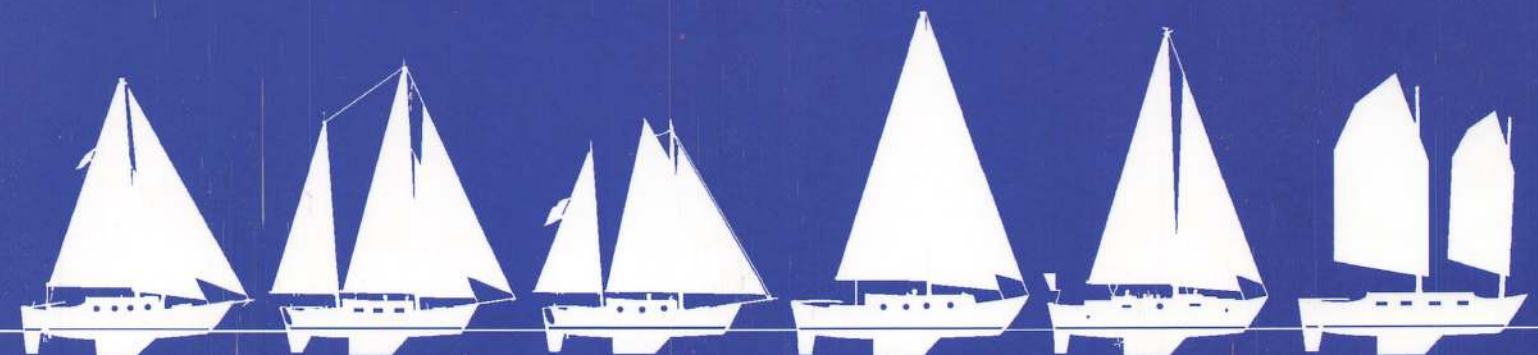


# BUILDING *BADGER*

& THE BENFORD SAILING DORY DESIGNS



BY JAY BENFORD AND PETE HILL





## From **Voyaging On A Small Income** To **Building *Badger***

By Jay Benford

Shortly after moving to the Chesapeake in the summer of 1984, before we'd gotten *Sunrise* moved East, Dona and I were heading out of Annapolis. We'd borrowed my in-laws Pearson 35 yawl and spotted a distinctive looking yacht anchored in the harbor. Coming close alongside, we inquired about it and were told that it was indeed a Benford design. It seemed appropriate at that point to introduce myself, and we had a nice visit with the Hills and learned more about their *Badger*.

Our next visit with them was several years later when they sailed into St. Michaels, where we'd moved. On this visit with Annie and Pete Hill, Annie mentioned that she had written a book, but was having a challenge getting it published. What was it about, I asked? An answer to all the questions they were getting about how they were able to keep voyaging so inexpensively, she said. Could I look at it? Sure. Annie dug out a boxed and plastic wrapped manuscript and seemed pleased with my interest.

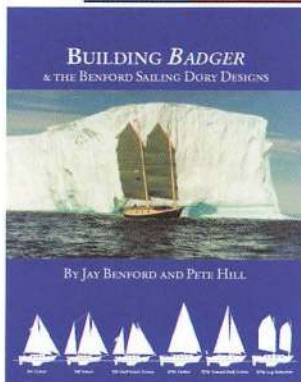
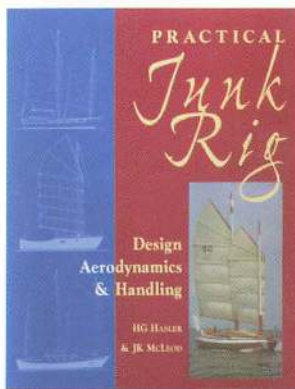
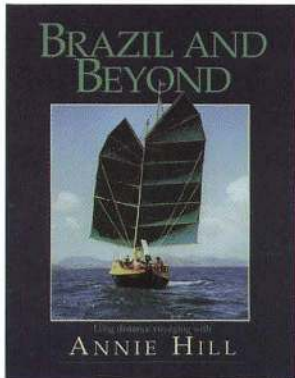
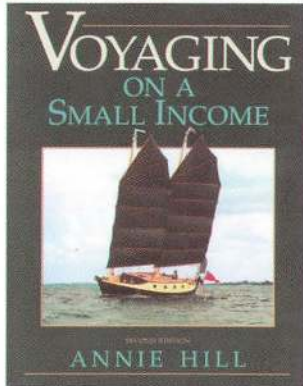
So, I borrowed the manuscript overnight. And read almost all of it. The next day, I suggested that we would be interested in publishing it. After some discussion, we agreed on the terms of how we would proceed. Our agreeing to do it got the UK publisher to also come on board, and we went about getting the book designed and laid out. Annie had a friend that would make the fun illustrations preceding each chapter and these were created and delivered to us. The UK publisher had a better idea to improve the cover design and this was incorporated. I spent a lot of time refining my Microsoft Word skills and was able to do laser prints we used as camera-ready copy of all the text in the book. We printed the books nearby in the US and sent a large shipment of them to the UK.

This was our first venture in publishing a book by someone else. Previously, we'd only been publishing books of my designs. However, it seemed to have a logical tie-in with our other books since it featured one of our designs. Two decades and six printings later, we're again reprinting; and **Voyaging On A Small Income** has become a best-seller and nautical classic. And led Annie to writing another book about *Badger's* travels; **Brazil & Beyond**.

The great interest in the first book generated interest in *Badger's* junk rig. After three years of importing copies of **Practical Junk Rig** from the UK, we arranged to have an edition with our imprint on it and were able to better keep up with the demand for the book. When that sold out, we created another edition.

The continuing interest in building the *Badger* design led to Pete Hill putting together this photo and sketch with captions essay about building her. And it led to me gathering up a lot of the materials that I'd written about our dory designs, enlarging on that material, and the creation of this book.

We all hope that **Building *Badger*** will prove useful and interesting – and spur others on to really examining what is the most effective way for them to get cruising quickly and affordably.



## Introduction

*By Jay Benford*

When my folks realized that launching me was forthcoming, they sold their Snipe and got a 21½' cruising boat, that had been built by a local Dutchman for his own use. Built originally as *Jericho*, they renamed her *Flying Dutchman*. My folks took me sailing before I could walk and I became an active part of the crew as I got old enough to be useful. I went along with my father when I was 12 and he was taking the US Power Squadron introductory course. I passed the final test and got a letter saying I would be welcome to join the Squadron when I came of age.

In the meantime, I was haunting the public library and reading all the materials on yacht design and boatbuilding I could find. My folks were persuaded to let me loose with the boat the summer when I was 15. A friend and I sailed it from Rochester to Fair Haven, 45 miles to the East on Lake Ontario. On the way, the engine threw a rod and we ended up sailing the rest of the way, on a day with light conditions. While we waited for the arrival of parts, I ended up living on it for a month or more there—and got a good deal of practice in making landings under sail. In retrospect, it was quite brave of my folks to turn me loose like this, but the boat and I survived quite well.

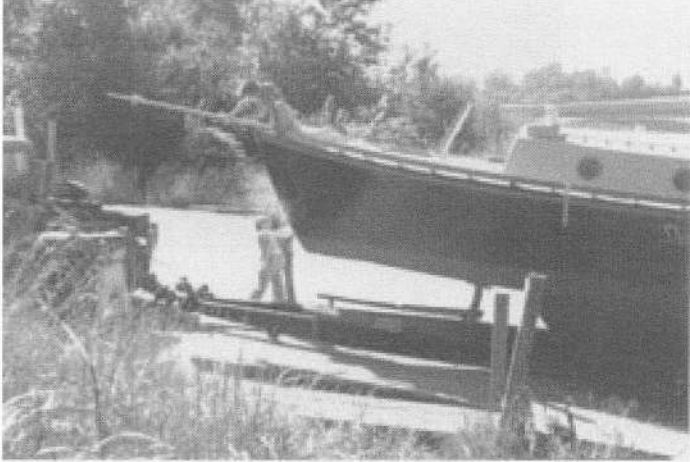
Along with me on this cruise were perhaps a dozen of the Motor Boating Ideal Series books. These were each full of dozens of designs, mostly by William and John Atkin. I loved their approach to creating a wide variety of small cruising boat designs. By careful study of the drawings and descriptions, I was able to learn a lot of boatbuilding terminology which served me well later on. Amongst the Atkin designs were some based on dory hull forms. Several years later, when I was fortunate enough to apprentice with John Atkin, we did a series of dory designs for Captain Jim Orrell's Texas Dory Boat Plans.

Later, upon setting up my own self-employment office in Seattle, I wrote to Captain Orrell and inquired if some of my designs might be useful for his plan sales business. This led to doing the 22' and 26' Sailing Dory designs and the 19', 23', and 26' St. Pierre Dory plans.



*Flying Dutchman the summer before I lived aboard.*

For myself, I was dreaming of a cruising boat for myself for Puget Sound cruising. Not having deep pockets, I recalled the appeal of the quickly built dory designs. So, I did designs for 30' and 32' Sailing Dories and got estimates on having them built. The 30' and 32' were included in my plans catalog and stirred a bit of interest. An inquiry that I got led to my creating the 26' V-Bottom Ketch, a design that looked much like the 26' Sailing Dory, using her profile and rig.



*Christening of Donna in Vancouver, BC.*

Then we got a client for a larger version of the dories. This became the 36' Sailing Dory *Donna*. She was built by a shoemaker who'd never built a boat before, but possessed a very strong work ethic. Building in Alberta, where there weren't other boatbuilders locally to visit and talk to on how to handle different construction tasks, he spent just over a year on her. He had her trucked to Vancouver and invited us to join him for the launching, which we did.

The builder/owner/skipper went on to do a lot of ocean voyaging on her. After several ocean crossings, he came back to us and asked for a larger sail plan, saying he wanted to have a taller rig to catch the wind as he was surfing in the Pacific. The resulting taller Marconi ketch rig did what he wanted and has offered an extra choice to other builders, in addition to the junk schooner and cutter rigs.

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We had another request for a dory a little bigger than the 30 and smaller than the 36, so we created the 34. The original version had a trunk cabin and a cutter rig. We also created a raised flush deck version and the Hills in building *Badger* did the first junk rig for her. They used Hasler and McLeod's **Practical Junk Rig** book for a guide and did a good job. In our visits with them, they shared the marked up prints they'd used and we had a starting point in making the junk rig drawings for her that have been so popular. We also created a gaff cutter rig which several builders wanted to use on her.

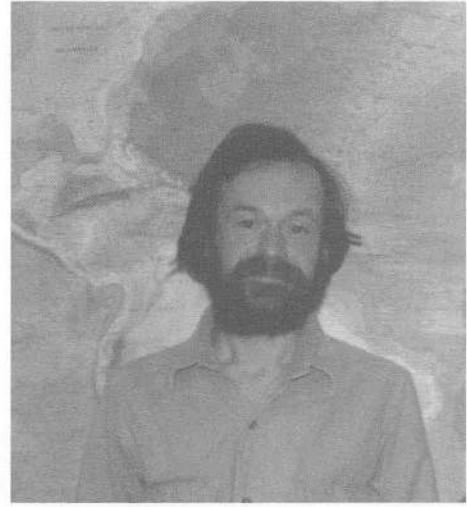
The 37½' Sailing Dory was done for someone who wanted a little bigger version of *Badger* and we've since done a variety of rigs for her too. Her design was done by tilting the stemhead forward a bit and slightly extending the sternpost to allow for the bulwarks at the stern. The structure and underbody are virtually identical with the 36 and many of the plans are shared between the two versions.

A concept for a three-masted junk rigged schooner, with a modified dory-like hull was done, but it never got past the very preliminary design stage.

We did do two 45' dory designs. The first was a sort of motorsailer and we looked at a variety of rigs for her. The client's theory was to have several staterooms that would make her suitable for charter work. The second one is a larger junk schooner that has a lot of room for living aboard and cruising. She has a rather thick fin keel which houses the mechanical-electric propulsion besides the ballast.

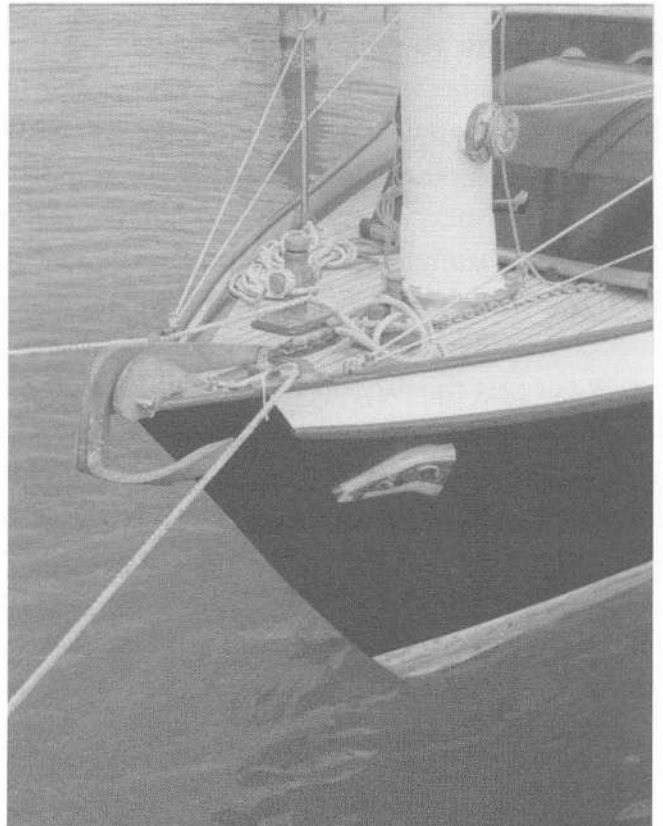
The most recent addition to the dory range is the trawler version of the 37½' and this is shown in the chapter with the sailing version. It's a very different approach to doing long distance voyaging under power.

Check out all these designs in detail in the chapters of this book! . . .



Above—Pete Hill in the designer's office in 1991.

Pete Hill's fine workmanship is evident in these photos of his *Badger*. They were taken by her designer on a visit aboard (circa 1992) while *Badger* was in Florida.





# **Building *Badger***

*by Pete Hill*

## **Introduction**

Annie and I built *Badger* because we had specific ideas about the sort of cruising boat that we wanted and there was nothing that fitted our ideas available on the second-hand market, at least not at a price we could afford. We were also attracted to the idea of building a boat for ourselves, for its own sake.

Make no mistake, building a boat is a major undertaking that may well take years of your life, and a great deal of your money. Be realistic about yourself and your circumstances. Do those around you support your enthusiasm? Have you got the drive to sustain yourself through the hard labour and the low times when things aren't going well? The satisfaction of sailing a vessel built with your own hands is countered by the depression of walking away from an unfinished project. Think long and hard; don't rush into building.

If you do decide to build, or if you are still considering whether building is for you, I hope the following advice will be helpful. Advice is always fun to give—you get to tell people what to do, without the responsibility of living with the results.

## **Money**

It probably won't come as any surprise to you that you're going to need money to build your boat. One of the advantages of building over buying is that you don't need all the money at once, but you do need a regular supply of it. Ideally, you will have enough money in the bank to buy all the materials, plus a reserve because it's going to cost more than you think. Amateur boatbuilders tend to be optimists, otherwise, they would never start, and they tend to underestimate how much it will cost and how long it will take. If you don't have all the money up front, you will probably have to go out and earn it, which, while socially acceptable, does cut into the time spent building. Remember also that time equals money. For example, most of the solid timber we used was second-hand, which gave us good quality timber at a very reasonable price, but it took a lot of time sawing it up. Making our own sails saved a lot of money, but they too, took many hours to make.

**Building site**

Unless you are lucky, finding somewhere to build is a big problem, especially in an overcrowded country such as England. A large, heated shed with electricity and water, situated right next to where you live is the ideal, but one that is rarely achieved. If you are thinking of building next to your house, make sure that *all* your neighbours are happy about it and that they will remain happy, until the boat is completed. They probably didn't move into their house to have a large polythene shed next door, with a whining power plane to listen to at all hours. Even if the neighbours are happy (in which case, they probably don't know what's involved), check with the local council about planning permission.

Travelling time to and from the building site is an important consideration. Apart from the time and money wasted by travel, it may mean that it isn't worth using those few hours that you have spare each evening, which all add up.

If you manage to rent a site or a building, make sure that you give the owner a generous estimate of the time that the project will take.

A building site without electricity is a major disadvantage, but you can get over the problem with a generator, in which case a diesel one will probably pay for itself. Once again, however, consider the fact that the noise of the generator will constitute a nuisance to many people.

If you need to build a shed, the Gougeon brothers' book or Buehler's *Backyard Boatbuilding*, will tell you how. (See section 1 below)

**Time**

How long will it take to build the boat? This is a tricky question. Annie and I spent three years building *Badger* and between us, we probably put in at least 10,000 hours. I'm sure that a professional boatbuilder could do the job in less than 5,000 hours. The extra hours that we took were due to several reasons. Lack of skill meant that it took longer to do the work than it would take a professional—this disadvantage was reduced with time as our levels of skill increased. Lack of access to professional quality power tools was another reason—these can save a lot of time. As I mentioned earlier, doing things in a way that saves money also takes a lot of time. A professional has his hourly rate and all money saving is based on that figure. On *Badger*, we also spent a considerable number of hours in working for a good finish, such as putting the veneers on the bulkheads, insulating the hull and laying teak decks. If you are happy with a much more basic finish, you can cut out a lot of time by simply having painted plywood on deck and below. On the other hand, don't fall into the trap of saying "Let's go sailing now and we'll finish it off as we go along." Chances are that you won't; you'll live with it the way it was launched for years.

If you build your boat to a similar standard to *Badger* and try to do it as cheaply as possible, our 10,000+ hours is probably realistic. Think about this. If there is only one of you building and you only work at the weekends, say twenty hours a week, that's only 1,000 hours a year, which means that she will take you ten years to build! This is why Annie and I put in all the hours we could and went sailing after three years. Life is too short to spend eight or ten years building a boat, if the object of the exercise is to go sailing.

**Skills**

To someone who has never built a boat before, the prospect is daunting. "Do I have the skills to carry out such complicated work?" might well be the average response. Some degree of skill is certainly required, but the average 'handy' person can soon acquire this. If you have never done any woodwork, it would be prudent to go to evening classes to learn how to use tools. The joints used in building a

plywood boat are straightforward and if you can cut to a line and plane a piece of wood to shape, then you will probably cope. If you have doubts about your abilities, try building a dinghy first—the skills needed are the same, it is merely the size of the project that differs. Ideally, the dinghy can be used as the tender to the yacht that you are planning and that will be one less job to do before you go cruising.

The great advantage of a design like *Badger* is that the construction of the hull is straightforward. You can't get much simpler than a dory, built out of plywood. By the time you have finished the hull, you will have learned a lot and will be more confident about tackling the rest of the construction.

### Management

To build a boat for yourself is the equivalent of setting up a small boatbuilding business. The fact that this particular business in non-profit making does not alter the fact that it still needs managing.

You will need to work out a budget for the project, make an estimate of the materials needed and the cost of overheads (site rental, electricity, tools, travel costs, etc) and ascertain whether this matches the money available for the project, or your expected surplus income. Materials will have to be ordered so that they are on hand as required; you will be doing the same job as a buyer for a boatyard. Find out how long the lead time is on ordering the various materials and get the best price you can. This usually means buying in bulk, if you have the money available. An offer to pay in cash can also produce a discount.

If more than one person is involved in the project, more management is required. You need to organise who does what so that too much time is not wasted waiting for someone else to finish a job so that the next person can get on with their bit. Sharing the creative work, as well as the tedious jobs, keeps everyone motivated—ensure that you are an equal opportunities employer.

In order to progress smoothly, the project as a whole will need managing. Plan the work ahead, so that everything comes together. Think through what you want to do next and try to see if there are going to be any hold-ups, such as waiting for glue to harden. You can then organise your work more efficiently. Long term planning is also required; this is especially important if the weather plays a rôle in what you can do. Having the materials on hand as they are required is an important aspect of the planning. Keep a check on your progress and, if the whole project seems to be taking too long, analyse what the problem is. You probably started building the boat in order to go cruising; make sure that you keep this goal insight. Don't get bogged down in building the perfect boat that would make a grand piano look shoddy by comparison.

### Power tools

Power tools are not essential to build a boat, and if you have no electricity available, you can do without them. However, they do save a great deal of time and often produce much better results for the essentially unskilled handyman. Whatever your budget, buy the best quality tools, designed for the professional. The handyman quality is generally a waste of money, in the long run. You are building a relatively large boat, not putting up kitchen shelves, once every few years. The professional quality tools will give better results, last the life of the project and you will probably be able to sell them at the end.

How many tools you have depends on your budget. The obvious ones to start with are a power plane, a jigsaw, circular saw, table saw, drill and sander. If you have the money a power mitre saw and a router are both very useful, especially when fitting out the interior. Tungsten tipped blades and cutters are always worth the extra money. They do need to be professionally sharpened, but they stay sharp for a long time. If you are going to be dealing with a lot of second-hand timber, have a spare, cheaper blade for the initial cut, when you might go through a nail that you missed when examining the wood.

