BOATBUILDING GUIDE

By Arthur N. Swinfield, A.M.I.N.A.

In the early days of the Pacific before the advent of the European small craft, thousands of beautiful canoes were built by Pacific Islanders, and in every case they fulfilled the needs of the people who built them. They certainly varied in shape and size, and their sails or paddles were shaped in many different styles, but the finished canoe itself was in every case as good as the builder could make it <u>with the raw material that he had at hand</u>.

This raw material limited his efforts, but it did not limit his care and perseverance, for the various methods of building canoes all over the Pacific speak volumes for the wonderful skill of these truly natural boat-builders.

If the Pacific Islander had had access to the finished material and hardware of the European he would no doubt have developed along the lines of the orthodox boatbuilder but without these aids he has been confined to primitive methods and primitive ideas. Let us therefore discuss the various fastenings, materials and tools used in the construction of a small wooden vessel, and find out why one is used instead of the other and how it is used.

FASTENINGS

The word 'fastening' means either nails, screws, or bolts, and these are all made in different sorts of material. The best are made of copper or 'brass'. Then comes galvanised 'iron', and lastly mild steel (or 'iron'). The reason that copper and brass are both better than 'iron' or steel is that copper and brass do not rust or corrode, whereas 'iron' or steel does. Galvanised 'iron' does not rust as quickly as ungalvanised 'iron', but it does rust eventually.

<u>Nails:</u> The copper nails used in boatbuilding are usually square, with flat countersunk heads. They should never be driven into or through timber without first boring the correct size hole to take them. This size is always the size of the nail over the flat sides (see Fig. 1). If the nail

is driven into such a hole it is always tight enough to be watertight, but yet not so tight as to split the plank or timber. A boatbuilder uses two methods of making sure that a copper nail does its job of holding the planks to the frames so that they do not come apart. The first method is to simply 'turn' the nail over at the point with a light clenching hammer (see Fig. 2). The operation of turning the point of the nail over is always done in the same way. A heavy weight called a 'dolly' is held firmly against the head of the nail, and the point is always turned and driven flat into the timber in the same direction as the grain of the timber (see Fig. 3) with the face of the clenching hammer (see Fig. 4). The heavy weight, or 'dolly', simply prevents the nail from being driven out of the timber while the nail is being clenched.

The second method is to rivet the nail over a small copper washer called a ROOVE. In this method the roove is driven onto the nail by a hollow punch (see Fig. 5). Then the nail is cut off slightly above the roove and finally riveted by means of the clenching hammer. The 'dolly' is again used as before. For the beginner, the first method is the easiest because it takes less experience to do a good job. The riveting is harder because the operation of riveting has to be done without bending or crippling the nail inside the timber. If a nail is crippled it tends to split the timber, but apart from this fault it does not hold the two pieces of timber together in the proper way, and leaks will eventually occur (see Fig. 6).

Screws: It will be noted that copper nails have been referred to as either turned over or riveted, and that no mention has been made of driven copper nails. The reason for this is that a driven copper nail does not hold for long in timber. It appears to shed a 'skin' of green corrosion and slowly slips away from the timber. The boatbuilder therefore uses brass or bronze screws instead of a driven copper nail and when using a screw he always bores firstly for the shank of the screw, then for the threat and lastly for the countersink head (see Fig. 7). It is bad practice to bore too tightly for the shank, as it tends to split the timber, while if you bore slack for the thread, the screw will not hold fast to its job.

The ordinary brass screw is the one usually used in boatbuilding, but unless the head of the screw is well countersunk and then covered with a good coat of watertight paint and putty, it also tends to corrode and become brittle, so that the head of the screw breaks and so causes the inevitable leak.

Bronze screws do not corrode so quickly but are not easy to get in ordinary stores. However for first class work they are the best.

<u>Bolts</u>: The best bolt for Island use is a copper bolt. It can be used either as in Fig. 8 - that is, riveted - or as in Fig 9 - screwed with a threat and nut. The screwed bolt is best because it can be tightened up at any time the timber shows signs of shrinking or becoming loose. However, the riveted bolt is quite good if properly riveted over with a light hammer and heavy 'dolly'.

When boring the hole to take a screwed copper bolt, always bore the exact size of the copper bolt (not tight or loose).

When boring for a riveted copper bolt, bore a hole about 1/16" smaller than the bolt so that the latter has to be driven tightly into position. Always slightly point the bolt before driving it into the hole, and grease it with oil or fat. Another very important item to remember is to always tie a small piece of cotton wick or oakum under the outside washer before the bolt is finally driven home. This stops any chance of the bolt hole leaking (see Fig. 10).

<u>Treenails</u>: We have been discussing metal fastenings for some time. There is no doubt that such fastenings are very good and in many cases they are the only ones that can be used effectively. However, there is another fastening that can be substituted for the metal bolt, and that is the TREENAIL. This fastening is made from wood and is simply a perfectly round stick fitted with a cut at each end into which are driven two tapered wedges (see Figs. 11 and 12). Notice that the wedges are always driven across the direction of the grain. If this was not done the wedge would split the timber. The hole to take a treenail is just a nice tight fit. The saw cut is made on the end of the treenail which goes into the hole first, and the second saw cut is always made when the treenail is about 2" short of coming through the hole (see Fig. 13).

The treenail could be a very useful type of fastening all over the

Pacific. All that is required - apart from the treenail - is the boring tool, or auger, and perhaps a saw. One very good feature of the treenail (apart from its low cost) is that if a mistake is made and the timber has to be taken apart, then all that one does is to saw the treenail in halves with an ordinary wood cutting saw.

Always remember that a treenail should be made of good, hard, straight-grained timber. An easy way to make treenails is to drive an almost round (or roughly round) piece of timber through a suitably-sized hole in a piece of steel bar or plate. Any engineer could drill a few different-sized holes in the one piece of steel, and then you could make any size of treenail that you needed (see Fig. 14). So much for fastenings (but always remember that a good boatbuilder always bores the right-sized hole to take any fastening. Timber split is timber spoilt, in any boat).

TOOLS AND THEIR CARE

Apart from the ordinary tools used by every carpenter, the boatbuilder or boat repairer uses many tools peculiar to his own trade. A list of tools follows. It must be remembered that each and every tool has to be kept in order, and never neglected, if the owner expects it to do its proper job.

1: Axe of medium weight, or a small tomahawk, preferably sharpened or ground on one side only. A right-handed man grinds his axe on its right-hand side, and the left-handed man grinds his on the left side (see Fig. 15).

2: Adze with about 4" blade and properly balanced on its handle. The most important thing to remember is to grind and sharpen the adze on the inside face only and to see that the length 'A' (from point to heel of the handle) is the same as from blade to heel (B). Unless this is done (by fitting the handle correctly) the user stands a very good chance of cutting his feet or shins because the tip of the blade digs in or the adze repeatedly hits on its heel (or eye) and bounces off the timber (see Fig. 16).

3: Shell auger, used for boring a very 'true' hole, or one that does not follow the grain of the timber. The auger has no screwed point but depends on its sharpness to bore the hole (see Fig. 17).

4: Bull nozed auger has the same advantage as the shell auger, but tends to snap or break off in the hole if not cleared of shaving (see Fig. 18).

5: The caulking mallet is a long-barrelled mallet, or wooden hammer, used to drive oakum into caulking seams on the ship's hull or deck. It is fitted with a long removable handle and has a ferrule, or ring of steel, at each end of its barrel (see Fig. 19).

6: Caulking irons are used to drive the oakum or cotton wick into the caulking seams (see Fig. 20).

7: Jerry iron is one made especially to lever the old oakum out of the seam before driving new oakum back tight again (see Fig. 21).

8: The rake is made from an old file, and is used to rake or pull the old cotton wick out of seams before putting new cotton in.

9: The plumb bob is merely a length of string or cord with a heavy weight at one end. It is used to ascertain whether any upright is truly upright, or plumb.

10: Chalk line is also a length of line or string which when chalked over and held tightly between two points gives a truly straight line. To mark the line you merely flick the string onto the surface to be marked.

11: A gimlet is a small tool for boring occasional small holes that cannot be easily bored with a boring machine or drill. However, a very good gimlet can be made from any suitable bit and an old-fashioned metal door knob (see Fig. 23).

12: Cutters, or nail cutters, are merely pincers with two cutting edges that are used to cut off any surplus copper nail before turning over or riveting.

13: Cutting Knife is a most useful tool, and one very easily made from an old saw blade or small piece of good tool steel (see Fig. 24). It is used to drive between two pieces of timber - say two planks in a small dinghy - or between plank and ribs and so reach the copper nail and cut it through. This tool is most useful when taking out faulty planking for repairs.

The ordinary tools of trade such as hammer, saw, chisel, plane, drill, etc., are not described here as it is assumed that any one interested in boat building would have sufficient knowledge of these everyday tools before enquiring about boatbuilding.

THE PARTS OF A SMALL WOODEN VESSEL AND THEIR DUTIES

Almost every small European type of wooden vessel is built in the same way and the same method of construction is followed. In the following pages each component will be described and its purpose in the finished vessel outlined. To do this, it is proposed to actually describe the building of a small vessel, from keel to final coat of paint. The type of vessel to be used as an illustration is a 30' 0" cutter designed for the Pacific Islands.

DESIGN

Every boat begins as a design, or model. The builder conceives the idea of building a boat about so long and so wide to do such and such a job. He either has a lot or very little experience, and dependent on this ability eventually builds a vessel which is successful or not so successful.

The older generations of Pacific Islanders depended on their canoe-makers to build certain canoes for certain jobs, and these men knew from experience (handed down from father to son in many instances) just what was required and what could be done with the materials available.

The modern boat-building yard depends on men who are specialists in wooden boat design to produce working drawings for the boat builder, who then builds the boat. Some boats are built from small scale models, which are just the exact shape of the finished boat, but so much smaller in every way. However we will assume that the builder has the drawings, sketches, etc., and is ready to start building the boat.

<u>BUILDING BERTH</u>

The building berth is the place where the keel is laid on the building blocks, or stocks, as they are called. It should be as near the water as convenient and if possible sheltered from rain and bad weather. A very good berth can be made in most of the Islands, as 'bush timber' can be used as posts and framework for the sheltering building, and coconut or sago leaves

<u>ROOF</u>

(plaited) for the roof. There is no need to go to too much trouble building this 'house', but it is important that all posts be deep into the ground and that the joists be strongly fastened to the posts. The reason for this is that these posts and joists are used to fasten the struts and props to when 'staying' or supporting the boat while it is being built. The roof is of course necessary to keep out the rain and hot sun, both of which can do a lot of damage to any boat. This building berth should cover the complete boat, and the width should be such that timber can be handled and 'bent up' <u>inside</u> the building posts.

Assuming that our boat is to be 30' long, 12' wide, 4' deep, we can design our building berth allowing about four feet on either side of the boat for handling timber, and then about four feet clearance above the stemhead before fitting the joists (see Fig. 25). The four-foot clearance is to make sure that we have enough room under the joists to work when fitting the deck later on.

<u>STOCKS</u>

The stocks are the building blocks which are bedded firmly into or on top of the ground and which when lined up take the keel. These stocks must be solid and true on top because the top of the stocks is in truth <u>the exact line</u> of the bottom of the vessel's keel. It is not necessary that the top of every solid stock be exactly true, because any small difference in finished height can be made up with small packing pieces or wedges (see Fig. 26). It is very easy to line up the top of the stocks and wedges by means of a strong

<u>DROP OR SPRING</u>

chalk line, and even if there is a small spring or 'drop' in the line, this does not matter very much unless the 'drop' exceeds $\frac{1}{2}$". It is better to have

<u>HOG</u>

a small curve in the bottom of the keel than have the keel 'hogged', or curve the 'wrong way up' (see Fig. 27).

<u>NUMBER OF STOCKS</u>

The number of stocks varies according to the length and size of the keel and the weight of the finished boat. For a boat 30 feet long and with a keel as strong as this one, we need four stocks, spaced as shown in Fig. 26, that is, about 9' 0" from centre to centre of each stack of blocks. With the building berth ready and stocks all laid, we now 'strike' a straight line right along the top of the stocks as near to the centre as possible. This represents the centre line of the keel. In order to make it easy to place the keel straight on the stocks, measure half the width of the keel out from the centre line and then nail a small block of wood to the stock (at every stock). These blocks then form a 'stop' for the full length of the keel (see Figs. 28 and 29).

CENTRE LINE OF KEEL

LAYING KEEL

We are now ready to lay the keel, but before doing this a description of the keel itself is given. The keel of any boat forms a very important part of the vessel and can be likened to the backbone of any animal or fish, insomuch that it is a common link between all ribs and limbs (arms, legs, fins, etc.). This backbone of course is flexible, whereas the keel is or should be very stiff. Fig. 30 shows a keel and describes its various points. It should always be remembered that the keel should be good, strong, hard timber that is not readily eaten by sea borer or worms. The keel need not necessarily be seasoned or dry timber and the back, or aft end, should always be given three or four good coats of white paint to prevent it from splitting open. The white paint is easy to pencil on if required later.

NIB

The curve is shaped on the front, or fore, end, and the 'nib' cut so as to fit in with the stem (see Fig. 31). The nib is about 1¼" deep.

