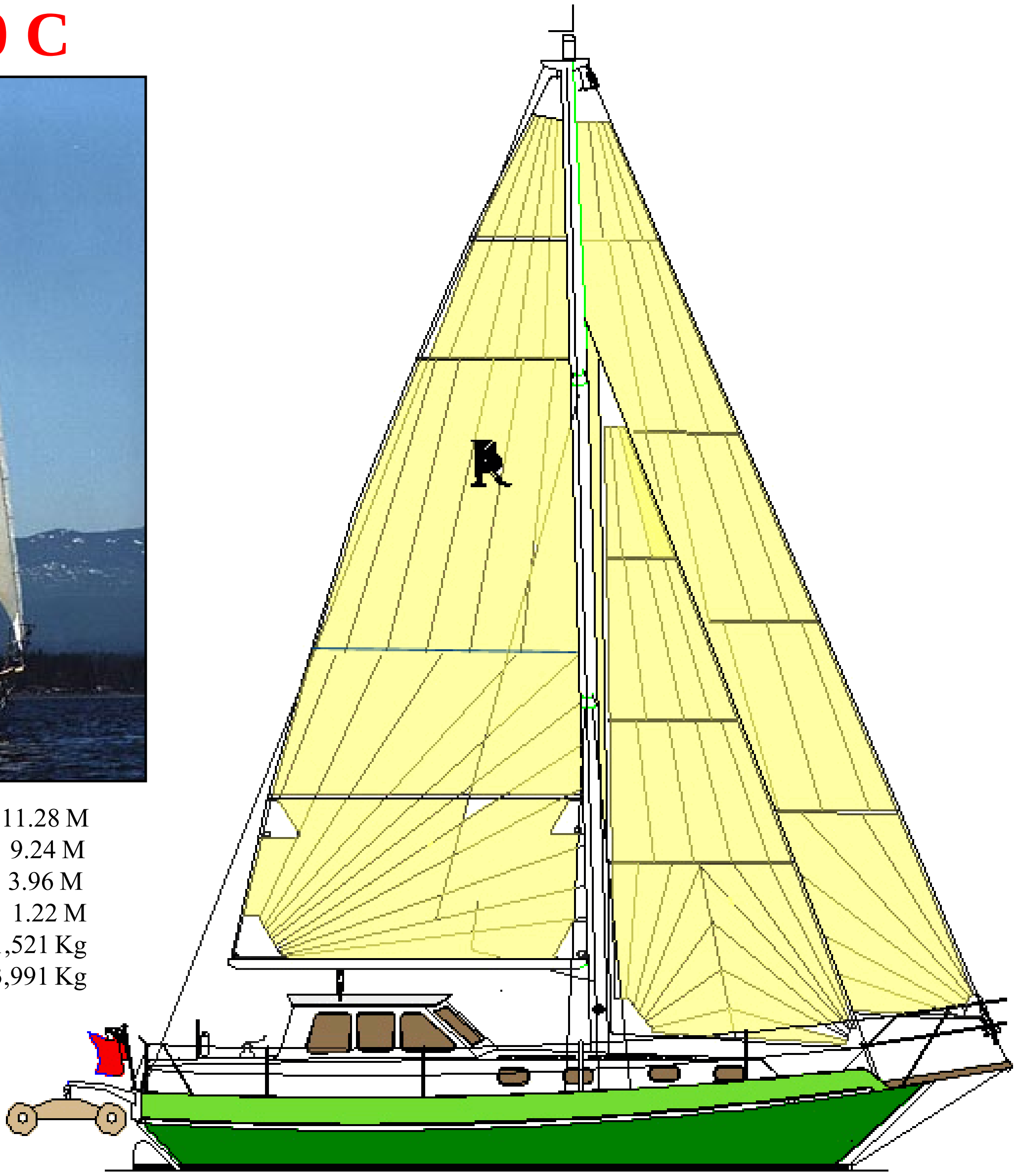
SPRAY 370 B

LOD .... 37'-00" 11.28 M
LWL .... 30'-4" 9.24 M
BEAM .... 13'-0" 3.96 M
DRAFT .... 4'-0" 1.22 M
DISPL .... 24,400 LB 11,521 Kg
BALST .... 8,800 LB 3,991 Kg

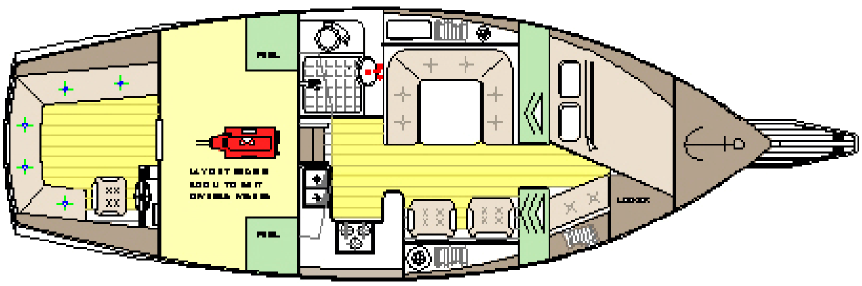


SPRAY 370 C

LOD	37'-00"	11.28 M
LWL	30'-4"	9.24 M
BEAM	13'-0"	3.96 M
DRAFT	4'-0"	1.22 M
DISPL	24,400 LB	11,521 Kg
BALST	8,800 LB	3,991 Kg



After we had the original catalog printed we made changes to the Spray 370 range so this is now the Spray 370 C and the poop stern version becomes Spray 370 version D .. Sorry about any confusion.



Spray 400 KIT A, B & C Versions

Drawings, illustrations, construction photos and general information about this Spray design that you can build from a KIT or Cutting files and plans. SEE SPRAY 40 Chapter 18

L.O.D.	12.19 m	40' 0"
L.W.L.	9.73 m	31' 11"
BEAM	4.37 m	14' 4"
DRAFT	1.27 m	4' 2"
DISPLACEMENT.	16,257 kg	35,840 lb
BALLAST	6,804 kg	15,000 lb
AUX POWER		50 to 70 hp

Spray 460 KIT – A & C Versions

Drawings, illustrations, construction photos and general information about this Spray design that you can build from a KIT or Cutting files and plans.

KIT....BIGGER, BETTER offshore cruising pilot house sail boat. The Spray 460 is longer plus the beam has been increased to maintain the proportional beam of the other proven Spray designs, this greatly increases the livable interior space and allows wider side decks. This boat sails more upright as is the case with the other Spray designs which rarely exceed 10 degrees of heel ... you family will love this feature.

The first Spray 45 was professionally built in North Carolina and is now in service adding one more to the huge fleet of Spray sailboats currently in use around the world. Because this Spray was to be the full-time home for an experienced cruising couple, we had to make sure there was adequate space to maintain a good degree of comfort under all conditions

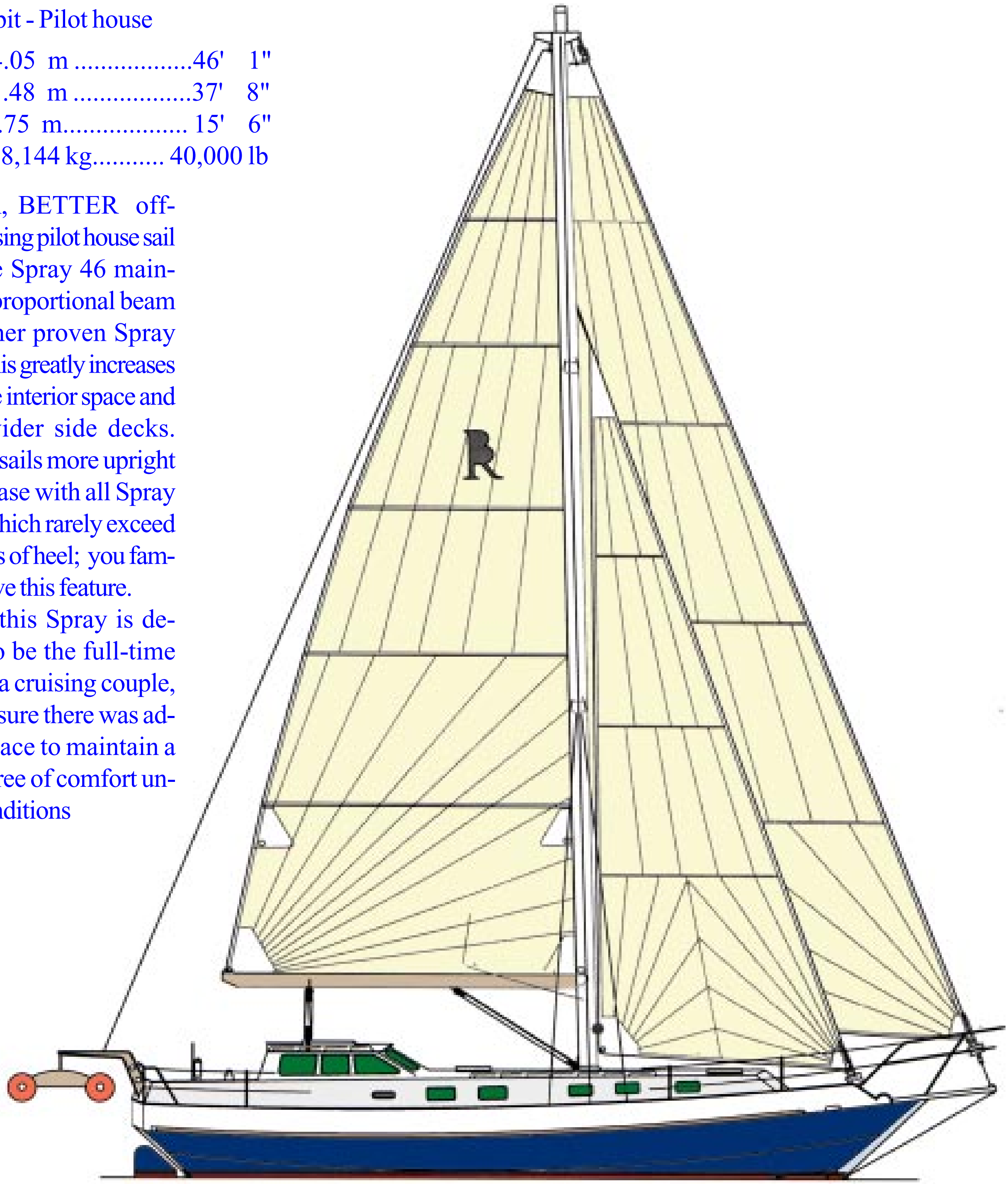
You may have your own ideas about the perfect Spray. We are always willing to comment on any thoughts you may have regarding your next boat. A custom version of this well-proven vessel could be your dream ship. Other accommodation & deck & cabin layouts possible.

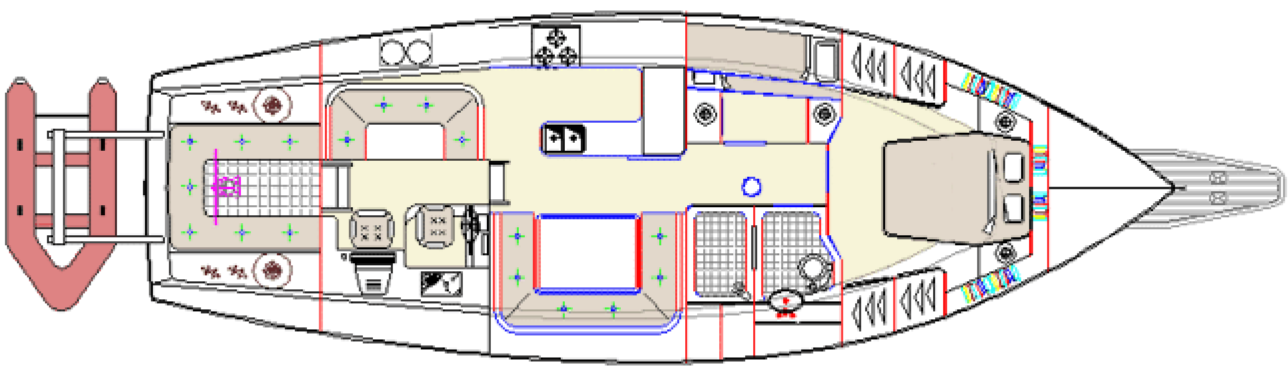
SPRAY 460 A

Aft cockpit - Pilot house

L.O.D.14.05 m ....46' 1"
L.W.L.11.48 m ....37' 8"
BEAM 4.75 m................... 15' 6"
DISPL. 18,144 kg........... 40,000 lb

BIGGER, BETTER off-shore cruising pilot house sail boat. The Spray 46 maintains the proportional beam of the other proven Spray designs, this greatly increases the livable interior space and allows wider side decks. This boat sails more upright as is the case with all Spray designs which rarely exceed 10 degrees of heel; you family will love this feature.
Because this Spray is designed to be the full-time home for a cruising couple, we made sure there was adequate space to maintain a good degree of comfort under all conditions



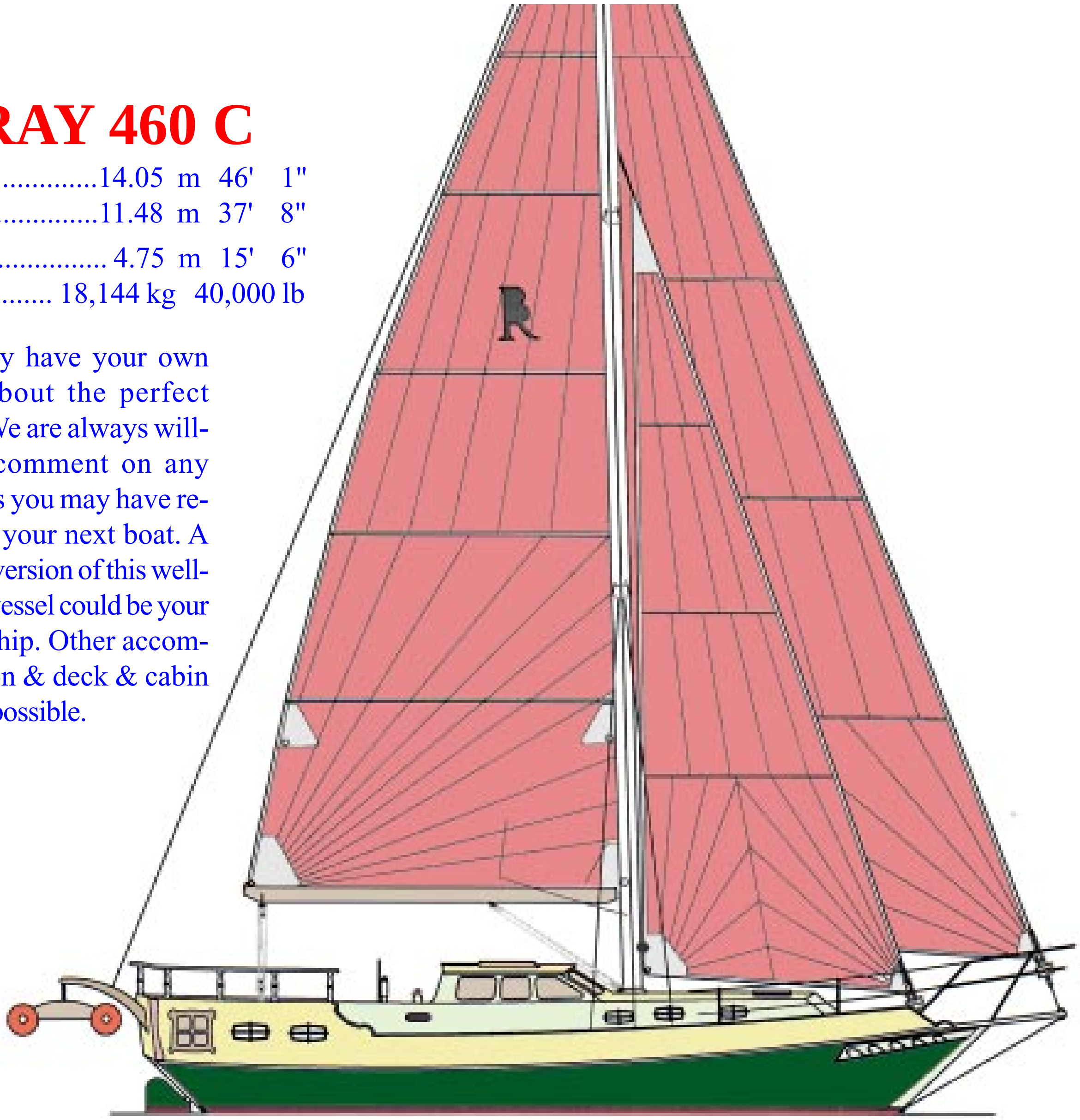


SPRAY 460 C

L.O.D................14.05 m 46' 1"
L.W.L................11.48 m 37' 8"

BEAM................ 4.75 m 15' 6"
DISPL......... 18,144 kg 40,000 lb

You may have your own ideas about the perfect Spray. We are always willing to comment on any thoughts you may have regarding your next boat. A custom version of this well-proven vessel could be your dream ship. Other accommodation & deck & cabin layouts possible.