## Plywood

There is a huge difference in the costs of different types of plywood. Top grade, marine plywood such as Bruynzeel™ or Aquaply™ is very expensive, but of excellent quality. If your budget doesn't stretch to that, then buying cheaper plywood takes a lot more care. We used WPB (will not delaminate, even if boiled in water), Lauan (Philippine mahogany), exterior-grade plywood to build *Badger*. It was of very good quality, with no voids in the veneers and the offcut that we still use as a board for gutting fish is showing no signs of delamination or rot, despite living in a deck locker for the past fifteen years. I have seen several so-called 'marine' plywoods, with voids in the veneers, that cost two to three times as much as our Lauan. Hardwood veneers will make it a lot easier to get a good finish.

The two things that are essential in plywood are that the glue should be waterproof and that it should be free from voids, which is where the rot starts. Never buy plywood unless you have inspected the quality first, or know the brand name. Building with epoxy, to seal the end grain, gives plywood a long life and after fifteen years of sailing *Badger*, we have found no problems with our exterior grade plywood. You pay your money and you take your choice. *Buehler's Backyard Boatbuilding* discusses the choice of plywood more fully.

## Health

Don't underestimate the health hazards of boatbuilding. Hand tools can cut you badly if not handled properly. Power tools can maim you for life. Sawdust is an irritant, so wear a dust mask. When chips are flying, wear safety glasses. Probably, the best eye protection is a visor, as used for chain sawing; glasses can steam up.

The most dangerous substance that you will be using is epoxy resin. The hardener is extremely toxic and it is very easy to get sensitised to it. What this means in practice, is that you come out in a very painful rash (contact dermatitis), if you are exposed to uncured epoxy on a sufficient number of occasions. To control this, you will need to use steroid creams on a regular basis: not a happy thought. You cannot be too careful about keeping epoxy off your skin. Use a barrier cream on all exposed skin, wear rubber gloves and use overalls, which are frequently washed. Work as cleanly as possible. If you become sensitised, it lasts for life and you may also find that polyester resin and polyurethane paints will bring you out in a rash. Once sensitised, the fumes of the hardener will be enough to start the rash off again. It is a fact that many people who build a boat, using epoxy resin, become sensitised—I am one of them. If you are scrupulously careful, you probably will not.

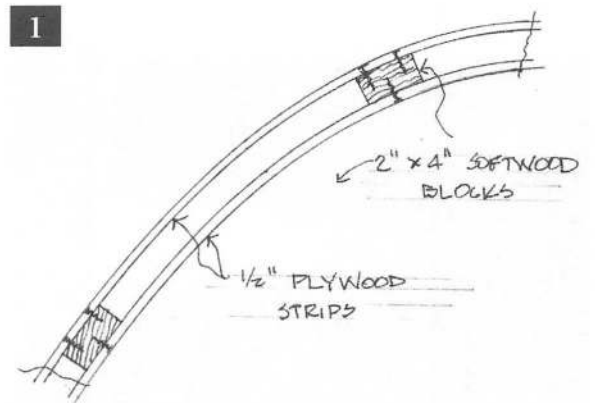
## Books

I am a great believer in learning from books—read as much as possible about boatbuilding before you start. A book that I would certainly recommend is:

*The Gougeon Brothers on Boat Construction*. This book is essential reading if you are going to use epoxy. I found it an excellent general boatbuilding book and all the advice in it is based on practical experience.

What now follows is how we built *Badger*. I'm not saying that this is the way to build a boat like *Badger*, just that it's the way that we did it. I hope it will give you an idea of what is involved. You may well come up with better ways of doing things, but if not, at least here is a method that worked, got the boat built and well enough that we are out here, still sailing her fifteen years and 100,000 miles later.

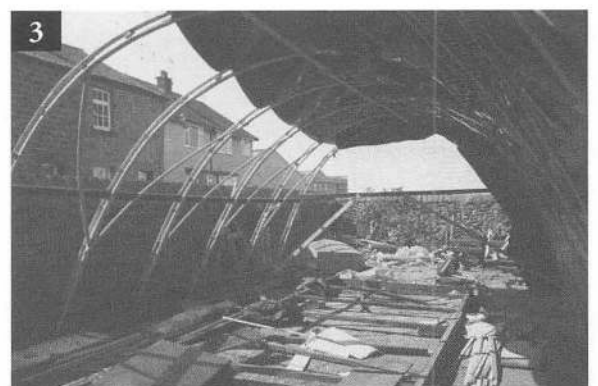
- 1 Having found and rented a site, we set about building a shed. The frames were two concentric 1/2" [12 mm] plywood hoops, spaced by softwood 2" [50 mm] x 4" [100 mm] blocks. They were made up on the ground, by screwing the blocks at regular intervals to one length of plywood. This strip was then bent to shape on edge, and held there by bricks while the second length of plywood was screwed to the other side of the blocks. The resulting frame was light and reasonably rigid.

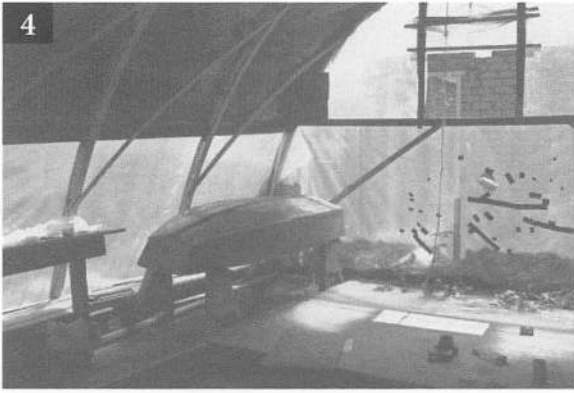


- 2 The frames were erected about 4ft [120 cm] apart and held together with longitudinal timbers and diagonal bracing.

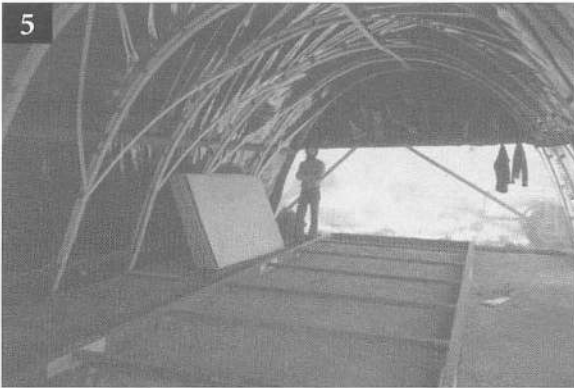


- 3 A thick black (ultraviolet-proof) polythene sheet was pulled over the top and nailed in place around the edges.





- 4 Clear polythene sheet was used to cover the end walls and along one side of the shed, to let light in. The shed was a bit flimsy, but lasted long enough to build the hull. A bad winter gale demolished it.



- 5 Lofting the hull, full size, was the first job. A framework of second-hand 2" [50 mm] x 4" [100 mm] timber, was laid on the ground and covered with sheets of 3/8" [9 mm] plywood (which were later used in the hull construction). A long length of clear 1" [25 mm] x 1" [25 mm] timber was scarfed together for the fairing batten.



- 6 Lofting a dory hull was very straightforward, because of the simple, hard-chine shape. Only the sheer and chine needed to be faired, in order to check the offsets. The shape of each bulkhead is taken from the lofting table, as is the profile of the curved stem.



- 7 The bulkheads were cut out of plywood. Most of the bulkheads could not be made from one piece of plywood and so were joined using a half lap. The waterline was marked on the edge of each side of the bulkhead.

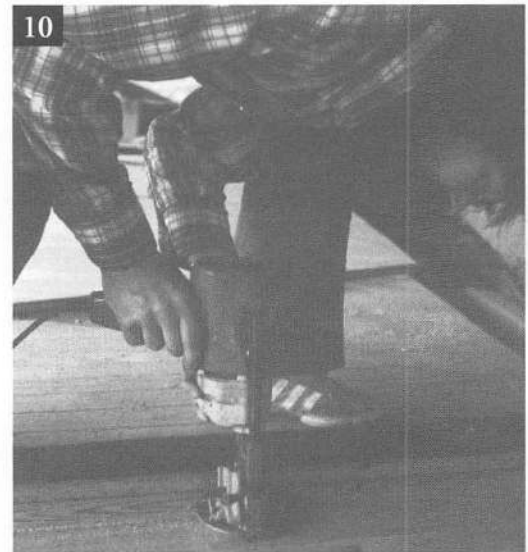
8 To cover up the joints and to provide an attractive finish, the bulkheads were covered with 1/8" [3 mm] veneers of pitchpine, glued on with temporary staples. We cut the veneers from second-hand wood on a circular table saw, but had no thickness planer, so the veneers varied in thickness.



9 When the glue had set, the staples were removed and the surface planed smooth, using a hand power planer, set to a fine cut. The surface was then sanded smooth.

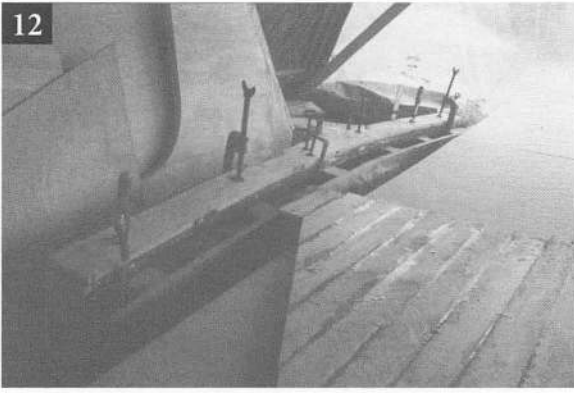


10 Using a router and a straightedge, a veed groove was made at the edge of each veneer, to give the effect of tongue and groove planking. The straightedge was clamped at the top and bottom of the bulkhead, half the width of the router base from the joint in the veneers. The router in the picture is, in fact, a power drill with a router attachment—we couldn't afford a router at the time.

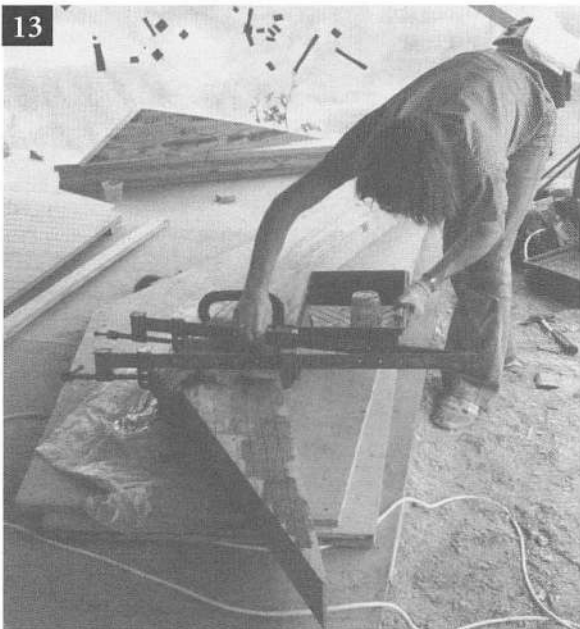


11 2" (50 mm) x 1" [25 mm] framing was glued to the edge of the bulkheads, remembering to put it on the side that would be planed off to take the curve of the hull. The notches for the chine log and sheer clamp were cut and the faces of the bulkhead coated with clear epoxy, to protect them during the building process. The midships bulkhead here, is in two halves and is joined together with one of the heavy floor timbers.

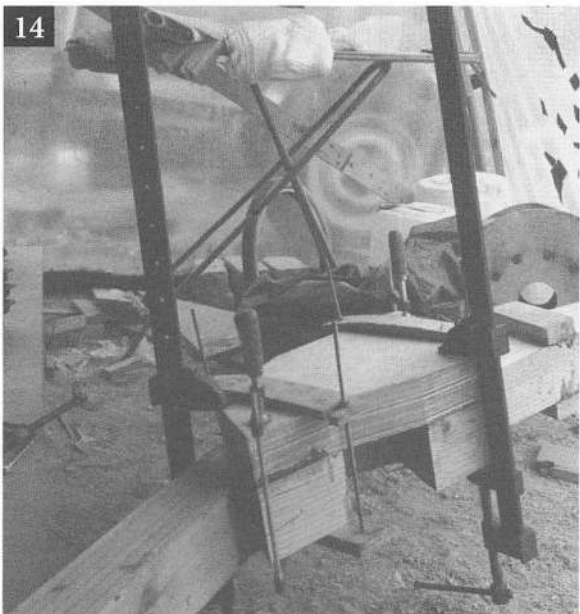




- 12 The stem was laminated over a simple strongback, which was made from scrap timber. The shape of the strongback was taken from the lofted profile of the stem.

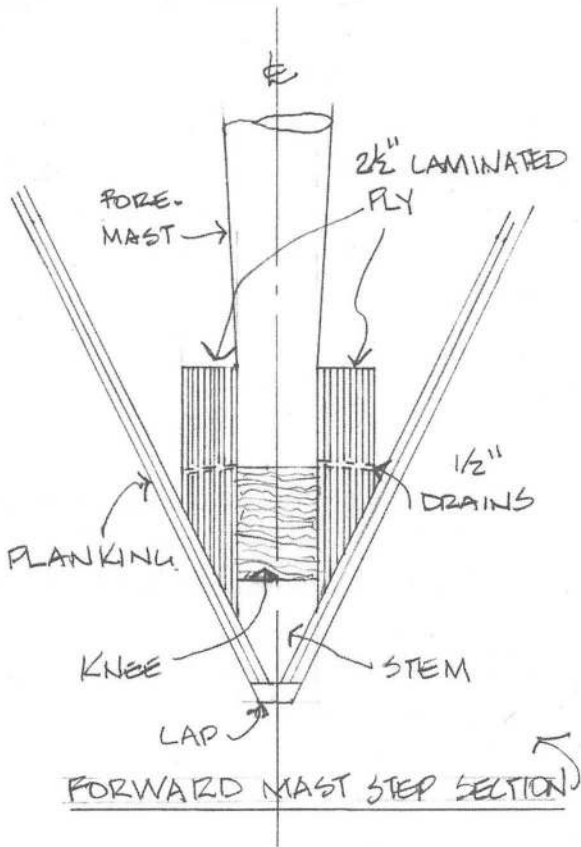


- 13 The bow knee was also laminated, shaped and glued to the stem piece.

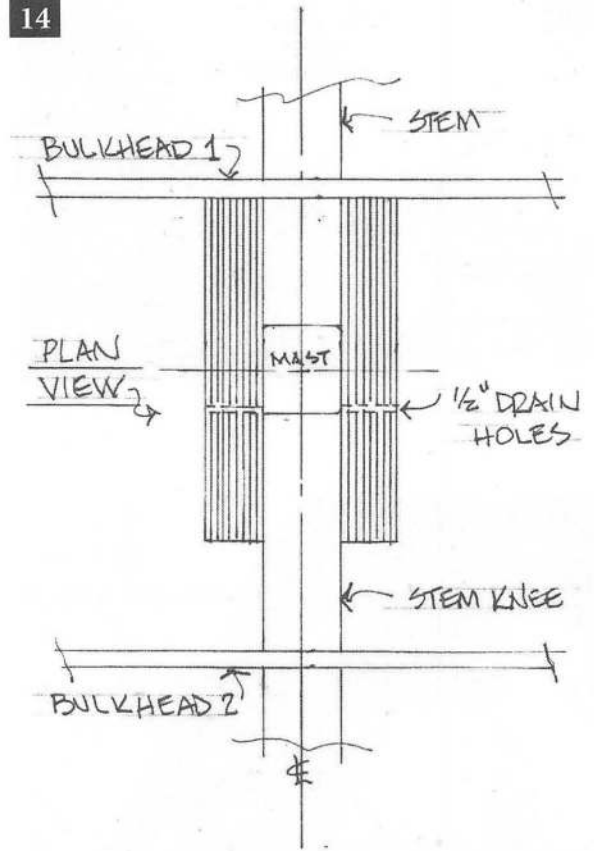


- 14 A mast step was built into the forward knee, with heavy plywood sides and a drain hole in each side, at the bottom of the step.

14



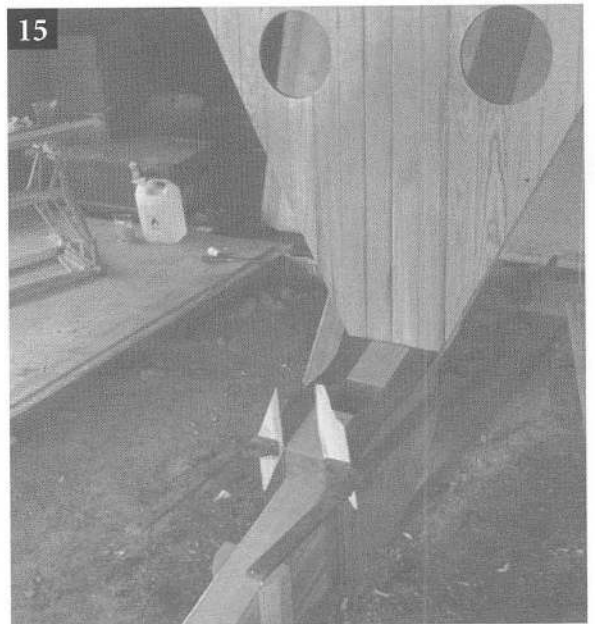
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- 15 The forward side of the step was used to locate the forward bulkhead, and wooden chocks on each side of the knee did the same for No 2 bulkhead.

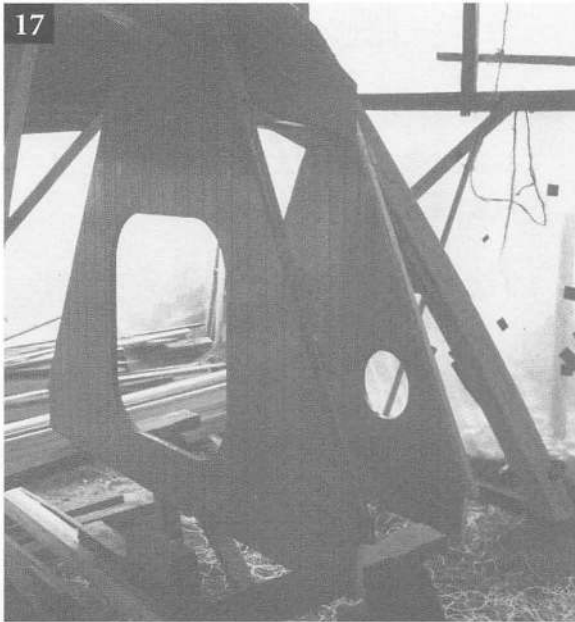
The bulkheads were glued in place.

15





- 16 The sternpost is straight and was laminated up from several thinner pieces. The stern knee was glued on in the same manner as the forward knee. Bulkhead No 6, at the stern, was made from 2" (50 mm) x 1" [25 mm] timber and joined at each corner with wooden gussets. This bulkhead was joined to the stern piece with a notch cut into the knee.



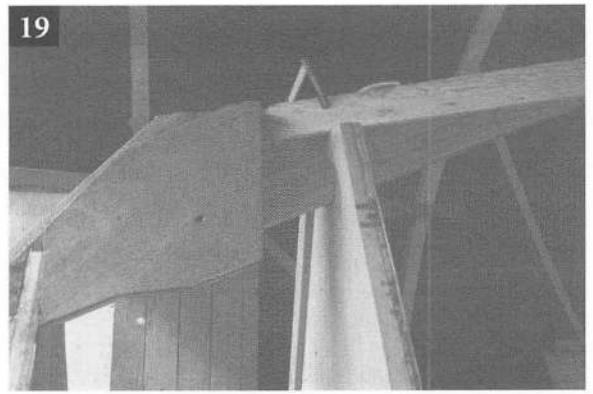
- 17 The next stage was setting the stem, stern and all the bulkheads in place. The stem is the highest piece on the hull and had to be set up first, as low as possible to make it easier to work on the hull, which was to be built upside down.



- 18 Once the bow section was set up level, the next bulkhead could be accurately positioned. We made a stand for each bulkhead instead of constructing a strongback. Using a plumb bob, the centreline of the bulkhead was lined up with a centreline wire, stretched just above the ground. The plumb bob was also used to check that the bulkheads were vertical. A water gauge (a length of clear tubing, almost filled with water) was employed to get the height of the bulkhead correct, using the waterline marked on the edge of each side of the bulkheads. The bulkhead could be moved up or down in the stand and clamped in place. It was essential to check that the distance between the bulkheads was correct and that each bulkhead was at right angles to the centreline wire. This was checked by measuring the diagonal distances between the bulkheads. Doing this was very fiddly as each time one bulkhead was slightly adjusted, all the measurements had to be checked again. However, it is one of the most important jobs, because the final shape of the hull is determined here, and it is worth being patient and careful.

- 19 Once all the bulkheads and the stern were erected, we double checked all the measurements again. The next task was to tie all the bulkheads together, with temporary battens nailed on.

