BOATBUILDING PRINCIPLES

By WESTON FARMER

ANYTHING that you understand thoroughly is always fairly simple. This is true of boatbuilding.

Understand the basic principles of getting out a hull, and you'll be pretty sure of coming up with reasonably good methods of getting the job done. And once you've built *one* boat, the principles will dawn on you. Then you can tackle almost any boat. But it does take work, and it does take mechanical horse sense.

Mechanical horse sense is something no written word can supply. You're either born a mechanic or you're not. If you are mechanically gifted, you can do well building a boat. But if you have no gift for working with your hands, you shouldn't try boatbuilding. If you can get good cuts with plane, saw, and chisel, you can attempt to make a boat with reasonable assurance of success. Thousands do it every year.

Once your first boat is built, you'll have the principles of boatbuilding. And after the first one, nothing seems to be too big or too tough for the skilled amateur to tackle.

The fun of building a boat satisfies something primitive in man. And after launching his first boat, the backyard boatbuilder can go about dreaming up the next one, for he will have assimilated boatbuilding principles. These principles are few in number and can be easily illustrated and made clear.

Boatbuilding is the process of fabricating wood, steel, aluminum or plastics into the vessel designed by the naval architect. The builder's problem is to construct the vessel to the size and shape the designer depicts in his drawings. Highly important is this shape.

To get your boat fair and the correct size, you must first prepare a full size drawing of the lines and the main members (keel, stem, transom, knees) on the shop floor. Then these members may be transferred to the actual timber to be cut.

This process of laying down the lines is called *lofting*. The process of fairing up all sections and correcting obvious errors in the architect's scaling is called *fairing*. Fairing is done by moving a line here and there so that all cross sections jibe.

Boats are drawn on a scale of 1/16 full size, or 1/12 full size, or on other scales. So many inches or fractions of an inch equal a foot. In preparing the table of measurements by which the builder re-constructs the drawing full size—the table of offsets—the architect must scale his drawing, take a reading and letter the dimension.

This human transmission is subject to error. The width of an ink line in most drawings when multiplied 16 times in a loft layout can become half an inch off on a loft drawing, maybe more. The fairing process uses the offset table to "box in" all mechanical errors such as this, and of course obvious ones like the architect's getting the right dimension in the wrong offset table column. That can and does happen to the best of naval architects.

The correction of errors is secondary, however. Lofting is done as a convenience for the builder; from your faired drawings you make your full size parts without further reference to printed dimensions.

Your next step is to prepare the rigid framework which will hold this full sized shape you have laid down, until all structural elements of the hull have been fastened in place. At the completion of planking you have a hull.

At this point any falsework used to preserve the shape while building is discarded. The hull is now a structure in its own right. Into it then go the pieces of wood such as clamps, flooring, cabin and joiner work to complete the job.

To sum up, here are the basic steps in boatbuilding: the lofting and fairing out to full size, next the construction of the "building jig," termed a mold, in round-bottom boats, and a frame in V-bottom boats. Then the planking, and final installation of joiner work.

Lofting is done on either a painted shop floor, which is most usual in good boat shops, or the lofting job can be done on brown paper scotch-taped to a floor. The baseline for the station lines is usually drawn in with a long straight edge, or snapped with a chalk line. The curves are put in with battens, either nailed to the floor or held in place by weights. Good lofting is the inescapable first step. Try to dodge this part of the work—the first step—and you're in for trouble.

Once your boat is lofted, and the sections have been faired, the next thing you do to these sections is to subtract the planking thickness from the section lines. The mold sections for a bent-frame, round-bottom boat will be made from this inner set of body sections. So also will the sawn frames for a hard chine or V-bottom boat.

It will be well to get this distinction of terminology firmly fixed at this point. When *molds* are spoken of, it is in reference to the round-bottomed construction: a mold or mould—spelled either way—is the framework around which ribbands of wood are fastened so that steam bent frames can be shaped to the hull. When the word *frame* is mentioned it is usually in connection with the setup for a V-bottom boat which usually uses sawn frames to preserve the hull shape, and which are usually built right into the hull, *not* being discarded, as are molds.

WHEN your boat is lofted and faired, your next step is to transfer the lofted lines to the lumber or timber to be cut. This is done in a number of ways.

If the boat is lofted on a shop floor directly, which is the usual practice in good yacht yards, the shape of the stem, keel, and sections is transferred to template lumber so the outline can be sawed to. This template lumber is usually about ⅜" thick.