Spray 52 KIT

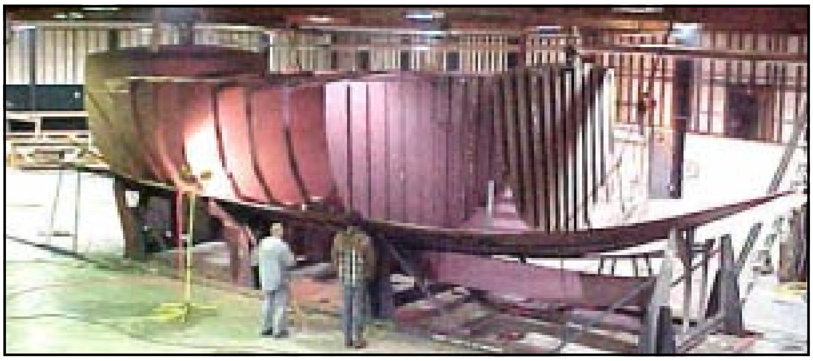
Drawings, illustrations, construction photos and general information about the Spray 52 that you can build from a KIT or Cutting files and plans.

LOA	52’-0”	15.85 M
LWL	42-8"	13.00 M
BEAM	15’-0"	4.57 M
DRAFT	5’-6"/	1.68 M

You can order a CD showing the step by step assembly of these kits.

LOA ....52'-0"/15.85 M
LWL....................................42-8"/13.00 M
BEAM (Wide Body).........17'-0"/5.18 M
BEAM (Slimline)................15'-0"/4.57 M
DRAFT.................................5'-6"/1.68 M
POWER...Various
SAIL..Various

The Spray 52 & 58 can be fitted with a variety of rigs to suit your purpose, taste or particular requirements. Several accommodation layouts are possible.



This new design is now available as a cut-to-size kit or cutting files. Study plans showing all versions. www.brucerobderts.com for details.

Spray 58 KIT

Drawings, illustrations, construction photos and general information about the Spray 58 that you can build from a KIT
or Cutting files and plans.

We received the following message from the owner of the first **Spray 58** kit which has now been successfully delivered to his building site....

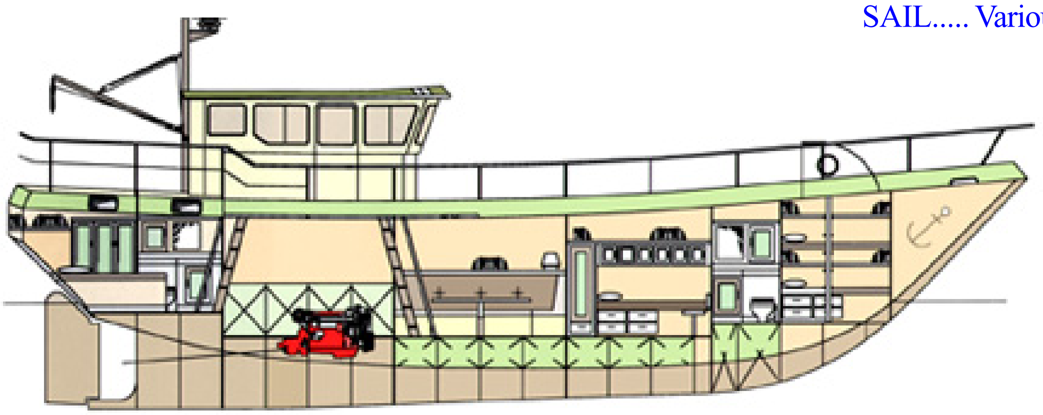
Hi Bruce, the project is off to a good start, jig is erected and a few frames have been built, by the end of today we should be finished with all frames. I have quite a crew of 3 good welders with lots of experience building and modifying boats, me and a friend round out the labor crew. We inventoried the parts and everything so far is accounted for, it really looks quite well done.......Regards STAN"

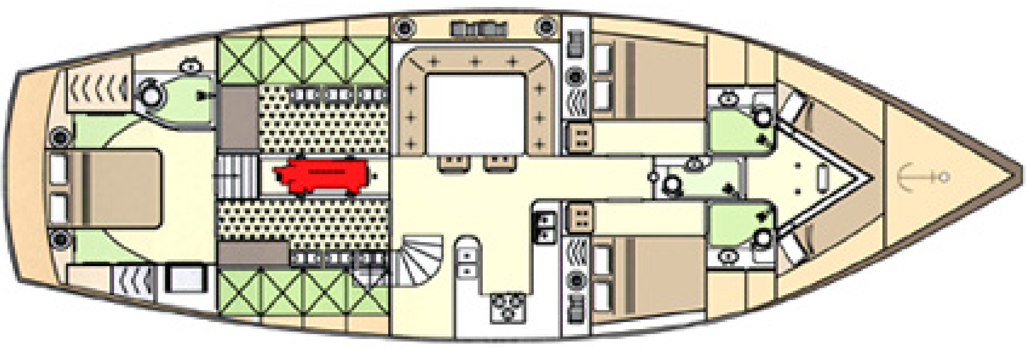
Hi Bruce: Launch occurred on June 28 right on schedule. Everything went very smoothly. Still about a week of welding to do but boat looks great, will put in windows & doors today & tomorrow. I leave for Alaska July 11 to fish other boat, will send you another group of pics soon. Stan

SPRAY 58

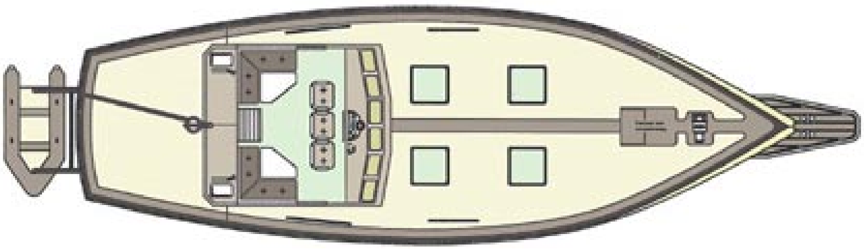
Pleasure Trawler Yacht and Trawler Sailer versions are available for this design.

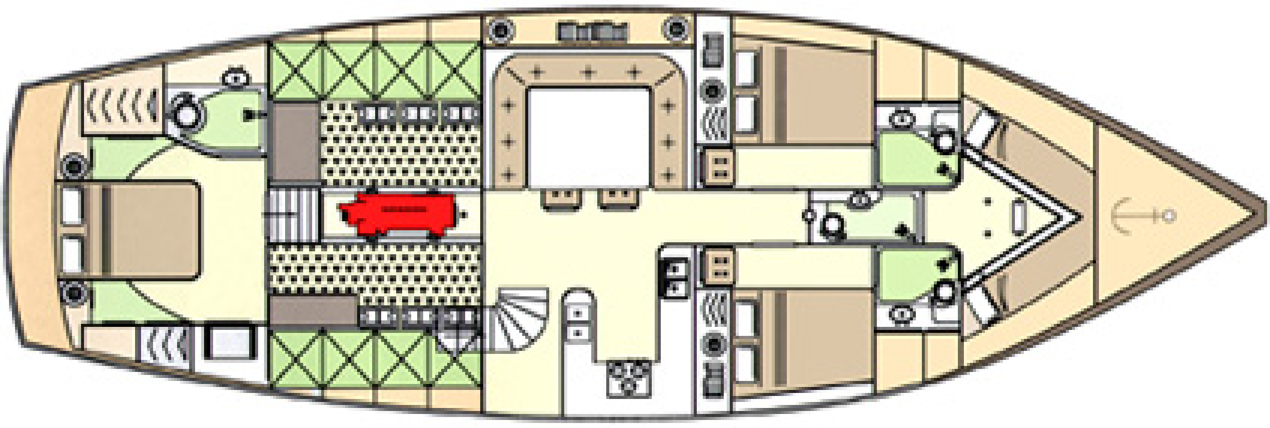
LOA.....57’-9”/17.60 M
LWL.... 47’-8”/14.53 M
BEAM... 18’-9”/5.72 M
DRAFT.6’-0”/1.83 M
POWER Various
SAIL..... Various





SPRAY 58 Trawler-Trader





This new design was prepared for a client who is useing her in Alaska as a commercial fishing vessel. The extra heavy quality kit is being cut from Lloyds 'A' grade shipbuiliding steel and will be delivered direct to the new ower's builder in the Seattle area. Pleasure Trawler Yacht and Trawler Sailer versions are available for this design.

ASSEMBLY INSTRUCTIONS
"SPRAY" DESIGN BOAT KITS

1: INTRODUCTION.

These instructions are intended to introduce you to building a boat from a pre-cut kit of the SPRAY design by Bruce Roberts. It is essential to read and absorb all these instructions and the kit assembly drawings before you start the assembly of your kit.

Throughout these instructions we will use the word metal which may apply to steel, aluminium or copper-nickel. There will be variations between the handling of the various materials and these will be drawn to your attention as necessary.

These instructions are not intended to replace good metal boatbuilding practices which need to be observed at all times, including common welding and safety practices which are equally important for a boatbuilding project. If you are not already a competent welder then please seek assistance.

The first thing to realise is that the kit differs in many ways from the methods you would use to build a metal boat from scratch. The kit is far superior to anything you could achieve by starting with the plans and delivery of raw steel plate and the various profile bars that are needed to build your metal boat.

Few of you will understand (or want to know!) the huge amount of work that is required to turn any boat plan into a cut-to-size boat kit. Every part has to exactly match that of its neighbour, the slots and markings need to be exactly in the correct locations and everything must fit perfectly together to enable you to complete the assembly of the hull, deck and superstructure with the minimum of problems. In spite of all our efforts to deliver a 100% flawless kit, there may be the occasional error requiring corrections to one or more parts. Before doing so, please check and re-check all dimensions and measurements of the adjacent parts and markings. Experience learns that corrections are rarely needed and more importantly can result in problems at a totally different position in the hull.

The first time boatbuilder will be faced with many questions at the start as well as during the finishing of the boat. For those builders we recommend to spend serious attention to planning and most important allow a generous overall timeframe for the entire project. Many people before you have succesfully completed a similar project so don't let the questions or a tight deadline discourage you.

Most metal boats built from scratch are built upside-down…most boats built from cut-to-size metal kits are built UPRIGHT. Not only is this a more appropriate way to assemble the kit but it saves cost and inconvenience of having to turn the hull.

Experienced yachtbuilders will have no difficulty in assembling the kit from reading just the kit assembly drawings. There is however one important instruction which is different from “common practice”, which is why we state it here as well as repeat it several times at the appropriate time:
YOU MUST TACK WELD THE COMPLETE HULL DECK AND SUPERSTRUCTURE TOGETHER BEFORE YOU RUN ANY FINAL WELDS.

Failure to observe this advice will almost certainly ensure you will end up with an unfair boat requiring a considerable amount of filler. In any case do NOT OVER-WELD or try and run long welds at one time and observe the “welding details” drawing included in the kit assembly drawing package.

In the interest of the quality of your work and an overall succesfull project we are always at your disposal for answering any questions you may have by email or telephone. Please ensure to have the drawings and these instructions available in order to maximise the efficiency of our communications.

2: RECEIVING YOUR KIT.

Depending on your location or delivery arrangements your kit may arrive on a flatbed truck or in a container. You should be aware of these arrangements before the actual date of delivery so you can make the necessary preparations to receive and store your kit.

The kits can either be packed on pallet(s) or stowed inside a container. Parts with an overall length less then 1m are always stored on a pallet. Pallets can be lifted off the transport using a small crane, front-end loader or similar equipment. For kits packed into containers you may find it more convenient to "drag" your kit from the container using a pair or planks as a ramp.

Once you have unloaded your kit you must make provision to keep it covered until assembly is underway. Make sure that the metal parts are not in direct contact with cement based floors like concrete, as this will affect the Sigmaweld primer.

You should go trough the kit and identify each part or group of parts so you can store these in the order that they will be required. The parts layout drawings will help you in identifying each part from it's number as well as it's shape and form and the parts list supplied enables you to tally the parts of your kit.

Each part has it's own unique code, consisting of letters and numbers allocated in accordance with the following system:

- Outside plating parts like bottom, hullside, deck and superstructure have a code starting with 1 or 2 digits.
- The parts forming the webs or bulkheads have a code starting with "ST" (=station), followed by the station number.
- Bottom longitudinals have a code starting with "L" (=Longitudinal), followed by the sequential position in the hull, starting from the boat's centreline.
- Side longitudinals have a code starting with "S" (=Stringer), followed by the sequential position in the side, starting from the bottom.
- Building jigs have a code starting with "J" (=Jig), followed by the digit indicating the relevant station number.
- The last digit in all part codes represents the number of identical parts in the kit.

Due to the requirement of packaging for transport it is impossible for the kit to be stacked in the order you will be using the various parts…you must take care of this. Later in this text we will suggest the order of assembling your kit so you will be aware of which parts you will need at each stage. If you do not find a particular part at this stage …DO NOT PANIC…there will be so many pieces that it will be easy for you to overlook one or two at this stage. If after several checks you find one or more parts missing then do contact the supplier of your kit so they may put the matter right.

3: ASSEMBLY SEQUENCE.