HOG

Attention is now drawn to the piece of timber on top of the keel in Fig. 31. This is called a hog, or hog piece, and forms a ledge along the top of the keel to which is fastened the two bottom planks (one each side). The hog can be fastened to the keel with bolts or treenails (see Fig. 32). Always remember to position bolts or treenails on <u>either side</u> of the centre line of the hog piece and keel. This holds the hog 'flatter' to the keel, and the chances of splitting the keel and hog piece right along the exact centre of the keel are greatly reduced. The wedges of the treenails go directly across the grain, <u>not</u> fore and aft (or with the grain).

Fig. 31 also shows some dotted lines; these will now be drawn in solid lines and given a name and duty (see Fig. 33).

FOREFOOT KNEE

Fastened to the fore end of the keel is the forefoot knee, which is usually the same thickness as the keel itself. This piece of timber is best made from a natural 'crook' (branch or root of a tree) so as to have a good 'flow' of grain right around the throat of the knee (inside of knee).

Its duty is to hold the stem of the boat to the keel. You will recall that the fore end of the keel has already been shaped to suit the shape in the forefoot knee.

This 'knee' is bolted to the keel in the manner shown. Treenails may of course be used here. (The lines across the knee mean that "bolts or treenails go here").

When boring the holes to take these bolts, or treenails, it is well

TO MAKE GOOD FIT ON END OF KEEL

to use this little trick, which makes a very good job at this point of the frame work. Before cramping the knee to the keel (or knee to the stem) place a piece of steel or very thin piece of timber between the knee and the top of the keel, then hold the knee to the keel with a strong 'D' cramp. Now bore the holes. Then uncramp the job, remove the thin piece of material and fit the bolts; you will find that the nib fits very tight on end and makes a very strong joint (see Fig. 33). In order that the nib and the end of the knee 'go down' together and remain good fits, it is essential that the angles of the nib and the end of the knee are both the same; and that both fit tight in the first place before boring holes. To do this, merely pass a saw between the end of the keel and the nib and between the end of the knee and the hog piece (see Fig. 33). The 'end fit' will be perfect, as the saw makes a parallel cut.

STEM

This part of the boat was mentioned earlier and is shown in Fig. 33. It also is the same thickness as the keel and the forefoot knee, and is fastened in exactly the same manner as described in the preceding paragraphs. A very important thing to remember is that the top of the stem should be left longer than the finished job requires, because the stays or struts which are fitted later (to hold the frame work vertical) can readily be fastened thereto

APRON

(see Fig. 35). The stem carries at its back the apron, which is fastened to the stem in the manner shown. This apron performs the same duty as the hog does for the keel. It forms a ledge to take the end of every plank and holds the ends of the planking to the stem (each side). The apron is always 1" or or $1\frac{1}{2}$" wider than the stem, and should be a solid piece of good timber that does not split easily. (See Fig. 34, which shoes the apron in more detail).

With the front end or fore end of the frame work in position, it is now necessary to keep it vertical and safe from damage by falling over on the stocks (which often happens). All that is required is two lengths of 3" x 2" timber, some long nails, and a plumb bob and hammer. Nail the stays to the top of the stem (in front) and nail the foot of the stays to the front posts of the building berth or shed (see Fig. 35). Make very sure that the stem is plumb, or vertical, by means of the plumb bob. To do this, hang the plumb bob from a nail in the centre of the stemhead (or top) and then line up the string with the centre of the stem and forefoot knee. By the way, all timbers should be marked with a centre line before they are assembled and erected on the stocks. Always stand directly in front of the stem and keel when lining up the stem for 'uprightness'.

STAYS

CENTRE LINES

And now we can begin to erect the back end, or aft end, of the boat. (The fore end of the boat is called the bow and the aft end the stern). Our 30 foot cutter is a square-ended or transom-sterned boat, and in order to describe the erection of each piece of timber in this end of the vessel a sketch is given (see Fig. 36) which shows the finished job and the name of each piece of timber in the job. This type of stern is a comparatively simple one, and although it has some disadvantages it has the big advantage of being easy to make and easy to repair.

PROPELLER APERTURE

The keel is shown running along under the propeller aperture (or space to put the propeller) and under the fore edge of the rudder. This is done to protect the propeller and rudder if ever the boat goes ashore or hits a reef.

On top of the keel is the hog, which goes under the stern knee and stops at the first piece of deadwood.

STERN KNEE

The stern knee is the piece of timber with two arms that tie the keel and hog to the rest of the aft frame work. This stern knee is made from a natural crook (just as the forefoot knee is made) and is cut the same thickness as the keel. It is bolted to the keel as shown in Fig. 37. Notice how the

GRAIN 'grain' is shown in the knee. With grain such as this the knee is very strong indeed. If the grain was 'short' as shown in Fig. 37A the knee would eventually crack and break across as shown in the sketch.

DEADOOD

PROPELLER POST

With the stern knee bolted, the next pieces to be erected are the two deadwoods and the propeller post. The deadwoods are used to fasten the ends of the planking to. The propeller post carries the stern bearing which supports the propeller shaft and the propeller. For these reasons each of the pieces of timber must be strongly secured and bolted to the keel and stern knee.

MORTISE

The bottom of the first deadwood is mortised into the keel; the mortise is not cut the full width of the deadwood and is about 2" wide (see Fig. 38A for details of this mortise). The mortise which takes the other deadwood also takes the propeller post; it will be the same width and depth as the first mortise but does not run up close to the seam or joint of the two deadwoods. (More of this later). The duty of any mortise is to locate or lock one piece of timber to another so that if the boat hits a reef the thin copper bolts or wooden treenails are not expected to take the big strains on their own. The mortises are much stronger and take most of the strain from the bolts. For this reason all mortises should be a tight, even fit.

POCKET BOLT

The bolting of the stern knee to the deadwoods is a simple matter as only three long bolts are required, but to hold the deadwoods and the propeller post to the keel we use a 'pocketed bolt' or a bolt which is 'nutted' at one end in a small mortise or pocket. This is a very useful way of holding 'deadwood' to the keel. Details are shown in Fig. 39, which also shows details of the hole or groove which takes the bolt. Always remember that you must use a really large heavy square washer under such a bolt, as the washer must be strong enough to hold the two pieces of timber down without bending.

The three long bolts are easily 'bored for' by the simple method of boring through each piece of timber before the whole frame work is erected. To do this, merely mark the centre line of each bolt on one side of the deadwood and then 'square' this mark across both edges of the deadwoods etc., until the squared marks cross the centre marks (which should already be marked on the edges). These cross marks are the centre marks of the bolt hole in every case, so you can bore from both edges (with even a short auger) and still bore a 'long' straight hole when all the pieces are erected together. However, in some cases the hole may not be exactly true and straight enough to drive the bolt or treenail through, in which case it may be 'trued' by means

RED-HOT STEEL ROD

of a red-hot piece of steel rod, slightly smaller than the bolt or treenail to be used. (See Fig. 40 for details of boring holes through the stern frame - deadwood etc. - and Fig. 41 for method of burning a hole true). Now refer again to Fig. 38 and note that two smaller pieces of 'packing' (or deadwood) are shown bolted to the propeller post. Note particularly how the propeller post has been cut away at the top and down to the curved shape at the bottom of the inner packing piece. This allows for a nib (remember the nibs at the

FEATHER ENDS

stem?) and prevents the formation of a thin feathered end of timber which cannot be fastened in any way. Allow for $1\frac{1}{4}$" nib.

The next timbers to be fitted are called horn timbers. One of these

DOTTED LINES

is shown dotted (because it cannot be seen on the other side of our frame work) on Fig. 36.

HORN TIMBERS

The duty of the two horn timbers is to carry the ends of some planks, and to hold the tops of the deadwoods and stern knee and the bottoms of the packing pieces all in line together. Fig. 42 shows how this is done by means of a few small bolts or treenails. Note that the horn timbers also form

REBATE

another ledge (or rebate, as it is also called).

Our frame work or backbone is almost complete, and with the bow end already stayed in position it is now necessary to stay the stern end in the same way. The top of the propeller post has been left long so that the stays can be fastened thereto.

The stays from the propeller post should be taken to the bottom of the two 'back' posts (see Fig. 25), and needless to say, the stern frame work should be plumbed exactly true and in the same manner as the bow or stem.

TRANSOM

We now come to the building of the transom, or stern. This is shown in Fig. 43. The transom is made, or built up, with 3, 4 or even more boards, depending on the depth of the transom. An important item to remember when 'making up' the transom is to keep the bottom board (in this case No. 4 board) as wide as possible so that the plank ends can be nailed to real solid timber rather than to thin ends, which can easily split and let the plank ends come loose and cause bad leaks.

THIN ENDS

The shape or outline of the transom is given in the design and drawings, but care has to be taken when actually 'cutting out' the transom that allowance is made on the inside edge for 'angling', or bevelling. In other words, the inside 'shape' is larger than the outside shape (see Fig. 44) so that the planking can lay up flat against the transom edge from inside to the outside.

BEVELLING THE TRANSOM

After the different boards have been cut out to suit the design (with the allowance made for bevelling) the four or more boards are 'seamed' on the outside so that the joints can be caulked and puttied. Such a seam is shown in Fig. 43. A good seam is made by showing an opening of 1/8" on the outside with a tight joint on the inside.

SEAMING BOARDS OR PLANKS

One easy method of making such a joint and seam is to place the first two boards together (edge to edge), hold them together with two light battens, and then run a saw right through the joint or seam. If one saw cut is not enough, try two or three, but nail the battens on in a new position every time. When a good fit is so made, merely plane or bevel a seam on the outside edges, as shown in Fig. 45. (By the way, this is a good method of fitting any two surfaces of timber). With all boards made to fit and seamed for the caulking, the next job is to fit the cross pieces and 'through nail' them to the boards as shown in Fig. 43. These nails are driven through the boards and then, on through the cross pieces. They are then 'turned over' or clenched on the cross pieces.

However, before nailing or screwing any two pieces of timber together, it is always wise to paint between the two fitting surfaces, so we therefore paint the fitting edges of every board and also behind every cross piece. This coat of paint helps to preserve the covered timber from dry rot. The transom is now ready for fitting into its position, but before bolting it to the frame work make sure that the outside pencil marks (those that show the finished shape of the transom) are clear and deeply marked, and that the centre line of

PAINTING BEHIND CROSS PIECES

the transom is shown on the outside and on the top and bottom edges.

POSITION OF TRANSOM

And now the transom can be bolted into position. The true position can be easily fixed at the top and bottom by placing the centre lines on the transom in line with the centre line on the aft packing piece, but remember that the transom must also be in position 'up and down' and this we fix from the bottom (see Fig. 36). Note that the bottom of the transom is in line with the horn timbers, but remember that it is the outside of the transom that has to be lined with the horn timbers so that if there is too much 'bevel' on the inside of the transom this can now be 'fixed' before the transom is bolted into place. By the way, notice in Fig. 43 that the bottom of the transom is the same width as the packing piece, and that Fig. 38 gives the position of the two main bolts, which should be $\frac{1}{2}$" copper screw bolts with the nut on the inside. The bottom of the transom should be fastened to the packing piece with two heavy brass screws.

AFT STAYS

The aft end (back end or stern) can now be fixed or 'stayed' into position, and this is done in just the same way as the bow. The stays are nailed to the top of the propeller post and to the bottom of the nearest building post (see Fig. 46). And now we have the backbone of the cutter up in position and 'on the stocks'. At this stage we can see just what our boat is going to look like in profile, or in side view. The next step is to make the shapes or moulds (as they are called) so as to give our cutter its correct 'body' shape.

MOULDS

These moulds are made from timber about 6" x 1". Fig. 47 shows one finished. The finished shape of each mould is given by the designer on a small drawing, but the man who builds the boat must know how to draw the full-size shape that the designer wants, using the small drawing as his guide. Full details of just how this is done will be given in a later part of this book; in the meantime, we will assume that you have the full-sized shape to work to, and are ready to make each mould. This is how it is done.

Our full-sized shape, or outline, has been drawn on a big sheet of 'building paper' say 'PABCO' or 'MALTHOID', or perhaps 'SISALCRAFT' (see Fig. 48). The job is to make a wooden mould or shape that fits this outline. The easiest and perhaps the surest way to do this is to lay the different pieces of timber marked 1, 2, 3, 4, 5 and 6 in position under the cut out shape of the mould, and then mark the shape of the paper on to the various pieces of timber, making sure that opposite pieces of timber are exactly the same shape, that is No. 2, 4 and 5 are the same shape on each side of the mould. No. 1 is the top stay or batten that holds the top of the mould together at its correct width. At the centre of this batten is drawn the centre line, which is of course at the half width of the cutter at whatever position the mould is designed to go. No. 3 is another batten that helps to strengthen the mould, and it should be positioned parallel to No. 1 batten. (PARALLEL means that two pieces of timber are the same distance apart at each end and all along the edges; see Fig. 47, where it says 'SAME DISTANCE RIGHT ALONG'). No. 6 is the strengthening piece at the bottom of the mould and must be placed on the same side of the mould as both No. 1 and No. 3 battens. The reason for this comes later.

The different parts of the mould can be either nailed or screwed together, but always make sure that the finished mould is true to shape, strongly made and complete with the exact centre line marked on the top batten and on the bottom cross piece No. 6.

We will now assume that you have made all the moulds. A lot of building paper has been used and cut up, but this is not very expensive, and provided you have made a good job of the moulds the cost of the paper does not matter a great deal. Do not throw the paper away at this stage because it will be useful for more shapes later on.