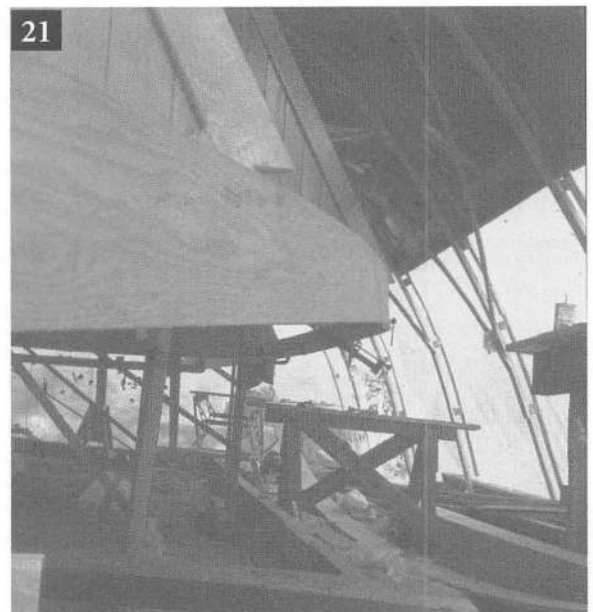
Using a faring batten, the notches at the chine were bevelled to follow the curve of the chine. The chine log was laminated in three pieces and the timber was cut to the correct width and bevel on the saw table. The first layer was scarfed to length, fitted at the bow and glued in place at each bulkhead, using temporary fastenings of steel screws, which were first greased, for ease of removal. Fitting the chine at the stern was tricky, because it had to be cut to the correct length and angle. In the picture, note that the mast step and the stem have not yet been faired in.

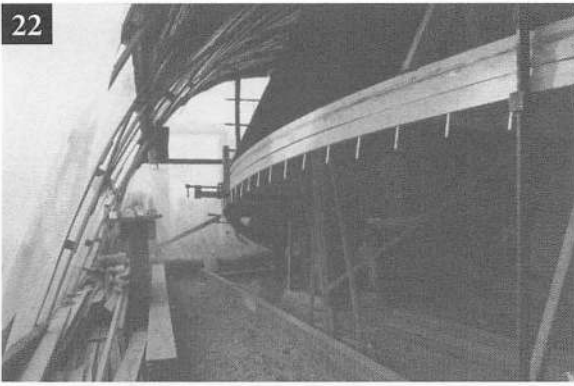


- 20 The chine log was built up, putting the laminates on each side alternately, in order to keep the pressure even. The second and third layers were glued and scarfed to length in place. Again, we used greased, steel screws as temporary fasteners until the glue had set. Once all the layers were fitted, the whole bulkhead assembly became very rigid.



- 21 After bevelling the sheer clamp notches, we tried fitting the first layer in one 5" [125 mm] wide piece. Because of the sheer of the hull, there is a lot of edge set and this caused the plank to twist out of true between each bulkhead.

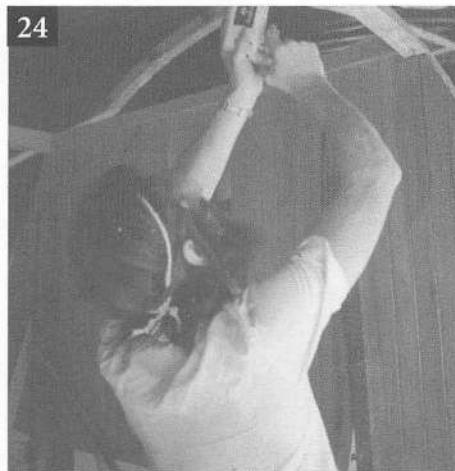




- 22 We got around this problem by sawing the plank into three and, in effect strip planking the first layer. Thin dowelling was used to keep the strips in line with each other.



- 23 The second and subsequent layers were glued on and scarfed to length using the full width, with no further problems.

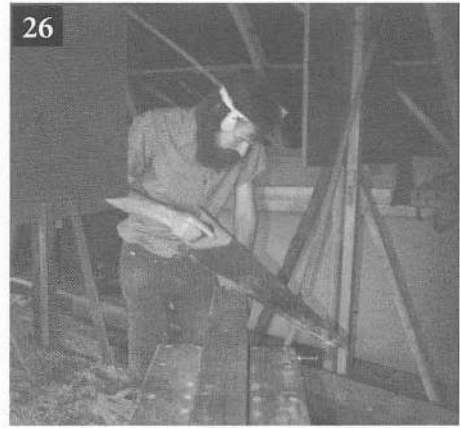


- 24 With the sheer clamp laminated up, the basic framework of the hull was complete. The inside edges of the chine log and sheer clamp were sanded smooth. It was much easier to do this now, before the planking went on.



- 25 The bottom of the boat was faired up ready for the first layer of planking. With the power plane, the chine logs, stem and stern were planed smooth and faired from side to side, using a batten to show the high spots.

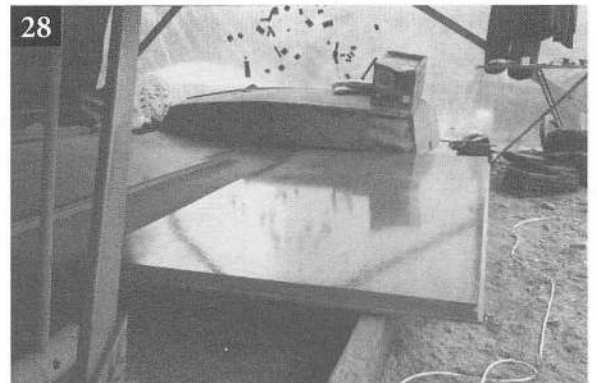
26 The floors are the heavy timbers, which span the bottom of the hull and through which the bolts for the ballast keel pass. They were laminated up to size, epoxy coated and sawn to fit between the chine logs.



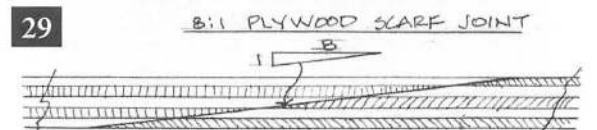
27 The floors were glued in place, held by clamps. Once the glue had set, a 3/4" [18 mm] dowel was glued through both floor and chine log at an angle, to tie them together. Note that the chine log was not notched to take the floor. The floors were faired smooth, with the rest of the bottom.



28 In preparation for planking the hull, sheets of plywood were flow-coated with epoxy. These formed the inside layer. Flow-coating effectively puts the equivalent of three coats of epoxy on the surface in one go, with no sanding between coats. Not only does this save a lot of time, but it also gives a good, smooth finish.

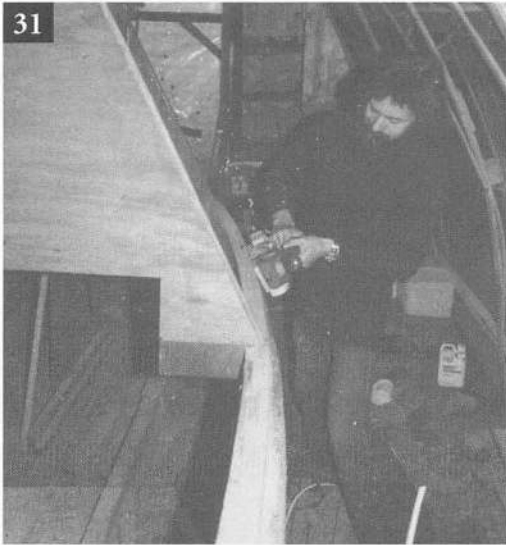


29 Using a scarfer attachment on the portable circular saw, the plywood was scarfed, where necessary, to the required width at bow and stern on the bottom of the boat. The scarfer gives an 8:1 bevel to the plywood.

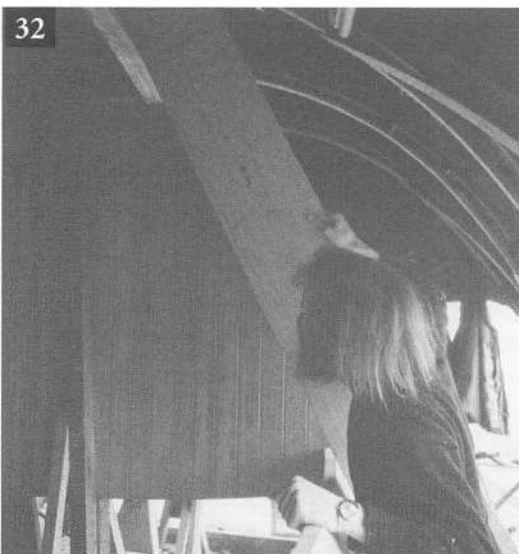
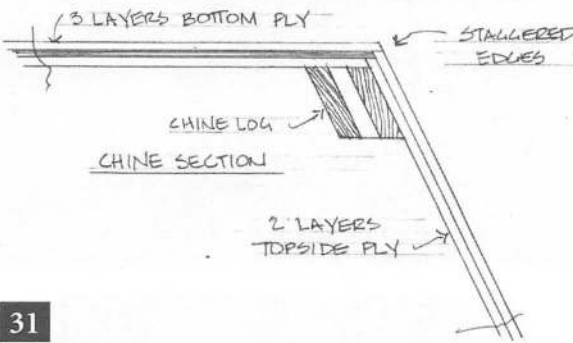




30 The bottom of the boat is built of three layers of 3/8" [9 mm] plywood and the topsides are of two layers of 3/8" [9 mm] plywood. The first layer of plywood was put on the bottom. The plywood was scarfed at the joints, which were arranged to be over bulkheads or floors.

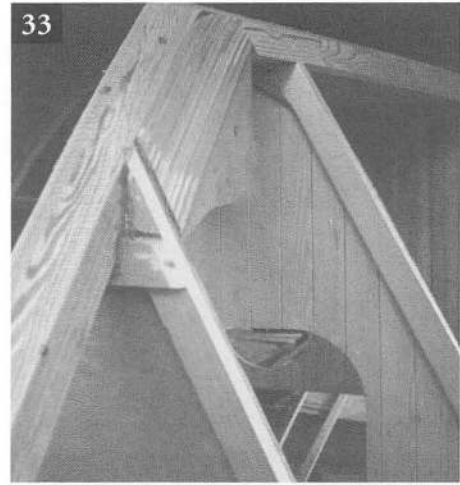


31 We decided to stagger the layers of plywood on the hull, so that as much of the endgrain of the plywood as possible, would be covered up, once the first layer was put on the bottom. The next job, therefore, was to put the first layer of topside plywood on. The sheer clamp, chine log, stem, stern, bulkheads and the edge of the plywood on the bottom of the hull, were all planed fair



32 A fairing batten was used to ensure that the plywood would lie flat.

- 33 The bow and mast step were also planed down to fair in with the hull, ready for the first layer of plywood.



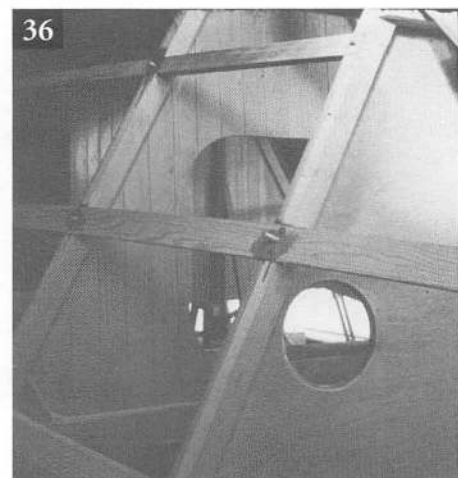
- 34 We decided to fit two stringers to each side of the hull in order to make planking easier and to add additional strength. Notches were cut into the bulkheads to take these.

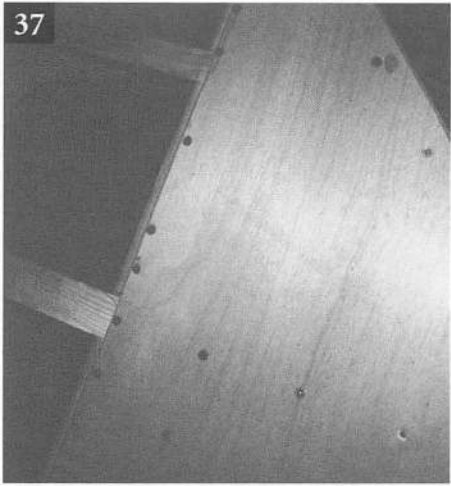


- 35 The photograph shows the stringer being fitted at the stern. The vertical piece of wood keeps the stringers in line with the chine and sheer, while fitting them to the stern. This was needed because of the large curve of the stern section.

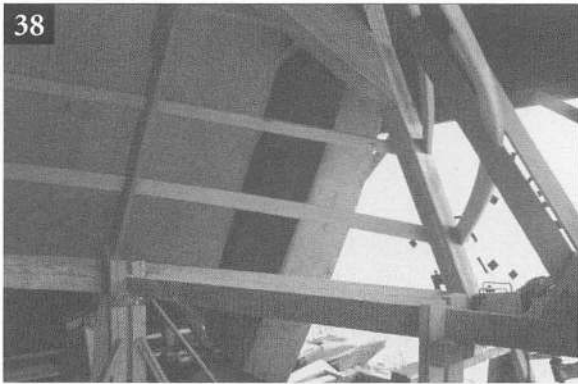


- 36 The stringers were glued to the bulkhead using temporary steel screws and permanent wooden dowels.





- 37 Starting at the bow, the first layer of plywood was fitted. Note the temporary greased, steel screws, with washers underneath. The first layer of plywood was butt jointed onto a bulkhead or stringer, wherever possible.



- 38 In this photograph, the first layer of plywood is being fitted at the stern, the flow-coated inside face can be clearly seen. The coated surface made cleaning up excess glue around the stringers and bulkheads much easier. It was very worthwhile to clean up the glue before it set.

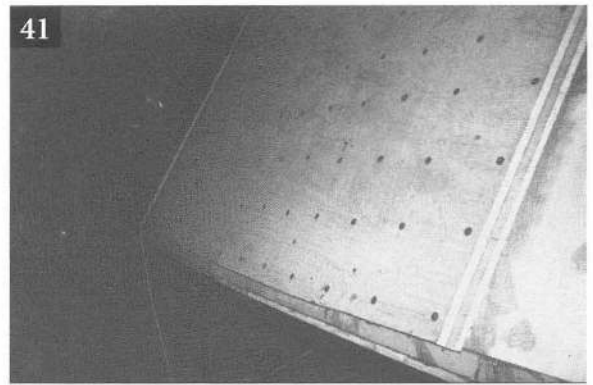


- 39 The first layer on the bottom of the hull was prepared for the next layer. The edge of the topsides plywood was planed flush and the joints on the bottom were sanded smooth, after which the screw holes were all filled.



- 40 The second layer was fitted to the bottom. The panels were scarfed together *in situ*, with the joints staggered so that they were in different places from the first layer. The sheets were held with a regular pattern of temporary 3/4" [18 mm] steel screws and by using a washer, we ensured that they did not penetrate the inner layer. Longer screws were used to secure the plywood to the bulkheads, floor and chine log. These were also removed once the glue had set.

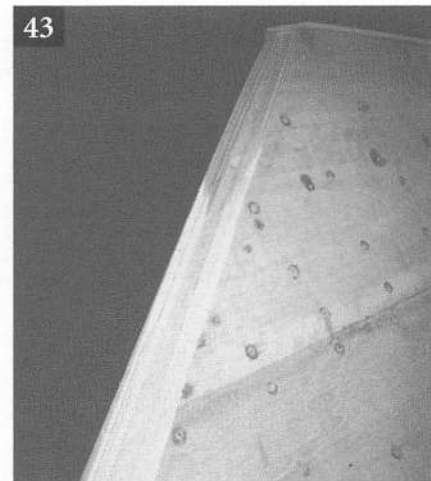
- 41 The second layer was fitted to the topsides. Each piece was scarfed to the next, *in situ* and the joints staggered from the first layer. As on the bottom, temporary 3/4" [18 mm], greased steel screws with washers, were used to hold the plywood in place, with larger ones in the bulkheads, stringers, etc.



- 42 Before fitting the final layer to the bottom, large dowels were glued into the stem and stern knees. These took the place of metal bolts, specified in the plans.

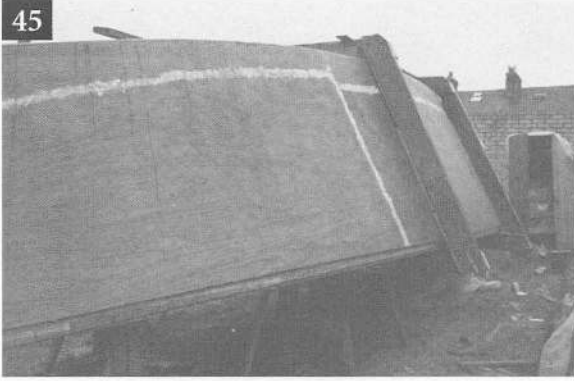


- 43 Once the final layer of plywood was on the bottom of the hull, the planking at the bow was planed smooth to take the capping piece of pitchpine, which covers the end grain of the plywood. The stern was treated similarly.

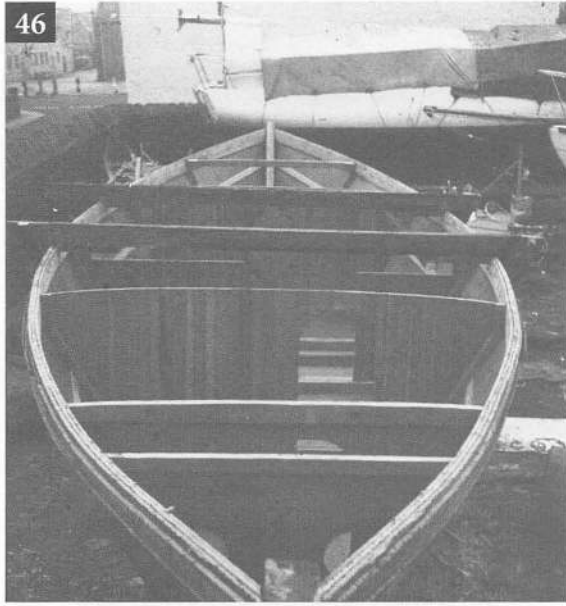


- 44 The hull was now planked up. The next job was to fill all the holes and joints and smooth them ready for covering with glass and epoxy. We started building the shed in May and finished planking up just before Christmas. Over the New Year, a severe gale demolished the shed, so we decided to leave sheathing the hull until later, but it would have been much easier to have done it at this stage.

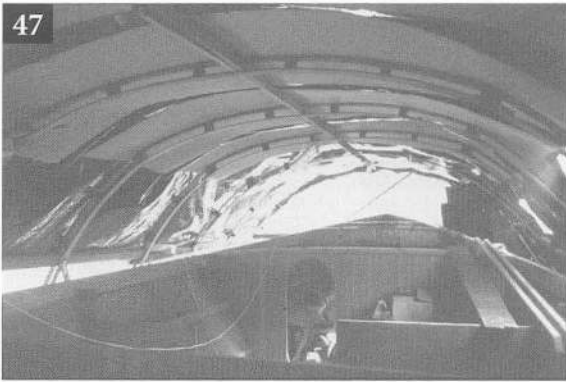




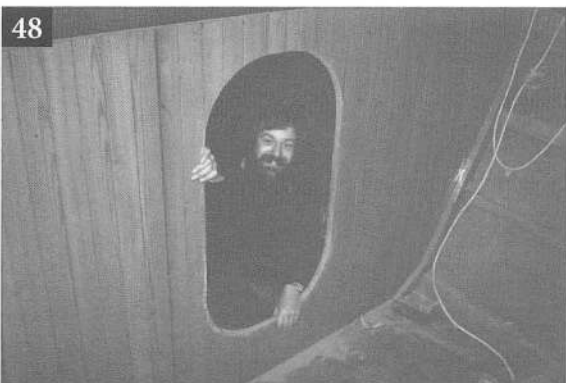
- 45 Having postponed glassing the hull, we prepared it for turning over. Two frames were built around the hull, designed both to protect its surface and to support it at deck level.



- 46 The hull was turned right way up using ropes and a gang of people recruited from the pub next door. Ropes to either side of the framework controlled the speed at which the hull rolled over. It only took half an hour, but this was as long as such a large crowd could be controlled.



- 47 Once the hull was the right way up, a new shed, similar to the first one, was built around it. The hull was carefully levelled, so that we could use a spirit level during the rest of the construction.

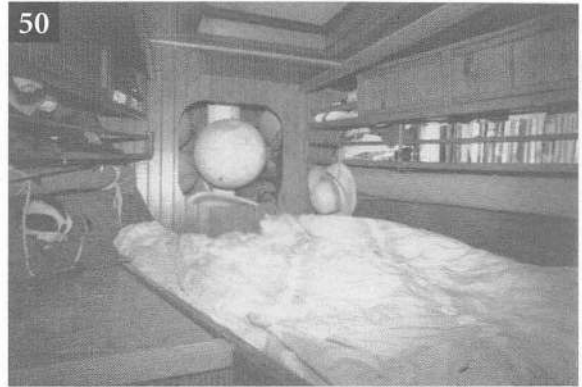


- 48 The openings through the bulkheads at either end of the main cabin, were cut out.

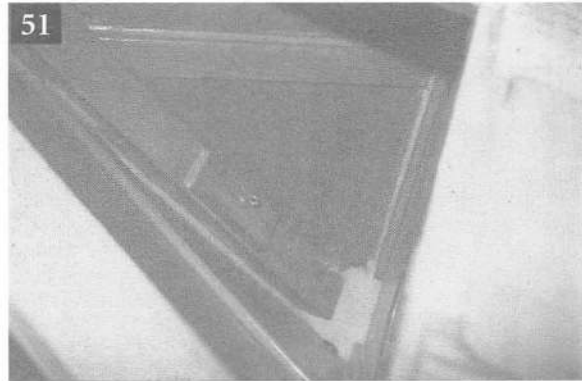
- 49 The forward cabin was fitted out before the deck was put on, which made things much easier. The foredeck framing was fitted, ready for the plywood deck.