Below is the RECOMMENDED sequence for assembling your kit, however this may vary depending on the model, building site and facilities available as well as individual modifications included in the design at your request. We advise inexperienced builders to maintain this sequence to avoid problems like for example parts that are no longer accessible for welding or affecting the overall dimensions and or position of other parts.

The first item you will need is the setting up jig. The transverse profile jigs will be supported by the metal "castles", all included in your kit. Not included in the kit is a supporting structure underneath the setting up jig. You can usually obtain ”I” beams / RSJ material from the local steel supplier or your local steel scrap yard and you will find the necessary measurements on the drawing included with your documentation.

ON NO ACCOUNT SET UP YOUR HULL WITHOUT THE USE OF THE ABOVE ”I” beams / RSJ’s STRUCTURE.

The setting up jig is intended to get the assembly of your hull started and may also be used to support the boat during the entire building process, for which we recommend to add extra support and bracing to the structure of the jigs to absorb radial and axial forces which occur during assembly of a hull by outside factors.

The recommended assembly sequence for the SPRAY kits is:

- Assemble the jig including the stiffening profiles as indicated on the drawings and secure the jig on the supporting structure below.

NOTE: If the workshop has limited floorspace available, you may consider assembling the webs and bulkheads first and do the jig later.

- Assemble the webs and bulkheads including the stiffeners.
- Assemble the keel.
- Put the keel bottom in the jig at the correct height and assemble the keel webs in the correct positions. Observe the markings and the position of the webs which may have different shapes for PS and SB.
- Assemble the keel sideplates.
- Assemble the bottom plates and tackweld to the keel sideplates. Observe the corect lining of the markings and check against the measurements on the drawings.
- Assemble the watertight bulkheads on either side of the engine room and tackweld to the bottom plates starting from the centreline of the bottom working outwards. Observe the direction of the arrow in the markings, indicating the direction of the tickness of the material.
- Assemble the bottom longitudinals (very small tack welds only and only in the middle between two stations).
- Put the webs into position over the bottom longitudinals and check frame spacing at the bottom as well as at the top.
- Tack-weld bottom longitudinal stiffeners to web-frames

- Insert side longitudinals (stringers) into web-frames whilst checking the correct spacing between the webs. Tackweld the stringers to the webs.
- Position the longitudinal supports for the transom.
- Position transom and tackweld to bottom plate and longitudinals.
- Assemble as many deck stringers as possible and tackweld to the webs.
- Assemble the deck plates and tackweld to the webs where possible.
- Place the upper sideplates in position, starting aftships and tackweld to the webs.
- Leave the lower sideplates (or radiusplates) until last.
- Tackweld the deckplates to the side hull plates.
- Assemble the complete superstructure, only tackwelding.
- Position the upper side (or radius) plate starting aftships and check the correct alingment of markings. Temporarily position the lower plate just to check alignment and size and continue with the upper plates forward.
- The radius plates require some trimming to make them fit to exact size. Check alignment and fairing of the entire radius section before trimming.
- Now is the time to commence running final welds, start welding the 2 bulkheads to the bottom plates working from the inside outward and never run any continuous weld longer than 1 meter on one side before switching to the opposite side.
- Leave the vertical welds in the outside plating of the hull until last. The final welds in these locations are great for tensioning and fairing the hull plates.
- All outside plating below the waterline must be double welded. Best to run the inside weld first, then grind the welding seam from the outside and run a final weld from the outside.

This is the recommended assembly sequence, however depending on local conditions and facilities available, alternative sequences may be prefered.
The better equipped your workshop is with overhead lifting and other equipment the easier and more smoothly will your job proceed. We do recommend that you read some of the literature available on metal boat building, which will answer many of those general metal boat building questions that are sure to need clarifying as the project proceeds, if only to get familiar with the terminology of parts and components of your kit. Contact your supplier for titles available in your area.

5- WHAT YOU NEED TO KNOW ABOUT WELDING

Attempting to construct a metal boat kit leads us to believe that at least the basics of arc and or Co2 welding are known. If in doubt about your abilities to weld , improving your skills on some scrap pieces of metal would be advisable as there are no great secrets in general steel welding but practising would set you of to a good start right at the beginning.

Welding aluminium or copper nickel should not be attempted without proper knowledge of the materials and welding sequences involved and should always be carried out in a covered and clean surroundings.

The metal kits are constructed in such a manner that the strength of the hull & deck is created from the build up of the frames and stringers as interlocking sections , <u>HEAVY AND CONTINOUS WELDING OF FRAMES AND STRINGERS SHOULD BE AVOIDED AT ALL TIMES.</u>

Especially important for all plate joints during the assembly of the hull is DO NOT APPLY CONTINUOUS WELDS. The plate joints should be <u>ONLY TACK WELDED</u> in three locations, one weld at the each of the ends of the join and one in the centre of the join. These tacks should be no more than 2 inches or 50mm long. If you weld the plates on the floor you will end up with a "hard-spot" in the hull plating.

All parts of your kit are cut to a precision of 2 mm and are designed to be welded together without any opening between the parts. Some plates will need to be bevelled before tacking in place or you may prefer to make the bevels after you have tack welded the plates and just before running the final welds. In all cases good metal boatbuilding practices will prevail.

The plate parts in your kit are cut and dimensioned to be (tack) welded without any opening between the plate parts. Some welds require the plate edges to be bevelled, for which please consult the welding details drawing provided. Use a cutter / grinder disc to effect the bevelling.

After the hull & deck are <u>COMPLETELY TACK-WELDED</u> together , the process of finishing welding can take place. The secret of creating a fair hull & deck after tack-welding is completed is to use a fairly high amperage and speed setting of your welding equipment. Welding with too low amperage and slow speed will create lots of heat on the spot and less penetration of weld material in the seam, causing strength problems and lots of grinding weld material away to obtain a smooth surface afterwards. This in turn would weaken the weld again.

The welding primer applied on all steel kits (Sigmaweld MC) is best welded with the CO2 method. Welding wires come in many different varieties but we have had good reports on the use of Bohler Thyssen TG50M welding wire.

Using common sense and practise should leave you to create a smooth and fair hull & deck structure with very little distortion. When running final welds make sure you weld approximately 15 minutes and certainly not longer than 30 minutes on one side before whitching to the opposite side of the boat.

<u>IF IN DOUBT ABOUT YOUR WELDING SKILLS , SEEK ADVICE.</u>

Any metal construction company or competent welder can help you with the basics.

Always observe personal protection and safety regulations.

6. ASSEMBLING YOUR KIT.

With the arrival of your metal kit, you received a packing list containing the names , numbers and quantities of all the parts in the metal package. Furthermore you received one or more large scale drawings called “Parts Layout” showing all the parts as flat surfaces and more or less grouped together as they appear in the metal kit.

Another set of drawings called “Construction” shows the longitudinal and transversal sections with the appropriate measurements of each frame as well as the profiles.

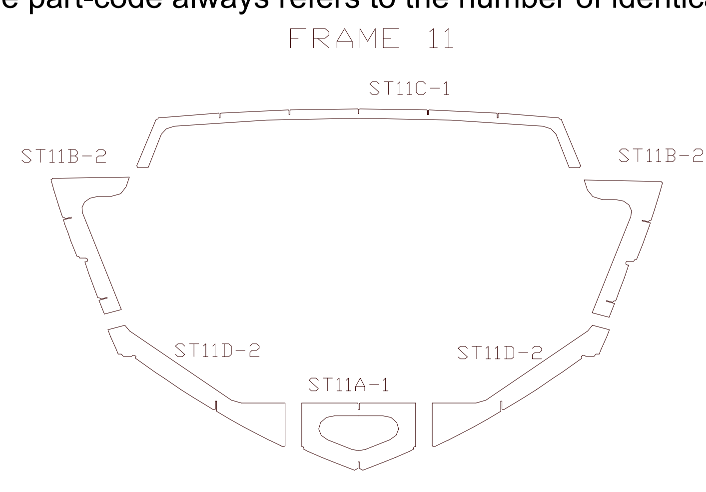
Studying these drawings will give you a first insight in the position of the various parts and it becomes apparent that the numbering is as much as possible a logical sequence of the way the parts assembly progresses.

Prior to using these drawings , we advise to make some copies of the drawings or parts there off or cover them with plastic as they could easily be destroyed during the construction and welding.

As explained in chapter 2, each part has it’s own unique code, consisting of letters and numbers allocated in accordance with the following system:

- Outside plating parts like bottom, hullside, deck and superstructure have a code starting with 1 or 2 digits.
- The parts forming the webs or bulkheads have a code starting with “ST” (=station), followed by the station number.
- Bottom longitudinals have a code starting with “L” (=Longitudinal), followed by the sequential position in the hull, starting from the boat’s centreline.
- Side longitudinals have a code starting with “S” (=Stringer), followed by the sequential position in the side, starting from the bottom.
- Building jigs have a code starting with “J” (=Jig), followed by the digit indicating the relevant station number.
- The last digit in all part codes represents the number of identical parts in the kit.

For example, frame parts numbered with ST…belong to the frame (station) no.11. The last digit in the part-code always refers to the number of identical parts in the kit.



In the above shown typical drawing it is easy to see how collecting the numbers will almost automatically bring a frame or part together.

The identification of the parts is done manually, which is why you MAY find certain codes to contain errors. This will sort itself out during the assembly and the best way to go about this is to keep the parts with unidentifiable codes stored separately and you will find the correct codes for the parts as the assembly proceeds.

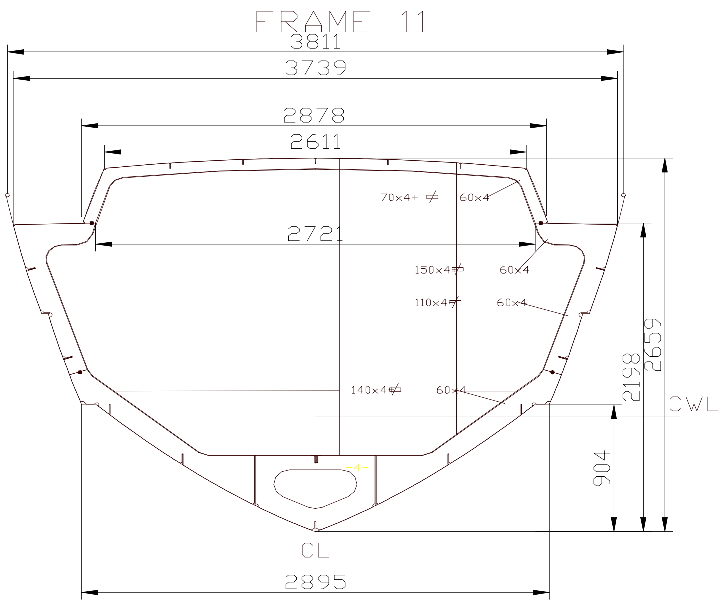
Spending serious attention to the sorting and organising of the parts may seem a waste of time at first but we can assure you that this is an important part of the preparation process and the assembly of your boat will greatly benefit from it.

Apart from the plate parts your kit also contains the profiles which are supplied at factory lengths of usually 6m. The supplied quantities are calculated on the basis of the exact length required, plus 10% margin for cuttoffs and rounded up to the nearest full length. You will find the breakdown of these profiles on the Packing list provided.

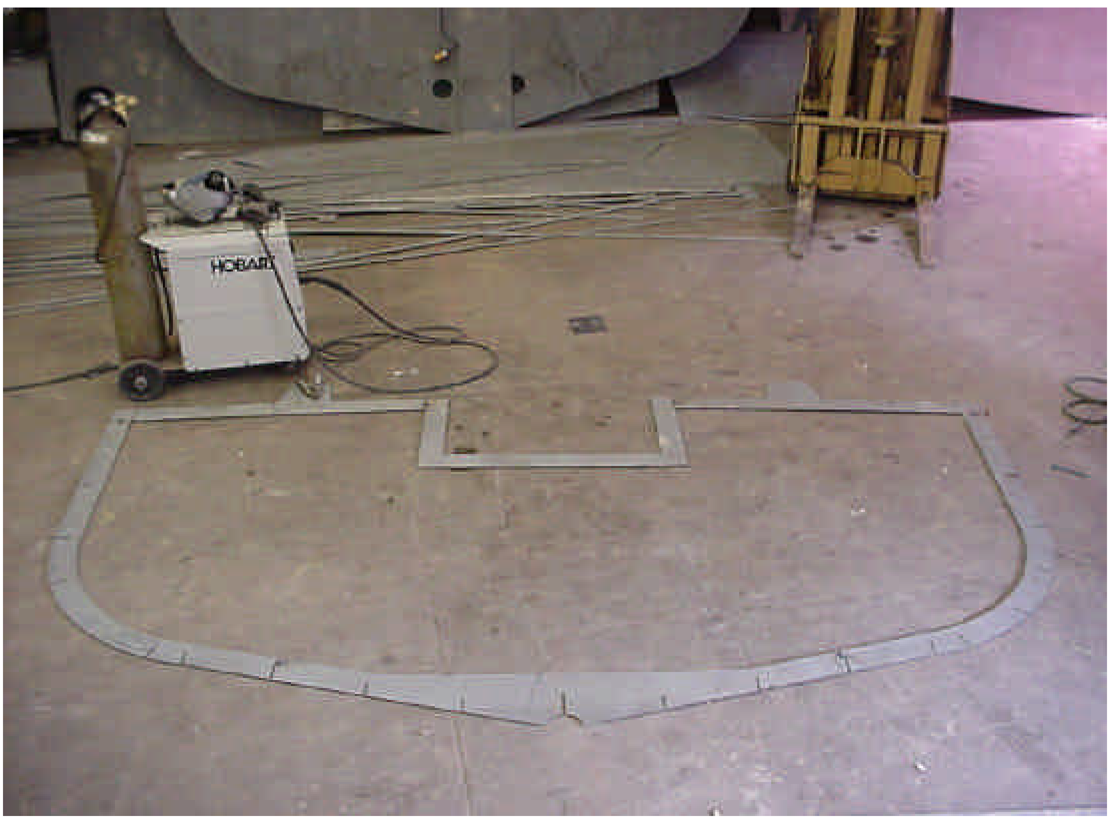
The Construction drawings provide you with the location and position of the profiles, which require cutting to size and bending to shape as part of the assembly process.

Once the sorting has been completed and depending on the preferred assembly sequence, the assembly of the frames (stations) is the next step. The easiest method is to lay the frame parts on the floor, check the overall measurements as given on the construction drawing and tack-weld the parts together to form the frame. Re-check the dimensions and run the final welds.

Most frames will have additional profile (Flat bar) welded on the inside which may be used to form a T- shape or an L- shape, whichever you prefer. There are certain positions that will only accept T or L which are indicated on the drawing.



Depending on the overall size of the boat it can be necessary to assemble only the bottom parts of the frames and complete the top part later. This may require you to use some temporary bracing between the frame-sections to keep the outside dimensions during assembly.