The next job is to fit the moulds up onto the 'back bone' of our cutter, making sure that they are erected in their correct place. (See Fig. 49 for a sketch of the moulds in position). The correct place for each mould is also given by the designer on his drawings. This position is marked on to the top of the hogpiece by means of a square and a hard, sharp pencil, and every squared mark is given its correct number 1, 2, 3, 4, 5. The edge of the mould is placed exactly on this mark, but always remember that moulds 1, 2, and 3 put their back edges on the mark whereas moulds 4 and 5 put their front edges on the mark. There is a long explanation for this but no attempt will be made to give this as yet. Now that you know where the face of the

POSITION OF MOULDS

UPRIGHTS

mould (or edge of mould) goes, you can easily fix the position for the upright; bear in mind that the cross pieces and battens are nailed to the upright so that the upright is about 1" behind the mark for moulds number 1, 2 and 3 and about 1" in front of the mark for number 4 and 5. This fixes the bottom position of the upright. The top is fixed by means of a plumb bob (see Fig. 50) which fixes the 'upright' and mould perfectly true and upright. All uprights are erected in this manner, and all moulds are nailed or bolted to the uprights as in Fig. 51, bearing in mind that the cross piece must be made perfectly level by means of an ordinary carpenter's level. As a check to all moulds, make sure that the top of every cross piece is 'lineable' with its "next door neighbour." Do not have the moulds erected as in Fig. 52.

MOULDS TO BE LEVEL.

With all the moulds erected it is now necessary to position and hold them in position squarely across the hogpiece. This is done very easily as shown in Fig. 53 and Fig. 49.

SQUARING MOULDS

In Fig. 49 is shown a fore and aft batten about 3" x 2" running along the full length of the cutter on top of every mould and nailed to every upright. This batten helps to keep the uprights firm but also serves to nail our stays to when squaring the transom and the moulds. To square the transom simply, drive a 3" nail partly into the top of the hogpiece (right on the centre line) about where shown on Fig. 49 and Fig. 53. Now take a light straight batten, place one end against this nail, and then mark the inside of the top of the transom on the batten, first on the left side (PORT) then on the right side (STAR) looking towards the stem in both cases. Unless the transom is perfectly square already, which is most unlikely, you will obtain two different marks as shown on the batten in Fig. 54. Now halve the distance between these two marks and with the batten back in its place up against the nail in the hogpiece, pull the transom into position until both edges come into line with our new mark, and hold it in this correct position with two strong stays nailed on to the upright and to the top of the transom. Notice the small saw cut at the end of the light batten. This stops the batten from sliding away from the nail.

The moulds can now be 'squared' by simply making No. 1 mould parallel to the transom, then No. 2 parallel to No. 1, and so on. To hold each mould in position, simply use a 3" x 1" batten and nail it to the top of the transom. Then nail it to every mould as each is made parallel to the other.

REBATE

And now we are ready to cut the rebate, which is usually regarded as a most difficult job by most wood workers, but which can be done simply if these step-by-step directions are followed. You may wonder what is meant by the term 'rebate', but it is simply another name for the ledge made by the hogpiece and keel or the apron and stem as well as the horn timbers and the deadwood. Fig. 55 shows what happens when the rebate is cut. The hogpiece is shown on top of the keel with an imaginary plank fitted squarely into the rebate or ledge on the left-hand side. Notice that this plank fits tightly at A and B. However, our moulds are not square or flat on the bottom, but shaped something like Fig. 55A, so if we require our first plank to fit snug and tight into the ledge we must cut the ledge to suit this new angle or bevel, as is shown in Fig. 55 on the right-hand side. Our plank now fits nicely at C and D. Yes! - you will say, but how do we make a ledge that is continually changing from mould to mould because each mould has a different bevel? Well, this is how it is done and it must be done properly, because unless the plank fits snug into the 'rebate' it may split when the nails are being driven from the plank into the hogpiece as in Fig. 55B. It is also possible to split the hogpiece if the plank bears tightly on its bottom edge and not on the top edge of the hogpiece as shown on the left-hand side of Fig. 55B.

Now look at Fig. 56 and Fig. 57, and note how the mould in each case fits down on top of the hog and how the ledge or rebate is shown square on one side of the sketch before beginning to bevel and then bevelled to fit the planking, when the job is done. To get a picture of how the bevel really occurs, simply imagine the plank being placed against the mould (above the hogpiece) and then being slid downwards through the dotted lines until the outside edge of the plank fits tight against the 'rebate line'.

To really do this with the plank itself would be very awkward but with the aid of a small piece of plank about 2" wide and 8" long it is much easier (see Fig. 59). This small piece of plank is used as a pattern, and wherever it fits so will the real plank itself fit. The bevelling process can be carried out with a $1\frac{1}{4}$" chisel and a wooden mallet, and although it may be a slow and tedious job it is a very good way to cut a rebate. Simply cut a small length of rebate at every mould (say about 4"), as shown in Fig. 58, and when these small lengths are all truly out, you have all the measurements necessary to cut the complete rebate along the keel, because if the tops of these 'checks' are joined together with a pencilled line (using a batten between each set of checks) this line then indicates the top edge of the rebate and is called the 'bearding' line. The most important things to remember are :

1. The rebate must be the same <u>depth</u> all along the keel.
2. The rebate must be free from lumps and hollows.

And now the rebate has to be cut on the stem. This is done in the same way, using a chisel and mallet and the same small piece of planking as a guide. However, to cut the correct bevel we use several thin battens nailed to the stem and to the first three moulds (see Fig. 59). These battens (say about 2" x $\frac{3}{4}$") indicate the outside shape of the boat and give the bevel of the planking at the stem and apron (see Fig. 58 and Fig. 60).

Using the same procedure as when cutting the bevels for the planking along the keel, each trial rebate 'check' is cut. These checks are then joined together by means of a light batten and a pencil. The whole rebate can then be cut and finished (see Fig. 61).

A similar procedure is used to cut the rebate at the aft end (back) of the cutter. Simply nail a few light battens outside the moulds (from No. 3 aft) and proceed to cut the trial rebate checks as you did at the stem. Then join them together with a light bending batten and a pencil, finally finishing the rebate with a sharp chisel and heavy mallet.

Pay particular attention to the rebate where it occurs at the horn timbers, but if a light batten is used all the while, little difficulty should be found in making a good job.

Always remember that it is better to leave a 'little bit of back rebate' for future adjustment (when the planking itself is being fitted) rather than take too much timber away (see Fig. 62).

<u>PLANKING</u>

And now we are ready to plank the cutter. There are many ways of setting about planking any boat, but in this case every attempt will be made to make this work simple and strong. A few important things to remember are :

1. Never try to use very wide planks. A good width for the cutter is about $4\frac{1}{2}$".
2. Always use the very best of good dry timber. Wet (unseasoned) timber shrinks badly and leaves very wide caulking seams which are impossible to caulk and always leak.
3. Use the longest lengths of planking available.
4. Always arrange the various butts (or joints) in the planks to be as far apart as possible.

The first plank to be fitted is the top plank, or what is known as the sheer strake. The second is the bottom plank or garboard strake. The next is the bilge plank. These planks are fastened temporarily to the moulds with either screws or nails, but fastened permanently to the keel, transom and stem (or apron) according to their positions. Once these three planks are fitted on each side of the boat the whole frame work becomes rigid. The next step is to fit a few light (but stiff) battens in between the planks, screwing each one to the moulds and at each end as required. The planks and battens then form a framework, inside which can be bent the frames or timbers (see Fig. 63).

Returning to the method of fitting the top plank, let us think of just what we are trying to do as we place each plank into position.

No doubt many of you have built, or helped to build, an ordinary weather board house. You will recall that each wall was the same height at each end so that every weather board was the same width and was nailed to the studs parallel to its neighbour. Thus the whole wall was filled or covered with planking.

Now if for some reason one wall was 10 feet high at one end and 8 feet high at the other, and if we required every board to finish at each end of the wall, it would be necessary to taper each board at one end before nailing them into position. Just how much taper would be required on each board if we were using 6" boards, is shown in Fig. 64, and it is given as $1\frac{1}{5}$". So that if each board was marked 6" at one end and $4\frac{4}{5}$" at the other, and these marks were joined together with a straight line, we would have twenty planks all correctly shaped to close the wall in exactly and still all finishing at each end of the wall.(see Fig. 64).

Planking a boat is something like this, except that we have to close in on shapes that are not straight and that are all different in width or girth (see Fig. 65). In these sketches the different widths or girths are shown by letters A B C D E F. It is shown that the girth A (at the stem) is smaller than B (on the middle mould No. 3) and that C (at the transom) is also smaller than B.

The same thing occurs below the bilge plank, where D is less than E and F is also less than E. Now there is a very simple way to calculate - or find out - what width these different planks should be (at any mould), and once this is learnt the business of planking a boat becomes much easier.

However, before learning anything about this business of fully planking a boat, let us learn how to mark out the shape of the first three planks and learn how to fit each one in its position. The top plank, or sheer plank, is fairly easy, so we will do this one first.

Earlier in this book we mentioned an average width of 4½" for any plank. This can be exceeded in the case of the top plank and the bottom plank because the top plank will be partially covered by the "rubbers" or beltings which should not cover the caulking seam under any circumstances (see Fig. 66), because if this seam is covered with the beltings it is impossible to caulk it at any future date and the boat leaks here forever after.

But to return to the top plank. Using 6" material, we decide to make the plank 6" wide at No. 3 mould and 3½" wide at the stem and transom. The reason for 3½" at stem and transom is that :

1. The narrow plank at the stem is easier to bend into position.
2. The narrow plank at the transom allows more planks to finish on or be fastened to the transom.

With these three widths decided upon the next job is to get the widths of the plank at every mould besides No. 3 mould. This is how it is done. See Fig. 67. Make a half circle using the greatest plank width (6") as the length of the radius. Now measure square up from the base line the smallest plank width (3½"). Next divide the distance (A) between the 6" mark and the $3\frac{1}{2}$" mark into three equal spaces and set up two uprights that cut the edge of the half circle. The length of B upright is the width of the top plank at moulds No. 2 and No. 4 and the length of C upright is the width of this plank at moulds No. 1 and No. 5.

So now we have every width that is wanted to mark out the top plank, and we mark these widths on the plank at the exact position of each mould. It is not necessary to bend the 6" plank around the moulds in order to mark the position of the moulds on to the plank. Simply bend a light batten instead, keeping one end of this batten tight against the stem rebate and marking the position of each mould on this batten with a piece of chalk.

Now place the batten flat down on the plank and mark these chalk marks on to the plank (see Fig. 68). For moulds No. 1 and 2, mark from the top of the 6" plank, and for moulds No. 4 and 5 mark from the bottom.

The reason for this peculiar way of measuring is hard to explain at this stage but it is well to remember that almost every 'top' plank is shaped something like Fig. 69 if correctly "moulded". (Mention will be made of "moulding" a plank later on). It should be noted that our plank in Fig. 68 is very much like that in Fig. 69. Any <u>difference</u> can be "bent" into the plank when it is steam bent around the moulds and fastened into position. But before explaining the use of steam in bending a plank it would perhaps be better to point out that every plank on one side of the cutter has an exact neighbour on the other side, so that once a plank is cut out and planed along its edges it should then be used as a pattern to mark the other plank for the other side.

Another important point to remember is that a "full length" plank is almost impossible to find for any cutter or boat over 18 feet, so that every plank will have to be made up in two lengths. This means that joints or butts occur throughout the whole of the planking. These butts must be spread apart from one another. Two butts should never be placed near one another. Fig. 70 shows how the butts should be placed in order to preserve the strength of the vessel. Notice that butts do not occur under each other unless at least two planks are between these butts.

STEAM-BOX

But to return to the use of steam in boatbuilding. Green or wet timber will bend fairly easily, but dry or seasoned timber is much harder, and if the bend or twist is difficult there is always the risk of breaking the plank while trying to force it "dry" into position. So in order to use dry or seasoned timber and still bend it into position, it is necessary to use a steam box and a small "boiler" as shown in Fig. 71. The box is made of boards, and for the cutter you require a box about 12" x 12" x 14 feet long. One end is boxed up tight and the other end left open to receive the timber to be bent. Always keep this end blocked up with a bag when steaming a plank.

The box is supported on two cross pieces resting on posts driven into the ground.

The amount of steam required to 'soften up' a plank for the cutter varies with the kind of timber used and the amount of 'wet' steam going into the box. However, for our purposes give the planks about twenty minutes to half an hour in good 'wet' steam, and then bend them into position.

The question of bending the sheer plank is easy enough, but how does one 'hold' a plank to its position without frames or bent timbers to fasten it to? The stem end of the plank is fitted to the rebate and held to the apron with two firmly driven copper nails. Screws are better than nails for this job, but no matter what method is used, make sure that the plank end is bored to take the fastening without any fear of future splitting. The stern end is also fastened to the transom in a similar manner.

The plank is screwed to every mould with heavy gauge iron screws. Why iron? Because although iron screws rust, they are stronger than brass and these iron screws are only temporary and will be taken out once the frames or ribs are bent into position.

Now if our plank is made up with two lengths the butt or joint is made with the use of a butt block (see Fig. 72).

With the top plank fitted and fastened on each side of the cutter, our next plank is the bilge plank, or the plank that runs around the boat about half way between the keel and the top plank (see Fig. 65). This plank can be marked out as a parallel $3\frac{1}{2}$" plank. That is to say, it is $3\frac{1}{2}$" wide all the way through, from transom to the stem. Fig. 65 shows roughly where to place this plank; but in any case let the plank lay up 'naturally' to the moulds and do not force it into position or try to bend it on edge. And now to the garboard plank. The garboard (as it is called) is not difficult to fit if one uses a pattern to arrive at the correct shape. An excellent pattern can be made from a standard Masonite sheet, which is 12' x 4', and can be sawn into 6" widths and joined together later by overlapping one 12-foot length on to another (see Fig. 73).