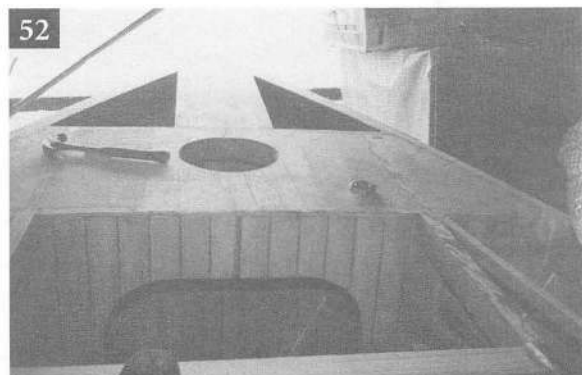
- 50 The completed forward cabin, looking forward. The top lockers on either side hold clothes and the lower shelves hold paperback books. The green tube to starboard contains the sail for the dinghy and the one to port is the sun awning to go over the cockpit. Underneath the shelf, alongside the bunk, is a locker for shoes and linen.



- 51 Before the foredeck was fitted, the bow section was completed. Left-over epoxy had been poured into the bottom in order to bring the level well above the waterline, so that it could be made into a self-draining chain locker. A hole was made through the hull near the top of the epoxy and a teak finger ring was glued into the hole, to seal the endgrain of the plywood. Slightly thickened epoxy was poured into the bottom until it reached the level of the hole. Note the eyebolt glued in for the bitter end of the anchor cable.



- 52 A 12" [300 mm] wide piece of 3/4" [18 mm] plywood was set in between the bow and No 1 bulkhead. This was to give extra strength to the foredeck, where the anchor windlass was to be bolted. The whole area between No 1 and No 2 bulkhead was beefed up to take the loads of the foremast. A laminated piece of Douglas fir, 4" [100 mm] thick and 18" [450 mm] wide, was set between the bulkheads. A piece of 1/2" [12 mm] plywood was rebated in on either side of it.

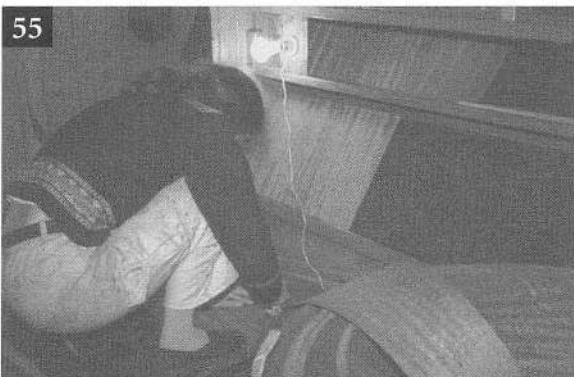




- 53 The first sheet of plywood was put on the foredeck. The plywood was butt-jointed on the fore and aft stringers.



- 54 The second layer of plywood was fitted to the foredeck. The joints were staggered from those of the first layer and scarfed, using the same procedures as when building the hull.

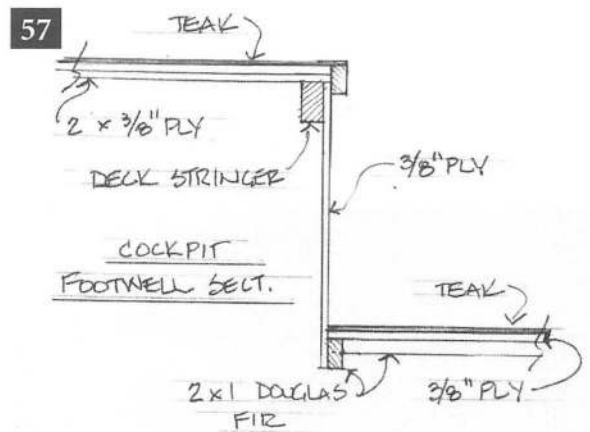


- 55 The interior—locker bottoms, topsides and deckhead—were clad with 1/2" [12 mm] cork, with a thin wood veneer glued on top. This was to insulate the boat and help prevent condensation. Although this has worked well, fire-retardant polystyrene foam might be a better alternative, being both lighter and easier to work.

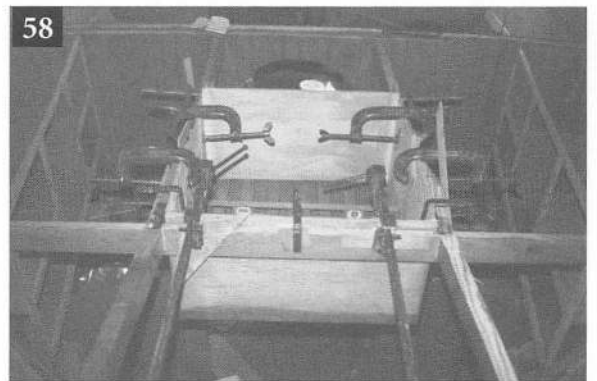


- 56 The lazarette was fitted out as a storage area, again before the deck was fitted. The lower lockers were designed to hold several 4 1/2 Imp. gallon [20l] drums, for storing paraffin.

- 57 The cockpit footwell was constructed, before installing it in the boat. The bottom has strips of teak glued on top and the four sides were filleted together at the corners and covered with glass cloth and epoxy.

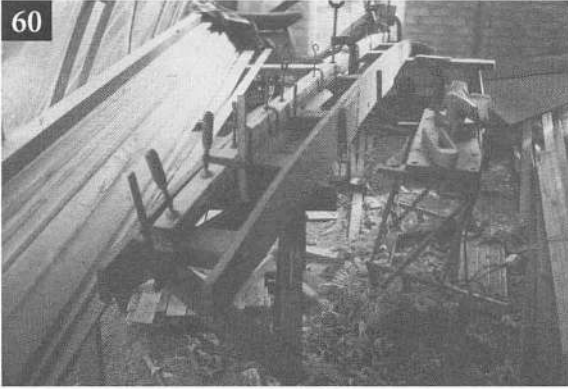


- 58 The footwell was glued in place between the deck stringer and the after frame, using a spirit level to ensure that it drained aft, where drainage holes were fitted in each corner.

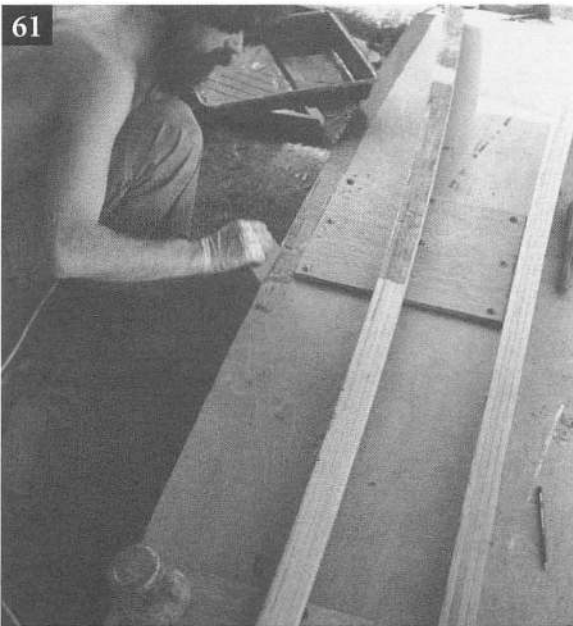


- 59 The two layers of plywood were fitted to the after deck.





- 60** A former was made to laminate up the deck beams. The beams were of five layers of  $\frac{3}{8}$ " [9 mm] pitchpine,  $1\frac{1}{2}$ " [37 mm] wide.

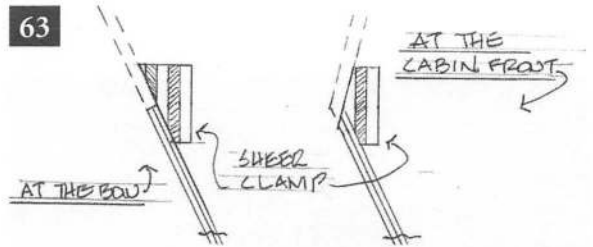
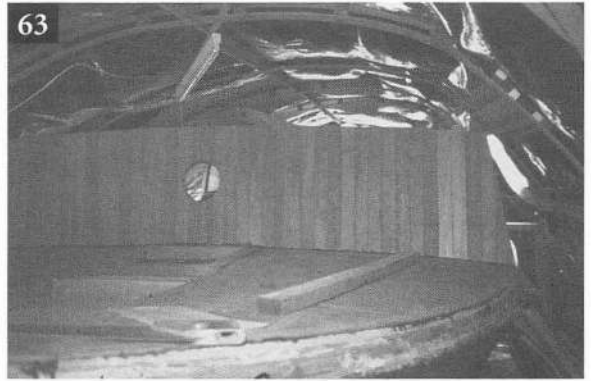


- 61** The front of the cabin was constructed of  $\frac{3}{4}$ " [18 mm] plywood, with a half lap where it was joined to get sufficient width. Laminated beams were glued to the inside of the plywood. Note the two  $\frac{1}{2}$ " [12 mm] plywood blocks for the forward scuttles. The rest of the plywood was covered with  $\frac{1}{2}$ " [12 mm] cork insulation.



- 62** The cabin front was dry fitted before finishing.

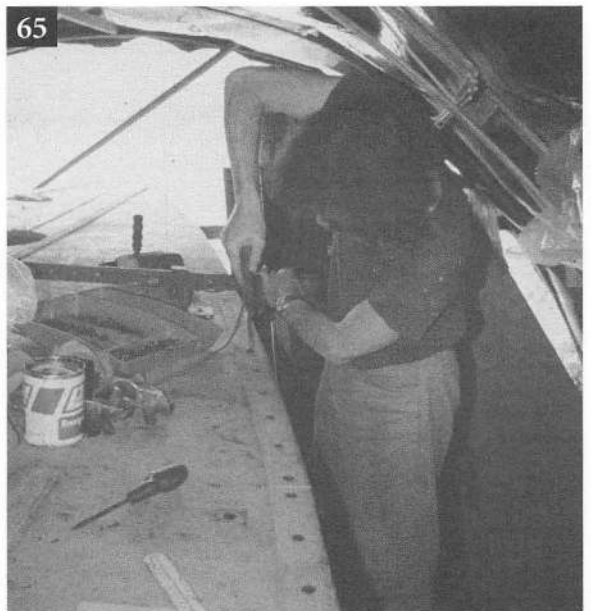
- 63 With the cabin front and back dry fitted, the sheer clamp could be planed down for the bulwarks/built-up cabin sides. Using a power plane, the sheer clamp had to be shaped from the flare at the bow and stern to the tumble home of the cabin sides.



- 64 Once the fore and after deck edges were planed true, the cabin ends were removed. The teak overlay decks were laid on the fore-deck. It was much easier to do this before fitting the bulwarks. In the photograph, a teak plinth is being glued on around the hole for the forehatch. The aluminium hatch was fastened down at a later date.



- 65 The covering board was fitted and glued into place. The teak used was 3/16" [5 mm] thick in accordance with the method described by the Gougeon Brothers.

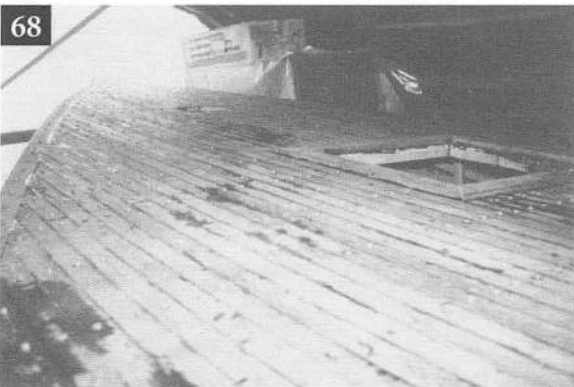




- 66 Using the edge of the deck as a guide, the covering board was routed to an even width, following the curve of the deck edge.



- 67 The rest of the deck was laid straight. It was dry fitted and then glued down, using temporary greased, steel screws and washers, until the glue had set. The excess glue squeezed up between the planks to form the 'caulking' seam.

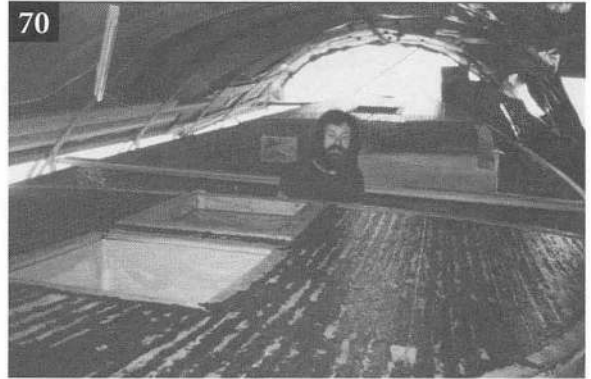


- 68 The screws were removed and the holes drilled out to take a plug. The plugs were tapped in after filling the screw hole with glue.

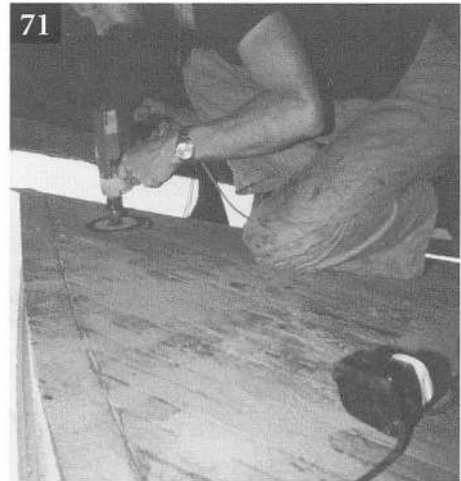


- 69 The afterdeck was laid in the same fashion.

- 70 This photograph shows the fore and after-decks ready for finishing.



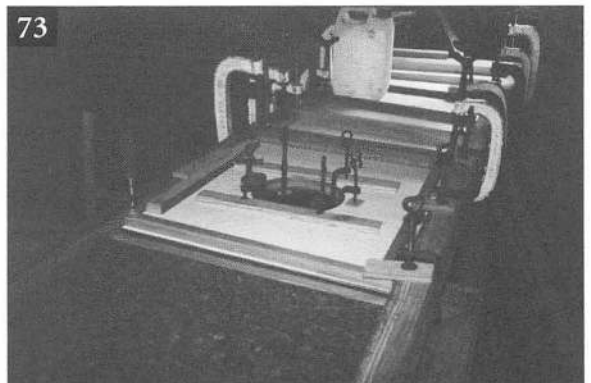
- 71 The deck was completed using a disc sander to remove the bulk of the glue and any high spots, before smoothing over with a belt sander. The final finishing was done using an orbital sander.

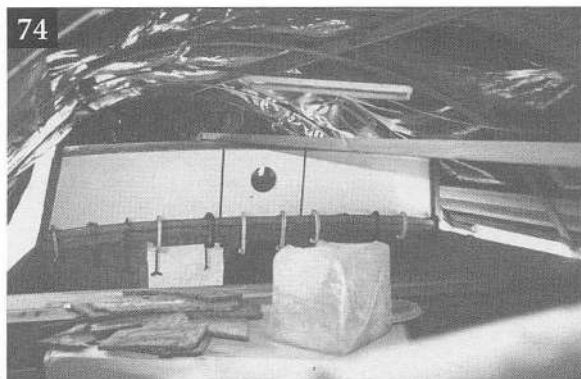


- 72 The front of the cabin was finished with teak veneers to give a tongue and groove effect—this was done the same way as on the bulkheads.



- 73 The inside of the cabin was insulated with cork and finished with matt white, melamine sheet.





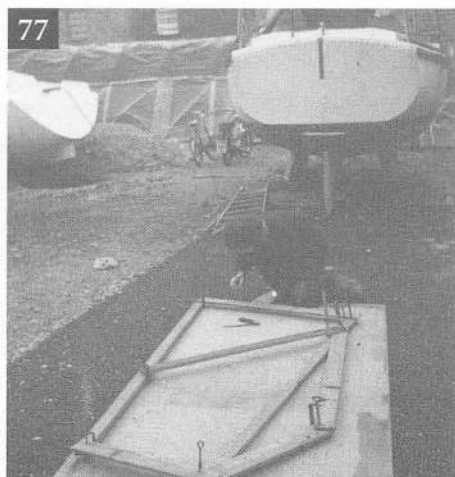
- 74 The ends of the cabin were glued into place and held with clamps. When the glue had set, 1/2" [12 mm] dowels were glued into the beams, vertically from the bottom. These took the place of bolts.



- 75 With the front and back of the cabin fitted, work could start on the framework for the raised cabin sides and the centre deck. Two small fore and aft partitions were fitted either side of the companionway. A pattern was made from scrap plywood (a glue gun works well at spot gluing the pattern together). In the photograph, the cut-out plywood is getting a trial fit.

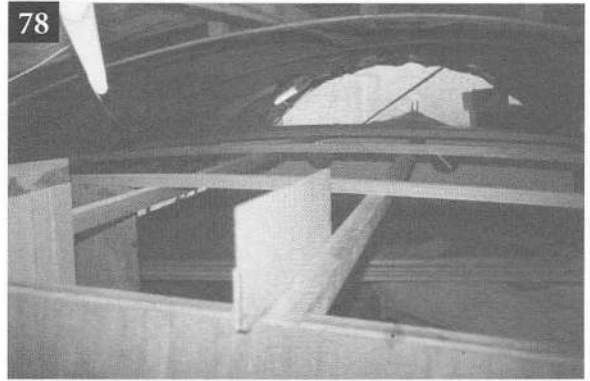


- 76 A former was made up for laminating the hanging knees that tie the cabin sides and centre deck together. The knees were made larger than shown on the plans in order to help support the extra load imposed on the centre deck by the unstayed mainmast. The former was made by bolting wood blocks to a piece of thick scrap plywood. The laminates were sawn just thin enough to bend around it, about 3/16" [5 mm] and finished up 2 1/2" [62 mm] thick by 1 1/2" [38 mm] wide.



- 77 A partial-bulkhead, forming the heads compartment was marked out on plywood from a pattern.

78 The main deck support is formed by two longitudinal stringers, either side of the centreline and from three deck beams, supported by the hanging knees and the heads bulkhead. The beams were laminated up on the same former as that used for the cabin ends. The stringers are in place, in the photograph, with the two after partitions and heads bulkhead. The deck beams are lined up and the stringer has been marked for notching.



79 The deck beams and hanging knees were glued into place, together with the heads bulkhead.



80 The raised-deck sheer clamp was then laminated to the cabin ends, the knees and the heads bulkhead. This was very similar, in method, to fitting and laminating the chine log.



81 The raised-deck framework was now complete and ready for fitting the cabin side. Note the extra-thick knees which take the main loadings from the mast. A finishing piece of wood has been glued between the knees on the sheer clamp, to cover the 'strip-planked' piece.

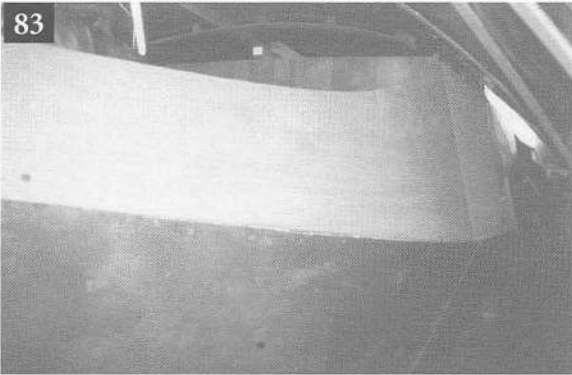


82



82 It would have been more convenient to have fitted out the centre cabin before the plywood sides and deck went on, but as we were about to be evicted from our building site, the plywood went on to make *Badger* weatherproof. The first layer of the cabin sides is shown fitted in this photograph.

83



83 The bulwarks at each end were scarfed to length and the insides coated with epoxy, ready for painting, before being glued on. The cabin sides were butted together on the cabin ends and centre knees. The next layer was scarfed in place, with the joints staggered as usual.

84



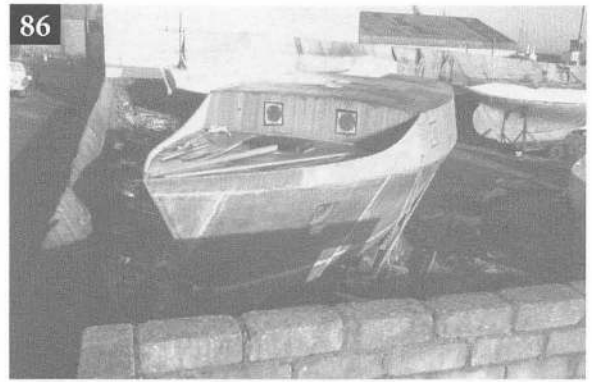
84 Before the centre deck was fitted, two layers of 1/2" [12 mm] plywood were rebated between the deck beams, all the way across the cabin, in way of the mast and glued in place. These were to strengthen the deck for the unstayed rig. The deck, two layers of 3/8" [9 mm] plywood, was then laid in the same manner as the fore and after decks.

85



85 The deck was now on. A 1/2" [12 mm] plywood filler block was put where the scuttles would be bolted on, then 1/2" [12 mm] cork insulation was stuck down and the sides finished off with melamine sheet. Note the plywood scuttle filler extends the full height of the cabin sides alongside the mainmast.