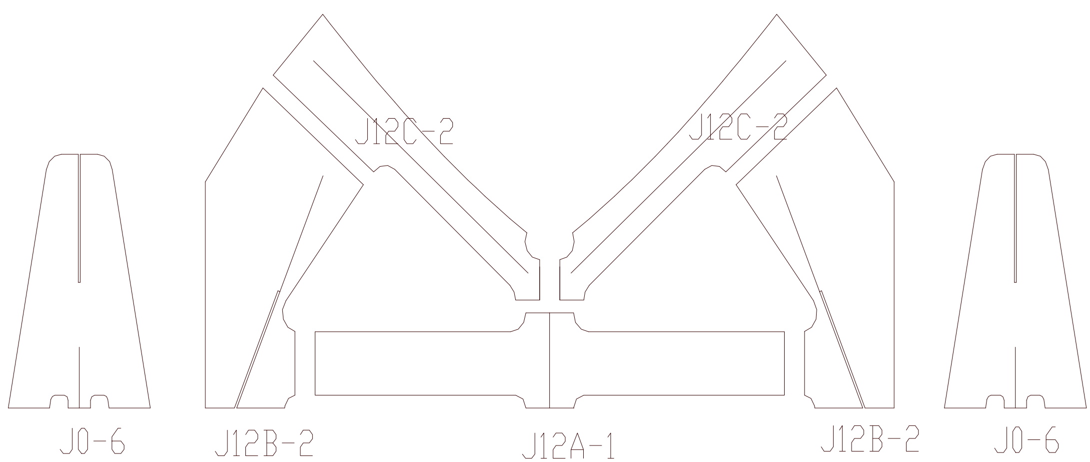


Depending on the available workshop space, you may want to assemble the bottom plates first before setting up the jig.

Assemble the bottom plates for each side of the boat and tack weld together, at least the centre section of the bottom covering the span of the jigs. Observe the correct lining of the markings and check the marking line distances against the frame spacing of the boat.

This pre-assembly must take place on a flat surface and not inside the jig. If the bottom plate exceeds the overall length of 12 m it is recommended to assemble the parts supported by the jig only as it will be difficult to lift and handle longer sections. Again only tack-welding here.

Now start assembling the jigs which have the shape of the outside hull at the location of the frame and are of essential importance to be placed in the correct location. The part-code of the jig-part refers to the corresponding frame number. The jig in below's sample drawing is placed at frame nr 12 in the hull. You will find the exact position and the correct mesurements for assembly of the jig in the Construction drawing supplied with your kit.

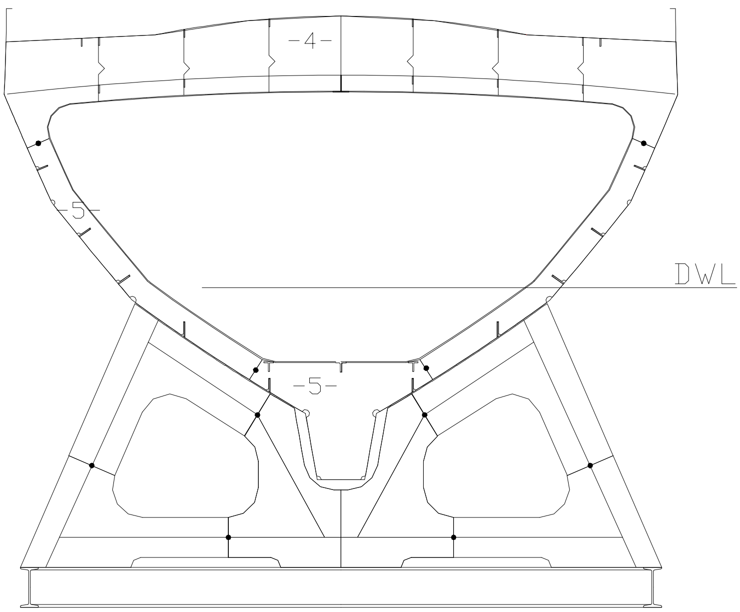


The supplied jig parts could be placed directly on a concrete underground, levelled and stiffened, but we recommend to have these supported on a frame of heavy RSJ's or I-beams picked up from a local scrap dealer. Check the condition of the soil underneath the frame for stability.

If you intend to use the "jig" during the finishing of the boat after assembly of the kit, it would be advisable to tack-weld a flat bar across the top of the plates to spread the point loading and avoid possible damage to the hull plating. Additional cross bracing between the jigs is also recommended.

Now place the jigs at the correct location matching the stations in the construction of your hull. Double check these measurements as these are extremely important throughout the entire assembly and building process.

Next place the bottom of the keel inside the jig and fill up the space between the jig and the keelbottom to the correct height. Put the first watertight bulkhead in position (check the arrows in the marking line indicating the direction of the plate thickness) and brace the top of the bulkhead to keep it in position.



Tackweld the second watertight bulkhead to the keel bottom and brace for stability. Now position the sidepates of the keel and tackweld to the keelbottom and bulkheads. Check frame spacing and overall measurements.

Depending on the size and version of your Spray, as well as the available workshop space, you may prefer to assemble the entire keel first to form the “backbone” of your hull and deck before putting any stations or bulkheads in position, as shown below.

Once the sideplates of the keel are in place, the bottomplates can be assembled and placed into the jig for tackwelding to the keel. The prefered sequence here is starting midships working your way aft and forward at the same time.

It is not possible to complete the bottom plates all the way to the bow due to the absence of jigs and webs at this time. Leave the forward part of the bottom plates beyond 1 m forward of the jigs loose from the keel and start placing the watertight bulkheads on either side of the engineroom if you have not already done this.

Place the bottom stringers between and fore and aft of the bulkheads and apply a very small tackweld to the bottom in the centre between the stations, just enough to hold these in position before placing the other stations.

Check that the bottom plates tough the transversal jigs to ensure the correct shape of the bottomplates in these positions. This is very important at this stage as it will determine the dimensions and fairing of the entire hull.

Proceed placing the stations and stabilise the assembly by adding side stringers and deck bearers in the slotted openings to prevent them from flopping about. Assemble the deckplates and superstructure walls and leave the side hullplates until last. This allows you to check the overall dimensions at each step and with the deckplates in position you will have the confirmation of correct alingment and fairness of the hull. Again only tackwelding at this stage.

On some plates it would be great to have marking lines on either side because there are relevant connections on both sides of the plate. Markings can be put on one side only so you have to manually “transfer” any lines to the other side of the plate. Refer to the assembly drawings for further information.

<u>REFER BACK REGULARLY TO THE DRAWINGS AND CHECK INTERMEDIATE AND OVERALL DIMENSIONS, AS WELL AS LONGITUDINAL FAIRING.</u>

The rounded aft corner plates need carefull checking on position and radius before putting in position. You will note the excess length on these and other formed plates which is marked on the drawings and parts as “OVL”. The forming of these plates cannot be done without this excess length and always results in a certain variance so trimming to size is required here to give a perfect fit.

Depending on the model and version of your hull it may be wise to consider placing the engine or tanks inside the construction before closing the deck and or hullplates. Your personal judgement is essential here but always ensure to support heavy objects and spread the load between at least two jig-frames and donot use the hull construction at this stage as it may distort alignment and fairing.

Having completed placing the deckplates and all stringers, the time is right to start assembling the hull sideplates, starting with the upper plates aft. Use a small forklift or tackle attached to an A-frame to lift and put the plates in position and check the markings. Still only tackwelding and only between the hullplate and the station, never use the stringer at this stage.

Continue placing the upper sideplates forward which will require additional force to bring the plate in line with the shape of the hull towards the bow. Use a small chain tackle and some lifting eyes (as included in the kit) to bring the plates into the right shape and continue to check the markings and overall dimensions of the hull very carefully.

Once the upper hullplates have been assembled and tackwelded in position, start assembling the lower sideplates or radiusplates for some designs. Radius plates always have excess length and width which is necessary during the complex forming and give some flexibility in the assembly and positioning, so some trimming to size is required here, but only after checking and re-checking the correct position against the markings and shape of the hull.

Experienced builders will find it easy to determine the final trimming line, others may want to make up dummy moulds for the various connections using different materials before cutting the radius plates to size. Use the moulds (see your parts-checking list) included in your kit which will help you in checking the correct shape and radius.

The prefered assembly sequence for the radius plates is to start with the upper-aft plates, working forward, thereafter the lower plates also starting aftships. Tackweld these radius plates to the adjacent hullplate or station but never use the longitudinal stringers.
Another important detail is to prevent vertical welding seams between the radiusplates to be continuous between two plates. Usually this has been taken into account during the development of the plates but may be relevant due to shifting and trimming.

CONGRATULATIONS, you are now looking at the shapely result of your perseverance.

Of course you have run into some difficulties during the building process and maybe even cursed a couple of times but it must be clear by now why we told you time and time during this manual ONLY TACK-WELDING. Any possible mistake you may have made was fairly easy to rectify as you only had to grind a couple of small welds away.

However careful the cutting of the material was prepared and cut , the material can behave unexpectedly, for example the grain in the plate runs diagonal and will resist shaping into the required form. More effort is than necessary to get the plate to fit.

It must also be said that , of course we can make a mistake also , the general consensus is that if you have to cut or reshape a plate (with the exception of radius plates) somewhere something is not right.

7. FINISHING THE ASSEMBLY.

Now the time has come to finish the welding process. Check the welding details provided in the assembly drawings of your kit.

DO NOT CONTINOUSLY WELD ON ONE SIDE OF THE HULL but change sides at least every 30 minutes. Never underestimate the forces of metal during welding which can destroy the fairness of the hull beyond repair and correction .

Firstly, finish welding all the seams between the frame sections applying a full weld, starting near the bottom working upwards. Then weld the longitudinals forming the engine bearers to the bulkheads and the frames, as well as the bottom plates.

All slotted connections between frames and bottom and side longitudinals are to be welded in full on at least two opposite sides of the connection.

Then apply intermittent welds on all frames and stringers to the hull and superstructure plating using the rule 50 mm. (2”) weld , 100 mm. (4”) clear , 50 mm. (2”) weld. Alternate the weld one side of plate , other side of plate and so on.

Now the outside plating of the hull can be welded. In case you have not made a 60° “V” between the seams of the plates yet, no problem, use an angle grinder and cutting disc and cut a groove in the plate where the seam is. Not as nice as having a “V” made first but the result will be the same. As explained before, alternate welding from side to side and finish the welding process.

The hull under the waterline must be welded inside and out. All other welding can be done one side only.

Grind away surplus welding whereby we advise to pre-grind the welds with a heavy duty grinding disc and finish grinding with one of these softer flexible discs to avoid having to use filler on the weld seams.

Clean the surface and apply a coat of primer and the basics of your pride and joy are ready for finishing.

CHAPTER 23.

SAFETY.

TOP LEFT: *The wearing of life jackets is now the norm! More the staff of marinas, locks and other marine related activities wear life jackets ...Make sure that you and your crew wear life jackets.*

TOP RIGHT: *If you have gas aboard make sure it is stowed in lockers located outside of the accomocation spaces*

MID LEFT: *Always wear appropiate safety gear for the job in hand.*

LEFT: *Where possible solid life rails with intermediate wire or pipe rails are to be preferred; make sure to stay with your boat !*

OVERVIEW

It recently occurred to me that *safety* should be spelled *preparation*. Many (but not all) accidents can be avoided by careful preparation and those that cannot be avoided can be mitigated by forethoughted planning.

There are books that go into these various safety aspects in great detail; my intention here is just to put you in the proper frame of mind where you will accept that you must give safety your most serious consideration. The next step is to decide what gear and equipment is most suitable for your particular cruising needs.

LIGHTNING PROTECTION

This subject is far too complex for me to cover it fully in the space available; however I can offer some general advice and alert you to the dangers of this potential killer. Lightning at any time and especially at sea can be one of the most unnerving experiences you will have when cruising. It is comforting to know that most lightning damage is preventable. If you are in an all-metal boat then you can feel well protected as the boat acts as a Faraday cage; in the event of a lightning strike the metal hull will almost certainly divert the strike around the boat and into the water.

The best way to avoid damage from lightning strikes is to provide a path for the strike so it passes through your boat (or better still, around it) and into the water. If you are unprepared and allow the strike to take its own path then it may destroy your electrical equipment. If your cruising boat was built of fiberglass or timber then you would need to have a bonding arrangement so that the lightning strike is able to take a path to the water while at the same time bypassing your electrical equipment. Bonding is connecting all large metal objects above and below-deck, such as tanks, engines, mast, life rails, pulpits, etc., to a common ground plate. Connectors such as 6 AWG (16 mm^2) cable or 4-inch (100 mm) wide heavy-gauge copper strap will be required to carry the current to the metallic ground plate or strip that is fastened to the hull exterior below the waterline. The ground allows the lightning to dissipate into the water after it reaches the plate via the system of conductors as outlined above.

You can relax with the knowledge that you, your crew, your boat, and equipment are much safer in an electrical storm when your boat is built of metal, especially steel! Bonding is not normally recommended for steel or aluminum boats. For additional information on this subject, seek professional advice from a fully qualified and experienced marine electrician.

Just as metal hulls offer a safety factor when considering lightning protection, carbon fiber hulls represent an additional danger. Carbon fiber is the most noble material on the galvanic series of metals and is a poor conductor. Electrical isolation of carbon fiber hulls is necessary to protect the hull from the effects of a strike. Any laminate containing carbon fiber no matter where it is used in the boat is subject to severe damage from the excessive heat produced from a lightning strike. In trawlers where you may have a sizable mast then you will need to ensure that a path, by way of a conductor cable is provided both inside and outside the spar; this is in addition to the normal path arranged through the cap shroud/chain-plate/ and on to the ground plate. Wooden masts will also need special attention by way of a conductor cable providing a path from the top of the mast directly down to the ground plate.

Lightning dissipaters are devices resembling a metal bottle brush and are mounted on the highest part of the vessel. The short-bristle metal wires extend in all directions and operate on the principle that the numerous wires will dissipate the effects of the strike. These devices have a good track record and should be considered if your present or future cruising area is prone to storms that involve lightning activity. One device, the Lightning Master, is available from Forespar in the United States.

In the event that you are caught in a situation where there is lightning activity then the safest place for you is belowdecks; another good argument for alternative inside steering positions and pilothouses. Keep away from large metal objects and avoid touching metal and other items that may form a path for any strike. Remove any metal about your body including watches, earrings, metal-framed eyeglasses, and chain jewelery. If you think this advice is overkill then note that I know of one case where a boater wearing a gold neck chain was struck by lightning in the throat and killed.

FIRE

An uncontrollable fire is one of the most devastating things that can happen on any boat. Once a fire really gets hold, there is very little you can do except abandon ship. You must avoid this situation in the first place as well as make sure you are prepared to extinguish any fire before it gets out of control. If all that sounds elementary then consider the following. Do you always introduce each new crew member (even those out for a day trip) to all of the safety aspects of your boat? Do you personally show all crew how to operate the safety devices including the fire extinguishers? You may feel that you are overdoing the "captain in command" routine by having safety drills before you set out on a short or long cruise but do not allow such feelings to get in the way; your thoroughness may save someone's life, perhaps your own.

As the regulations change and vary from one country to another I will not try and list the numbers and types of extinguishers required for all types and sizes of cruising powerboats. Check your local regulations as well as those of your insurer. But here are a few guidelines. You will need at least one fire extinguisher for each compartment of the boat. In the average-size cruiser this means a minimum of four units. Make sure these are in current service, check and log the expiration dates so that you either have them examined by the appropriate authority or refilled and/or replaced as necessary. Unfortunately it is not possible to test these units but do read and make sure you understand the instructions. Pass all this information to all members of your current crew.