Now apply one length of this 12-foot 'plank' to the moulds and push it into its rough position at the stem. Let the end over-run the rebate so that a rough shape or outline of the rebate can be marked on the pattern later. This pattern will probably lay up to the keel - something like Fig. 74. Now roughly shape the stem end to fit the rebate and replace the pattern up in its first position. In all probability the pattern is still a long way off making a good fit to the rebate along the keel and to the stem.

However, this is easy to rectify with the aid of a pair of compasses. Set the point of the compasses to the greatest gap (between the edge of the pattern and the outside edge of the rebate) and then mark a parallel line on the pattern, keeping one point and leg of the compasses in the rebate, whilst the other point marks the Masonite. Make sure that the legs of the compasses are always directly above one another while the mark is being transferred on to the pattern (see Fig. 75).

After making a clear mark on the Masonite, the next step is to cut along this mark with a saw and plane the edge exactly true to the mark. Now bend the shaped template into position. It should fit exactly true to the rebate. If so, fasten it lightly to the moulds and stem with a few iron nails (not too heavy).

Next fit another 12-foot length of Masonite planking into its position at the stern (or deadwood) end of the cutter. Do this in exactly the same way as you did the stem end of the rebate. The next and easiest part of the template is made by simply 'laying up' another 12-foot length of 6" Masonite along the middle portion of the rebate (fitting it if necessary as before). And now, with three separate but overlapping patterns, it is easy to nail all three together and so form one long continuous pattern of the bottom edge of the garboard (see Fig. 76).

The next step is to mark the position of every mould on to the outside face of the pattern, and to mark 'the pitching spot' on the pattern and on the keel (see Fig. 77).

It is now possible to mark the bottom edge of the garboard on to a suitable plank. Do this, and at the same time transfer every mould mark and 'the pitching spot' on to the plank. The next move is to mark out the top edge of the garboard plank. In the case of the cutter this edge can be marked straight (see Fig. 78). Now cut the plank to shape and plane both edges true and free from any bumps. Don't forget to plane a 'little bit of seam' on to both plank edges. Then mark out the opposite side garboard (that is, make two garboards, one for each side of the cutter). While cutting this second garboard to shape, put No. 1 garboard in the steam box and leave it in the steam for about twenty minutes.

As stated some time earlier, it is very difficult to get all planking in one length, so of course one must consider the garboards to be in two lengths. If this is so, make sure that the butt is made about halfway along the bottom edge of the garboard and in between two frames (or timbers, as they are called). This last instruction may at first seem very difficult to carry out, for how is it known where the frames occur? This is easy, because the position of every frame should be clearly marked on the hogpiece, after the framework has so been erected that the frames can be bent at the correct, even spacing intended by the designer. This spacing is always given on the drawings. With the butt or joint properly made <u>between</u> two frames, it is easy to fit the butt block in its correct place later on (see Fig. 72).

And now comes the time to bend the front end of one garboard into its position. To do this, clamps are needed. For the cutter you will need about six good quality clamps, with say a capacity of 9" between jaws. You will also need a helper to hold the plank at one end while you clamp the stem end up into its position. As soon as you are ready with your cramps (fully opened), act very quickly. Out with the steaming hot plank, fasten one end to the stem with the clamp, and then twist and bend the garboard into its correct position. Don't waste any time. Use your clamps when you notice they are required, and if necessary use short pieces of stick to 'prop' the garboard in position wherever it shows signs of not fitting hard up into its position (see Fig. 79).

Speed is the secret of good bending. It is useless to try and bend cold timber and will only result in split planks.

After bending and holding the stem end of the garboard into position, allow it to grow cold, for as it becomes cold and dry it also 'sets' in its twisted shape. This will take about half an hour. Now, rather than waste this half hour, bend up the stern end of the other side garboard. This allows you to work away from the previous bending, and while this piece of planking dries out you can fit and fasten your first stem end of the garboard in position. By 'fit and fasten' is meant the process of carefully fitting the plank right back snug into the rebate and tight down along the seam. This can only be done by using care and common sense. If your template has been correctly made there will be very little need to 'fit' down into the seam (this will be correct), but you may still have to take away any slight bumps that occur along the back of the rebate. However, it is a matter of observation to see where and when to do this, and provided you use a wide sharp chisel (say $1\frac{1}{2}$" wide), the job is perhaps slow, but really easy.

As for fastening the garboard, this is done by driving suitable length copper nails into the stem and along the hogpiece (see Fig. 80). For the cutter allow say $2\frac{1}{2}$" nails. Space these nails about 6" along the hogpiece and 3" up the ends of the garboard. Always bore for each nail, through the plank and into the "back timber". Do not bore too loosely or too tight. Try out your boring gear in an old piece of timber before going to work on the real job. Always countersink each nail along the garboard seam. One important point to remember is that the end nails of every plank are always liable to split because the nail is very close to the end of the plank. Make a special effort to bore these end nails slack (through the plank only); this will help to avoid split ends in your planks.

Having nailed one end of the garboard into its position, the rest of this job should be easy. You simply fit and fasten the stern piece of garboard into position, and then go ahead and bend the other two pieces of garboard into position as before.

The join, or butt, is made about the middle of the hogpiece in between a frame space. Always leave a small seam along the butt for future caulking. The butt block fits tight down to the hogpiece and stands about $1\frac{1}{2}$" above the top edge of the garboard. The fastening is made each side with two copper nails driven through the butt block, and one into the hogpiece (see Fig. 81),

At this stage we have our cutter up in frame with three planks fastened into position and to the moulds. The next step is to close in the space between the top plank and the bilge plank on each side, fitting a plank first one side and then its twin on the other side, so using the first plank as a pattern on the other side of the cutter.

The problem is, however, to decide on the number of planks to use each side, and then to arrive at a shape for each plank, so that when all are bent into position, the space is truly filled.

This can be done by dividing the space on each mould into so many equal spaces (with the aid of a pair of compasses); or by using what is known among boatbuilders as the 'scaling method'. However, in any case the actual number of planks required is easy to reckon, as no plank should exceed $4\frac{1}{2}$" wide. With this width set out on your compasses, simply mark off the number of planks on the amidship mould (No. 4). If necessary, keep altering the compasses until the correct equal width is found. Assuming that the width of every plank on the amidships mould is known, you now count the number of planks required, and if the "compass method" is used then every mould has to be divided by the compasses until the same number of planks occur on each mould as occur on the amidship mould. This is a long job, but it is a sure way of doing this part of the work.

The other method is quicker, although perhaps a little harder to understand. Look at Fig. 82. Here you see the amidship mould, stem, and stern girths, (or the distance between the edges of the top and bilge planks) all clearly shown.

Now divide the girth on the amidships mould into the number of planks you are going to use, making sure that they do not exceed $4\frac{1}{2}$" in width. Having obtained this number, divide the girth at the stem into the same number of planks. This will give you the width of the planks at the amidships mould at the stem. (Use a pair of compasses for this job).

Then take a light batten about 1" x 1/8" and place one end on the top edge of the bilge plank amidships; bend the batten around the mould and mark the bottom edge of the top plank on the batten.

Square this mark across the batten and call it whatever width the planks are at this point, (say 4½"). Now take the girth at the stem, mark it square across the batten (on the same face as before) and call it whatever width you found necessary for the stem planks (say 3"). At this stage refer to Fig. 82. Note that the sketch shows both these girth marks - but has twelve more equally-spaced marks as well, between the marks. These marks represent eighths of an inch, and you will note that the number of eighths shown are the number of eighths difference between 4½" and 3"; that is, twelve eighths. You can therefore see that to lay out any 'scaling' batten, all you do is to girth the amidships mould and stem, mark the plank widths in each case, then divide the distance between each girth into the number of eighths difference between the two plank widths.

<u>EXAMPLE</u>: If amidships mould widths were 4¼" and stem widths 2¼", the number of "eighths" difference would be 16. You therefore mark 16 equal spaces between the two girths and <u>call each one</u> <u>1/8 of an inch</u>.

Now, with this scaling batten you can find the correct width of any plank on the topsides between <u>the amidships mould and the stem</u> by simply placing the bottom end of the batten against the top edge of the bilge plank and bending around to the shape of the boat at any mould. Mark the bottom edge of the top (or sheer) plank on the scaling batten; then read the width of all planks on this mould from the scaling batten (see Fig. 82). This shows the FORWARD batten, with the girths of mould Number 5 and 6 marked with light dotted lines. If the moulds give a girth as shown on the sketch, then the plank width at No. 5 is 4", and at No. 6, 3⅞". Make perfectly sure that you understand this system. Then make up a scaling batten for the "FORWARD" end, and then for the "BACK" end - (bow and stern). Mark each batten FORWARD or BACK, and bore a small hole in one end so that they can be hung safely on the wall of the boatshed.

And now we can proceed to plank in the space between the top plank and the bilge plank. With careful choice of good timber and perhaps some 'steam work', it is quite possible to 'make up', (or mould), all the topside planks exactly the same as one another and simply fit and fasten them to the bent timbers, or frames, one after the other. However, care must be taken to position the butts (or joints) of each line of planking well clear of each other (see Fig. 70).

But before proceeding to fasten these 'easy' planks to the bent frames, we must first have the frames properly bent into their positions. This takes patience and care - but is not so hard to do when using 'light' frames, as in the cutter.

Earlier, mention was made of marking the position of each frame on the hogpiece. This should have been done carefully. It is a good plan to paint the top of the hogpiece with white paint so that the frame marks are easily seen on the hogpiece in the rush to bend the hot frames.

STEAM BENT FRAMES

Fig. 63 shows the cutter with three planks fitted to each side, and battens fastened in between the planks to form a framework, inside of which the "timbers" are bent. These "timbers", or frames, are bent square up from the hogpiece and parallel to each mould. Do not depend on your eye when bending timbers inside the framework; it is much better to mark the position of every frame (inside the planking and on every batten) with a good, heavy, easily-seen mark and then bend your timbers to follow these marks. The frames, or timbers, of the cutter are not very big, and provided they are steamed for about half an hour in a good 'wet' steam box it should be an easy matter to bend them into their positions with the aid of a few clamps.

The bending process is carried out as follows :

1. Make sure that the "timbers" are about 1 foot longer than is required so as to go from the hogpiece to the top of the sheer plank. This allows enough length for the boatbuilder to use leverage when bending the top of the timber. Do not cut this excess length off until the "shelfs" are fitted. (See later).
2. Even though you do not plane the timbers on all sides, make

sure to take the corners off the face of the timbers. This helps to protect your hands from splinters and helps the timbers to bend without splintering on the edges and face.

3. Do not place too many timbers in the steam box. Separate each timber from its neighbour with small cross battens at the front of the box. This allows the steam to get around all surfaces.

4. In actually bending the timbers, always remember that the <u>hottest end</u> of the timber goes to the place where the bend is greatest. The hottest end is usually at the back end of the steam box.

5. Two men can "timber" the cutter, but it is easier if three men do the job; one to hand the timbers from the steam box to the man inside the cutter, one inside the cutter to actually use his feet and hands in bending each timber, and the third man to use the clamps outside the cutter and so hold the hot timbers in their proper place until they are held there by copper nails. The man who hands the timbers to the "bender" also stokes the fire and keeps the "bag door" down in the closed position - so keeping the steam in the box.

6. When bending the timber, do not force or bend it suddenly. A good steady effort is required, pulling the top of the timber toward you while keeping one foot on the timber at its bottom end, and the other foot further up the timber towards the bilge plank. As soon as the inside face of the timber touches the garboard, the "cramp man" fastens the cramp to the timber and garboard. Then, when the timber comes up close to the bilge plank, he again uses another cramp, finally holding the top in position when the whole operation is complete (see Fig. 83).

7. The first timber to be bent in the cutter is that alongside No. 4 mould. The next one would be alongside No. 5 mould; then alongside No. 2 mould, and then No. 3, and so on (see Fig.

84). The reason for this is simply that it helps to keep the battens and planking from being distorted and causing bumps of unfairness between moulds, which could possibly occur if timbers were bent halfway between the moulds.

8. Having bent a timber in position, fasten it to the three planks with copper nails. Bore for each nail. Countersink the head about 1/8" below the plank surface. Drive and punch the nail right home, cut off the surplus nail inside the timber face, then clench it over with a claw hammer, using a good heavy dolly and punch outside the nail.

9. It will be necessary to fasten the timbers to the battens <u>in some cases</u>. Use 2" iron nails, nailing the timbers <u>to</u> the battens. If the nails protrude through the battens, this does not matter. Use light gauge nails so as not to split the timbers.

10. Once a timber is bent and fastened in position the cramps are free to be used on the next timber. This may seem a slow and tedious job, but with practice it becomes easier.

<u>A few points to remember are</u> :

A. Although most timbers can be bent "square to" the hogpiece and parallel to the moulds, those forward of MOULD No. 5 and No. 6, and those aft of MOULD No. 2 may have to be allowed to go forward at the top so as to avoid excessive twist in the timber. Practice will show how this occurs.

B. If a timber cannot be readily bent into its position even after good steaming it will help (and it is quite permissible) if the timber is cut through its depth with a saw. This reduces the strain on the timber and allows it to bend without breaking. It may be necessary to do this between Moulds 2 and 3 (see Fig. 85).