The lines can be transferred a number of ways. Old-time journey-

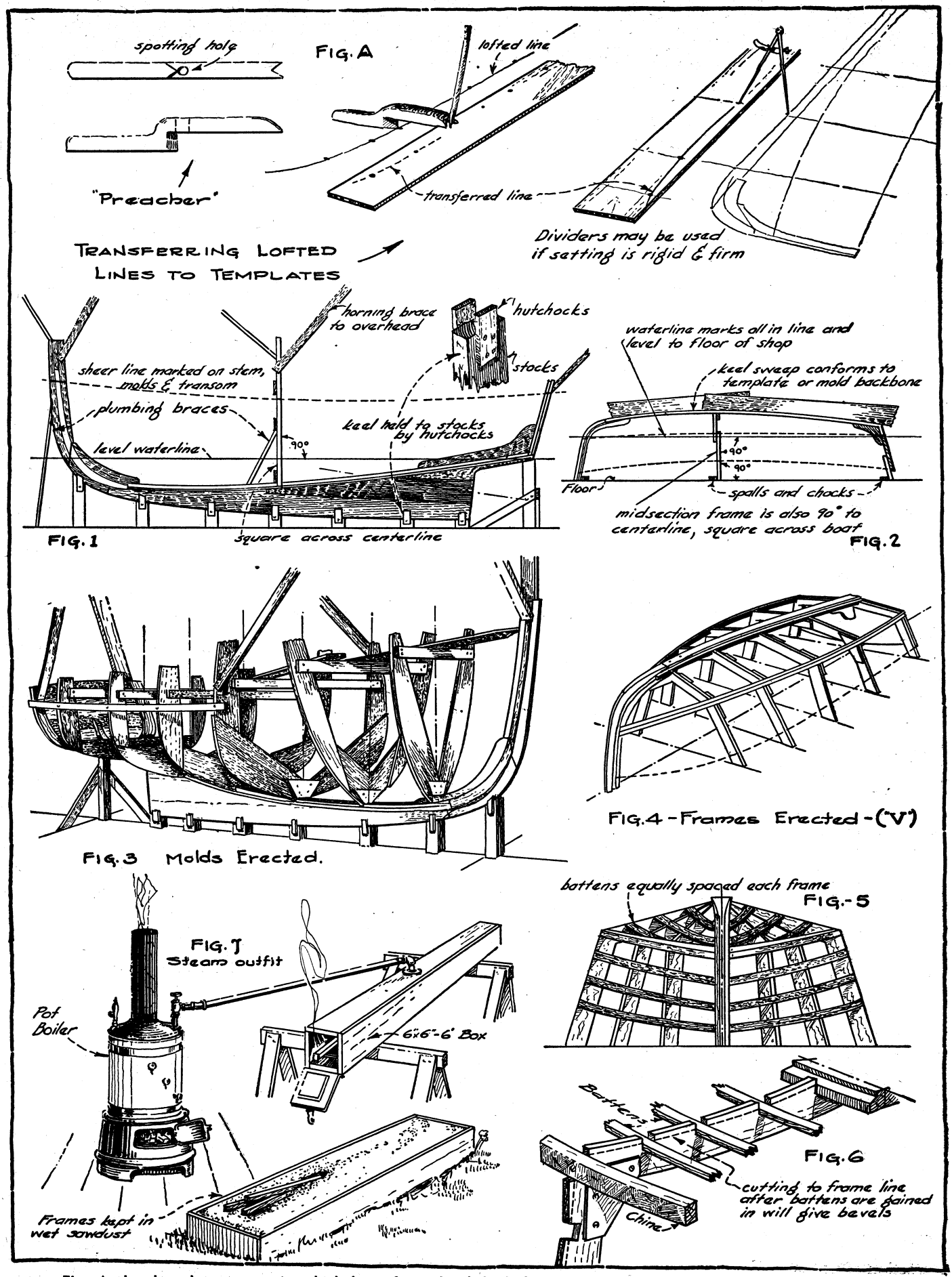


Fig. A sketches the manner in which lines from the lofted drawing may be transferred to templates. Fig. 1 shows the keel and stem for a husky round bilged craft as set up on stocks and hutchocks. Fig. 6 shows how frame bevels in a seam-and-batten job can be easily cut right on the frame after it is set up.

men boatbuilders use a "preacher" for this. See Fig. A, which explains the principle. Dividers can be used, as also shown, but a preacher is preferable as the dimension from heel to toe is fixed. A divider must be very rigidly set or it will creep, resulting in baffling errors. After the points are transferred from drawing to template, join the points and draw in the mating line.