The two most obvious places for a fire to start are in the galley and in the engine compartment. Give these areas your special attention. Never leave a galley stove unattended; this is easier said than done but make it a *strict rule* on your boat. Insist that rubbish and highly inflammable items are not allowed to accumulate in these areas and never store highly inflammable liquids in the galley area. Keep your engine compartment spotlessly clean. Regularly remove any buildup of spilled fuel or oil as well as any grease splatters in the galley. Do not leave oily rags *anywhere*, and dispose of all items used as wipes, immediately after use. *A fire blanket is an essential item for every galley;* make sure you have one and that it is stowed near the stove and in a location where it is visible. After you are totally satisfied that the galley and engine space are as safe as possible, then check the rest of your boat for other areas that may present fire hazards.

Recently I saw a survey that proved that more fires on boats were caused by electrical faults than by any other means. In many cases shore power attachments, badly engineered and installed 120-volt or 240-volt systems contributed to these fires. Keep this in mind when selecting and installing electrical equipment and be scrupulous in your maintenance practices.

Automatic engine room extinguishers should be considered in larger craft or in those that venture offshore. You may find that your insurance premiums will be lowered by the inclusion of this safety device. These systems can be powered by either Halon or carbon dioxide (CO_2). Halon is the choice of most owners as it has the advantages of being more effective, will not corrode electrical or electronic equipment and will not asphyxiate you if you are caught in the engine compartment when it activates. The sensors are normally secured to a permanent bulkhead and alarm should sound at the steering station when the system is activated. As Halon can act as a supercharging element to your engines, you should consider having an automatic engine(s) cutout built into the system. As this feature may adversely affect your ability to run your boat for the shore or have other ramifications, you should carefully consider all aspects when having one of these systems installed in your cruising powerboat.

FLOODING

Equally as devastating as fire on your boat is uncontrollable inflooding of water. This hazard can enter your boat from several sources. Accidental holing of the hull, damaged inlet pipes, and swamping are the most common causes of this problem. One interesting case involved a boat off the coast of Queensland, Australia. The boat had black antifouling paint and was attacked and damaged by a whale. There is some speculation that the whale thought the boat was actually a potential mate! Fortunately a metal boat, especially steel-hulled boats, have proven safer in this regard than a vessel built of any other material. There are many recorded incidents where a collision with an underwater object simply scratched a steel hull where similar incidents have badly damaged fiberglass or wooden vessels.

Now examine the boat and make a list of the vulnerable points. Hopefully your hull is strong enough to withstand a grounding, limited contact with rocks or a reef, or unavoidable contact with whales and other marine mammals. The possibility of being sunk by a whale is no joke. There are many well-documented cases where whales have actually attacked cruising boats, so if possible change course and stay out of their way. Through-hulls, seacocks, rudder tubes, rudder bearings, and propeller shaft tube and bearings are all potential hazards and need regular checking and maintenance. Make sure the rudder tubes are at least 6 to 9 inches (150 to 250 mm) above the waterline. Allow a bit extra if yours is a custom-built boat, and remember at the start of any long cruise that she may float lower than intended!

Through-Hulls and Seacocks

Make a careful assessment of your hull inlet fittings, standpipes, underwater exhaust fittings, valves, and hoses. Make sure every member of the crew is familiar with the locations of all these fittings. Renew any suspect items, double-clamp all hoses, and check all seacocks; these should be turned off and on every month or so to make sure they do not freeze in one position. Pay particular attention to any plastic through-hull fittings. The flanges can be destroyed by sunlight; use a scratch test to make sure the plastic has not deteriorated to the point of failure.

Check if it is possible to reinforce areas where pipes enter and/or leave the hull. In steel hulls, you may consider welding a reinforcing piece in place, using plate that is cut from plate around 150 percent of the thickness of the hull plating. Any thickening of any hull as suggested above or for any reason should have the edges of the thicker portion chamfered to avoid creating a localized stress point.

You should have a bag of shaped, round timber plugs handy; you may need these to block off any inlet holes that have to be plugged in a hurry. Make sure you and the crew know the location of this collection of plugs; better still, have one suitably sized plug tied to each seacock so it is quickly available in the unlikely event of it being needed. A collection of scrap timber, plywood, nails, and glue could come in handy for making urgent repairs. You don't an excessive amount, but a small selection of these items is recommended.

Float Bags and Foam Flotation

Float bags are an option that I have always believed were a good idea but one that most of us would not consider because of the additional expense and some minor loss of stowage space. In their deflated form these bags, together with their individual compressed air bottles, take up very little room and can be stowed in convenient areas of your boat's interior. In the event of an irreparable flooding situation, the crew simply inflates the bags, which more or less fill the particular section of the interior of the boat and thus keep it afloat. The extra time gained can be used to make repairs or keep the boat afloat until help can be summoned. As mentioned elsewhere it is sometimes difficult to obtain comprehensive insurance for long-distance cruising boats, and this makes airbag flotation devices worth your consideration. There are a few boats that have been designed and subsequently built with sufficient foam flotation permanently installed so that in the event of flooding the boat will still remain upright and afloat. Most of these arrangements only allowed for enough flotation so the deck and superstructure were just above the water; just a little better than a life-raft situation. The problem with foam flotation is that it takes up considerably more room than the deflated air bag. In most cruising boats stowage space is at a premium, so consequently permanently installed foam flotation has not been exploited as a safety feature.

OTHER SAFETY EQUIPMENT

Radar Reflector

For your own safety you must have one of these devices aboard; in many countries they are mandatory. There are several types, including the traditional, metal, diamond-shaped version that can be stored flat and then assembled when you go to sea. Remember that this type must be hung in the rain-catching position and not by the top of the diamond. Metal-hulled boats have an advantage here; they present a better image on a ship's radar screen.

Life Jackets

In the United States, life jackets are categorized by the U.S. Coast Guard as Type I to Type IV. Type I (offshore life jacket) is recommended for use when help may be delayed. It has at least 22 pounds (9.99 kg) of flotation and turns an unconscious wearer faceup. They are bulky, and it is difficult to swim while wearing this model. Type II (inshore life jacket) is recommended when there is a chance of a quick rescue. It has at least 15.5 pounds (7.03 kg) flotation, and some models turn an unconscious person faceup. Types III and IV have less buoyancy and I would not recommend these for use on cruising powerboats.

Australia, New Zealand, and many other countries have their own rules for the manufacture and use of marine safety devices including life jackets. When arriving in those countries in a foreign yacht, you could not reasonably be expected to have life jackets that necessarily meet the local standards. You should ensure that these items meet the requirements of the country where your boat is registered and/or from where you start your cruise. New Zealand may be an exception to the above; in this country they have been recently insisting on inspecting your boat before you continue your cruise, so if New Zealand is on your list of expected ports of call you should check with their embassy regarding the current situation.

At some stage (hopefully before you ever leave port) you will need to take inventory of or purchase life jackets for all of the crew. Do not be impressed by the words *life jacket* that may be printed on the garment. Many items sold as life jackets are really only flotation devices; these may be totally unsuitable for use in a serious emergency.

When you buy a life jacket the most important factor is the buoyancy rating. Assuming the jackets you are considering are all brightly colored and are equipped with whistle, reflective tape, and a light, then the one with the highest buoyancy rating is the right jacket to buy.

In the EU since July 1995 manufactures have sold only life jackets and buoyancy aids that have been tested to the new European specifications and carry the CE mark. Look for this label; it will clearly show how much buoyancy the approved garment contains. There's no legal requirement for yachtsmen to replace serviceable life jackets that they already own.

EPIRB

An EPIRB (emergency position-indicating radio beacon) works in much the same way as the emergency locator transmitters (ELTs) that have been standard equipment aboard aircraft for many years. When activated the EPIRB sends out a signal on a VHF channel that is monitored by shipping and aircraft, and many sailors have been rescued due to their plight being registered by a ship, aircraft, or shore station. Unfortunately these regular EPIRB signals are in a crowded area and not always monitored, so for safety's sake you should seriously consider the COMPAS/SARSAT, which are mandatory in some countries.

COMPAS/SARSAT devices are newer versions of EPIRBs and operate on 406 MHz. They are designed to take advantage of the latest satellite technology and are more accurate than the regular EPIRBs. These new systems are expensive but as with all electronic devices the prices should soon start to come down to an affordable level.

Life Rafts

A life raft is an essential piece of gear for any cruising boat. When it comes to choosing this important piece of equipment, there are several different approaches you can take. You may decide that by obtaining a Tinker inflatable lifeboat you will get the best of all worlds—a reliable rowing and sailing dinghy plus a lifeboat all in one package. The Tinker is made in the UK, is obtainable worldwide, and has become a popular alternative to a traditional life raft. The Tinker inflatable dinghy can be outfitted with sails and makes an excellent dinghy that can be used for ferrying stores, yourself, and your crew to and from shore. You may have to remember to restock it as a lifeboat after it has been used in a more utilitarian manner.

Traditional life rafts come packed in one of three basic cases. The suitcase (valise) is the lighter alternative and needs to be packed in a waterproof locker; if not kept dry, then salt water will soon attack your flares, flashlight (torch), and inflation gas cylinder. This type of packaging is usually favored by the racing set. A vacuum-packed case has been developed to prevent saltwater incursion; a unit packed in this way usually only needs servicing every 3 years.

The third and most often seen option is the canister-packed life raft, which graces the coach house tops and transoms of many cruising boats. Because of the cost of the canister itself, these units are generally more expensive than the suitcase-packed life rafts. These units are designed to be exposed to the elements and so do not take up valuable locker space. You will need to check where the drain holes are located in your unit as some can be stowed vertically while others will need special packing to allow them to be mounted in that manner. One of the drawbacks of the canister-packed life raft is that its exposed position on deck increases its vulnerability to theft.

There are different types of life rafts, each designed for a different purpose; not only are the rafts different but the emergency equipment and contents vary depending on the intended use for the raft.

The basic inshore or coastal raft is usually built to for cost-conscious buyers, and there are many models available at this lower end of the market. These units usually only have a single buoyancy chamber and often do not have an inflatable support for the canopy. In my opinion these so called life rafts are only one step up from a regular inflatable dinghy.

You will need to add the emergency pack (referred to as the E-pack) of equipment and emergency provisions. Your life raft should contain paddles, handheld red flares, parachute rocket flares, signaling mirror, fishing kit, water, food, first-aid kit and a bailer.

If you want a well-equipped raft then you should consider adding the following items (before the raft is packed): multipurpose knife, sea anchor and spare, raft repair kit, antiseasickness pills, signal card, scissors, graduated cup, radar reflector, and most importantly a reverse-osmosis desalinator. This latter item will produce about a cup of fresh water from seawater by pumping in about 15 minutes. An alternative is to have these additional items form part of your grab bag. There are many other things you may want to have with you when you are out in the middle of an ocean in your life raft but remember you have to fit yourselves in without overloading the raft.

Grab Bag

Your grab bag will contain your valuable, small possessions such as passports, credit cards, ship's papers, extra water and food, plus other items that you feel will be essential in the event you have to abandon ship in a hurry. Remember to include appropriate quantities of any prescription medicines required by yourself and your crew, including children. Taking the grab bag may not involve transferring to the life raft but rather being transferred to another vessel or helicopter; keep this in mind when preparing your bag.

Medical Problems

Residents of the United States, Australia, and many other countries who intend to cruise in water outside their own county will find it worthwhile to investigate the availability of suitable medical insurance to cover serious emergencies. If you already belong to a medical plan you will most likely find that the coverage does not extend to areas other than your country of residence.

Non-EU residents can sometimes obtain free care under the National Health Service when in the UK especially if they are sponsored by a UK resident. If you are cruising in Europe and you have a medical problem. if possible have it happen in France! This country has the best health and emergency medical system I have ever seen; the French look after the sick and injured in a prompt and efficient manner. If you normally reside outside Europe you will have to pay for the service, but the quality and efficiency make this almost a pleasure!

For Europeans, if you require medical attention in neighboring countries, you need to make provision for this in advance. European residents cruising in EU waters should have an E111 certificate for each member of the crew; this will ensure that they are entitled to medical care in any EU member state. Those venturing outside the EU or not wanting to rely on the facilities of member states, should consider expatriate medical and health insurance such as provided by BUPA and similar organizations. Be warned that medical insurance rates for the United States and Canada are usually twice the cost of the same coverage for the rest of the world. You may be able to obtain short-term holiday insurance coverage for the period that you are in North American waters.

Medical Kits

There are no medical emergency or casualty departments in midocean. Even when conveniently close to shore you will find that the facilities that are taken for granted at home are often not available in areas where you may be cruising. The time to plan the medical care of yourself and your crew is before you leave your home port.

You will need to carry a medical kit; hopefully you will not need the type of package that was reported in the UK boating magazine *Yachting World*. Lynne Oakerbee wrote that when the Department of Transport's Code of Practice for small commercial vessels was applied to the letter (remember that word) the following is a small example of what was required to be included in the yacht's medical kit: a body bag (large); 1,000 aspirins (one adviser suggested that they would need six body bags if they took all of those aspirins on their short cruise to the Mediterranean); and listed as an "optional extra" were 72 condoms (quite a large number for a crew of six during the two-week delivery voyage). The Yacht Charter Association suggested that they would need to tow another boat behind to carry all the medical supplies and equipment specified by the Code. After considerable time talking to officialdom, a revised list was supplied (still including the body bag) but thankfully this list was only nine pages long.

If you plan to undertake coastal or even canal cruising, you still may find yourself in a location where you have to depend on your own resources to deal with a medical emergency that may involve yourself or your crew. At least one member of your crew should therefore undertake an advanced course on first aid. One source or such training is the St. John's Ambulance Brigade, which is a worldwide organization that has extensive experience training people to deal with medical emergencies.

Many of the first-aid kits advertised in mail-order catalogs or available in department stores contain a minimum variety of dressings and plasters and not much else. Do not be fooled by the Red Cross insignia; this is no guarantee that the first-aid kit will meet your needs. You will need a much more comprehensive medical kit for first-aid purposes.

Fortunately there are specialized companies who produce kits for boats. Check with your local chandlery or ship's store and your pharmacy regarding the availability of the latest medical kits. When selecting your kit you should consider your special requirements: Where will you cruise? What type of protection will you need from the local insects, etc.? How many crew are you likely to have aboard at any one time, and what are the medical conditions that may require special attention? The foregoing is in addition to planning for the normal run of cuts, scratches, and burns that are all too easy to acquire on a moving boat.

The Royal Yachting Association's cruising guide, *Yacht Safety Sail and Power*, points out that unless a patient is bleeding profusely, unconscious, or not breathing, then they will usually survive an accident even if you do nothing. Not withstanding these comments, I believe that for your peace of mind and to inspire confidence as well as to relieve pain it is wise to be prepared.

As a minimum your medical kit should contain items to treat the following: severe pain, coughs, seasickness, wounds including infected wounds, burns including scalds and sunburn, allergic responses to insect bites and stings, diarrhea, constipation, hangovers, splinters, athlete's foot, and conjunctivitis.