With our cutter fully "timbered", or ribbed, it is now possible to finish off the planking process. Start with the first plank below the sheer strake (or top plank); one edge of this plank can be made straight and the other edge can be obtained by using the "scaling" battens mentioned earlier.

Once again, instead of bending the board around the moulds to obtain the actual position of the moulds, use a light batten - say 2" x $\frac{1}{2}$" - and with one end of this batten fastened to the stem, bend it around the moulds (close to the bottom edge of the top plank). Now mark the position of the stem and every mould on to this batten, and transfer these marks, or positions, on to the board intended to be used as the plank (see Fig. 86). Square each of these marks across with a square.

Now take the "forward" scaling batten and apply it to each mould from the stem to the amidship mould, carefully noting the width of the plank given by the scaling batten, and writing this width on the board at the correct mould mark.

Next mark these widths at each mould, measuring from the fair straight edge which should have already been planed true, on to the board, and at each mark drive a light gauge iron nail. Now bend a fair, light batten up against these nails, holding it into its position with further light gauge iron nails (see Fig. 87).

Now mark in this edge of the plank. Remove the nails and the batten - then saw the board along the line, keeping about $\frac{1}{8}$" from the line for planing purposes. Plane this edge fair with a jack plane. Then obtain the correct bevel of the stem end of the plank by use of your rule (see Fig. 88). After this is sawn to shape, the plank is ready for bending. However, it must always be borne in mind that the various butts of each line of planking must be kept clear of one another so that the length of every plank should be marked on its neighbour already in place on the boat, and carefully checked for position of butts.

MOULDING OF PLANKS

You will recall that one edge of this plank was left straight, and this can very often be done as the planking proceeds. However, it does happen sometimes that a straight edge cannot be fitted to a plank already in position. When this occurs it becomes necessary to "mould" this edge to suit the plank already in position.

Moulding is carried out as follows: Take a light batten, say 3" x $\frac{1}{4}$"

and slightly longer than half the length of the cutter. Bend it up to the frames (or timbers) and push it gently up to the bottom edge of the plank to which we are moulding. Fasten this batten lightly in position with light iron nails. Mark the position of every mould on to the batten. Now slide a piece of parallel timber, say 2" wide by 3" long by $\frac{1}{2}$" thick, along the bottom edge of the plank already in position and on top of the 3" moulding batten - keeping your pencil against the small parallel piece of timber and down onto the moulding batten. This then transfers a pencil mark parallel to the plank edge on to the moulding batten.

Now remove the batten from the hull and place it on the board intended as the next plank. As the pencil line is the top edge of the next plank, keep it to the top edge of the board, letting the moulding batten lie easily in place. Now lightly nail it to the plank through the pencil mark and continue to drive a light nail through the line on the moulding batten into the plank at about 18" centres. Be careful to mark the position of every mould on to the new plank.

Remove the moulding batten and drive a light nail into every hole made when the moulding batten was nailed to the plank. Next, bend the marking batten, which should be about $1\frac{1}{4}$" x $\frac{3}{8}$", against these nails and lightly fasten it in position. Now pencil in the top edge of the plank. Next, with the aid of the scaling batten, obtain the width of the plank at every mould and set these widths down on to the board, measuring, of course, from the pencilled edge that was drawn along the moulding batten. Again lightly nail one edge of the moulding batten to each of the width "spots", and make sure that the batten runs true and fair before marking in this edge of the plank. Now saw the plank to shape and plane each edge fair. Don't forget to plane the caulking seam on each edge of the plank.

This plank should bend around the framework without steam, but to make sure that all is well fasten it up in position with cramps. If the edges are true and fair, each edge should fit up close right along the plank without undue effort. Any unfairness will cause "open seams". Make sure that the forward, or stem end, of the plank fits neatly into the stem rebate, but always leave the caulking seam. A slight tap on the end of any plank (with a claw hammer) will drive it forward into the stem rebate. Always protect the end of the driven plank with a piece of timber (under the hammer blow).

This plank is now ready for fastening, which is easy enough provided the correct size bit is used for the copper nails, and provided every nail head is counter sunk in the correct way. Carefully note Fig. 89, which shows how a plank should be fastened to the stem and the timbers. This is most important. More damage is done by badly-arranged fastenings than is usually realised.

With this piece of planking in position the next move is to mould, fit and fasten the aft, or stern, piece in its place. The same method is used as for the stem piece of planking, taking care that the butt joint is placed in the correct place.

At this stage it may be helpful if the whole purpose of planking is explained in more than usual detail. Turn your attention to Fig. 90. With the sheer plank, garboard plank, and bilge plank in position, all that remains is to fill in the rest of the space with planking. But how? And what are the signs of good or bad workmanship? Why does the job look good or bad, once the planking is complete?

Firstly let it be clearly understood that the art of planking is not something that any boatbuilder learns overnight. Every boat sets a different problem of planking to the boatbuilder, but he in general uses certain basic principles which apply to every vessel.

Among the very desirable requirements necessary to the boatbuilder are :

1. Long lengths of planking; the full length of the boat, if under 28 feet in length;
2. planking which is curved on edge (not straight).
3. planking about 8" in width;
4. soft or semi-hardwood, but not too soft or too hard;
5. planking free from splits, knots or checks.

The reasons for such requirements are as follows :

1. Full length planking avoids the use of joints, which mean use of butt blocks - but it also gives the boat-

builder a better chance of providing nice fair edges to every plank. Fair edges make for fair seams, and fair, even seams make nice caulking seams, and good tight even caulking.

2. Strange to say, straight-edged boards are not desirable or necessary for boat planking (see Fig. 91). In this sketch notice that the moulded shape of almost any plank tends to become a curved shape, so that a curved board is less wasteful than a straight board. (a) shows a straight board and (b) a curved board.

3. Planking of approximately 8" width gives a very good chance of cutting all planks to size and shape without any great waste (see Fig. 92). In this figure notice how an 8" board can produce a "moulded" plank of almost any desired shape, including the very wide sheer strake or garboard. An 8" plank can also produce two planks of almost 4" width. Such narrow planks can be used where straight edged planks are readily used.

4. Generally speaking, the softer woods are better for small boatbuilding than the very hard woods. They are easier to lift into place, and they usually bend well. Boring is easier and when one considers the number of nails in one boat, this is important. However, a good plan is to use hardwood for the planking which covers the underwater part of the boat, and then use soft wood for the topsides, or part out of the water. This then gives the boat greater strength to withstand the dangers of coral reefs and also gives greater holding power to the copper nails that fasten any metal sheathing that may be used to protect the boat from borers.

<u>SEASONING OF TIMBER</u>

The question of seasoned timber is important, and should always be borne in mind by every boatbuilder. The tropics are generally unkind to timber unless the timber is stacked under cover, protected from rain and the sun. Each board should be separated in the stack by means of a small spacing strip about 1" thick (see Fig. 93). A period of about four months (in the dry season) should produce reasonably "dry" timber of 1" thickness. The "wet season" would not produce seasoned timber so easily, as the air would be saturated with water. It would be necessary to allow much longer time for "seasoning" boatbuilding timber in any country that has a heavy rainfall.

The most important thing to remember about preparing a stack of timber for seasoning is to arrange the timber in such a way that it is protected from the sun and rain, and so stacked that any rainwater runs off down the sloped surfaces of the boards. Do not stack timber in the open with all surfaces level, as this helps to hold any water between the boards and stacking strips, and encourages "dry rot" (see Fig. 93).

<u>CAULKING</u>

(a) Every plank should show fair sweeping edges, top and bottom. This helps to make good, even caulking seams.

(b) Very wide planks should be avoided as these tend to shrink unduly and then if fitted tightly, buckle and split once the boat is in the water and in service.

(c) Very narrow planks also should be avoided as they are wasteful of caulking, nails and time.

(d) All caulking seams should fit tightly along the back edge and show an even, open seam on the outside. A good allowance for seams is 1/8" for every inch of plank thickness. This means that 1/16" is taken off the edge of <u>each</u> plank so that when the back edges of the planks come together, a seam of 1/8" is provided on the outside. However, it must be remembered that when planking around the turn of the bilge or up into the horn timbers (aft) this rule does not apply.

(e) Plank ends at the stem or stern should never be less than 2¼" in width (for 1" planking) as it becomes difficult to fasten them with more than two nails or screws without a risk of splitting the end of the plank.

(f) Uneven widths of planking betray the careless builder.

All plank widths should generally grow less from the garboard to the bilge, where they are at their least width (amidships), and then gradually increase towards the sheer strake. It is a big mistake to show wide planking on the turn of the bilge and this should never be allowed.

(g) Every plank with the exception of "stealers" (see Fig. 90) should diminish (or grow narrower) from amidships to the stem and to the stern. Apart from showing a professional finish, this has a practical reason, particularly when the vessel is planked as shown in Fig. 90. In this case there are two full length "shutter" planks, or four pieces of planking if each length of planking is in two pieces. In the latter case each piece of "shutter" plank becomes a very powerful wedge if fitted "back" from the stem or stern and then driven forward or backward to the stem or stern until the ends fit tightly against the stem or past the transom; this wedging action helps to force all plank edges tightly together.

With the help of the foregoing remarks about planking it should perhaps be easier to commence this part of the job with confidence. Turn again to Fig. 82. This gives one good method of getting the widths of practically every plank with the exception of the "stealers". Provided no plank exceeds $4\frac{1}{2}$" in width it should be easily bent up "cold" into position and just as easily fastened or nailed to the steamboat frames (or timbers).

SHUTTER PLANKS

However, the problem of fitting the "shutter" planks and "stealers" does eventually arise - and we deal with that of the shutters first.

First of all, mark the exact position of the butt (for the "shutter") on the nearest plank. Then, using some of the longer pieces of Masonite, cover the "shutter" gap temporarily - tacking the Masonite to the planking with small iron nails. Do not butt the various lengths of Masonite together, but overlap each one on its neighbour, and then fasten them strongly together with clenched iron nails - so forming a long continuous "plank" or cover strip of Masonite from the stem to the butt and then from the stern to the butt (see Fig. 94). Next, pencil (from the inside of the boat) the shape of both edges on to the Masonite cover strip. Now remove the cover strip and carefully saw the Masonite "plank" to its true shape. Plane each edge, then "try it up" to its proper position as if it was in fact the real "shutter" plank.

After making sure that this pattern fits back onto the bent frames and is a good fit between both plank edges, mark out the real shutter plank itself - then shape and fit it into position. The same method is used for any shutter plank in any position. This is not the only way to fit a shutter plank, but at least it is a sure way to make a good job.

STEALER PLANKS

The "stealers" are not so easy to fit, though with patience they are not so difficult. Before fitting any templates first make sure that the edges of the upper and lower planks that take the "stealer" are bevelled in such a way that the inside width of the "stealer" is equal to, or less than, the outside width at any point along the complete length of the "stealer" plank (see Fig. 95 - a little study of this sketch may help to clear this point). The small sketches (A), (B), (C), and (D) are sectional views along the "stealer", and show this plank going into position (in square form) along the line of arrows. Now, it can easily be seen that unless the square edges of the upper and lower planks were bevelled on the outside, the "stealer" would be tight on the outside but "slack" on the inside. If this was the case - and it very often is - then a very poor seam would result, as it would be almost impossible to caulk the seam properly, and bad leaking would result.

It must be borne in mind, however, that a certain amount of "dovetailing" is allowable at the forward end of the "stealer" because the finished plank is "shipped", or fitted, into position like a wedge which grows wider as it is pushed or driven forward.

The next step is to make a template (or pattern) of the "stealer" in much the same way as was used for the shutter plank. This should give the exact shape and length of the plank but does not give the rounded inside surface which should fit closely up against every bent frame. The amount of rounded surface is shown in Fig. 95 at (A), (B), (C), (D). It is not difficult to obtain the correct amount of "rounding" at any point along the "stealer" - but every care must be taken to do this job properly, step by step.

Fig. 96 shows just how easy it is to make a small template of the round required at every bent frame or timber. Having obtained this round, it is a simple matter to get the hollow required for the outside surface. The rest is simply a matter of using the correct plane or spokeshave,making sure that the plank ("stealer") is not undersized in any thickness before it is steam bent into its position.

At this stage it might be helpful to remind the builder that once the inside round is completed, true and free from bumps - the thickness of the finished plank can be gauge marked from the inside surface.

The cutter is now planked. It is now necessary to remove the moulds in order to fit the internal woodwork. However, before any mould is removed, "spreaders" must be fitted at each to hold the vessel to its shape along the deck line (or sheer).

SPREADERS

A "spreader" in this case could be made from 3" x 2" timber with the necessary cleats say 3" x $1\frac{1}{2}$" nailed thereto (see Fig. 97). Make sure that the cleats are strongly fastened to the spreader.

Having fitted a spreader at every mould, nail them temporarily in position and remove the moulds. Each mould should be numbered and stored away carefully for future use.

CLAMP

The first piece of internal timber to be fitted and fastened in the cutter could be the clamp, because this could be used to help position and hold the bilge stringer (by means of shores or struts). The clamp is the long piece of timber which carries the deck beams and which is fastened to every second (or alternate) bent frame with a riveted copper nail (see Fig. 98). A careful study of this sketch shows that the clamp is positioned below the top edge of sheer plank in such a way that the top of the curved deck beam fairs in with the top edge of the sheer plank, so that when the deck is laid it fits snugly along the edge of the sheer plank without leaving any gaps. Sketch (A) shows the clamp about amidships, and sketch (B) shows it towards the bow end of the cutter. One important feature worth noting is that the deck beam is checked (or steps) over the clamp about $\frac{1}{2}$", so that in the event of hard usage against a wharf the end of the deck beam does not take all the punishment.