Another transferring method is the use of nailheads set along the loft line, but this method is good only in the hands of excellent mechanics. (See Fig. 7 in another story, *How To Understand Boat Drawings).* The nailheads are tamped into the floor with a hammer, and the timber for the knee or other part is laid over these nailheads. By tamping the timber in turn, the outline of the part can be impressed in the timber, all points connected by a line, and sawed to.

One advantage of lofting on paper is that you can transfer shaped parts directly through the paper using a brad awl, or a dressmaker's wheel (See Fig. 4 in the story *How Prams Are Built).* Another advantage of lofting on heavy paper is that it is often possible for you to loft a 30-footer in a 15-foot room by doing the forward half first, then the aft half of the boat, using a short midsection to connect the faired ends.

The *disadvantage* of paper is that it creeps, and in some cases will shrink in one direction and expand in another. Not too serious if you watch for it.

With the stem cut out to rough shape, and likewise the keel, do you have the woodworking skill to cut the subsequent rabbet and taper the proper bevels? If these details of tool usage are not familiar, you might get a copy of Cliff Bradley's *Building the Small Boat.* That book deals with *method,* and we are talking of basic *principles* here.

Once the backbone elements of stem, keel, apron, transom, etc. are got out, most of the heavy "noodling" is over and the battle is half won. The next step after lofting and cutting of major parts is this: erect and hold in place the mold, in the building of a round-bottom boat, or the frame in the case of a V-bottom. There are dozens of ways to do this.

First, let us run through the mold erection of a round-bottom hull, and then later come back to the V-bottom system.

In the drawing, Fig. 1, the preliminary erection of the backbone and the midship mold has been carried out. All planes about which a hull is shaped are aligned: The keel, stem, and the transom are plumb in the vertical plane. The waterline is level to the loft floor. The keel has been set on stocks which extend at each section point the dimension necessary to reach the floor, or baseline. The midsection or midship mold has been "plumbed and horned." This term means that all is fair and square.

Plumbing of the molds means that they stand 90 degrees to baseline and to waterline. Also, that the centerline is actually plumb above the keel. Horning means that the mold is square athwartship. Plumbing and horning means that all planes are at 90 degrees—all square—and that the mold is level and without twist, or, as boatbuilders call it, "sny."

THE preliminary mold set up at Fig. 1 is then filled out as at Fig. 3. This view shows the molds erected, plumbed and horned, ready to have the ribbands fastened in place. The fastening of the ribbands is called *streaming*—a term used by boatbuilders to lay a thing in fair so it flows about the hull shape. The ribbands are streamed in at about six- to 12-inch spacing. It is about these that the frames are steam bent.

A word later about steam bending, but first notice that the keel of our boat is supported on stocks, and is kept from traveling off the stocks by cheek pieces which a boatbuilder calls *hutchocks.* Stocks can be toenailed to the shop floor, or cleated down. Or if the boat is built outdoors as can be done in a dry climate, stocks are simply driven into the ground and lopped off at proper height by template. The hutchocks prevent movement due to pounding, climbing and clamping down of frames.

Fig. 8 shows how the frames of steam-bent oak are bent into a hull mold. This view shows the use of the ribbands in helping to clamp the steam-bent frame in shape. Fig. 9 shows the Fig. 3 job pretty well along in construction: The frames have been bent in about the ribbands, the garboard plank next to the keel has been secured in place.

Next, the sheer strake has been secured and the hull has been planked down toward the turn of the bilge. A strake has been left out just above the garboard strake. This is called the *broad* in boatbuilding parlance. It is usually left out until the hull is closed in because this makes cleaning out chips and shavings thereby much easier.

As the planking progresses, the last plank put in is called the *shutter.* Often this is called the *whisky plank* for no better reason than in some yards the bottle of grog is passed and all hands take a pull.

Fig. 9 shows sufficient progress for the beginner to grasp the procedure from the sidewalk superintendent's point of view. The hull is, of course, planked out, planed, then caulked, sanded and primed with the first coat of paint. That covers the basic procedure on round-bilged hulls. The molds, of course, are not necessary now, and one by one are pulled out as the interior building goes along.