There are several books and publications available advising on the treatment of accidents and illnesses when professional help is unavailable. At least one (or preferably more) of these books should be purchased and thoroughly read before the medical emergency arises. Use your favorite Internet search engine to check for the latest titles and their content.

If you prefer to make up your own medical kit (you may have to do this in any case due to your special requirements), rather than purchase a ready-packed version, most of the essential items can be obtained from any pharmacy without prescription. Add your special needs to this list and make sure that all are packed in a moisture-proof container, easily identifiable, and readily accessible when required in a hurry. Whenever possible keep your medical kit up to date, and keep track of the expiration dates of any medications, especially those to be taken internally.

Safety Lines

If you venture far offshore, even in moderate weather you will find lifelines a necessity. There will come a day—or worse, a night—when you or one of your crew has to venture out on deck to secure some rogue piece of equipment that is about to destroy itself or damage the boat. Safety harnesses and jack lines should be rigged to the decks and superstructure so the crew can clip on when moving around the boat. Make sure these lines have secure anchoring points and are arranged so they do not form a hazard such as tripping up an unwary crew. Make sure you and all the crew are familiar with the hook-on arrangements. Use only tested devices; there have been many well-publicized instances where the snapshackle or other clip-on arrangements have failed under load. Be warned and only purchase the best-quality items in this area.

Man Overboard and Personal Recovery Devices

It is imperative that you practice your man overboard drill as soon as you can after you have acquired your boat. Check that you have life rings and other recovery devices in place and that you know how to use them.

You should consider purchasing one of the special slings that are available for recovering a person in the water. As it is often very difficult to help or pull a rescued person back on board (even if you do get a line to them), you should have a ready-made device similar to a sling made from sail cloth or netting that can be slipped under a person and used to hoist him or her back on board. Practice the recovery procedure with this item after taking precautions such as having your "victim" wearing a life jacket. Make sure that the dinghy is launched and then only allow this practice to take place in temperate water. At all times stow your recovery sling where it can be quickly brought into service and most importantly, advice all the crew of its location.

Emergency Steering

As well as carefully checking your steering arrangements you must have some form of emergency steering that has already been tested before you go far offshore. The emergency tiller is the simplest and best method of arranging alternative steering in the event that your regular steering equipment fails. The simplest tiller arrangement is to have the top end of the rudder shaft squared off to take a tiller with a matching squared-off fitting to quickly slip over the shaft. The tiller may have a pipe extension and a hatch above the rudder shaft location (to allow you to see out) or a deck fitting to allow the passage of the tiller extension will be required.

YOUR RESPONSIBILITIES

As the owner and/or skipper of your cruising sail or powerboat you are responsible for the safety and well-being of yourself and your crew. Assuming that you are familiar with all the safety devices and equipment aboard your boat the next step is to make sure you pass on this knowledge to every person who is aboard your boat before it leaves the dock. It would be a good idea to make several copies of a checklist containing brief operating instructions and most importantly location of the items involved. Use this checklist when showing new crew members over your boat. On completion of the inspection and familiarization tour, give the sheet to the person concerned so they can refer to it as required.

CHAPTER 24.

GROUND TACKLE AND WARPS

Types of anchors. Selecting chain and line. Anchor winches. Snubbing devices. Mooring bits or cleats. The bitter end. Dock lines and warps. Fenders. Anchor lockers. Hawse pipes. Recommended anchor weights and chain sizes.

The owners of most cruising boats will be unable to afford or unwilling to pay the high insurance premiums required when long distance cruising is planned. Most *long distance* cruising people find that the yearly cost of insurance premiums would keep them in cruising funds for the same period. If you are presently cruising locally, then your boat will most likely be covered by a comprehensive insurance policy. Unfortunately you are in for a severe shock when you start to enquire about purchasing cover for your boat which includes a long distance cruise. Armed with the knowledge that very few cruising boats are lost at sea and those that come to grief are mostly lost when at anchor; you should pay serious attention to the entire subject of anchoring and associated gear. Even if you can afford to fully insure your boat (and yourself and crew) you will still desire the feeling of security afforded by adequate anchor(s), chain and line all collectively known as *the ground tackle*. Do not underestimate the seriousness of this subject; it is all too easy to be complacent when sitting in a marina or lying in a snug anchorage.

Apart from the times where you are forced to anchor off a lee shore in a open harbour, a howling gale and a strong contrary tide; there will be other times when you are ashore and you can not even get back to your boat to improve the situation. If you vessel can not be left on it's own in all but the most threatening and inclement weather, then you will never feel free to accept many invitations ashore and you will miss out on may of the most enjoyable aspects of the cruising lifestyle. So let us consider just what equipment you will need to be able to safely anchor your boat in the conditions you are likely to encounter once you venture offshore.

Your anchor has to be good. As experienced cruising adventurer Alan Lucas put it *'When you drop anchor you must be able to say, I have arrived and not, I am here as long as the anchor holds.*

HOW MANY ANCHORS
Two bower anchors, one main and one spare, both

can be of the plough type or you may choose one plough and one ‘Bruce’; if your boat is over 40 ft (12.19m) then you may wish to add a heavy admiralty or fisherman type. You will also need a dinghy anchor, a coral pick and a grapnel for retrieving fouled chain and line.

ADMIRALTY PATTERN

This is the style of anchor that comes to mind to non boating people when the word anchor is used. This type has fallen out of favour with the cruising fraternity; it does have some desirable features but many see it as old fashioned and select their ground tackle without giving this type a thought. This anchor will hold in almost any bottom but it does have some drawbacks. The fact that one fluke projects above the ground makes it subject to fouling when the vessel swings due to a change in wind or tide. As a stern anchor, the admiralty pattern has a lot of merit and under these conditions the head of the vessel will be secured by your main anchor. In conditions where lack of space or other factors make it desirable to moor the vessel fore and aft, then you may find the admiralty pattern anchor very much to your liking. As this anchor needs to be collapsed for convenient stowing, it will have to be ‘made up’ before it can be reset.

CQR OR THE PLOUGH TYPE

These are the anchors that were until recently the most commonly seen devices gracing the bows of many cruising boats. Several new and redesigned types have in part usurped the CQR as the most popular cruising anchor. If you have limited knowledge in this field than you could choose this pattern for you main anchor, safe in the knowledge that it has been a well proven friend to thousands of cruising yachtsmen in the past.

This anchor is easy to stow either on a specially short bowsprit/anchor roller or on deck. It even stows readily into a reasonably sized anchor or chain locker. If you could only carry one anchor then the CQR or plough type would be the one to choose. (Make no mistake, *never* carry only one anchor; even the smallest cruising boat will need a back up anchor and accompanying chain and or line.) Faults in this type of anchor are rare, however very occasionally a weakness will show up by way of a crack in the casting where the shank meets the bow; make sure you inspect this area on a regular basis. To summarise the attributes of the CQR, it holds well in mud and sand, needs care when setting it in weed, and should be seriously considered when selecting your number one anchor.

DANFORTH AND DANFORTH TYPES

Danforth type anchors are a good choice for your number two anchoring system; they hold well in mud or sand. These Danforth types have only one main weakness and that is in the size and strength of the shank. I have seen several which sported very distorted shanks while the rest of the anchor remained intact. It is possible to obtain this type made entirely of high tensile or stainless steel.

This anchor stows flat but does have a number of corners to catch lines at awkward moments; it you stow your Danforth type anchor on deck, make sure it is secured in proper chocks and is out of the way where it is unlikely to catch sheets etc. Most cruising people agree that they would choose the Danforth type as their second anchor.

BRUCE ANCHOR

This type is a more recent development and has gained a lot of admirers at the expense of both the CQR and the Danforth patterns. The ‘Bruce’ has similar characteristics to the CQR type however it is a one piece unit and offers some benefits in that regard. The Bruce sits well on any well designed bow roller arrangement and should be considered for either your number one or two anchor.

CORAL ANCHOR
The Coral pick as it is affectionately known, is an anchor that as it's name suggests, has been developed for anchoring in coral. With more attention being paid to conservation matters, however it may be an offence to either deliberately anchor in or use this type of pick in any coral outcrop. The idea behind this type, is that it will hold in the coral by the individual tangs. The tangs will bend straight and release when you move over the anchor.

MUSHROOM ANCHOR
This is used for those occasions where you intend to stay for a long period and where no satisfactory permanent moorings are otherwise available. The anchor would be most likely made up on location and not carried on board. You may not trust the local moorings and as it is usually impossible to inspect them thoroughly even by diving, you may decide to create your own. If you do decide to lay your own mooring then make sure you have adequate *very* heavy chain laid out from the mushroom anchor especially if you intend to turn this mooring into an all weather haven. You must use a suitably sized swivel between the end of the heavy chain and your regular mooring chain.

ANCHOR WEIGHTS
For your main anchors (non-specialised types) you can budget for units that weigh one pound for each foot of you boat's overall length [1.5 kg per meter of boat length]. If you are planning extensive stays in foreign parts where you may have to rely exclusively on your ground tackle, then you should carry at least one anchor that is double the 1 lb to 1 ft (or 2 lb per 1 ft of boat) guideline. More accurate weight guidelines can be recommended by the manufactures of the various types of anchors. Excellent performance figures have been published in recent years

ABOVE: *Twin anchor winches are a nice touch as is shown on the Roberts 532.*

of the extensive testing undertaken for and by the various boating magazines. As well as the anchors already mentioned, you may require a selection of specialised types, depending on where you intend to cruise.

ANCHOR CABLES

The serious offshore cruiser may carry the following inventory; main anchor 300 ft (90 m) short link tested chain, matched to your winch gypsy and marked at regular intervals so you can judge the amount you have laid. Two 50 ft (15 m) lengths of the same chain to act as leaders for the anchors fitted with rope line or cable. Three by 300 ft (90 m) heavy nylon line for use with second bow or stern anchors. You may want to consider having these lines on spools to facilitate handling and stowage. For the coastal cruiser or one that is too small to reasonably carry the inventory as suggested above, then you can modify this list to suit your requirements.

Chain is not necessarily the strongest anchor cable available but it is the most widely used and for many good reasons. Chain is very resistant to chafe where it lies over rocks and whatever else is lurking on the bottom ready to cut, chafe or otherwise separate your boat from your well set anchor. If you are intending to cruise far from home then it is recommended you carry at least one set of all chain ground tackle. Make sure you select adequate size chain, (see suggested sizes), inspect it regularly and replace it when it shows any sign of wear. All shackles should be secured using soft stainless wire. As with anchors do not stint on the cost of this item.

Rope line can be used in combination with chain to make up your second set of ground tackle. As mentioned earlier two sets of all chain make for the best security, however if weight is a problem or if you carry a third anchor, then a rope/chain combination is acceptable. The chain should be about twenty five percent of the total length of the total. Again pay particular attention to the arrangement of shackles, splices and other joining arrangements.

Recently woven nylon reel mounted lines have come on the market; the idea is to mount one of these arrangements in or near the cockpit or stern. These and other similar arrangements can be acceptable only in addition to your two main fore and aft anchoring arrangements as discussed earlier.

THE BITTER END

Unless you are student of nautical terms or an experienced sailor you have probably heard this term and wondered what it meant. The bitter end is the inboard end of the anchor chain which should be attached to a eye in the anchor locker or to another appropriate location. The safest way to attach the bitter end to the strong point is to lash it on with several turns of strong line; the lashing should be of sufficient strength to take the strain in the event you accidentally let all of the chain run out of the locker. The reason for lashing and not bolting or using a shackle is so in an emergency you can ‘slip’ the chain by cutting the lashing. As a general guide, when choosing anchor chain you may use the following sizes as a guide only.

Boats LOA to 25 ft [7.62 M]	1/4 in [6 mm]
Boats 25 ft to 30 ft [9.14 M]	5/16 in [8 mm]
Boats 30 ft to 40 ft [12.19 M]	3/8 in [10 mm]
Boats 40 ft to 50 ft [15.24 M]	1/2 in [12 mm]
Boats 50 ft to 60 ft [18.29 M]	5/8 in [15 mm]

These sizes can only be a guide for preliminary estimation of weights and similar calculations. The exact chain sizes will depend on you intended cruising grounds and the conditions you are likely to encounter.

MOORING LINES

You will need a variety of mooring lines and warps. At least two of these lines should be two and one half times the length of your boat, add another four lines that are one and a half times you boats length and finally two that are about the same as your boat’s LOD. There are several types of synthetic line available and each has its advantages and drawbacks. For myself I prefer plaited lines similar to the ones used for sheets.

OTHER ANCHORING HARDWARE

Here are a few items that you will require to assist in safely anchoring your boat; an anchor light, electric with a hurricane lamp as a back-up, and a good spot light for picking out hazards in the dark. Make sure you carry a pair of polarised sun glasses; you will need these to see the bottom in strong sunlight and they are great for picking out coral heads and other underwater obstructions. Tested galvanised shackles for each anchor plus spares. One coil of soft sizing wire. One large shackle for running weight of trip line down main chain cable. Two heavy duty swivels, two heavy duty hooks one shackled to 1/2" [12 mm] rubber snubber. A suitable buoy for marking the location of your anchor. Don’t forget a bucket and brushes for scrubbing down the chain and anchor as it comes aboard. Anti chafe gear: A selection of anti chafe gear will get plenty of use and should include, split heavy plastic pipe that will fit over chains, spare rags and cord to secure anti-chafe material in place. There are many other items that are associated with anchoring such as depth sounder, dinghy for laying kedge anchors etc., however these items are covered in some detail elsewhere.

Choosing a place to anchor is one of the most important decisions you will have to make each time you reach a new port. You may be tired, relieved to have reached this destination and tempted to drop the hook at the first likely spot. Not a good idea, you must seek out a safe spot that has reasonable access to the shore. You will most likely find the best spots are already occupied by the locals!

When selecting a location to anchor you should consider the following: Availability of facilities such as dinghy landing as well as negative factors such as the proximity of shipping movements and obvious dangers such as wrecks and reefs. You should consider the direction of likely adverse weather, and exposure to wave action, length of fetch, the depth of water and the tidal range. You will need swinging room to avoid the shallows, other craft, fairways and wrecks.

Before you set your anchor in the spot that you hope will be your location until you are ready to move, you must ascertain the type of bottom. Your choice may lie between mud, sand, broken coral or less desirable heavy weed, general debris or old moorings.

ANCHOR WINCH

Now that you are equipped with the correct number and types of anchors you will need to turn your attention to the methods used to lower and more importantly raise the entire set of ground tackle. In my early days of sailing, the boats I owned were not equipped with anchor winches; these were considered devices required by old men! Now that I am an *older* and hopefully a wiser man, I pay a lot of attention to selecting the correct anchor winch and associated equipment. My current attitudes make anchor handling, if not a pleasure, at least not too onerous a chore.

Hand operated anchor winches come in a wide variety of types and sizes and it is impossible to list the most suitable type for every type of ground tackle. If you select a well known brand that has been proven over a number of years and seek the manufacturers advice you will be well on the way to making the right choice. The two speed variety offer obvious advantages.

If your boat is over 40 ft (12.19 m) or if your crew is not physically strong or your pocket is deep enough, then either an electric or hydraulic anchor winch is worth the investment. In any case make sure that the winch can be operated both mechanically as well as in its powered mode.