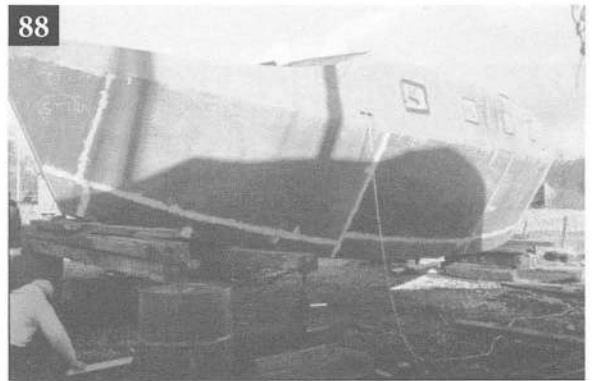
- 86 We now had to move *Badger* round to a new site. The shed came down and we saw her for the first time with the basic structure completed.



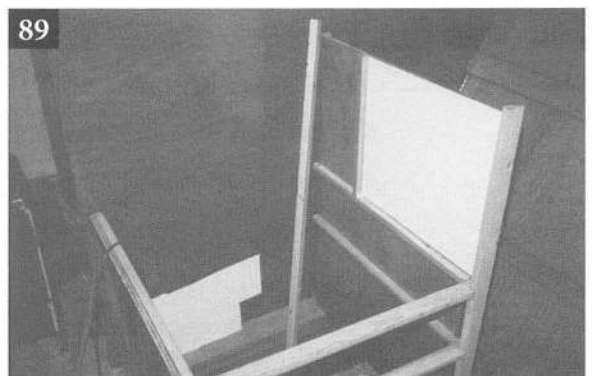
- 87 We were lent a trailer and, after jacking up the boat, the trailer was run underneath. A friendly local farmer towed us around to our new site, a marina, one mile away.

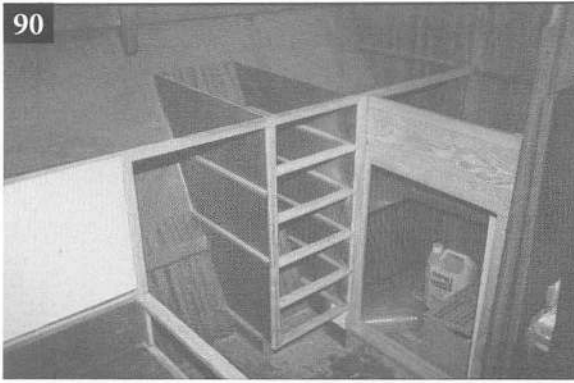


- 88 Once off the trailer, in her new home, *Badger* was levelled up. We did not bother rebuilding the shed and just put the old cover over her.

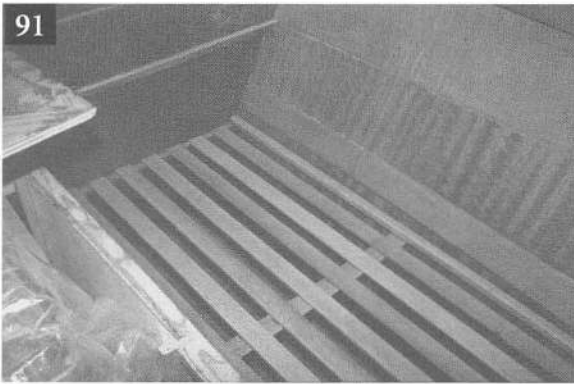


- 89 Work now started on fitting out the centre cabin. In the galley, the cooker, a Dickenson 'Bristol' diesel range, was fitted athwartships and a shelf was built below for pan stowage, with a storage locker underneath.





- 90 The rest of the galley was fitted out. The two bulkheads, of 1/4" [6 mm] plywood, which support the drawers, were filleted to the hull. The drawers run on rails of 1" [25 mm] x 1" [25 mm] timber, glued to the bulkheads.

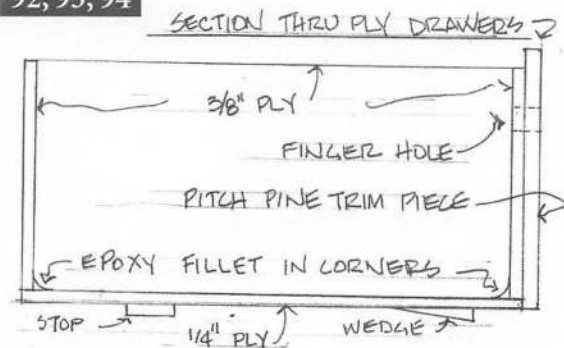


- 91 The shelves in the lockers were made of slatted wood, to help air circulation. Box fiddles then divided up the space, to prevent the contents from sliding around at sea. The sides of the hull had already been insulated with cork and covered with veneer.

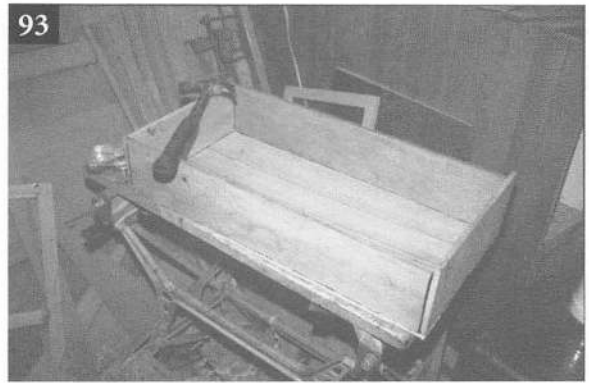


- 92 The drawers were simply made from plywood, the sides being 3/8" [9 mm] and the bottom of 1/4" [6 mm]. A wedge was glued on the bottom at the front of the drawer to lock it in place when the drawer is shut, and a stop was fitted near the back, to prevent the drawer from coming out.

92, 93, 94



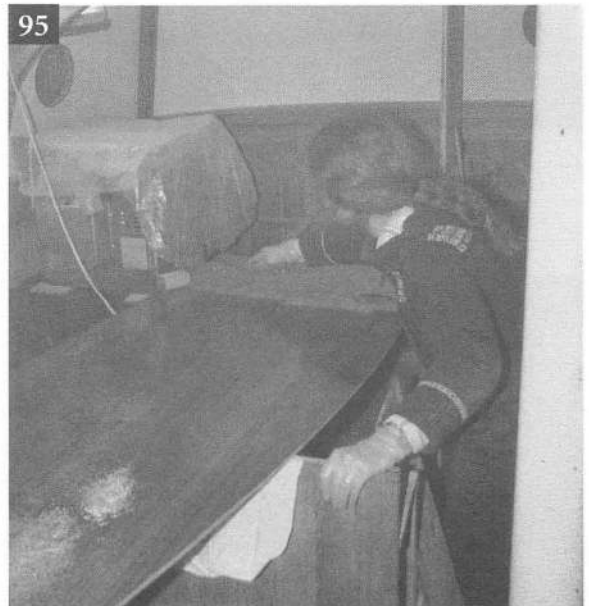
- 93 The pieces were butt joined and glued, then all the corners were filleted.

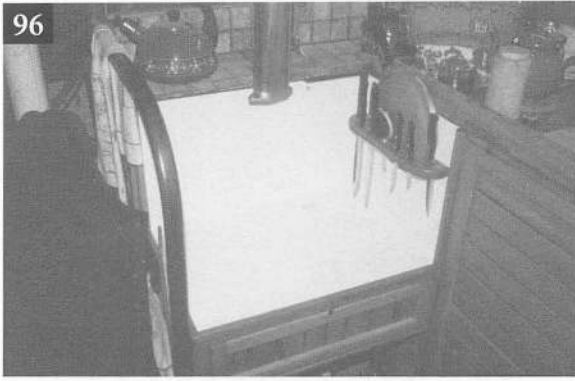


- 94 A trim piece of pitchpine was glued to the front to finish off the drawer. Two finger holes are used to lift and open the drawers.

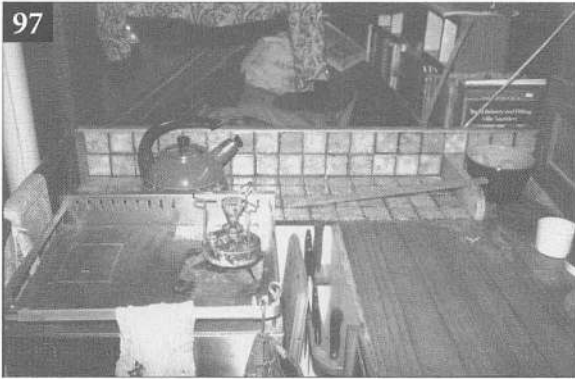


- 95 The galley counter, which is 6 feet [1.8m] long, was made from 1/2" [12 mm], teak-faced plywood. It was coated with epoxy before being installed.





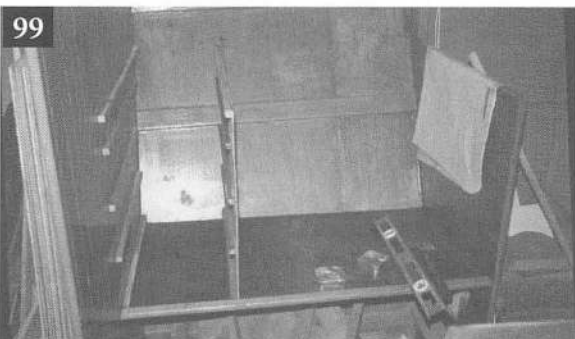
- 96 The cooker shelf was lined with melamine sheet. To the right in the photograph, is a knife rack and stowage for the pressure cooker lid. To the left is a laminated teak hand rail (a good place on which to hang the tea towel to dry!).



- 97 The Dickenson range was installed; a tiled shelf forward of it provides a good place to put hot pans. We later added removable fiddles to divide it into four, to stop pans sliding about at sea.



- 98 In the finished galley, there are lockers outboard of the counter, with a shelf for herbs and spices. To the left is the double sink made of teak-faced plywood, with hand pumps for fresh and salt water. A deep fiddle runs along the edge of the counter.

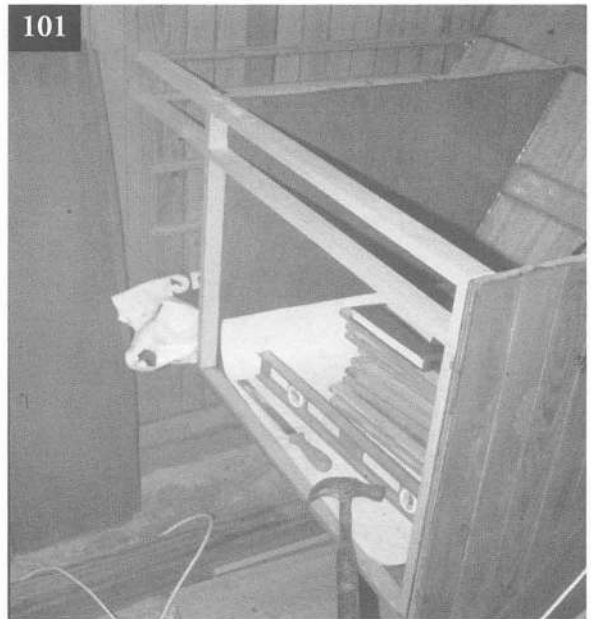


- 99 The chart table will take a standard, unfolded British Admiralty chart, and is used standing up. To the left, in the photograph, will be a stack of drawers and to the right, a large chart stowage locker.

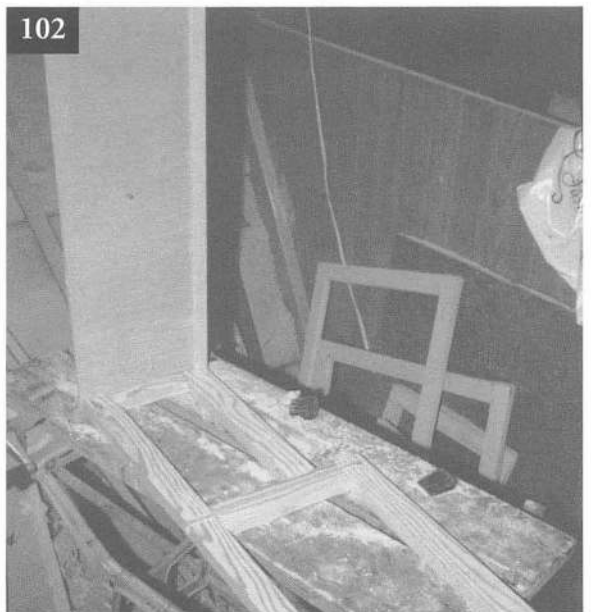
**100** The hull was lined with cork and thin veneer.



**101** The framing for the doors and drawers was built in. The top of the chart locker forms a ready-use shelf for charts. Underneath the locker, is stowage space for the battery and jerricans of water.

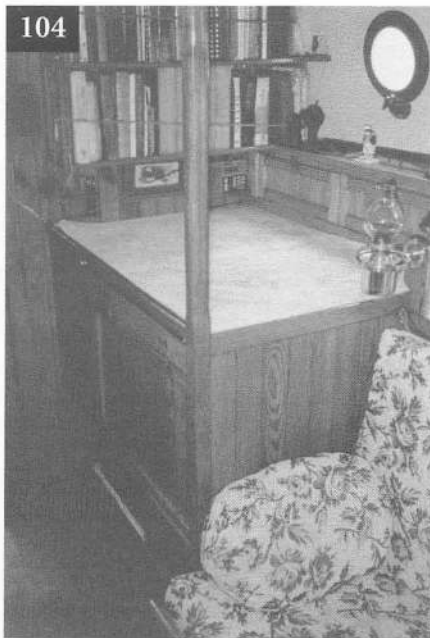


**102** A bookshelf on the heads bulkhead, over the chart table, was framed up and shelved with plywood.

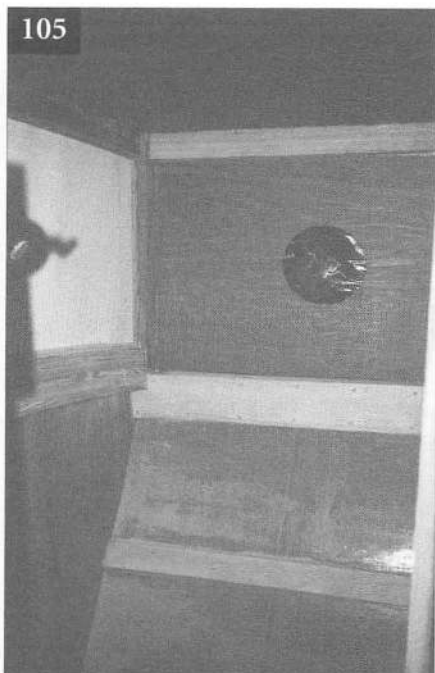




**103** The basic structure of the chart area was completed, ready for the drawers, doors and the melamine sheet which covers the chart table top.

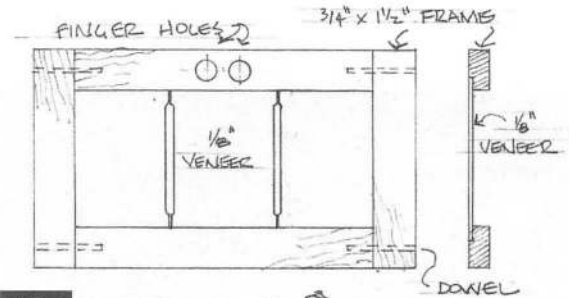


**104** The chart table was finished and varnished.



**105** The heads compartment was fitted out next.

**106** In this photograph, the heads is nearly finished. The locker fronts were simply made of butt-jointed  $1\frac{1}{2}$ " x  $\frac{3}{4}$ " [38 mm x 18 mm] framework, with the joints doweled after the glue had set. A rebate was routed into the back of the framework and  $\frac{1}{8}$ " [3 mm] veneers of pitchpine were glued in. The backs were planed smooth and a few air gaps were routed out. Finger holes were made in the framework.



**106** LOCKER DOOR

**107** The heads compartment was finished and varnished. The bulkhead to the right, in the photograph, is covered in melamine sheet. The washbasin is simply a stainless steel bowl, which is emptied down the heads. The hand pump feeds from a 1 Imp gall [5 litre] jerrican which fits under the counter. The heads itself, a *Porta-Potti*, is out of sight, to the left, against the after bulkhead. Oilskins hang on hooks, next to the heads.



**107**

**108** A simple framework and veneer door was fitted to close off the heads. The holes in the partition form a ladder leading to the top 'control' hatch.



**108**



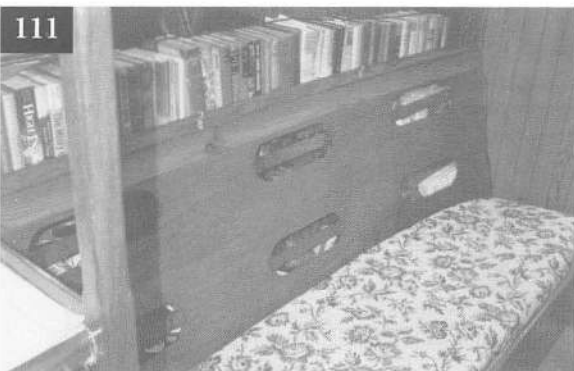
109

**109** The saloon was fitted out with settees on either side. There are lockers under the settees and lockers and bookshelves behind the back rest. The settee front, shown here, was made of plywood covered in pitchpine veneers.



110

**110** The settee front was fitted around the floors and glued and filleted to the bottom of the hull. Two small plywood bulkheads divide the locker up and support the front and top.



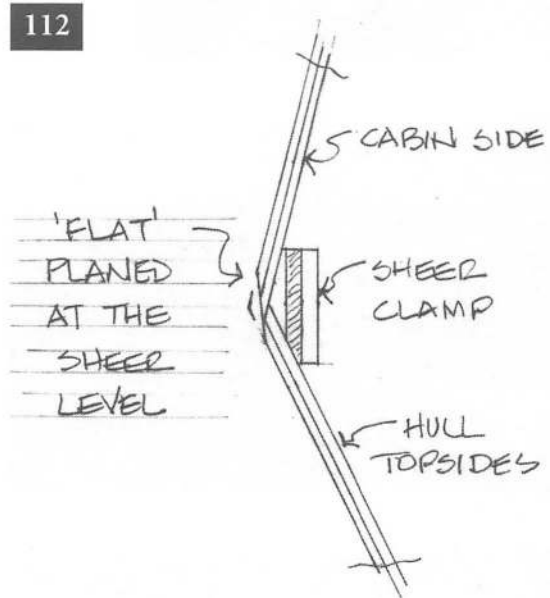
111

**111** The lockers behind the backrest are simple cave lockers with removable fiddles to hold the contents in place. The rope over the books keeps them in place in rough weather.

**112** Ideally, the hull would have been fibreglassed before we turned it over, but, you may remember, a gale blew the shed down before we could do that. We fibreglassed the hull in two stages. The cabin/bulwarks and the hull topsides were done in one stage and then the bottom, of the hull, after the keel had been fitted.

The first job was to plane a vertical 'flat' at the junction of the hull and cabin sides, using a power plane. The width of the 'flat' was to be that of the rubbing stake and the 'flat' also tapers out at the bow and stern. The accurate planing of this 'flat' is very important as it defines the sheer of the hull. The hull and cabin had been given a coating of epoxy previously, and the first pass with the planer had given a very distinctive lighter line along the sheer. Being in the open, it was easy to stand back and look at its fairness. As it happened, the sheer needed lowering amidships, to produce a sweet line. This was fudged by planing more of the hull side of the 'flat' amidships, which meant that the 'flat' was not quite vertical amidships.

However, I feel that a sweet sheer will make or break the look of the boat, so it is very important. Once the rubbing strake 'flat' was planed on both sides, the whole hull was sanded with a coarse grit, to give a good key, and any nicks or dings in the surface were filled with epoxy putty and sanded smooth.



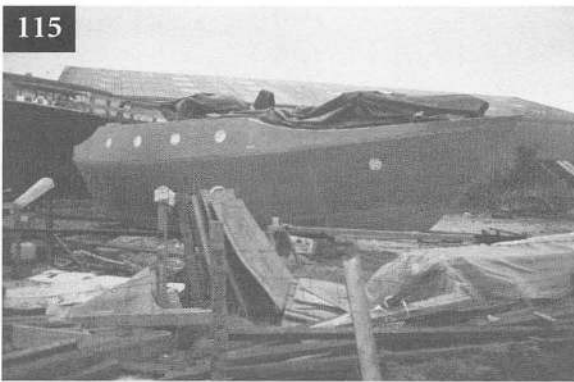
**113** The object of sheathing the hull is to give a hard surface, and to make sure that there is a good thickness of epoxy over the plywood. We used 6 oz [140 gm] cloth and put it on in vertical strips, from the top of the cabin, down to the chine. Using a full-width roller and a paint tray, the hull was given a preliminary coating of neat epoxy resin for the width of the cloth.





114

114 The pre-cut length of cloth was then hung from the deck and smoothed over the wet epoxy by hand (encased in a rubber glove!). The epoxy is sticky enough to hold the cloth in place. Another coat of epoxy was then rolled over the cloth to wet it out completely, making sure that there are no resin-starved white spots or shiny patches with too much resin. A squeegee helps here. Before the epoxy goes off, check again for any trapped air bubbles and get rid of them. The next strip was given a little overlap on the previous one. This is pleasant work if you do it on a calm day.