The actual job of bending the clamp is helped along with the aid of steam. It is not necessary to steam the full length of the clamp - but if one third of this length can be so treated, that is all that is necessary.

The procedure to position and fasten the clamp is as follows :

1. Ascertain "distance K" as shown in Fig. 98 to bring beams into their correct heights.
2. Mark this distance along the inside face of the bent frames (at say 3-foot intervals).
3. Fit suitable wooden cleats (or stops) on the top edge of these marks in order to hold the clamp in its exact position.
4. Steam the clamp.
5. Remove (temporarily) the two aft end spreaders so that the clamps can be "shipped" inside the boat.
6. Arrange about 5 to 6 clamps (or "D" cramps) ready to cramp the hot piece of timber into its position.
7. Now bend the first clamp into position and hold it up against the bottom of the wooden cleats. Use the "D" cramps as so required. Allow about $\frac{1}{2}$-hour steaming for the clamp itself.
8. Fasten the clamp off with riveted copper through nails at every second timber.

<u>STRINGER</u>

Assuming that the clamps are now fastened in position, the next step is to bend the two stringers into their respective positions on each side of the cutter.

The position of each of these is usually given on the amidships section drawing by the designer. This of course does not show the stringer positions at any other point. However, it is quite simple to arrange each stringer in its correct position with the aid of a long bending batten, say about 3" x $\frac{1}{2}$". This batten need not be any longer than say 22 feet, but it should be as straight as possible.

Now lay the batten full length along the inside of the boat, keeping the <u>top edge</u> on the position of the stringer (as shown in the design) amidships.

At this stage do not attempt to bend or twist the batten unduly. One rather awkward step in fitting the clamp, or any other long length of timber, is the cutting and fitting of these long lengths to their exact length inside the transom. This is done with the use of a thin bending batten (see Fig. 99, which is practically self explanatory). Simply let the batten fall into its natural position - but flat against every bent frame face (see Fig. 100). By "natural position" is meant the obvious fore and aft position that the batten takes (not diagonally across planking) along the lines of the planking edges generally.

Having satisfied yourself that the batten has assumed a reasonably easy position, tack it lightly to the timbers with iron nails - and then mark the top edge of the batten at every timber. If any great difficulty is experienced in bending the stringers "cold", use steam as mentioned regarding the clamps. Shores (struts) can readily be used (from the clamps) to hold the stringers in place while being fastened. Fastenings, by the way, are riveted copper nails on every alternate timber (see Fig. 101).

FLOORS

Once the vessel is fitted with clamps and stringers, the floors (not flooring) can now be fitted. These are the heavy pieces of timber that fit over the hogpiece and up against the lower planks, as shown in Fig. 102. Notice how they are fastened. In the usual European-built vessel the keel bolt is of copper. However, for purposes of economy, a "treenail" may be used without undue loss of strength. Floors are usually fitted at about 2-foot spacings with the same number of bolts as shown in the sketch. The smaller "driven" fastenings can be either heavy copper nails or gunmetal dumps. When positioning the bolt through the keel, always place it first to one side of the centre line, and then on the other. This helps to stop any splitting that possibly could occur if all bolts were placed exactly on the centre line. Properly fitted and strongly fastened floors give great strength to the bottom of any vessel and help to "tie" both sides of the boat together over the keel. With the floors all fitted and fastened, the

DECK BEAMS

next step is to fit all deck beams into their proper positions on top of the clamps. But before this can be done the actual beams themselves must be made.

Every deck beam has a rounded (or curved) top edge. This "round up" is called camber and is usually about $\frac{1}{4}$" to every foot of beam. This means that a cutter with 12 feet of beam would have a deck camber of 12 x $\frac{1}{4}$" - which of course is 3". One very easy way to mark a true camber on any deck beam is shown in Fig. 103. This sketch is self explanatory, but a brief description may prove of assistance. First of all, set out all these measurements on a piece of Masonite, or thin timber. Then once the beam is drawn out this may be cut to shape, and a template of the beam is ready for use at any time.

DECK CAMBER

The method of marking out the camber is as follows: Refer to Fig. 103. Draw a straight line equal in length to the widest part of the boat (in this case 12 feet). Divide this line into two equal parts (6 feet). At this point, mark out a half-circle with a diameter equal to the camber required in the deck beam (in this case 3"). Now, divide the base line marked A-B into 6 equal parts (in this case, 2 feet) and at each division set up an upright line square off the base. Give each upright a name - L, M, R, S. Now, divide the base of the half-circle into 6 equal parts (in this case 1" each) - and then divide the two quarter circles into 3 equal parts (making 6 equal parts in all). Now join these dividing points as shown (with straight lines). Give each dividing "line" a name similar to those given to the uprights - L, M, R, S. Now mark off distance L on upright L, distance M on upright M, distance R on upright R, and distance S on upright S. All these points, along with the top of the circle and each end of the base line, give a very good outline for a truly cambered deckbeam.

The position of every deck beam is usually marked on the drawing made by the designer. This drawing is set out something as in Fig. 104, which gives the position and number of beams required. This small sketch shows 7 full-length beams (or beams that run right across the boat). Ignore the beam marked Y at this stage.

Using the template of the deck beam, mark out 7 beams slightly longer than those shown. These can now be sawn and planed true to camber, ready for fitting in their proper places.

Always fit the longest beams first, so that if by some mistake these are cut too short, they can still be used in a shorter deck beam position. To fit the beams, merely place them in the right position on top of the sheer plank and mark the exact length as shown in Fig. 105. This sketch is deliberately exaggerated to show the method clearly. Having fitted the longest beam (making sure that it has been checked over the clamp as in Fig. 98) nail it with a driven galvanised nail to the clamp. Use a galvanised nail here so as to hold the beam temporarily into its position.

Now fit each long beam into its correct position and nail it to the clamp. Do not nail the two aft end beams at this stage - leave them loose. Then fit the shelf into position under these main deck beams (see Fig. 106). Now it becomes obvious why the deck beams are fitted onto the clamp before the shelf (which holds the beams) is bent and fastened into position.

SHELF

By fitting the beams first, the shelf can be bent against the clamp and held up against the bottom of the beams, thus giving an exact indication of the amount of bevelling required to make the shelf fit close against the face of the clamp.

FIG. (A) shows the shelf about amidships.

FIG. (B) shows the shelf forward towards the stem.

FIG. (C) shows the shelf bevelled and fastened complete.

CARLINE

With the main beams all installed, it is now possible to fit all carlines (see Fig. 104). A carline is simply a straight or curved piece of timber, running between the main beams, supporting the inner ends of the spur beams, and the coamings. There are several ways of fitting and fastening spur beams and carlines. However, the ends of all carlines should be dovetailed into the main beams as shown in Fig. 107. Another method of fitting spur beams is shown in Fig. 108. This does away with the use of dovetails and uses a simple "housed" joint. The tie rod (usually galvanised iron rod) makes this method very strong.

BREAST HOOKS
QUARTER
KNEES

At this stage of building, all knees, the breasthook, and quarter knees should be fitted. Fig. 109 indicates where these are usually fitted, and also how any ordinary hanging knee should be fitted. The simplest way to fit any knee is to make a cardboard or Masonite pattern of the "fit" or edge which goes against the deck beam and the planking of the cutter - and then mark this on to the "knee timber" itself. Cut this timber to shape and then fit it carefully into its position. After this, mark out the inside shape of the finished knee and cut it to shape. A spokeshave will finish off the inside "saw cuts" in any way the boat builder desires. Fig. 109 shows two methods of finishing the inside of a knee.

BULKHEADS

Now that all knees are fitted, the next job is to fit the bulkheads in their positions and fasten them to the "grounds" and deck beams as strongly as possible.

The bulkheads are a very important part of a cutter's strength, and should be very carefully fitted. Fig. 112 shows how they should be fitted in a small cutter. The "grounds" fit right around the "edge" of the bulkhead and should butt against a "floor" on the bottom edge and a deck beam at the top. The designer should always attend to this important item. However, if it is not shown on the drawing, then the boatbuilder should arrange his "floors" and beams to suit the bulkhead. The "grounds" are usually made of straight-grained timber, sawn to shape, and through fastened to the planking with copper nails and bolts. Naturally the stringers, shelfs and clamps run through the bulkheads, so packing must be used under the stringers at these points as shown in the sketch. The packing should be carefully fitted and "set up" in thick paint - otherwise the bulkhead will leak. The "grounds" fit over the stringer and packing and are "set up" on canvas or heavy felt (well painted) before fastening down.

The "studs" or uprights are usually "housed" (very shallowly) into the beam and floor. One "skew nail" each end is sufficient to hold them in place. The actual bulkhead itself can be made of $\frac{1}{2}$" waterproof plywood (not ordinary plywood) or two layers of $\frac{5}{8}$" timber, with painted canvas in between the layers. The bulkhead should be well fastened around the edges with driven galvanised nails at say $4\frac{1}{2}$" centres for plywood. Stud and crosspiece fastenings could be at 9" centres.

FLOOR BEARERS

The next step could be the fitting of flooring bearers in the hold and cockpit. The height of the flooring (above the hogpiece) is usually given on the drawings, so with this information available the bearers can now be fitted. Those bearers carrying the cockpit floor could be carried on a special short stringer, fastened through the hull with riveted copper nails (see Fig. 110).

HOLD FLOOR OR CEILING

The hold flooring should be very strongly supported, and could be fitted on top of the main floors or on top of bearers fitted along the top edge of each floor (see Fig. 111).

ENGINE BEDS

The engine beds can now be fitted. These beds are merely two pieces of timber placed on top of the floors to carry the engine. They must, however, be "in line" with the shaft hole in the deadwood, and so placed that they can take every engine "holding down bolt" (see Fig. 113). It may be necessary to shape the "floors" (cut something out of the middle) so that the bottom of the engine or reverse gear box can be accommodated; so for this reason do not fit the bolt through the middle of the floors until <u>last</u>. The engine bed should always be so arranged that it can take a long wedge on its top face. This wedge can easily be made to fit the bottom of the engine lugs, and serves to lift or lower the engine if ever this becomes necessary for future alignment.

Although the engine bed bolts are shown under the wedge, the inside nut should always be available for future tightening. This is arranged as in Fig. 114. (<u>NOTE</u> how the engine 'holding' down bolts are fitted. They do <u>not</u> go through the hull planking. If they did, any slackness and vibration would cause leakage).

The shaft hole is always one job that requires patience and care. It must be remembered that this hole can be bored and finished much more easily if the correct diameter of the stern tube is known <u>before</u> the cutter is even planked up (i.e. the type of engine and size of propeller are known beforehand). However, this is not always the case, so we will assume that we have to bore the stern tube hole through the deadwood <u>after</u> the vessel is planked.

STERN TUBE HOLE

Refer to Fig. 115. Here is the cutter shown side view with the engine inside the boat, sitting in its position on the engine bed. If the boat has been previously designed by a competent naval architect or boatbuilder, the engine position and propeller position would be given on the drawing of the cutter. If not, then the builder will have to fix the position of the engine and propeller by "trial and error". We will assume that the positions have been given to us, and that the engine is now in its correct place. All we have to do is to show the "true" position of the centre of the flywheel (or the centre of the crankcase) on the <u>outside</u> of the cutter and then line this mark up with the centre line of the propeller.

Here is one way to do this. First, mark the centre line of the shaft line on the aft side of the deadwood, and square this mark across the deadwood. Now fasten a strong straight piece of 4" x 1" timber in such a way that its top edge is exactly on the centre line of the propeller shaft, and exactly level. Allow this straight edge to stand out about 7' 0" long on one side only, and hold it up in its position with a strong upright. Then place a long straight piece of timber right across the boat directly over the front of the engine. (This is shown in Figs. 115 and 116 as (E)). Temporarily nail this in position (square across the boat) and then fasten an upright piece of timber (say 3" x 1") to the end of the long straight edge (see Fig. 116).

If the boat has been built correctly and is upright in its position, the bottom of E will be level. Now measure the distance from the underside of E to the centre line of the flywheel or crankshaft, and transfer this measurement to the upright batten on the outside of the boat. The point F is now the centre line of the flywheel on the outside of the boat. Next, measure the distance BB and transfer this distance to the 4" x 1" piece of timber nailed across the deadwood. Drive a light nail into point F and point G, and stretch a chalk line between these two points. Let it continue on for about 5 feet. This is the line of propeller shaft, and it is out from the centre line of the boat by the distance BB. Fasten the aft end of the chalk line to a strong stick driven hard into the ground, first making sure that the chalk line is absolutely straight from this strong stick to the upright marked E.

Now nail a straight piece of 4" x 1" timber upright and exactly in line with the centre line of the transom (see Fig. 115); that is to say, keep one edge exactly on the centre line of the transom (see Fig. 117). This upright is to be the guide for the auger which is to bore the first hole through the deadwood. Nailed in a truly vertical position, it is a good guide for the fore and aft position of the auger, and in order to fix the vertical position it only becomes necessary to place a light straight edge under the chalk line (square out from the 4" x 1" upright) and level this straight edge across to the upright. Now mark the 4" x 1" upright. This mark is the centre of the auger which will be used to bore the first hole through the deadwood. Call it

(H) on Fig. 117.