When setting up your anchor winch make sure the chain and gypsy are perfectly matched otherwise you will be forever clearing jams and your gypsy will be subjected to undue wear. Vetus Den Ouden and other winch manufacturers offer matching winch/chain combination and these are worth your consideration.

Anchor handling should be as easy as possible. The leads between the winch and the anchor roller must be arranged so that there is the minimum of friction caused by any unfair leading of the chain. The bow rollers should be as large as practical and arranged so the chain can not jump out when you are winding it in, or as it runs out. If you do not have an anchor bowsprit (recommended) then make sure the anchor rollers project as far forward as possible, this will avoid damage to your topsides.

ANCHOR CLEATS

It is most important to have an adequate anchor cleat, sampson post or other arrangement for securing the anchor chain. Simply letting the winch take the strain is not good enough. Make sure you have a method of securing the chain so it will not accidentally run out when put under extreme stress in the event something goes amiss with your winch. In the event that you vessel needs to be towed, then you will need to have a very strong cleat or other arrangement for securing the tow line.

BUOYING THE ANCHOR

Buoying your anchor is recommended when you drop the hook on a dubious bottom. If you feel there may be debris, other anchor chain or when anchoring in coral it is recommended that you buoy the anchor. Use a trip line so you can come up onto and over the anchor and then trip it using the buoyed line. This may also have another use if you have to slip your anchor in an emergency; you may be able to return and recover your anchor at a later date. It is a good idea to mark your buoy ‘Anchor buoy only - do not touch’, hopefully this will stop someone else from using your buoyed anchor arrangement as a mooring when you are asleep, or temporarily away from your vessel.

CHAIN STOWAGE

Chain should be stowed as low as possible. As a designer I am aware of the problems of getting the chain low versus not allowing the chain locker to intrude too far into the accommodation. Perhaps it would be a good idea if the US Coastguard rule that there must be a watertight bulkhead five percent aft of the forward end of the DWL, was a requirement for all cruising boats; this would make for an adequate chain locker. I favour an arrangement where the chain locker is divided by a fore and aft bulkhead, this could be an extra strength factor

while allowing you to stow two complete sets of ground tackle without them becoming entangled as has happened to most of us on more than one occasion.
A deck mounted chain pipe is a good arrangement since it funnels the chain down to where you want it and allows the opening to be closed off making an almost watertight arrangement. On *K*I*S*S* there are twin chain pipes each with a screw down plastic cover that ensures absolute watertightness.

If the distance from the deck opening to where the chain enters its stowage area is an appreciable distance then a sloped pipe will be required to guide the chain to its stowage destination. The pipe should be set at an angle and for quietness of operation, a strong plastic pipe is recommended.

MOORING BITTS

On my own boat I prefer mooring bitts to cleats. Cleats are fine for sail handling and control but when you have the weight of the entire boat plus a surging action wanting to separate the line from your boat, then a well built set of bitts is preferred. Six of these fittings should suffice on boats up to 55 ft (16.76 m), one pair up near the bow, one pair amidships and another near the stern. These bitts make the best termination for your mooring lines and will provide a perfect arrangement should you decide to take your sailboat through some of the canals and waterways of Europe, the USA and elsewhere.

ANCHOR LOCKER

The anchor locker is usually below decks so it has to be considered along with the accommodation layout. You will want to decide if you want the self draining variety, that is one where the drains are at the bottom of the locker and where the locker is sealed off from the rest of the boat. Water can drain out; it can also flush in through the drain holes. I prefer a locker that drains via a pipe down to the bilge to the area where the bilge pump is located.

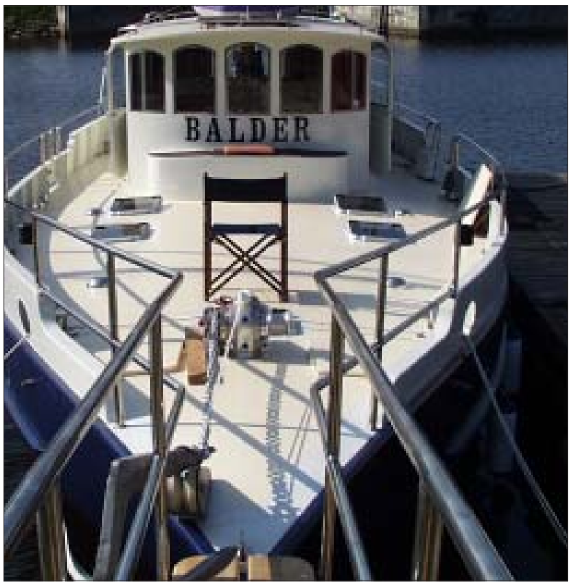
Many cruising boats carry two anchors in the forward anchor locker however very few are divided so that the rope anchor line and or chains do not become mixed between the two anchors. Generally the main anchor, plough or 'Bruce' (no relation) style is kept stowed on bow rollers or small bowsprit and ready for use. The secondary anchor, usually a 'Danforth type' is stowed in the locker along with its rope and/or chain. Some anchor lockers are arranged so that the chain runs through a tube down towards the centre of the boat thus putting the weight where it can contribute to the stability of the vessel. If you decide to arrange your anchor chain in this manner, make sure that you can gain access to assist the chain to stow neatly and also ensure that it can not get loose in the event of a knockdown. In the case of a third anchor, you may want to consider carrying this at or near the stern where it can be useful in situations where you wish to anchor fore and aft.

FENDERS

If you are to protect your boat from external damage when you are in harbour or moving through any of the worlds canals, then you will need a good supply of fenders. The most sensible type are home made from small car tyres that are covered with a fabric to keep the black off your topsides. If you prefer the bought variety then choose a dark colour. In any case you will need at least five per side and if you are very protective towards your topsides you could consider a 'horse blanket' type of cover that is slung between your topsides and the fenders. Fender socks look great on boats that are seldom used but they soon become tatty with everyday use.

BOARDING PLANK

While a boarding plank has nothing to do with anchoring it can be used as an ultimate fender. When lying along side a wall where there are intermittent posts normal fenders will not do the job. The plank, usually a builders scaffold plank is a good start, and is fitted with a hole each end so it can take a line and be slung outside the fenders to keep your topsides away from damage.



ABOVE and BELOW: *The fold down section of the transom combined with a boarding plank makes a nice arrangement especially if you are cruising in Europe where stern to moooring is commmonplace.*

abaft—Behind or toward the rear.

abeam—A point beside the boat; usually refers to a point relative to the boat such as "abeam of midships" or abeam of the bow, close abeam, etc.

ABL, or above the baseline—Usually given as a measurement, for example: Stem is 6 feet 6 inches (1.98 m) above the baseline.

AB ratio—Area of side view of vessel above and below the water. In most vessels except submarines, the amount above the water will be greater. A number between 2 and 3 is desirable.

AC electrode—Welding rod.

AH (amp-hour) capacity—The ability of a fully charged battery to deliver a specified amount of electricity at a given rate for a definite period of time. This number may give a false impression because you cannot use all the AH or you will flatten the battery, and the AH capacity of any battery will vary with age and condition.

alternating current (AC)—Household and shore electrical power of 220 or 240 volts in Europe, Australia, etc.; or 120 volts in North America. It's also the type of power usually supplied by your generating set. Some generating sets can supply 12-volt DC power. See *direct current*.

ampere, amp, or A—Unit of measure of flow rate of current through a circuit.

ampere-hour, amp-hour, or AH—A unit of measure of the battery's electrical storage capacity, obtained by multiplying the current in amperes by the time in hours of the discharge.

angle—A term used to describe L-shaped bar.

arc radius—The radius used to draw an arc of a circle, quoted when discussing radius-chine construction.

athwartships—Across the boat. For example: The webs are mostly athwartships, when located in the keel.

backbone—Another name for the centerline bar that runs most of the length of a hull and could include the stem and the aft centerline bar.

back-chipping—The techniques used to remove unwanted weld metal. Usually undertaken between weld passes. Usually achieved with a chisel or special tool, by hand or using mechanical means. On aluminum welds, a power saw may be used with care.

back gouging—Grinding back on opposite side of plate or back of weld to find root of weld material.

back-step welding—Welding from unwelded join are back to previous welded area.

baseline (BL)—A line that runs parallel to the waterline. It's used on some plans and drawings as a common reference line. The baseline may sometimes be above the hull, but more usually the bottom of the keel acts as a baseline.

batten—A long piece of fine-grained timber, plastic, or steel used for fairing purposes. The timber variety are used by loftsman as an aid to drawing the long waterlines and buttocks on the loft floor. Shorter versions are used for drawing the frame sections. Before the advent of computer design, naval architects used miniature versions called "splines" for the same purpose.

beam—The width of the boat at any given point. Usually given as a measurement at the maximum width of the hull (beam overall, the widest beam) or waterline beam (beam at the waterline).

bedlogs—Used when setting up hulls upside down. Can be steel I beams or 6 by 2 inch (150 by 100 mm) timber or similar. See *I beam*.

body plan—Also referred to as "stations," or "sections," this is the drawing of the hull divided into stations, usually equally spaced, and may actually represent the frames. The waterline length is divided into a number of equal stations (usually ten) and the 90-degree view of these, plus the ones at the bow and stern, are shown in the body plan. In most cases the forward stations are shown to the right of the centerline and those aft of the centerline are shown on the left.

boottop—A decorative stripe painted parallel to and about 6 inches (150 mm) above the waterline. This stripe separates the topside and bottom paints. It is wise not to paint this line until your boat has been launched and loaded for cruising.

bracing—Extra bar across, or vertically installed on, frames as a temporary measure to stiffen them until the hull is completed; it stops stringers deforming the frames at an early stage of construction and is also used to support frames or other members of the hull during the setting-up stage.

brazing—Usually done with oxyacetylene equipment and is used to join two light metals.

breakwater—A vertical bulkhead above the deck, usually located ahead of the wheelhouse. As the name implies, the breakwater deflects the force of any water or spray that may wash onto or over the foredeck.

bulkhead or blkd—Any "wall" in a boat. May run longitudinally or athwartships (fore and aft, or across the boat).

bulwark—Topsides that extend above the main deck. Can be combined with life rails to provide security for the crew. Usually extend from bow to stern. Can be any height from 4 inches (100 mm) to 36 inches (914 mm).

buttock line—A line dividing the hull longitudinally and vertically. When viewed in profile can reveal a considerable amount of information about the shape of the hull. They appear as straight lines in the body and plan views of the hull and as curved lines on the profile view. Used by loftsman as another set of reference lines when lofting a hull full size.

butt weld—Used to join two pieces of plate or bar edge to edge.

CAD—Computer-assisted drafting.

camber—Denotes the amount of upward curve in the deck, cabintop, and transom. For decks, a common amount of camber is ⅜ inch (10 mm) for every 12 inches (305 mm) of beam. Sailboat cabintops tend to have more camber; powerboats with flying bridges tend to have less, pilothouses have more, and so forth. If the plans include camber patterns (as ours do) or specify cambers, do not change them without consulting the designer.

camber pattern—See *camber*. Patterns are supplied, or you need to make your own from measurements supplied with your plans.

castles—Steel forms used in setting up steel kit building jigs.

ceiling—Longitudinal planking attached to the inside of the frames. In traditional timber boats, this inside planking was installed to add strength to the hull. In modern boats, the ceiling planks are about 1½ by ⅜ inch (35 by 10 mm) and are intended only as a lining material.

centerboard—A device used in sailboats to reduce draft while reducing leeway. Used in place of a deep keel. See also *drop keel*.

centerline (C/L)—An imaginary line running down the center of the vessel; also a line drawn on the plan view and body plan of the designer's plans.

centerline bar—The bar on edge that runs long the centerline of a metal boat. The stem is usually part of the centerline bar, as is the bar running from the aft end of the keel to the stern. On some powerboats, especially planing hulls, the centerline bar runs full length.

chainplate—These days seldom used for chain, this is the tang on the hull to which the turnbuckles or rigging screws are attached. Part of the rigging setup on a sailboat.

chine—This, when used alone, generally refers to a "hard" chine, or abrupt change of direction between the sides and bottom of the hull. In general terms, a chine is the point where the hull bottom and sides meet in a "chine boat." A hull can have more than one chine (double-chine), or several chines (multichine). See also *radius chine* and *knuckle*.

chine flat—The area at the chine on a planing powerboat that is parallel or near parallel to the waterline. The forward end deflects spray while mid and after parts are underwater and provide additional lift.

chord—A straight line joining two points on an arc, curve, or circumference.

circuit—The path of an electric current; a closed circuit has a complete path, and an open circuit has a broken or disconnected path.

collar—The lining of a hole through a bulkhead (short length of pipe) so electrical cables or other similar items that penetrate a bulkhead do not chafe on the sharp edges.

compound curvature—A surface that has curvature in more than one direction is said to have compound curvature. A regular round-bilge hull has a considerable amount of compound curvature.

computer lofting—Drawing out the boat full-size in the computer and then plotting patterns for the frames, stem, keel, deck beams, etc. See also *lofting*.

conical developed or developed surface—A surface that is part of a cone or several interconnected cones, so that a flat sheet of metal or plywood will "drape" over the surface. Many modern powerboat designs have computer-generated developed hull surfaces.

construction drawing—A single sheet of drawings, measurements, and written instructions that usually forms part of a set of drawings. The construction drawings are usually prepared by the designer but additional drawings may be prepared by the builder, marine electrical engineer, or marine plumber.

consumable—Welding rod or electrode or welding wire or other metal that is used in welding and joining two pieces of metal.

copper-nickel—Alloy metal consisting of mainly copper and a smaller amount of nickel. Often described as 70-30 or 90-10 to indicate the percentage of copper (first number) and nickel (second number).

crevice corrosion—Cracks that often appear in stainless steel rudder shafts and other stainless parts that are underwater and suffer from oxygen starvation. In simple terms, stainless steel needs to breathe.

current (electrial)—Rate of flow that is best described by comparing it to a stream of water; the unit of measure is an ampere.

curve of areas—A line plotted by the designer from measurements taken from the lines plan. The curve represents the areas of the vessel's immersed sections and provides information to the designer about the shape of the hull. The computer now generates this line that was not, and is not, used for lofting.

custom-built—Any boat that is not built in series production may be one-off or could be part of a series of boats built one at a time with special features to suit individual owners.

cycle—One discharge, plus one recharge, is one battery cycle.

deadrise (hull deadrise)—The change in elevation in relation to the horizontal plane of the bottom of the hull. Most often used to describe the angle of V in the bottom of a powerboat hull. Deadrise is often quoted at the transom, say 18 degrees of V or 18 degrees deadrise. The deadrise in a boats hull usually increases towards the bow.

deck plan—Drawing of the deck, cabin, etc., looking down from above.

deck stringer—The stringer that intersects the hull and the deck and is used to accept the deck plating and the outboard ends of the deck beams.

descaling—Removing mill scale and other impurities from the surface of metal may be done chemically or mechanically.

designed waterline (DWL)—The line around the hull where the designer expects, hopes, or predicts that the boat will float when completed and launched; stores, half the fuel, water, and crew should all be aboard when the boat floats on this line.

developed or developable surface—Any surface that can be constructed from a flat plate. See also *conical developed surface*.

diagonal—Another line used by the designer to fair round-bilge lines at the design stage. Generally not used for lofting.

dipswitches—A series of small switches used for alternate programming in all types of electrical and electronic devices.

direct current (DC)—Electric power from a battery, generator or a 12V battery charger.

discharge—When a battery is delivering current it is said to be discharging.

displacement—True displacement equals the actual weight of the vessel when in cruising trim. This is turn equals the weight of the amount of water displaced by the vessel.