115

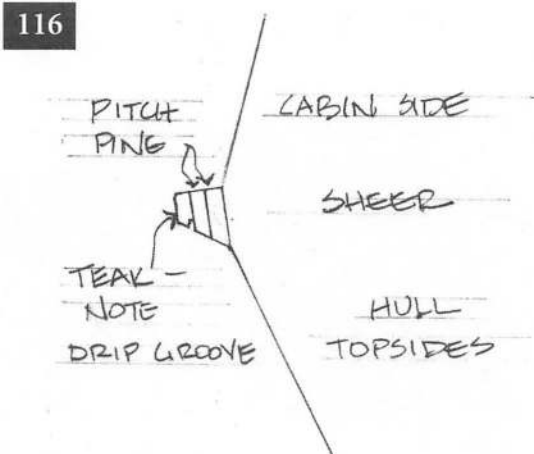
115 The overlaps were sanded smooth, followed by sanding the whole hull ready for the next coatings.



116

116 Before putting the final coatings of epoxy on, we glued the rubbing strake onto the hull. This was done in two layers, using pitchpine. The inner layer was scarfed to length and dry fitted to the 'flat' on the hull. The sheer was checked by standing back and sighting along it. The rubbing strake tapers out at each end, and this was marked on the wood. The wood was taken off, the ends shaped and the top and bottom edges planed smooth. This piece was glued in place using steel screws (which were removed when the epoxy had set). The next layer was shaped to fit, with an allowance for final finishing, and glued in place (the scarf joints being glued on the hull).

Once the glue had set, the screws were removed and dowels glued into the screw holes. The outer layer was planed flush, top and bottom, with the inner layer. The final layer of the rubbing strake was of teak, which was put on in the same manner as the second layer. This was, however, done at a later date.



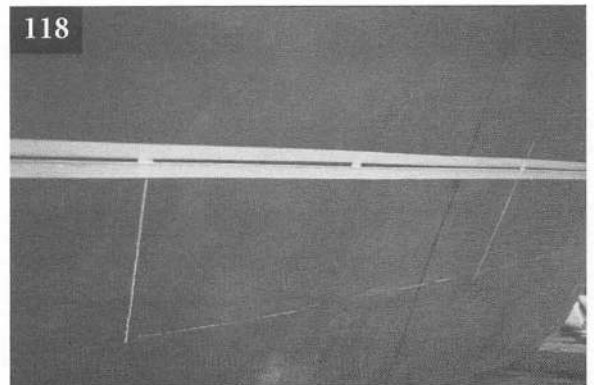
116

- 117 The weave of the cloth was filled, using pigmented epoxy, thickened with some fillers. As we planned to paint *Badger* black and cream, we used black pigment below the rubbing strake and light grey above. Filler was added to the epoxy to help fill the weave, but not so much that it would make it difficult to roll out the epoxy. The rubbing strake was coated at the same time. Two coats were used on top of the glass.



- 118 Jay gave *Badger* a generous boot top (which is now our waterline!) and we glued a piece of whipping twine to the hull to mark it. This has proved very successful and makes painting either the topsides or the bottom an easy job, with no masking tape required.

The (designed!) waterline was marked on the hull using the water gauge and measurements were taken up from the waterline at regular intervals, to get the boot top line (as shown on the plans). Masking tape was run between the marks and sighted along, to check for a fair line. A second length of masking tape was run along the hull about 1/4" [6 mm] above the first. The whipping twine (unwaxed) was taped to the bow and stretched along the hull in the 1/4" [6 mm] gap. A piece of tape kept it in place at regular intervals. Using a small brush, pigmented epoxy was brushed over the twine and the 1/4" [6 mm] gap. Once the epoxy had set, the short pieces of tape were removed from the twine, and these places were also soaked with epoxy. Finally, the masking tape either side of the twine was removed.





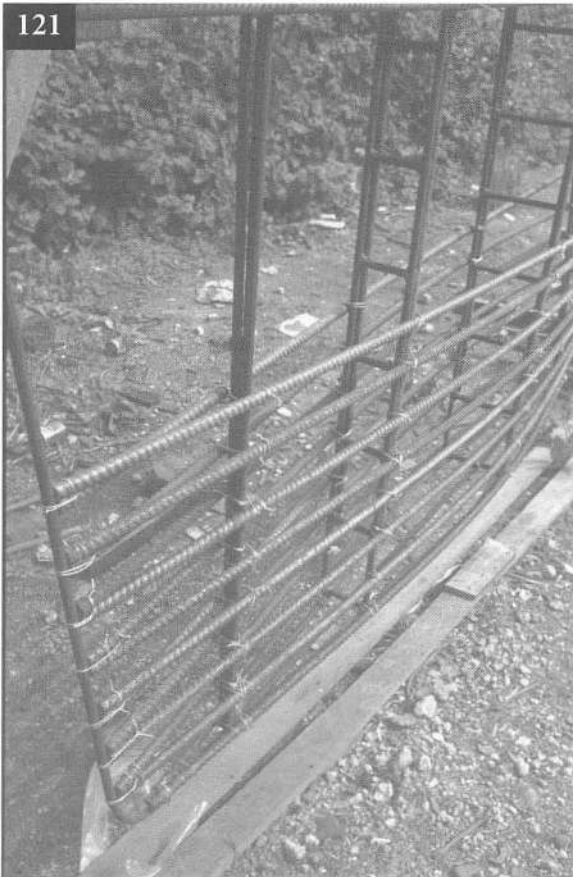
119

- 119** The ferro-cement keel has the distinct advantage of being fairly easy to build, with only a small amount of welding to do. However, the materials are not that cheap and the centre of gravity of the keel is quite high. We have since changed the keel to a cast-iron, Collins Tandem keel (a wing keel) which we bought cheap. It has a centre of gravity 12" lower than the ferro keel and reduced the draught by 7" [175 mm]. We found *Badger*, with her heavy masts, initially tender with the ferro keel. If we were doing it again, I think that we would get someone to weld up a steel keel box, which we would fill with lead to the desired weight. A flange at the top of the keel could be used to bolt it to the hull.



120

All that aside, here is how we built the ferro keel. Having cut out the steel for the ladder frame and keel bolts (steel threaded rod), we got someone to weld up each frame from our kit of parts. The frames were then hung from a simple overhead framework by the keel bolts and all lined up with the drawings.



121

- 120** The leading and trailing edges were wired in place. Note that the keel is suspended some distance above the ground—this made it much easier to work on without bending down all the time, and enabled us to get at the bottom of the keel.
- 121** The longitudinal reinforcing bars were wired on at the correct intervals. I used pliers and steel wire to do this. A loop around both pieces of metal and a few turns of the pliers, snip the excess wire off and push the turns flat. You get quite quick at it after a while.

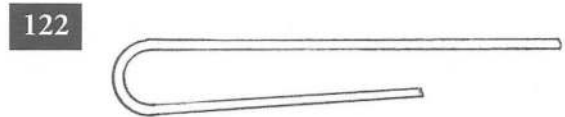
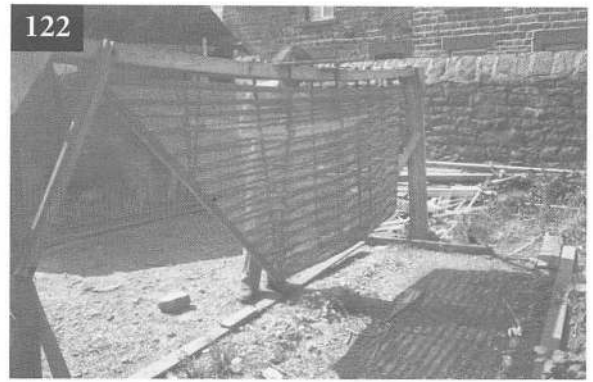
**122** The upper longitudinal should be level with the top of the ladder frames and I was careful to check again, that the curve it took matched that of the bottom of the hull. A simple plywood pattern was made to fit the curve of the bottom, where the keel would fit. Once all the longitudinals were on, the first layer of weldmesh was put on, followed by the other two—all joints staggered.

Now the tedious job starts: wiring the whole together at 3" [75 mm] centres. I found that the easiest way to get the wire through the mesh and out again was to bend it in this shape:

Holding the long end with the pliers, I pushed the loop through a hole and pulled it with the pliers. With any luck, the short end will come out of a different hole. The ends are twisted tight and any excess wire snipped off, with the twist pushed into the mesh.

**123** With the metalwork of the keel completed, it was lowered to the ground onto a board, covered with plastic sheeting. A simple framework held it upright, so as to provide easy access to the top of the keel. We were lucky that a friend, Barry Whorral, had built a ferro-cement boat and he gave us good advice on pouring the keel. For ballast, we were using steel punchings from a neighbouring silencer [muffler] factory. (We got a good deal because Annie worked there) Barry suggested pouring in a layer of concrete, followed by a layer of punchings and using a vibrator to mix the two together and get rid of any air bubbles. Barry was in the building trade and offered to borrow a vibrator over a weekend. We hired a cement mixer and had the cement, sand and aggregate all ready, together with a supply of water.

Barry duly turned up with the vibrator and then stayed around to check that we



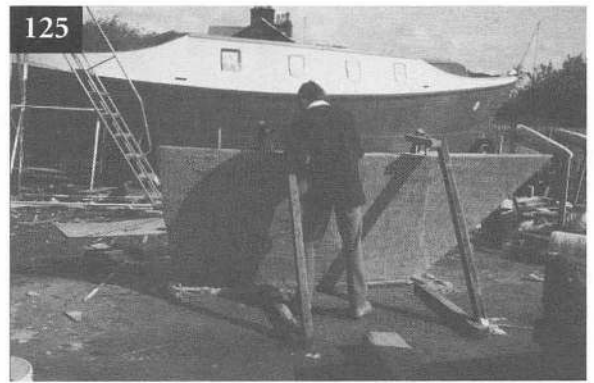
were doing it properly. We soon got stuck in, with Barry doing more than his fair share of the heavy work. I mixed up the concrete and Barry poured it and the punchings into the keel. While the cement was mixing, I vibrated the concrete and punchings. Meanwhile, Annie scraped up the excess concrete that vibrated through the mesh and slapped it back into the keel. It was a full time job keeping up with the curing concrete. All was going well, with the end of the job in sight, when disaster struck. Without warning, the keel fell over with an earth-shattering thud. It just missed flattening Annie—one of the keelbolts actually grazed her arm. What had apparently happened was that the vibration had very slowly moved the keel sideways across the plank and once it was no longer perfectly vertical, it broke the supporting framework and fell over.

So, what to do now? The keel was a banana shape and would have to be rebuilt, but could we get the concrete and ballast out before it set? The cost of materials was too much for us simply to abandon it, so we set to work with a hose pipe and a length of reinforcing bar, to knock and wash out the cavity of the keel. It took hours of work, but we just managed before the concrete at the bottom had set hard. I then dismantled the keel and put the pieces to one side to think about it.

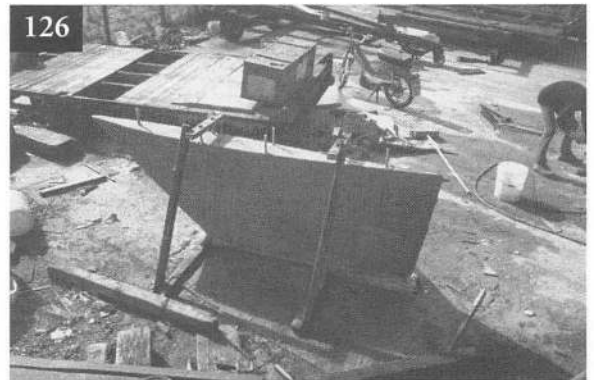


**124** As it turned out, we were evicted from our building site and it would not have been easy moving the keel. When we had almost finished *Badger*, I started on the keel again and the photograph shows us preparing to pour once more. The vibrator is the red and white object behind the keel.

**125** We poured the concrete and ballast as before, but made certain that the bottom of the keel could not slide and that the support framework was strong and solid. In the photograph, I am smoothing the top of the keel flush with the top reinforcing stringer—checked with the plywood pattern.

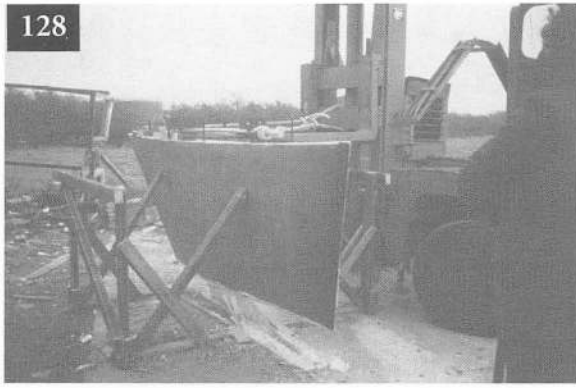


**126** Once the keel was poured, it was covered with sacking and kept damp for two weeks while it cured.



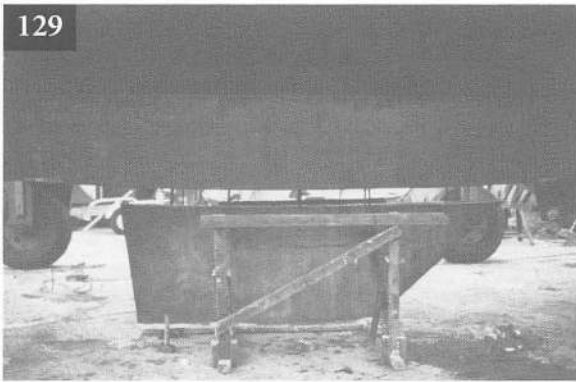
**127** When the keel had cured and dried out, any small holes were filled and it was faired with epoxy filler. The leading edge needed quite a bit of work to get a nicely rounded surface. A caulking tube, cut in half lengthways, made a good tool to apply the epoxy putty to the leading edge. We then covered the sides of the keel with cloth and epoxy.





**128** In order to attach the hull to the keel, a plywood pattern was made of the top of the keel, with the centreline and the keelbolts all marked. Inside the hull, a centreline was drawn across the floors, using a piece of string pulled tight between the centreline marks on the bulkheads at each end of the central cabin. The plywood pattern was lined up on the centreline and the keelbolt holes positioned over the centre of the floors. The measurement between the forward bulkhead and the front of the keel was checked against the drawings. When everything was lined up satisfactorily, the centre of each keelbolt was marked on the floors. We followed the Gougeon Bros.' system to attach the keel: the bolt holes were drilled oversize, using the appropriate flat bit in an electric drill.

Building *Badger* in a yard was expensive, but it did have the advantage of having a travellift to hand for putting *Badger* on her keel. Firstly the keel had to be moved by a forklift truck.



**129** The hull was lifted over the keel and lowered down onto the keelbolts for a dry run, to see that everything fitted. Fortunately, it did (the oversize keelbolt holes allowed a certain small leeway in the accuracy of their positioning—a useful advantage).



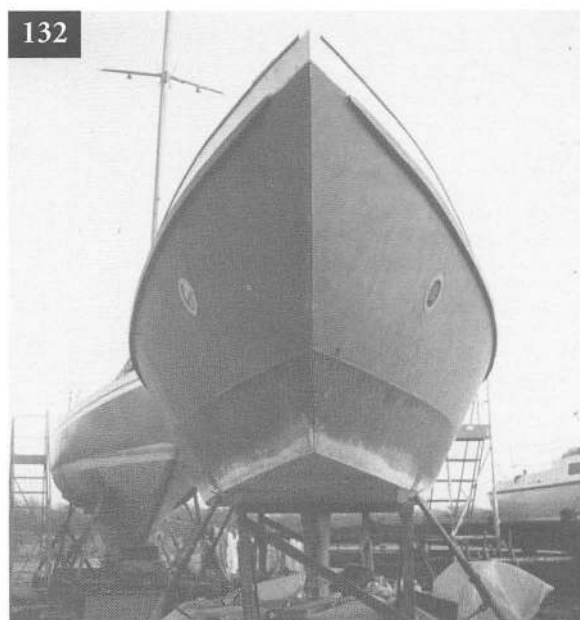
**130** The hull was lifted up again and the epoxy mixed up. The insides of the holes were coated with neat epoxy, after which fillers were added, to form a non-sag mixture, using colloidal silica. This was spread over the top of the keel and slathered around the threads of the keel bolts. The hull was gently lowered down. The excess epoxy that squeezed out all round was scraped away and finished with a fillet all around the keel. Most of the bolt holes had squeezed out epoxy, but any that hadn't were filled to the top with epoxy and the oversized washers and nuts were screwed down.

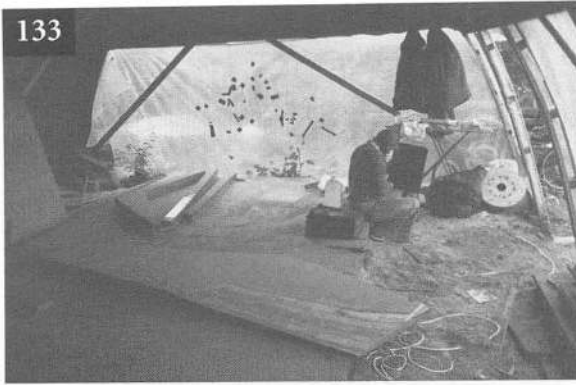
131 We were very fortunate in that the travellift was not being used for any other job, so the hull was supported by the slings until the glue had set.

It is interesting to note how well this system works. *Badger* had run aground on several occasions and once went ashore in a gale, so the keel to hull joint had been well tested. When we came to remove the keel (to put on the new Tandem keel), we took all the nuts off and, using a long hole saw, made from a length of steel tubing, I cut around each keel stud down to the concrete on the keel. We jacked *Badger* up, expecting the keel to hull joint to break. It didn't: the keel came up with the boat. When there was about two or three inches of daylight under the keel, I drove an oak wedge into the trailing edge of the keel to start it. The wedge cracked the joint, but the keel needed wedging off for nearly the whole length before it parted from the hull. Pretty impressive.



132 When *Badger* was put on her keel, she was sufficiently high off the ground that we could fibreglass the bottom of the hull. We did this in the same manner as the topsides, but working overhead was not easy and it would have been much, much better to have been able to do it when the hull was upside down. If you are forced to do it this way, wear a hat.





133 The rudder was built to the original design (which has since been changed) but we found on sea trials, that *Badger* was very heavy to steer and in strong winds, uncontrollable. We built a new rudder and have subsequently added a full-length skeg in front of it. I have had no experience of Jay's new rudder design, but I expect that the balance built in should correct the excessively heavy steering of the original. *Badger's* new rudder, with the skeg, works very well, but it does have the disadvantage that the skeg can only be added to the hull after the keel has been put on. So far, we have had no structural problems with either the skeg or the rudder.

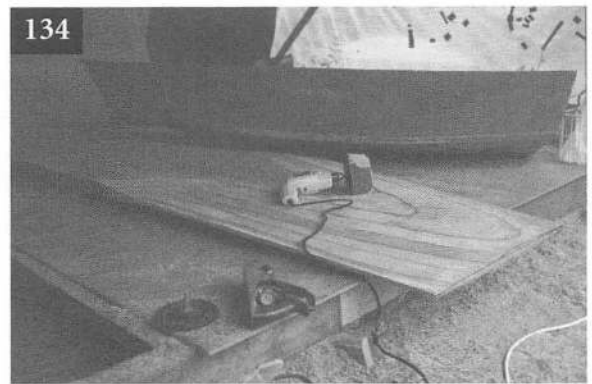
The photograph shows how we built the original rudder and the same system could be used for the re-designed rudder. As we wanted to have a trim tab for self steering, we made the rudder wider and then sawed off the trailing edge as a trim tab, after shaping the rudder blade. The correct size for a trim tab appears to be 20% of the main rudder underwater area.

The rudder was built up of sheets of plywood, glued together with epoxy, using temporary steel screws and then filling all the screw holes. The aerofoil shape was drawn on the bottom (stretched by 20% for the trim tab) and the waterline marked on. Using a power plane, the rudder blade was tapered from the waterline to the maximum thickness at the bottom of the rudder. (This is a very noisy job, because the rudder vibrates with the planing—wear ear defenders and warn the neighbours!) The veneers give a very good guide to help make the taper straight.

A line was drawn from the maximum thickness at the waterline down to the maximum thickness at the bottom. No more wood should be planed off this line. I found that the best way to mark the shape of the rudder aerofoil at the waterline was to make a pattern. Using scraps of plywood glued

together to the same thickness as the rudder (ensuring that the same plywood as the rudder was being used), I transferred the aerofoil shape to the endgrain with a cardboard pattern. Where the shape crossed a veneer joint, I drew a line across the wood with a set square. Measuring from the trailing edge, I then transferred these lines to the rudder at the waterline. From the point of maximum thickness (already marked on the rudder), each line either side indicated where a new veneer should be visible. The rudder was then planed down to shape, using the veneer line marks at the waterline and the veneer lines at the bottom of the rudder. A straight edge was regularly used to check the taper. Once one side was done, the rudder was turned over and the same done on the other side.

- 134** After the rudder was planed to shape, a sander was used to smooth the transition from the aerofoil to the full thickness of the rudder above the waterline. The whole rudder was sanded smooth and fair with an orbital sander and the leading edge nicely rounded.