It is now necessary to make a true guide for the auger on the 4" x 1" upright (see Fig. 118). Simply screw a piece of 2" x 1" timber (about 10" long) to the 4" x 1" upright, then bore a hole through both the upright and the guide block (half on the block, half on the upright) making sure that the hole is the same size as the shank of the auger.

We are now ready to bore the shaft hole. Unscrew the guide block to take the auger. The diameter of the shaft hole varies because powerful engines need large propeller shafts, while small engines require small propeller shafts. Although we speak of the shaft hole, what is really meant is the stern-tube hole because the propeller does in fact run inside the stern tube and the stern tube fits through the deadwood. Fig. 119 is a rough sketch of a stern tube for a small cutter. This part of a boat is usually made up by the engineer from measurements given to him by the boatbuilder. These two measurements (A) and (B) are as shown on Fig. 119. The diameter of the tube is the size of the hole required to take the tube easily through the deadwood. Provided this diameter does not exceed $1\frac{1}{2}$", it is possible to bore the hole in one operation with a good auger. If possible, always use a shell auger or one without a screw point because the screw point always tries to follow the grain of the timber and makes a bad hole.

However, it is always necessary to make a starting hole for the shell auger, and this must be done with a screw-pointed auger in order to start the hole exactly at the right centre. (It is of course possible to make a starting hole with the careful use of a chisel or gouge).

Having made the hole as nearly perfect as possible, it may be found that the tube is slightly large for the actual hole, due to "fuzz" inside the hole - or to slight ridges. These troubles can easily be overcome with the careful use of a red hot piece of shafting or pipe. Do not heat the piece of shafting or pipe over its full length. Twelve inches at one end is sufficient if care and speed are used. One very common mistake often occurs when fitting stern tubes, that is, in not fitting the flanges of the 'bearings' or castings truly to the deadwood or knee. Make sure that this is properly attended to, because if flanges are forced to fit against the timbers, the bearings are twisted out of true alignment and the propeller shaft made tight in each bearing. This results in worn bearings and shafts.

So far no mention has been made of the fact that although the tube fits the hole we still have the gunmetal castings to fit inside each end of the tube hole. This can be done with the aid of a chisel or gouge and should be done very carefully and "true".

When the stern tube is ready for installation and fastening, it can be fitted and all holes bored ready for the "coach bolts" through each flange. It is not necessary to use the ordinary type of "coach bolt" with its very coarse thread, in fact, the "engineers" Whitworth thread on an ordinary bolt is much superior if properly used (see Fig. 119). However, in using this type of bolt, make sure that the hole is exactly the right size (that is, the diameter of the bolt <u>after</u> the thread is cut). With all holes bored, the tube should now be taken out so that all shavings and chips are removed from behind the flanges.

Now wind a length of cotton wick or caulking cotton behind the inner flange (about two turns) and paint the timber (around the flange bolt holes). Then "run" a light roll of putty (very thin) over the cotton thread and push the tube into place from the inside of the boat. Begin to screw the flange bolts into place so that they hold the flange from turning around.

Now screw the outer gunmetal casting (bearing) on to the tube, but before going too far treat it in the same way as we did the inner flange. The flange may next be screwed tight into its place and the "coach bolts" fitted. Use plenty of grease on these bolts before fitting them into the holes.

The most difficult part of the engine installation is now complete, and at this stage we can return to finishing the construction of the boat itself.

<u>DECKING</u>

Refer now to Fig. 104. This shows the cutter with all deck beams fitted, but without a deck. If a deck had been fitted, we would have had much less light when fitting the engine beds and stern tube. However, the deck can now be fitted and fastened in position. The decking itself can be made of 4" x 1" tongued and grooved (T and G) oregon or similar timber, or it can be made of <u>marine</u> plywood of about $\frac{1}{2}$" thickness, both of which should be covered with medium-weight canvas (for best results) and painted. On the other hand, the decking may be constructed of $2\frac{1}{2}$" x $1\frac{1}{4}$" oregon or similar timber ("veed" for caulking) and caulked with caulking cotton. Such a deck would not be painted.

Fig. 120 shows the various ways of fastening a deck. (A) and (B) give details of "T" and "G" and marine plywood decks. (C) gives details of a caulked deck. Note the care with which all fastenings are arranged. In T and G decks they are staggered out of "the line of grain" in each deck beam so as to avoid splitting the deck beam with each successive wedge-like fastening. In marine plywood decking, screws are used as necessary. Do not use unnecessary screws but make sure that all seams and joints are carefully "flush" fastened so as to avoid tearing the canvas covering after it is painted. In every case, paint the top surface of the deck beam and the underside of the decking before fastening the latter in position. Also make sure that the finished surface of the deck is truly smooth and without ridges, and that all fastenings are punched or screwed below the surface and covered with putty.

CAULKING OF DECK

The canvas deck covering will be discussed later. In the meantime, refer to the caulked deck in Fig. 120. $1\frac{1}{4}$" decking is suitable for caulking with cotton; anything under this thickness is too thin to provide a satisfactory watertight deck. The caulking seam is usually made $\frac{1}{8}$" wide by about half the thickness of the decking in depth. Caulking with cotton is not difficult provided the cotton is not put in too loosely - or too tightly. The usual procedure is to first "spin" the cotton by means of a small hand drill. Merely grip one end of the cotton wick in the chuck and tie the other end of the "ball" to some convenient place. Now wind the drill handle and so make the loose cotton thread into a tight thread, ready to be "punched" into the seam with the aid of a caulking iron and a light mallet. Drive the cotton right to the bottom of the caulking seam - but not through the deck seam itself. The caulked seam may be filled (paid) with marine glue (pitch) or putty. If marine glue is used, do not overheat it, and use properly-made ladles. If putty is used, paint all seams first with good paint and then fill them with putty.

PUTTY

Good putty can be made by mixing ordinary whiting with ordinary paint and then kneading the mixture by hand, to the right "thickness".

If marine glue is used do not scrape the seams clean and flat until the boat is ready to be launched. This allows the glue to settle deeper into the seams.

COAMINGS

And now we can begin to fit the coamings and cabin to the cutter (see Fig. 121). This is not a difficult job, but it should always be remembered that the face of the carline must be plumb (check with a spirit level) and that the coaming must fit flush against the deck edge and the carline. Screw the coaming to the carline with brass screws after painting the face of the carline and deck and the "back" of the coaming. This paint reduces the risk of "dry rot" and leakage. Any addition to the height of the coaming is made by simply butt-joining the top to the bottom piece of coaming and then covering the seam with a light batten, which should be fastened at both edges with clenched copper nails. Paint behind all battens.

CANVAS DECK

Next is the covering of the deck with canvas (see Fig. 120 (A) and Fig. 121). The canvas should never be laid over bare wooden decks. These should be liberally coated with paint and allowed to dry. All seams should be "flushed" with putty, all nail holes filled with putty. The "threads" in the canvas (or grain) should always run straight. Stretch the canvas tightly and evenly, using cut copper tacks for fastenings. Do not use tacks in the "body" of the canvas - but only at edges and seams. Note how in Fig. 121 the canvas is taken down the side of the planking and bent up the coaming. In the first case the belting covers the lap, and in the second, the quadrant. Always paint the canvas laps as well as the belting and quadrant before fastening either into place.

Wide coamings are usually stiffened by means of uprights screwed to their inside face. Corners are usually made watertight by means of solid corner posts (see Fig. 122). With all coamings in place, and to the correct height, it

COACH HOUSE

is now possible to fit the deck beams and then the coach-house top (see Fig. 123). Note that the deck beams check, or dovetail, into the stringer that reinforces the side coamings. Each beam is screwed to the stringer. The roof is either of 4" x 1" T & G oregon or $\frac{1}{2}$" marine plywood, covered with canvas in exactly the same way as described for the main deck. The canvas fits down past the deck edge and over the coaming, where it is tacked and held in position with cut copper tacks until such time as a moulding is screwed into position. (Note: When fastening canvas with tacks, space tacks about $1\frac{1}{2}$" apart at edges, under mouldings or quadrants, and about $1\frac{1}{4}$" along laps). All mouldings and quadrants should be fastened down with brass screws so that they may be readily removed if ever new canvas is required.

RUDDER

The rudder can now be made. If more than one rudder is to be made it is a good idea to make a template from Masonite or thick paper.

All measurements should be obtainable from the drawings. First of all make the actual blade of the rudder by dowelling together two or more boards, and from this, mark out and make the cheeks. Then cut a piece of timber (over length) to make the distance piece between the cheeks. Next fit and fasten the gunmetal gudgeons to the blade. Make sure that they are square across the blade. Then cut the grooves in the cheeks to fit over the gudgeon straps. Now fasten all three pieces of timber together (cheeks and blade) with rivetted copper nails. Do not fasten the distance piece at this stage. Next make the tiller and then set it in its position, holding it secure by means of a distance piece. Now hold the distance piece in its place with two driven copper nails. Finally, fasten the distance piece in place with rivetted copper nails (see Fig. 124).

Do not cut the distance piece to its exact length until all rivetting is complete. Do not leave the rudder head square - round off all corners with a plane and sandpaper. Earlier in this description of the rudder, mention was made of "dowelling" together two or more boards (see Fig. 124A for details). The actual procedure is as follows :

(1) Select flat boards, and either plane them to exact thickness required - or plane one side only. Call one side "face" side, of each board, and mark it "FACE".

(2) Plane the edges to be dowelled together, straight and square, and fit them together by hand.

(3) Mark the positions of all dowels on each board.

(4) Square these marks across the edges of the boards.

(5) Now gauge mark the centre line of the boards on the joining edge, making sure that the face of the gauge is held against the "FACE" of the boards in each case (very important).

(6) Bore the holes for the dowels at the crossing of the gauge mark on the square mark.

(7) Insert dowels, making sure that they are <u>not over length</u>, then lightly tap the two boards together.

<u>Points to Remember when Dowelling</u>:

(A) Always make truly round dowels with same diameter for the full length of the dowel stick.

(B) Plane a very small flat on the dowel stick (this allows the air to escape when driving the dowel "home" into the plank).

(C) Do not make all dowels the same length as this only weakens the joint.

(D) Carefully check your drill or bit size <u>before</u> making a dowel.

(E) Always paint between the fitting faces of any joint.

After fitting the cheeks and distance piece in position, note that a small piece of timber is fitted across the bottom edge of the rudder. This is the "sole", and it is screw-fastened to the rudder blade before being cut to length, and then rounded up at each end. The "sole" helps to strengthen the rudder blade - and protects it from hard knocks. The rudder can now be "hung" on the transom by means of the cast gunmetal gudgeons.

<u>MAST</u>

The mast can now be made from the square piece of timber (usually oregon or a similar light strong timber) which has been procured especially for this important job. Rather than describe the making of the cutter's mast we will describe the making of any mast, large or small.

First lightly plane the face and one side of the square piece of spar timber. Then (if it is straight) mark a centre line on the planed surfaces with a marking gauge. Now set out the various measurements as given in the plans (or as usually used by well-known boats) from this centre line. Next mark the required taper on each of the four sides with either a long batten or a chalk line. Now adze the "waste" timber away and plane each surface true and free from bumps. We now have a <u>square</u> spar tapered to suit the diameter of the mast bands. The next step is to "round" the spar by the following method. At any convenient position measure twelve inches diagonally across the square spar. Then along this line measure $3\frac{1}{2}$ inches from each end of the line. These points represent the edges of a chamfer, or flat, which if planed truly on each of the four edges will produce an eight-sided or octagonal spar (see Fig. 125). From this almost round shape it is easy to produce a truly round spar by simply planing each of the corners evenly on the eight flats. This produces a sixteen-sided spar and of course further careful planing makes a truly round mast or spar.

Mast bands should always be tightly fitted to the mast, and every care should be taken when cutting the shoulder to take the mast band. Do <u>not</u> cut this shoulder square; always scallop it as shown in Fig. 125A. This prevents rainwater from soaking into the end grain of the mast behind and under the band, and so prevents dry rot. Always fit the truck <u>over</u> the top of the mast instead of simply fixing it flat on the mast top. This also prevents dry rot (see Fig. 126). The jaws of the boom and the gaff are usually made of very strong hard timber, and if possible from a root or branch with some regular shape.

<u>GAFF</u>

The gaff jaws should be fitted with a "tongue" or "shoe" which should be free to move on a strong copper bolt or hinge(see Fig. 127).

<u>BOOM</u>

Needless to say, the boom is made in the same way as the mast. It is usually the same diameter at the gooseneck (near the mast) and middle of the boom, but tapers away slightly towards its outer end.

Always make sure that the gooseneck fittings are well fitted and properly fastened through the boom with copper rivets. "Stops", or cleats, for rope strops or topping lifts can be fitted as shown in Fig. 128. Note that the cleat is checked very slightly into the boom and fastened with brass screws.

<u>BUMPKIN</u>

This part of the cutter can be fitted in many different ways, but no matter how it is fitted it must be made very strongly to take the heavy loads placed upon it. One good way to fit a bumpkin is shown in Fig. 129. This shows the stem head cut off short and mortised into the underside of the bumpkin. Do not make the mortise too deep as this merely weakens the bumpkin.

Note that the bumpkin is thick and wide at the stem head but tapers away towards both ends. The inner end mortises into the samson post, and the outer end is shaped into a "round" which takes the eye-band. There is no need to "overfasten" the bumpkin to the stem head, but a $\frac{1}{2}$" copper bolt is very useful if placed through the breasthook or nearest deck beam. Such a bolt will hold the bumpkin in place until the bobstay and forestay are fitted.