D/L ratio—Uses a formula to compare the displacement versus the waterline length.

down-hand welding—Welding from above.

drop keel—A ballasted centerboard. Often airfoil-shaped, it is pivoted on a strong pin and can be raised and lowered as required. For safety's sake, it should be capable of being locked in the down position.

ductile—Easily stretched, bent, or formed without breaking.

elevation—A flat scale drawing of the front, rear, or side of an object.

engine beds or bearers—The longitudinal bearers or girders on which the engine is mounted, usually via flexible mountings.

equalizing charge—A controlled overcharge of the batteries that brings all cells up to the same voltage.

fair line, faired surface, to fair—A curved line or surface devoid of humps and hollows; to fair is to take some action to achieve this end.

fillet weld—The weld on the intersection where the end of one piece of metal rests at an angle on a flat plate. The weld in the corner is termed a fillet weld.

flare—The outward slope of a hull above the waterline. Also used to describe the hollow seen in the bow of some fiberglass powerboats. Example: the boat has a flared bow. The opposite of tumblehome. See *tumblehome*.

flat bar—Metal formed or cut into strips. For example, ¼-inch (6 mm) plate that is only 2 to 8 inches wide (50 to 205 mm). After that, it may be called *sheet*. Flat bar can be any thickness.

flux coating—The coating on some welding rods.

frame—A structural member, usually on the same plane as a station.

frameless—Some smaller metal boats are frameless, which is really a misnomer as the stringers and chine bars are longitudinal framing.

framing—The structure inside the hull. Transverse framing is generally known as the *frames*, whereas longitudinal framing is known as the *stringers*.

freeboard—The height of the boat's side above the water. Often quoted at various parts of the hull, usually the lowest freeboard is quoted as "the" freeboard measurement.

freeing port—An opening in the side of the hull above the deck (usually through a bulwark) to allow the surface water from the deck to flow overboard.

full-size patterns (FSP)—Patterns of the frames, stem, deck beams, and other construction members that have been obtained by manual lofting or computer fairing and lofting. Can be supplied on paper or Mylar film. A great aid to getting on with the job and highly recommended by this writer.

galvanic action—Similar to corrosion and caused when two dissimilar metals are joined and unprotected by coatings or other methods. Especially prevalent in a saltwater environment.

garage (for main hatch)—See *turtle*.

gel-cell battery—A type of battery that has the electrolyte in gel form.

girth—A measurement around a curved surface or arc.

good boatbuilding practice—A recognised standard among boatbuilders that denotes good-quality workmanship and the use of good-quality materials. The opposite of shoddy practice.

gouging rods—Very high carbon used with high power to gouge out bad welds.

grid—All the straight and parallel lines used by loftsmen to prepare a loft floor for drawing up a set of lines. The grid includes the baseline, waterlines, and buttocks.

ground—To ground is to connect an electrical conductor to the ground, or the water, so that it becomes a part of the circuit and is at the earth's potential or voltage. A ground is any part of an electrical circuit that joins to the circuit to the ground or water. In electronics, automobiles, and sometimes boats there are often "pseudo grounds" (a chassis, a frame, or even an engine block, where all wires of one polarity are connected) that float at some potential other than the earth's.

gusset—A bracket connnecting two parts to reinforce a join, usually at a 45-degree angle. Similar to a knee in a timber boat.

half breadth—The distance from any point of the hull to the centerline, when taken horizontally and parallel to the DWL. All symmetrical hulls have the same half breadths for each side.

headstock—A length of L-angle or timber installed across the frames and used as part of the bracing and setting-up procedure.

heat-weld puddle—The pool of molten metal or consumable that is present prior to cooling of weld.

house—As in deck house, doghouse, or cabin.

hydrogen embrittlement—Caused by incorrectly matching electrodes and metal to be welded results in poor ductility and hairline cracks.

I beam—A steel section shaped like an "I" and used in the construction industry. This type of beam is used as a setting-up base for kits and when setting up the frames in hulls that are built upside down.

inboard profile—Elevation drawing, usually showing one half of the accommodation viewed in profile (a slice from bow to stern along the centerline).

initial (or form) stability—The shape of a hull as a form of stability as opposed to ballast-induced stability.

intercostal—Fore-and-aft stiffener inserted between frames or deck beams, as opposed to a continuous stiffener or stringer.

ISO—The International Standards Organization.

jerry-built—Unacceptable or shoddy workmanship.

jig—An arrangement specially made to hold parts of an object in a certain way until they can be permanently assembled. For example, if you were building a number of similar hulls, you may have a building jig for forming up parts of the hulls or superstructure. A temporary framework as used in frameless construction is a building jig.

keel and ballast keel—The lowest portion of the hull; may hang well below, as in a fin keel, or may run almost the full length, as in traditional boats like the *Spray*. There are long keels, three-quarter keels, fin keels, bulb keels, and wing keels.

keelson—The inner keel; usually runs the full length of the hull, from the stem aft to the transom. More applicable to timber boats, but the centerline bar in a metal boat may be thought of as the keelson.

knuckle—A definite change of direction in the hull plating or other surface. In true terms, a chine is a knuckle. The change in direction is usually not as abrupt as with a chine. See also *chine*.

ladder—As in ship's ladder or boat ladder; another term for a set of stairs or steps, usually more vertical than either of the latter.

laid deck—A timber-planked deck usually installed over a regular deck, for instance over a metal deck. Depending on the thickness of the timber planks, this deck can contribute to the strength of the decks and the vessel.

lay-back—Used to describe or measure the angle the front of the cabin is angled from the vertical, usually expressed in degrees.

lay-in—Used to describe or measure the angle the cabin or pilothouse sides are angled from the vertical, usually expressed in degrees.

laying out—Measuring and locating a point on a drawing, loft floor, or on a boat.

LED—A light-emitting diode, often used as an indicator light.

lightening hole—A single hole or a series of circular holes cut in a web or similar beam to reduce the weight without materially reducing the strength. Often arranged to allow the passage of cables and plumbing beneath the sole.

limber hole—A hole cut in the bottom of a frame or web or elsewhere to allow the passage of water between frames or webs. In wooden boats, a light chain was lead through the series of limber holes to clear accumulated rubbish preventing drainage to the lowest point of the bilge.

lines drawing, or lines—The original drawing of the hull, made by the designer or naval architect, that presents the hull in plan view, profile, and sectional view (stations). The hull is faired on the drawing board, today in the computer, by using waterlines, buttock lines, and stations. From the lines plan the designer takes off a set of offsets that are used by the loftsman, or computer, to draw out the hull full-size on the loft floor, or by plotting on a printer/plotter.

LOA—Length overall, including bowsprits and other appendages.

LOD—Length on deck; this figure is often shown as the LOA, but should not include bowsprits, etc.

loft floor—An area of floor that has been prepared for drawing out the lines full size. Usually painted off-white to allow a clearer view of the various lines to be drawn, seen, and identified. A small version of this floor is useful for transferring Mylar or paper full-size patterns to a semipermanent surface.

lofting or computer lofting—Drawing out the boat full-size on the loft floor so as to provide patterns for the frames, stem, keel, deck beams, etc. Today, the lofting is more likely to be done in the computer.

longitudinal—Fore and aft; for instance, a longitudinal, when discussing framing of a hull, usually refers to a fore-and-aft stringer.

margin plate—A narrow plate welded inside the hull at the deckline to accept a timber and plywood deck. This plate is located in the same position and would replace the deck stringer.

midships (amidships)—Around the center of the hull in the fore-and-aft plane; for instance, midships cabin, midships steering, or something is located midships.

MIG—An abbreviation for the metal inert gas welding process.

mullion—The narrow space or post between windows.

NC cutting—Computer-controlled cutting of metal, used to cut out metal parts from sheet material in a semiautomatic operation.

negative—The negative terminal is the point from which electrons flow during discharge.

nibbed—The way ends of deck planking are fitted to king plank or covering board.

nicad battery—Nickel-cadmium battery, rechargeable and used in small appliances; larger varieties are too expensive for most boats.

offsets, or table of offsets—The figures or dimensions shown on a lines plan, these are offset from a known point such as a centerline or baseline.

ohm—A unit of electrical resistance.

outboard profile—Side view of the boat as seen from outside.

pad eye—A small metal plate welded to a plate or structure. It has either an eye or a hole to which a line or chain can be attached for lifting the plate or structure.

passagemaker—A term, popularized by Robert P. Beebe, meaning a long-distance, ocean-crossing powerboat.

passageway—Space between bulkheads or joinery used as access, usually fore and aft.

pickling—One method of cleaning metal by the application of acids to copper-nickel and other metals to remove impurities.

planing chine—A surface running mostly parallel to the waterline and longitudinally where the sides and bottom of the hull join that assists in lifting the hull on to a plane.

planing strake—Angled surface on the bottom of a planing hull added to assist the boat in getting on to and remaining in a planing attitude. Very effective on boats that perform at less than 30 knots.

plate-mill stock—Plate that is supplied flat and has never been coiled.

plug welding—Welding through slots or holes; for instance, when attaching the outside shell of a keel to the inside webs, where access from inside is not possible. Also used to weld one plate on top of another; not recommended, at least for steel, due to potential corrosion problems.

plumb bob—A pointed weight on a string line; used from above a frame or other section to ensure that the frame is truly vertical or plumb.

porosity—Used to describe welds that have small voids or are porous.

port—To the left when looking forward, as in port side, left side. Any window in a boat can be termed as a port. Large ports are now usually referred to as windows.

portlight—Another boating term for window.

pulsed-arc transfer—Welding at low heat; usually done with automatic welding equipment.

radius chine—A chine formed by part of a circle, where the radius is constant from the stern right through to the bow. Most radius-chine boats are designed with complex yacht-design computer software. The amount of arc may vary in a radius-chine boat, but the radius remains constant. The largest amount of arc is at the stern, tapering right through to the bow.

scale—Ratio of size relative to actual size; for example, a scale of ½ inch equals 1 foot means ½ inch on the drawing equals 1 foot on the boat. In drawings prepared the metric scale, 1 = 50 would mean that 1 unit on the drawing equals 50 on the actual boat.

scale, on steel—Generally referred to as *mill scale*, impurities usually on the surface of the steel left over from the steel manufacturing process.

scantlings—Sizes and dimensions of materials used to build the boat. The thickness and other dimensions shown on the list of materials are the scantlings.

seacock—A tap or valve used to shut off a flow of water or other liquid into and out of the hull. Drains, inlet pipes, and other pipes that pierce the hull surface should all be fitted with seacocks.

shaft horsepower—The horsepower actually available at the propeller.

sheer, or sheerline—The top of the hull, viewed in profile.

shell—The outer skin of the hull; as in shell plating.

shoal draft—A boat with shallow draft is said to be a shoal-draft vessel.

shotblasted—Steel that has been blasted with either sand, grit or small shot to remove impurities and/or rust from the surface of the steel, brings steel back to bright metal.

shroud—A side stay or wire support for the mast.

S/L ratio—Speed-to-length ratio is the speed of the vessel in knots, divided by the square root of the waterline length in feet.

slag—Impurities that form on a weld and need to be removed as part of the welding process.

snaping, or to snape—To cut off the ends of a stringer or similar member at a 3:1 angle, leaving about one quarter of the width as a right-angle cut.

Spanish windlass—A loop of rope or wire twisted with a stick or rod to draw in one surface or section to another.

stanchion—The posts around the edge of the deck.

starboard or stbd—To the right when looking forward, as in starboard side.

station or stn—A slice through the hull from side to side. Usually, there are ten stations dividing up the waterline.

stay—Fore-and-aft wire supporting the mast; as in forestay or backstay.

steel, low-carbon—This is steel with a low carbon content, generally speaking steel with carbon content of between 0.15 and 0.28 percent.

steel, mild—This is a generic term for general-purpose low-carbon steel.

stem—The vertical forward end of the boat.

stern—The aft end of the boat; as in counter stern (a long overhanging stern), transom stern (a squared-off after end of the hull), and canoe stern (when the aft end of the hull comes to a point similar to that of the bow).

stiffener—Frames, stringers, and chine bars are all stiffeners. A stiffener supports an area of the hull from inside and breaks up areas of hull shell into smaller stiffened or supported areas.

strake—A stiffener or stringer on the outside of the hull. Traditional timber boats often have strakes on the outside to add strength. Workboats have strakes to protect the hull against fishing gear, etc. Modern planing hulls have planing strakes to assist them in reaching and maintaining the planing attitude.

stringer—A fore-and-aft stiffener, as in hull or deck stringer.

strip-mill stock—Steel that has been coiled after production and is then uncoiled to be sold as flat plate. Can have a "memory" so it should not be your first choice for boatbuilding material.

strongback—A jig used to set up the frames during the initial setting up of the hull.

stuffing box—A packing gland used to keep the water from entering the hull from the stern or rudder tube.

superstructure—On a boat the cabin, pilothouse, deckhouse and other structures above the deck are collectively known as the 'superstructure'.

T-bar—A bar shaped like a T and used for transverse frames, deck beams, and other structural members in a metal boat.

tack-weld—To apply a small spot of weld to temporarily hold two pieces of metal in place. This has many uses and all steel boats are best tack-welded together before any permanent welding is undertaken.

tang—A strap or flat bar, usually at a point on the mast where the rigging is attached. Can be used elsewhere on the boat.

temper—To treat metals with heat to change their mechanical qualities; for example, to make a metal more or less ductile.

template—A pattern. A plate template is a pattern made directly off the framework of the hull. It is then transferred to the plate, which it cut to the exact shape and installed on the hull.

TIG or tungsten inert gas—A welding process suitable for most metals; uses a nonconsumable electrode and a shielding gas.

transom—A form of stern. A transom stern is squared-off. Reverse transoms are seen on many modern sailboats.

transverse—Across the boat at 90 degrees to the centerline.

transverse profile jig—Used to support the bottom plates when setting up a hull using a precut kit.

tumblehome—The inward inclination of a boat's sides from the widest part of the hull to the sheerline.

turtle—A low boxlike structure that covers the main sliding hatch when the hatch is open. Acts as a spray delfector.

unfair (hull)—This means a hull or other part of the boat that does not present a smooth and fair exterior. Often caused by using incorrect sequences of welding and by overwelding.

ultimate stablity—This is the factor that measures will the hull return to its upright position from a complete capsize. This factor is more related to positive stability than to the form stability.

volt—A unit of electric potential.

waterline (WL)—The line the water describes around a floating hull. The "designed" waterline is where the designer hopes it will float. On a lines drawing, waterlines are drawn at regular intervals above and below the true waterline.

watt—A unit of electrical power. Volts times amps.

wet-cell battery—A battery that uses liquid electrolyte.

wheel—A boating term for the propeller.

work hardening—Making metal harder by hammering, or a similar method.