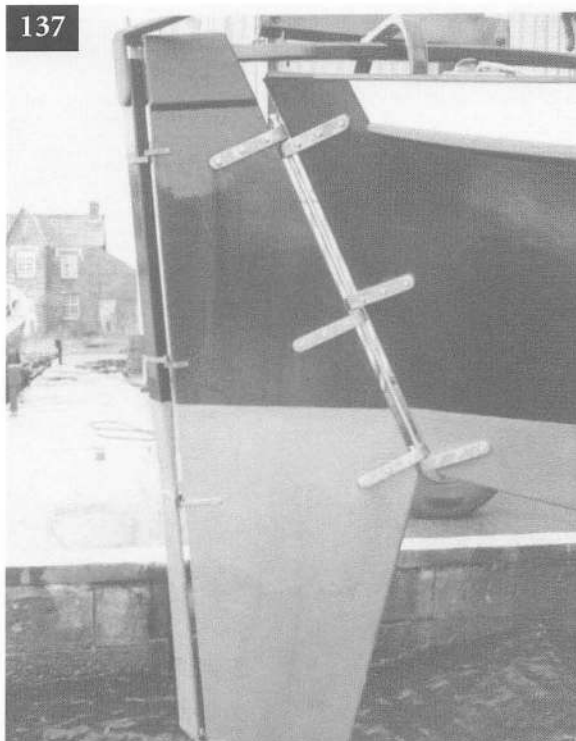
- 135** When the rudder was finally shaped, the trailing-edge trim tab could be sawn off.





136

- 136 The rudder and trim tab were coated and sheathed in glass and epoxy in the same manner as the hull. Cheeks were added to the rudder head for the tiller.



137

- 137 The rudder fittings are of cast bronze. I made up patterns out of plywood to fit the rudder and the stem. Making the patterns was quite straightforward. An important point is to taper the fitting slightly (called the draught), to allow the pattern to be easily removed from the casting sand.

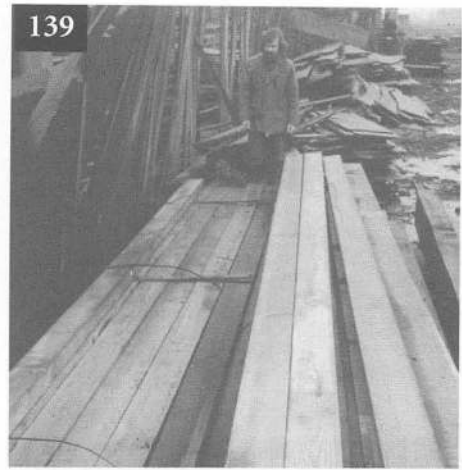
They were cast at a foundry and Annie had the holes for the pintles bored out by the machine shop at the factory where she worked. The pintle is a 3/4" [18 mm] stainless steel bar that passes through all the fittings. Great care was taken to line up the holes. The fittings were through bolted to the rudder and, on the hull, the bolts were glued into the sternpost. The trim tab was hinged onto the rudder using dinghy rudder fittings.



138

- 138 Before we had even chosen a design to build, we knew that we wanted to have junk rig. Once we had the plans for Jay's 34 ft dory, we set about designing the rig. We bought the junk rig design folios from Jock McLeod (now incorporated and expanded in *Practical Junk Rig*—published by Tiller). The design process is very straightforward and well explained. Anyone who can do simple mathematics need have no fears.

**139** The ideal unstayed mast is probably one constructed of carbon fibre. To buy one ready made, would cost a small fortune and even if building it oneself, the materials are expensive. Wood seemed the cheapest option for us. Originally, we were going to buy two poles and have grown sticks, but we were offered a pile of good Douglas Fir at £4 a cubic foot and we decided to build laminated, solid masts.

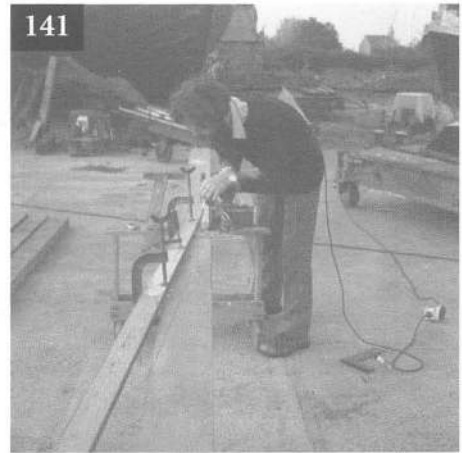


**140** We had hired a pickup truck to transport the wood the 100 miles back to Glasson Dock. The pickup was way overloaded and it was quite a hair-raising drive back: the brakes could barely cope with the load, going down hill.

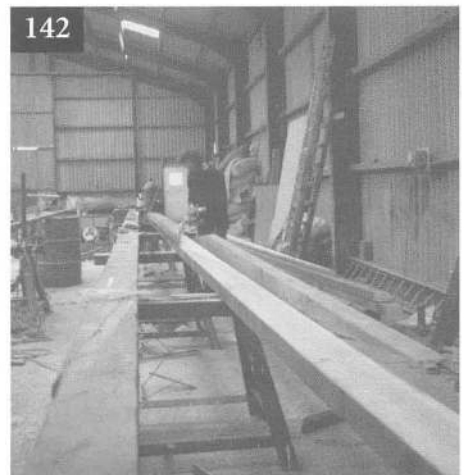


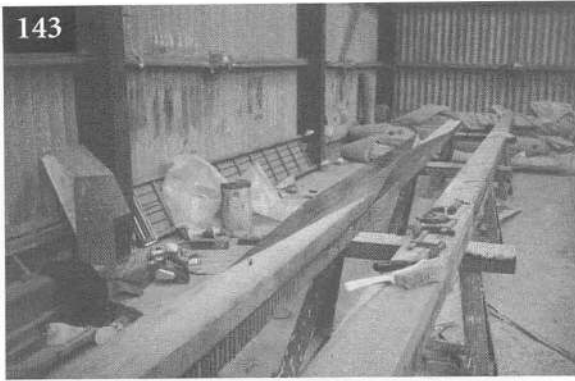
**141** Peter Latham, the owner of the marina where we were building, had gone away on holiday and it was hinted to us that now would be a good time to build the masts, in the empty boat shed. We had two weeks, so dropped everything else and got to work. The timber that we bought was 6" [150 mm] x 3" [75 mm] and about 18 ft. [5.5m] long.

The first job was to cut the scarfs to that these timbers could be joined to length. A batten was clamped on at an angle of 8:1 and the circular saw run along the batten.

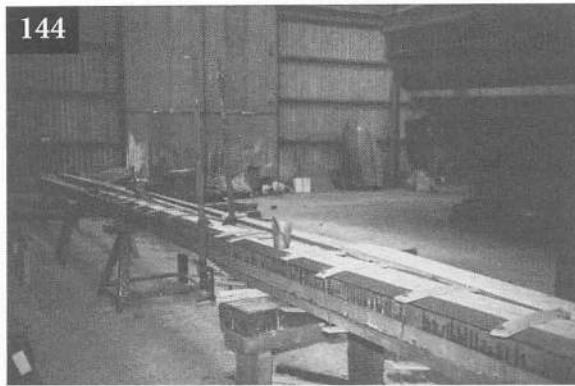


**142** The timbers were glued together to get the required length (the mainmast is 39 ft. [11.8m] long). The joints were dry fitted first, to check the fit and cleaned up with a hand plane as necessary. The scarfed lengths were set up level on saw horses.

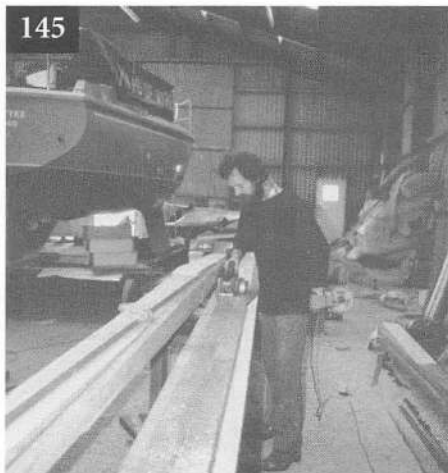
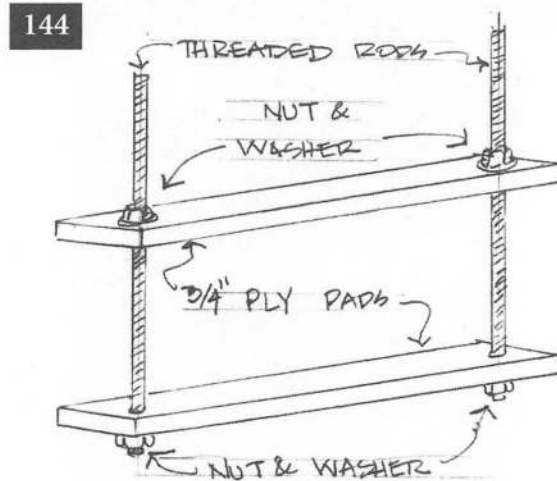




143 The top of the planks were planed smooth and the next layer was glued on top, with the scarfs staggered above the lower scarfs. They were glued in place, piece by piece.

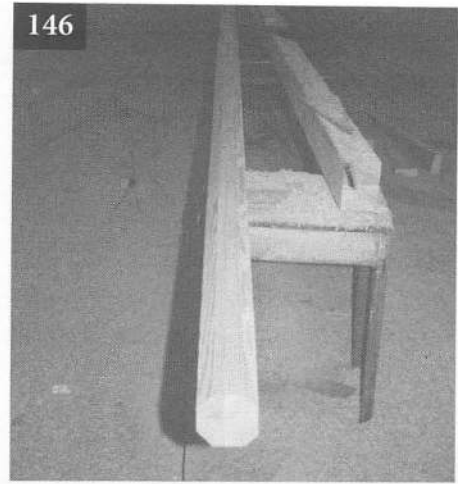


144 The problem of clamps was solved by making some simple ones, using scraps of 3/4" [18 mm] plywood and threaded rod.



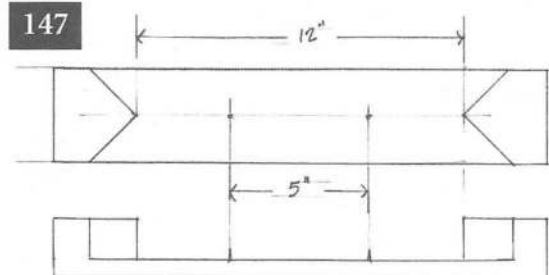
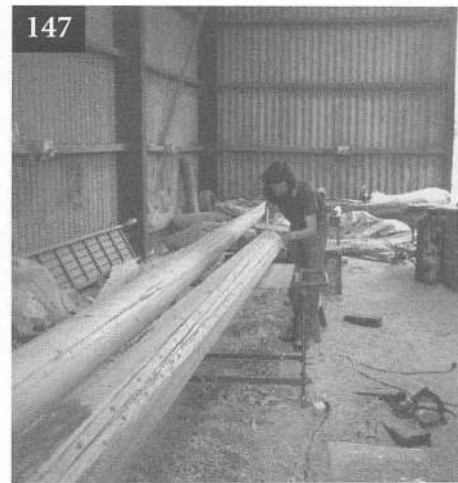
145 When everything was glued up, we had two 6" [150 mm] x 6" x [150 mm] timbers, one 39 ft. [11.8m] and one 36 ft. [11m] long. However, the masts were to be over 8" [200 mm] diameter at deck level and tapering at each end. To get the extra thickness, we glued on more pieces of wood in the required places. The photograph shows where pieces have been glued to the side; the top is being planed before gluing further pieces in place.

- 146** When all the pieces were glued together, the mast was sawn and planed down to a square cross section, of the correct taper—as seen on the right of the photograph, then it was marked and planed down to an octagonal section, as on the left.

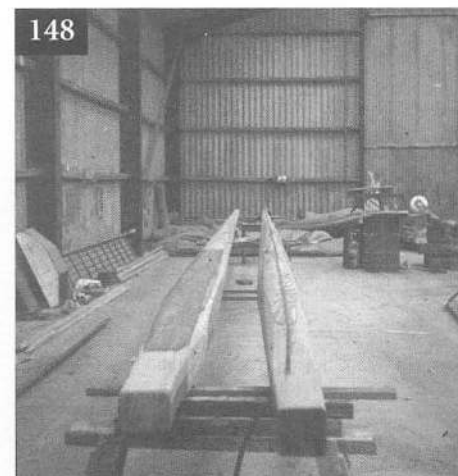


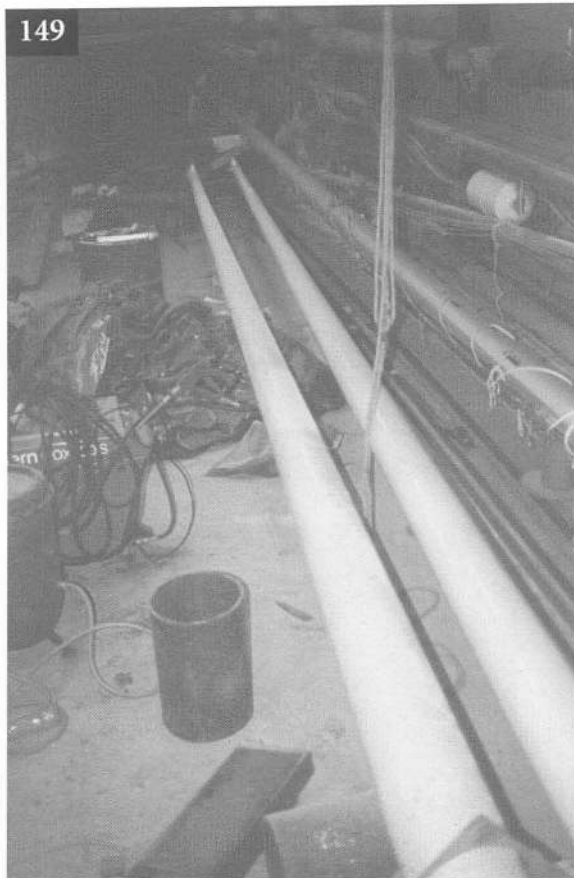
- 147** To mark the square section mast before planing down to 8 sides, I used a spar gauge, which is very simple to make.

The distance between the wedge points is 12" [300 mm] and the distance between the nail points is 5" [127 mm] (the nail points are 3 1/2" [89 mm] from each wedge point). The gauge is run along the mast as in the photograph. These corners are planed down to the mark.



- 148** Once down to an octagon, the corners are taken off by plane and the whole mast rounded by eye. They were faired, using a long length of 60 grit sand paper, which was pulled back and forth around the mast. They were finally sanded along the grain with progressively finer paper. In the photograph, the finished masts are ready to be covered with glass cloth. Notice the black line on the right hand (main) mast. This is the three-strand cable for the masthead tricolour and all round white lights. A groove was cut up the mast using a router and the cable set in with epoxy filler. If you plan to put in a wire for a lightning conductor (which we did at a later date), now would be the time to do it, before the masts are sheathed in fibreglass.

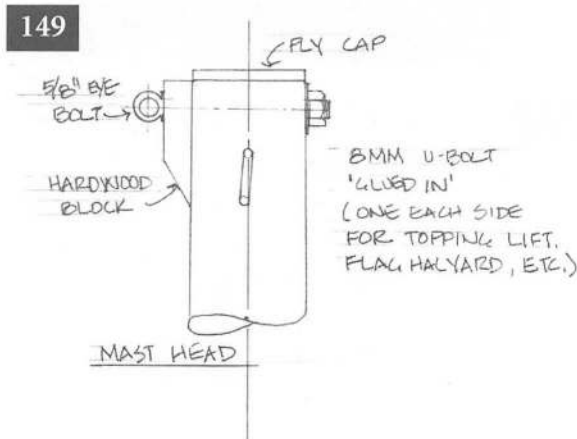




149 The masts were covered in glass cloth and epoxy and painted with two-part polyurethane paint. The covering has proved most successful and the masts still look like new. They seem to require repainting about every five years, because the gloss has gone by then.

Before painting, we installed the masthead hardware. A 1 1/2" [38 mm] block of wood was glued to the masthead and a 5/8" [16 mm] galvanised eyebolt was bolted through the mast. From this is hung the halliard block. We glued two 5/16" [8 mm] U-bolts into the masthead for attaching the lazyjacks, halliard blocks and mast lift. [Illustration here]

These simple fittings take the place of the more complicated fabricated fittings shown in *Practical Junk Rig* and work well.



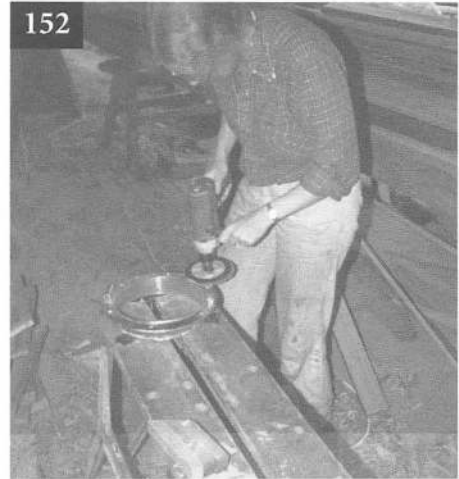
150 Our first suit of sails was made from some green, proofed canvas that I bought very cheaply. It was old stock and I suspect that the proofing had gone, as the sails rotted out after a year. The sails were simply made, using a straight-stitch, Singer, hand-cranked sewing machine. We have since used acrylic fabric (*Sunbrella*<sup>TM</sup> or similar), which is often used to make sail covers. It appears unaffected by sunlight and we have never used a sailcover. It is easy to sew and comes in a wonderful range of colours. The only drawback is that it is susceptible to chafe when it is wet, so we try and cover ropes that might chafe it with plastic tubing. We also have a thin 'battenlet' on the opposite side of the sail to the batten, to protect it from the lazyjacks. Our last suit of sails lasted 10 years and 70,000 miles.



151 *Badger* has thirteen bronze scuttles [port-holes], which look wonderful and would cost a small fortune to buy. We were lucky to get them from a wrecked motorboat, that my father saw being dismantled, for £1 each. As you can see in the photograph, they were in a dreadful state.



152 After removing the broken glass, Annie spent hours grinding off paint and what was left of the chrome plating.

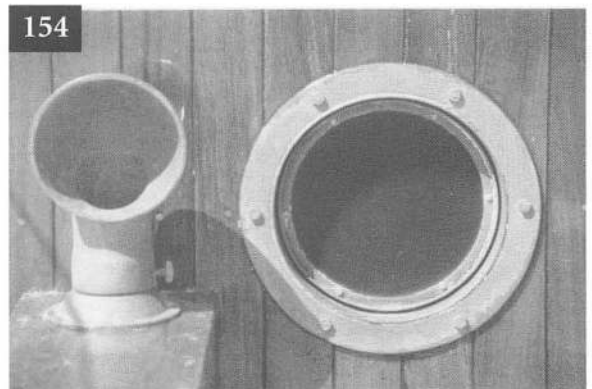


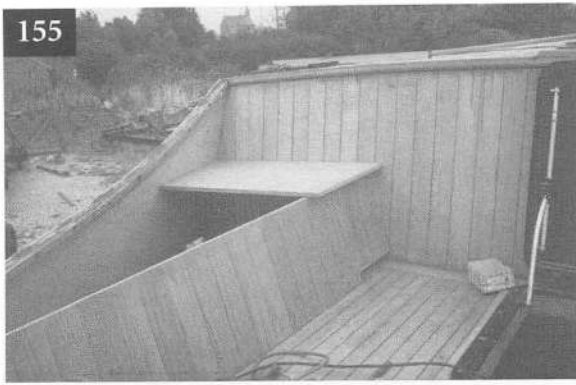
153 The scuttles were polished, using a polishing mop and compound. If you take into account Annie's labour, I expect that they were very expensive, but we had much more time than money.



154 To reglaze the scuttles, we used polycarbonate that Jack Sharples, the skipper of the Ocean Youth Club's yacht, *Francis Drake*, gave to us. This was bolted into the frame with small stainless steel bolts and silicon rubber. We had to make our own outer rings, which was simply done by making a 1/4" [6 mm] plywood pattern and having them cast in bronze at the same time as the rudder fittings.

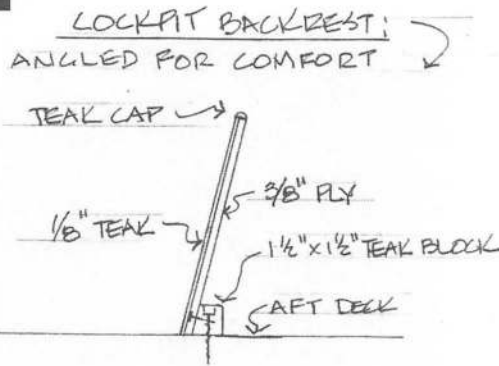
Ten of our thirteen scuttles are opening, but we only ever open the two in the forward end of the cabin, the one in the heads and the after one in the galley. The others would be equally satisfactory if they were fixed and would be easy to make, by bolting the bronze finish ring over a piece of polycarbonate/acrylic on the outside of the hull. Then there would be only the four opening ones to buy new or second-hand.