SAMSON POST

This very important piece of timber should be well secured at its heel, and so fastened to a deck beam that it never lifts out in a seaway, but if necessary, it can be easily removed for inspection at any time. It is usually mortised into the forefoot of the stem (or fore-deadwood if such is used in a larger vessel). It can be slightly tapered from the deck to the heel, and should be checked under the deck beam to prevent it being lifted out and so take the load off the copper through bolt (see Fig. 130).

CHAIN PLATES

These are fitted and bolted to the upper strakes of the cutter, and should be regarded as most important items. Do not necessarily fit them "square off" the line of sheer. It is much better to so position them that they lie on the same centre line as the stay or shroud which fastens to them (see Fig. 131). If possible, it is always easier to fit them before the beltings and decking are fitted. Always fit strong chocks or reinforcing pads between the bent frames; these then take the through bolts, which should be copper. The chocks should always cross over at least three planks and be fastened to them with copper through nails.

FALSE KEEL

This should not necessarily be sheathed with copper. However, it is good practice to sheath the under face and sides of the main keel before fitting the false keel. The false keel need not be in one complete length, but every separate length should be strongly fastened to the main keel with copper driven nails or gunmetal dumps.

CLEAN OFF HULL

Cleaning off the hull, or planing the hull smooth ready for painting, has always been a very laborious task, and unless done properly results in a most unsatisfactory and amateurish job. In truth it takes a very good tradesman to really "clean a vessel off" to perfection. However, a few remarks may be helpful in this regard :

(1) Do not "finally" clean off until the vessel is caulked, because caulking results in lifting one plank above its neighbour and making the seams stand out through the

finished paintwork.

(2) Do not use sandpaper until the surface of the hull is truly free from bumps and hollows. Sandpaper is only used to <u>smooth</u> the finished planed surface; not to take out bumps. The smoothing plane and joiner's scraper do that.

(3) Mark out the whole surface in equal areas by using a piece of chalk, and then carefully do each area in rotation.

(4) The planing procedure is as follows :

(a) German-jack any high seams.

(b) Smooth over all high seams (fore and aft).

(c) Smooth total area diagonally (light-cut).

(d) Smooth total area diagonally (fore and aft) very light-cut.

(e) Joiner's scraper.

(f) Sandpaper, coarse then fine. Use good paper.

<u>CAULKING OF HULL</u>

If the planking procedure has been carried out carefully, all seams should be ready for caulking with cotton. In the case of the cutter, seams should not exceed 3/16" on the outside, and slightly less on the inside. However, oversize seams can sometimes be reduced if all tight or close seams are caulked first, followed by the open or large seams.

Very tight seams must be opened up with the aid of a "buster" iron or the sharp (bent over) tang of a file. Caulking cotton is usually supplied in "ball shape" and fairly loosely rolled. This is not suitable for caulking purposes. However, if these loose threads are wound tightly, they become firm and are more easily driven or caulked into the open seams.

Provided the seams are of regular and even size, it is quite in order to caulk the cotton direct into the seam as it comes "off the ball". However, if the seam varies in size, it becomes necessary to "cinch" or loop the thread into the seam in order to make a tight drive for the thread of cotton; or in other words, to form a tight wedge of caulking cotton that will not easily loosen in the seam or allow leakage in service.

Big vessels are always caulked with oakum (not cotton) but in the case of the small cutter it is by far the better job and much easier to use. Do not use a heavy caulking mallet when caulking with cotton. An ordinary carpenter's mallet is quite all right, and is much easier to use than the usual shipwright's caulking mallet.

<u>PUTTYING OR PAYING SEAMS</u>

This operation is most important, and if properly carried out really makes a watertight and safe boat. However, it can be "slummed over" and then result in a very unsatisfactory boat. After the vessel is caulked it then becomes necessary to paint thoroughly the inside of all seams with a $1\frac{1}{2}$" wide, <u>long</u>-haired paint brush. Make sure that the caulking cotton is properly painted, because this has a very important part to play in holding, or keying, the putty (or "stopping" as it is known) in place. Without paint, the cotton tends to absorb the oil from the putty and so causes the putty to become "powdery". With paint, the putty keys to the cotton and remains tight in the seam.

Always press the putty well back <u>into</u> the seam so that it eventually leaves a slight mound along the seam rather than a depressed seam. Make sure that all nail heads are properly "stopped" with putty. (Incidentally, excellent putty can be made by mixing ordinary lead-and-oil paint with whiting). After puttying has been completed and the putty has "set" it becomes necessary to prepare the hull for painting.

<u>PAINTING</u>

The first or priming coat of paint is always a <u>flat</u> finished paint; that is, a finish which does not shine. Glossy paint does not readily "key" to the next coat of paint. It is sometimes necessary to use two priming coats of paint and then one finishing coat, but in any case do not try to make a perfect finish for launching day. Wait until the vessel has been launched and then after a few weeks in the water or perhaps a month or two of working conditions, go right ahead with careful sandpaper work, and then apply the finishing coat of gloss.

<u>FUEL TANK</u>

The cutter usually depends upon gravity feed to convey the fuel from the tank to the fuel pump. For this reason the tank must be positioned in a slightly higher position than the engine's fuel pump. It should always be securely fastened in position and supported by a strong wooden framework.

Small tanks of up to 15 gallons capacity can be made from sheet steel, all seams of which should be riveted and soldered. For tanks of over 15 gallons, it is advisable to have heavier material and use welded construction.

All tanks should be fitted with "splash" or surge plates. These are used in order to reduce the internal pounding produced by "loose" fuel in a seaway. Excessive pounding will always lead to leakage.

The pipe line from the tank to the engine should be securely clipped to the vessel and provided with means to absorb undue vibration. In other words, the pipe should never be led direct to the fuel pump in a "stiff" straight line; rather should it be "looped".

A shut-off valve should be fitted as close to the tank as possible and a good fuel strainer is a very good insurance against engine stoppage at sea.

A vent pipe should be provided, and this should be led up through the deck as high as possible, clear of any fouling from salt or rain water. Filling pipes should always be run <u>through</u> the deck and the top of the tank should be connected direct to the filling pipe with a tight nipple. Do not use a funnel through the deck to fill any tank; always fill through a deck plug and filling pipe <u>direct</u> to the tank.

<u>PAINTING A WATERLINE</u>

Painting the waterline of a boat is not quite so simple a matter as some suppose it to be. Many are surprised to find that the bottom paint is considerably higher on one side than on the other after the boat is afloat, making her appear to be resting lopsided on the water. Others find that an apparently straight line develops into a decidedly crooked one when close to the absolutely level surface of the water. The line looks straight enough when painted, but the water's surface proves that it is not.

A new boat, built in a workshop with a smooth, level board floor, can have her waterline scribed or marked around her by cutting a stick the exact distance from her proposed waterline to the floor and then, holding this stick vertical, going around the hull making a series of spots every few inches apart. To strike in a new line on an old boat or a waterline on a new boat is simple enough if done correctly, but results in a great tangle if short cuts are employed.

The first thing to be done is to drop a plumb bob from the centre line of the stem and off the centre of the stern, and see if the boat is standing perfectly upright. If she is, you are ready to begin; if not, wedge up or ease the shores or blocking until you get her perfectly true.

<u>MARKING A WATERLINE</u>

You need two long straight-edged boards, at least twice the width of the boat. Nail the middle of one of these boards so that its straight edge comes just level with where you want the waterline to be. Hold the ends up by nailing two posts to the floor and put braces aft so that as you pull from one to the other to tighten the line they will not move. Secure the other board aft in the same way, being careful to have the two perfectly levelled up with the spirit level. Now, with a fishline made fast at one end - or quicker yet, let another man hold it - you can swing this line out on one board and in on the other so that a third man with a pencil can make a series of spots around the hull that will guide you in getting a perfect waterline (see Fig. 132A). By bending a thin batten the line can be scratched in through these spots. To handle this thin batten properly seems a simple job - so simple that many people make a great mistake and get the line unfair. They try to nail the batten flat against the hull and the result is that the ends curl up, following the sweep of the boat's bilge, and in trying to hold these ends down an unfair line is produced. To do the work properly and to avoid this difficulty, get a batten about an inch wide and less than $\frac{1}{4}$" thick, and a handful of 1" or $1\frac{1}{4}$" iron nails. If the side of the boat is vertical the batten will, of course, lay flat against it, but you can readily see that if the side of the boat is rounding under - as it is at the turn of a boat's bilge - the batten if nailed flat will incline to curl up at the ends; this is what you must guard against. Let only the upper edge of the batten touch the planks, and send the brad diagonally through it into the planking, so it holds the batten as shown. Keeping the batten vertical will help to make the line a true, straight one as you bend it around. But let it get canted so it twists under and it will insist on going up and above the true waterline. Scratch the waterline in with the point of an awl or compass point deep enough so that it will show through one or two priming coats of paint to guide you when you paint the last finishing coat. When you paint, remember to do the top coat before you do the last coat of bottom paint, for two reasons. One is that the thick copper paint generally used on bottoms of boats will cover the edges of the white more completely. The principal reason, however, is that paint will not run up hill, and you can cut the line sharp and distinct from below, with no fear of the paint running onto the other coat (as it would be sure to do if one tried to cut the line clearly from above).

RIBBON LINE

Where a band of colour like a ribbon is wanted between the top and bottom colours, the most common way is to strike one line as previously explained, and then tack a thin batten the width of the desired line around the hull and scratch it in parallel to the first line. However, this has the disadvantage of showing its full width at the middle and apparently diminishing as the hull slants under at the ends. To avoid this tapered line appearance, some men strike two lines by the straight-edge and string method, using the same boards and simply holding on both of them a block the thickness of the band.

This gives an entirely different effect. The line retains its full depth to the eye, yet if the boat were to roll you would find that, measured on the surface, the band is many times wider aft where it goes under the stern than it is amidships. Because of this effect, many prefer the parallel line scratched from a batten of even width. It is better to paint the waterline a little above the actual floating line for the reason that there is generally some place that you visit frequently where a scum of dirt on the water washes up and leaves a dirty wavy line on the white topsides. This does not show if the dark coloured bottom paint is carried up a few inches above the waterline aft and about twice as high forward. Such a band of exposed bottom paint is called a boot-top, and originated years ago when the boats were sheathed with copper instead of being painted with copper paint, the copper then being carried up above water to preserve the plank.

SCRAPERS

The matter of scraping and scrapers is a highly important one, and should require considerable care. The novice is apt to buy one of those triangular boat scrapers and then think that he is fully provided for. There is where he makes his first mistake. The experienced man has a number of flat cabinet scrapers. You can buy them, or else get an old saw blade - as that is the same kind of steel that scrapers are made of - and break it up into various sizes. Clamp it in a vise, if one is at hand, and you can break it off flush along the top edge of the jaw by giving it a quick, sharp blow. Or with a large pair of tinker's shears you can cut it straighter and save the work of filing them smooth.

For flat surfaces make a couple of scrapers about 4" long by 3" wide; a couple more half this size, say 2" by 3"; and then one or two either ground or filed into a variety of curves to scrape into corners, beadwork, and for quickly getting over the half and quarter-round mouldings. If near a boatshop where an emery wheel is running, it takes but a moment to grind one scraper into all the shapes required; otherwise you will need a round file to shape them.

For sharpening the scrapers, get a fine-cut flat file. Hold the scraper in the left hand, with its end resting on something solid, and run the file diagonally across and along the edge of the scraper so that it makes a true, square edge. Be careful that the file does not slip or you will get a nasty cut on the sharp edge of the scraper. If you try to use it in this way you may wonder why your scraper does not take hold and cut, as another more experienced man's does. The reason is that he takes a "slicker" - as it is called - a smooth, triangular piece of steel, like a smooth ground three-corner file (in fact, many men make their own "slickers" by grinding out all the teeth of an old file so that it is smooth). A few strokes of this or of any similar piece of steel will, if lightly pressed as it is rubbed back and forth on the edge of the scraper, roll over the edge, raising a small "burr". This burr is what does the scraping, and must be renewed by re-filing and re-slicking as it gets dull.

Professional scrapers can so sharpen these flat pieces that they will cut off a thin piece of wood the whole width of the scraper, no thicker than tissue paper. While the novice cannot expect to equal them he will find such a flat scraper more effective and far less liable to skate off sideways and dig a nasty deep scratch across the decks than the three-cornered boat scraper.

For heavy scraping, such as scraping off the paint on a boat's bottom or to remove the lumps of paint left on the topsides after burning off, a scraper made from an old file is excellent. Get a worn-out file about $1\frac{1}{2}$" wide and heat it in the fire. Then bend it like a hook turning over about 1" of metal at right angles to the rest of the file. By flattening out the end of this turned-over portion you can make a scraper that is hard to beat, and one that when ground to a sharp edge on a grindstone will cut like a plane. By being able to get hold of it with both hands you can bring great power to bear on it. A good practice to prevent this file from blistering your hands is to wrap electrician's tape about the end that you hold.

A handle for the square cabinet scrapers which makes them much easier to hold can also be made by sawing a slot into the edge of a piece of board, say of about 2", up into a $4\frac{1}{2}$" piece $7/8$" thick and as wide as the scraper. By slipping the thin steel scraper into this slot you will find it much less tiresome to grip the inch block than the thin steel blade. With a nail punch you can knock a hole through the middle of the scraper and put a round-headed screw through the block to hold the scraper solid (or else wrap electrician's tape around it).