155

155

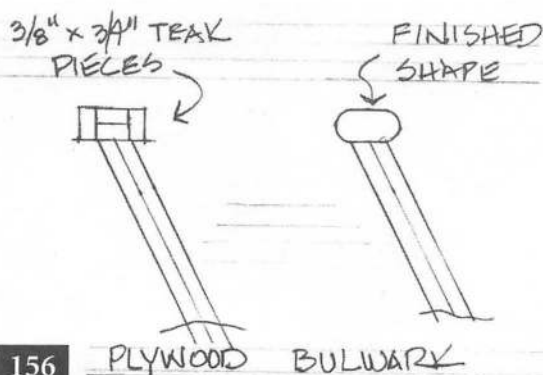


155 The cockpit had now to be finished and we decided to fit backrests, with deck lockers at their forward end. The backrests were made from 3/8" [9 mm] plywood, covered on one side with 1/8" [3 mm] strips of teak, giving a tongue and groove effect. A piece of 1 1/2" [38 mm] square teak, its face cut at the correct angle for the shape of the backrest, was glued to the deck and the backrest glued to this. A length of 1" [25 mm] square teak was also glued to the back of the cabin, to support the forward end of the backrest. Note the hole at the bottom edge of the backrest, by the cabin, to allow water to drain out through a similar hole in the bulwarks. Another piece of 3/8" [9 mm] plywood, similarly clad in 'tongue and groove' teak, was fitted between the backrest and the bulwark. The box thus formed was covered with a hinged lid. This deckbox makes a very useful seat, as well as taking the tail of the halliards and providing a store for odds and ends.



156

156 The capping on the bulwarks was built up from 4 pieces of teak. We found 3/4" [18 mm] x 3/8" [9 mm] to be the maximum size of teak that would bend in the two planes of the bulwark sheer. Each piece was scarfed to length and then glued on using temporary steel screws, to hold it in place. When the glue had cured, the screw holes were filled with teak plugs. After planing and sanding it fair, a router was used to round over the top edges; the lower edges were sanded round by hand.



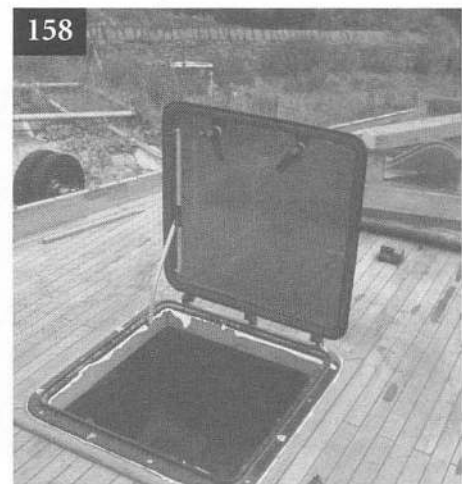
156

**157** We bought cast aluminium hatches at a good price. They have the advantage of being ready-made and waterproof, but unless you can get a good deal, they are expensive. They are also prone to condensation in cool climates.

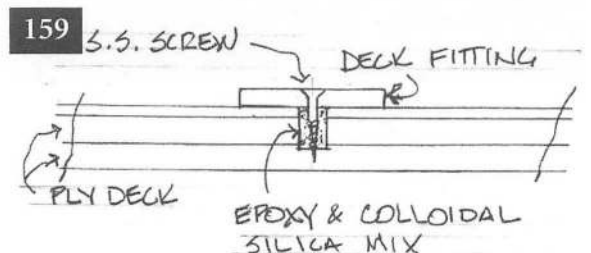
Each hatch is fitted on a raised teak plinth. The plinth was planed flat, but even so, the hatches have to be put down absolutely level for the sealing gasket to work. To achieve this, the hatch was bedded onto thick epoxy to make a completely fair surface. Plastic film was used on the hatch to prevent it from sticking to the epoxy. The excess was cleaned up from around the hatch, while the epoxy was still a little soft. After it had set, the hatch was removed.

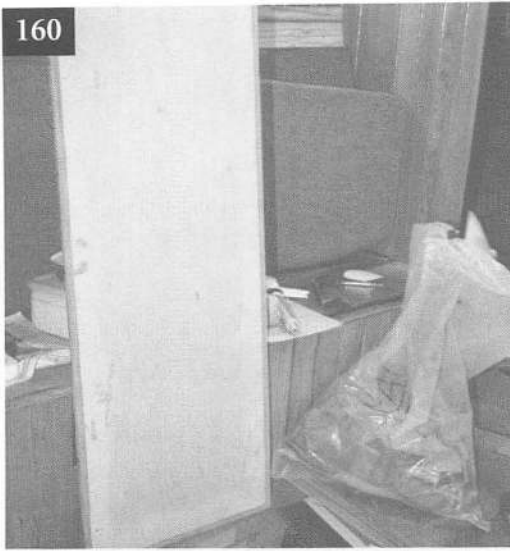


**158** Finally, the hatch was bedded down on silicon rubber and held down with stainless steel screws. We used silicon rubber as a bedding compound in order to be able to remove the hatch without destroying it, and the joint has never leaked.



**159** All the deck fittings, blocks, cleats, stanchion bases, etc, were screwed to the deck, the screws being set in epoxy, as in the Gougeon Bros.' book. Where there was no solid wood under the deck, we installed a piece of 1/2" [12 mm] plywood. This system works extremely well and, besides preventing any water from getting into the plywood, it is also very strong and there have been no deck leaks from the fittings. Some years ago, a 45 ft. steel yacht accidentally rammed us amidships, while we were at anchor. The whole force of the collision was taken by the stainless steel stanchion, which was bent at right angles. The cast bronze base was badly distorted and just starting to pull the fastenings out of the deck. These were 2" [50 mm], No 14 stainless steel wood screws, glued into the deck. The screws had held so firmly into the deck, that the slots on the heads had squeezed shut; they had just started to pull out. Impressive. The photograph shows the fore-sail sheet blocks being attached to the deck—you can see the oversize holes, filled with epoxy.





160

**160** The table is the centrepiece of the saloon, so we tried to do something special here. Having seen an article about Vic Carpenter, in *Wooden Boat*, we decided to copy the 'grating' effect that he used for the cabin sole in one of the yachts that he built. Using solid blocks of teak and ebony, he created a solid 'grating' for the sole—the ebony corresponding to the holes.

The table is a double leaf, hinged to a centre section. The basis of it is 3/8" [9 mm] plywood and the endgrain is capped with teak strips and planed flush with the surface.



161

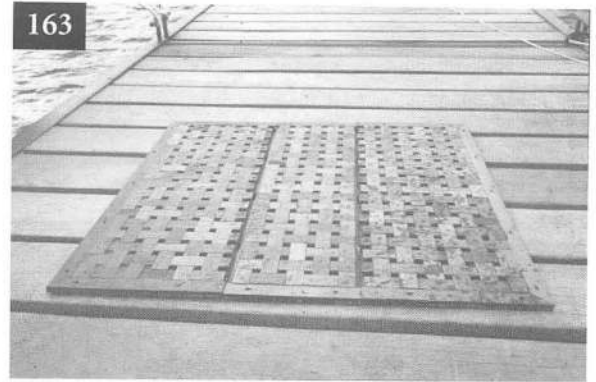
**161** A border of 1 1/2" [38 mm] x 3/16" [5 mm] teak was dry fitted to three sides of the plywood, with a mitre joint at the corners. This teak border was held down by screws.



162

**162** The teak to make the grating was offcuts from the deck. (There were plenty of 1 1/2" [38 mm] x 3/16" [5 mm] short lengths.) The majority of the pieces were cut to 3" in length as accurately as possible. The pieces that butted up to the border were 2 1/4" [56 mm] long. Everything was dry fitted to check the fit and the border pieces were glued and screwed down. Generous amounts of glue were spread on the plywood and then the teak pieces were pressed down into place, held there by gravity and friction. Instead of ebony for the 'holes,' the epoxy glue, blackened with graphite, squeezed out and filled them. Once all the pieces of wood had been fitted, the 'holes' were topped up with surplus black glue. The advantage of using epoxy instead of ebony was that it allowed for a certain leeway with the fit of the small pieces of wood.

- 163** The leaves and the centre section were all made and ready for finishing.



- 164** We made use of the boatyard's thickness planer, which made short work of levelling off the teak, to give a smooth, flat surface. An orbital sander gave the final finish, ready for varnishing.

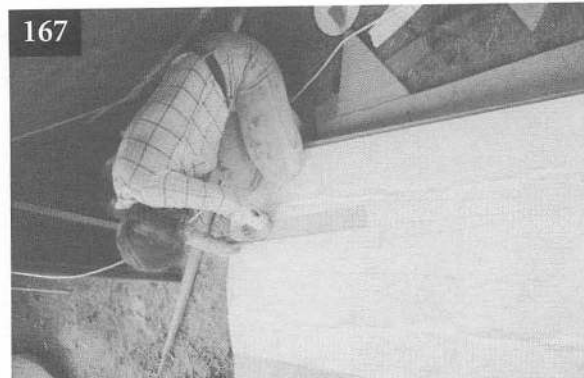


- 165** The completed table's forward end is fastened to a block of wood on the bulkhead and the after end to the grab post. The leaves are attached by way of piano hinges and are supported by knees that hinge out from the bulkhead and grab post.



- 166** A similar system was used to make the cabin sole, with 1/2" [12 mm] plywood being covered with 3/16" [5 mm] teak in a parquet pattern. This was a good way of using up small pieces of teak.





167

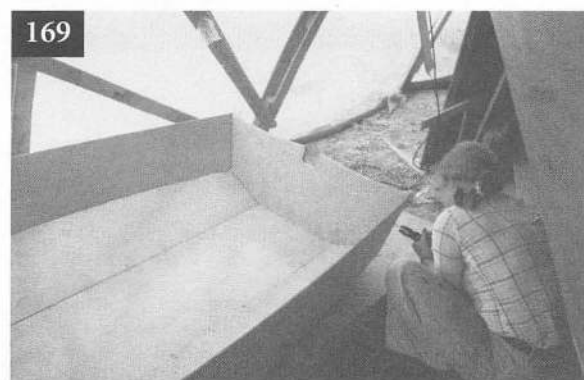
**167** *Badger's* dinghy was a nesting one, built to the design of *Two Bits* by Danny Greene. It was constructed of plywood, using the 'stitch and glue' method.

The plans included full-size patterns for all the pieces, which were transferred to the plywood.



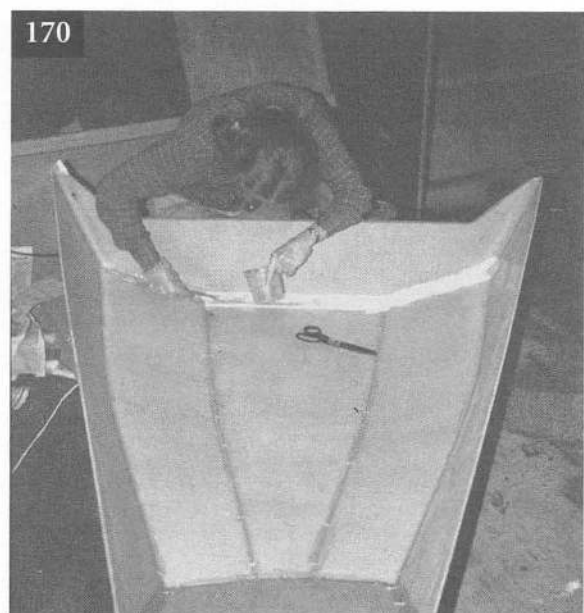
168

**168** The plywood was then cut out carefully to size with a jigsaw. The hull was held together with copper wire (the stitching) to get the correct shape. The two edges to be joined, were placed face to face and small holes (just big enough for the copper wire) were drilled about every 6 inches [150 mm], about 1/2" [12 mm] from the edge. A loop of wire was then pushed through both holes and lightly twisted on the outside.



169

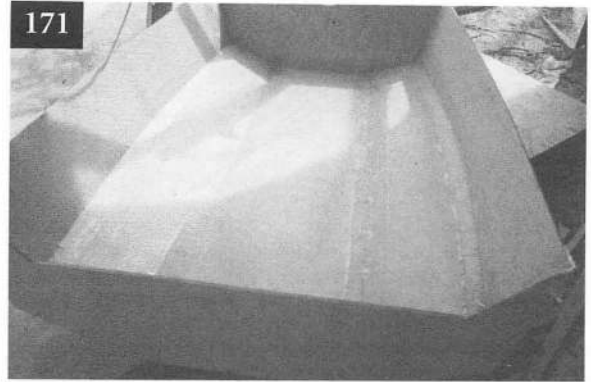
**169** When all the wires were in place, they were twisted tight with pliers, until the hull is the correct shape, with all the edges fitted tightly.



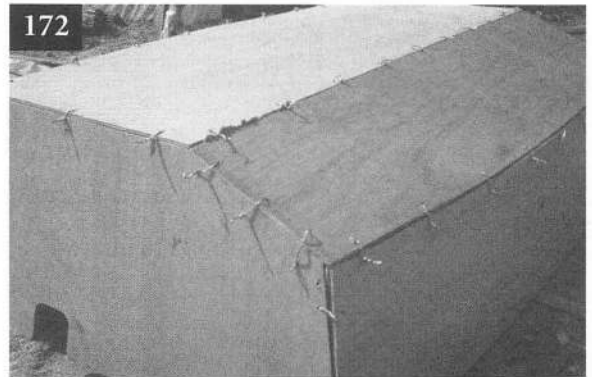
170

**170** A fillet of thickened epoxy was used to fair in the joined pieces of plywood and a layer of glass tape used to 'glue' the joints together.

- 171 The photograph shows the stern section of the hull glued together by the glass tape and ready for finishing.



- 172 The hull was turned over and all the wires cut off close to the hull. The joints in the dinghy are sanded smooth, with the edges rounded over.



- 173 All the seams are covered with glass tape, following which, the outside of the dinghy is sheathed with glass cloth and epoxy.



- 174 When the two parts of the dinghy are completed and ready for finishing, the skeg on the stern section was glued on.





- 175 The forward thwart, used as the mast partner for the sailing rig, was marked.



- 176 Once the thwarts and mast step were installed, Annie coated the plywood with pigmented epoxy, prior to painting.



- 177 The finished dinghy, *Brock*.

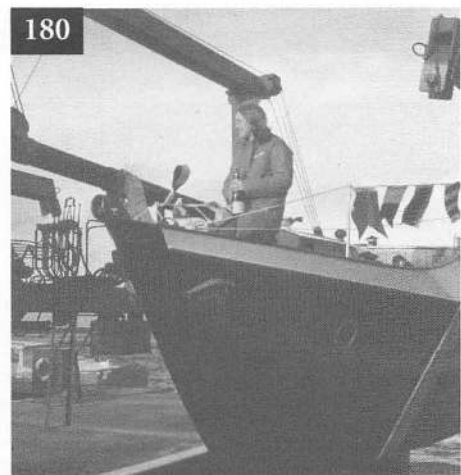
**178** *Badger* was painted and varnished, ready to go in the water.



**179** On a wild and windy day at the end of January 1983, *Badger* was trundled along to the water.



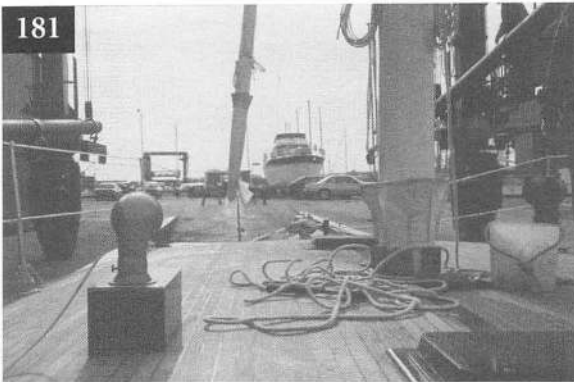
**180** It was a great moment as she touched the water for the first time. Annie had the champagne ready to pop.



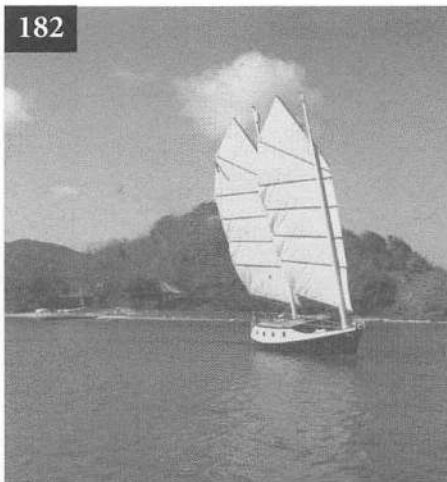


181

**181** The masts were stepped and held in place with wedges, over which was secured a waterproof mast coat.

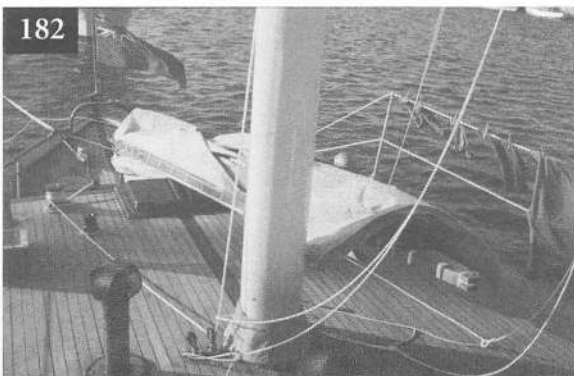


181



182

**182** The sails were bent on.

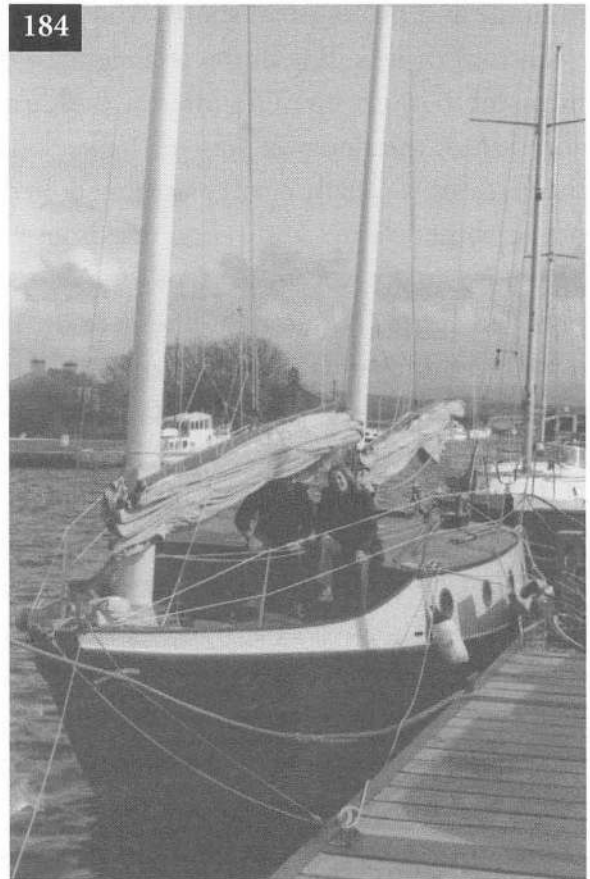


182

183 And hoisted.

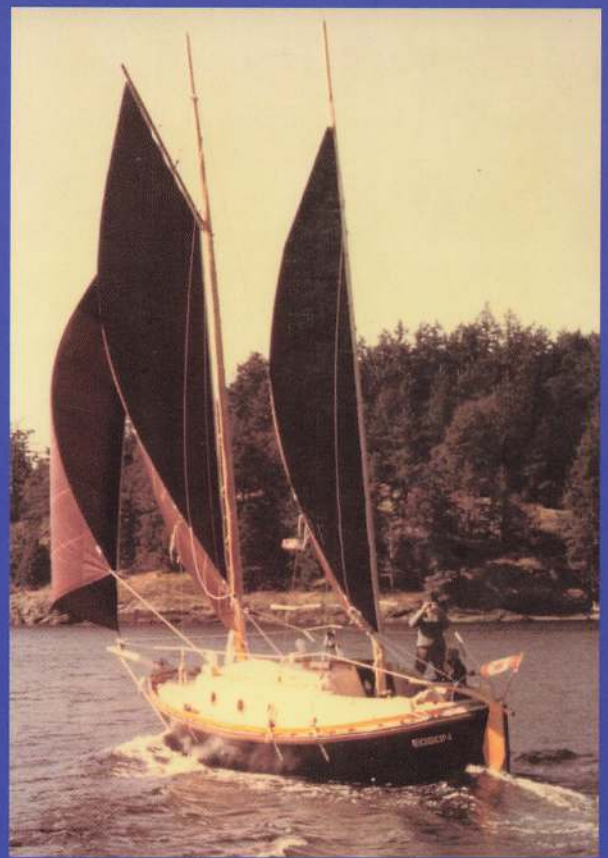


184 *Badger* was now ready to go cruising. We started building at the beginning of May 1980 and set off for our first cruise exactly three years later. That was three years of hard work for the two of us. We both had jobs and spent every evening and each weekend working on *Badger*. There were no holidays and very few days off. As I worked at a teachers' training college, I had quite long 'holidays,' which helped progress a lot. By the end of three years, we were about 'built-out' and I don't think that we could have kept up the single-minded pace much longer. We often thought that had we not finished *Badger* in three years, it would have taken five! Another interesting point is that after launching and sailing *Badger*, it took quite a long time to get out of boatbuilding mode—it took some time to settle down to cruising. I'm sure that if someone had offered a good price for *Badger*, we might have been tempted to sell her. All in all, though, it was a completely worthwhile project and it has been very satisfying to voyage in a boat built with our own hands.



### Postscript

In point of fact, after cruising her over 100,000 miles, Pete and Annie succumbed to the lure of an attractive offer for her and *Badger* passed on to new stewards.



Clockwise from top left:  
Anthony Swanston's 37½' *Wild Fox*, Fred Schreiner's 36'  
*Donna*, Pete Hill's 34' *Badger*, Greg Krivonak's 34' *Willow*

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