When you come to bending the frames, blessed are the uses of steam! The professional boatbuilder who can call himself a journeyman will always prefer to build a round-bilged hull because for him it is easier. He can make that useful tool, the steam box, say "Uncle." Those who have not used steam will shy away from it, preferring to build the more obvious built-in frame of the V-bottom type. Fortunately, no two men think alike on boatbuilding matters, which keeps the game changing. But you'll find that among men who have actually earned their living at the trade of boatbuilding, the preference is for bent frames—the molds don't have to be faired and bevelled to such accuracy, and the ribbands fair the job in. Also the steam-bent frames almost always bevel themselves in so that preparation for planking takes less time. So, a word about steam bending. There is no mystery about it—anyone who can boil oatmeal can do it.

Steam bending is merely the art of getting wood hot, and *wet* heat is best. Usually oak that is cut green and sized and stored in wet sawdust will be best. Air-dried oak, if soaked, can be used, but sometimes may fracture. Kiln dried wood is no good at all.

The steaming process is simple: a wood box, reasonably steam-tight is prepared. Into this is piped steam at atmospheric pressure. The frames are put into the steam box, and the steam gets the frames hot. One by

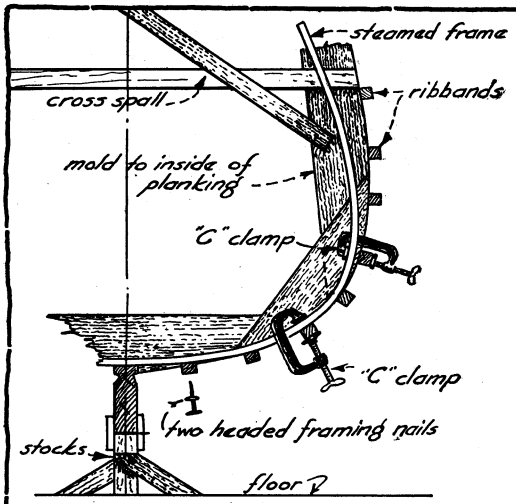
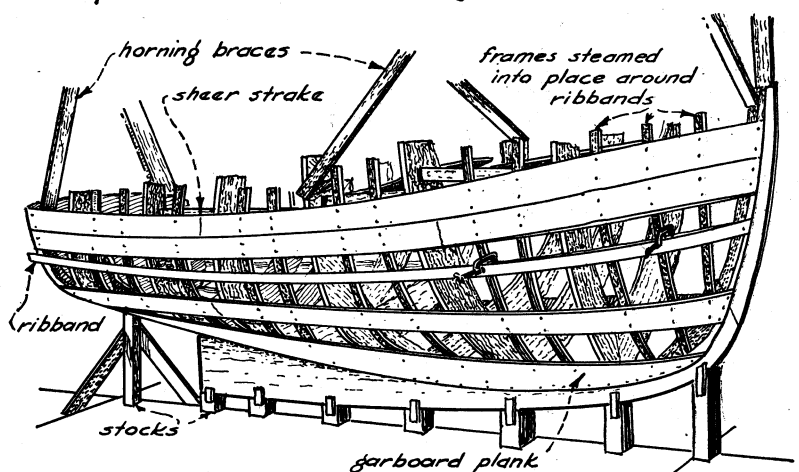
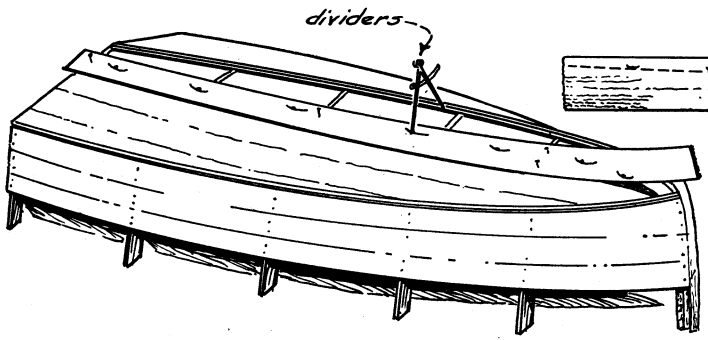


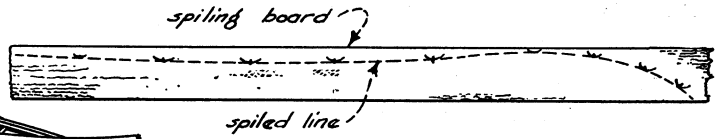
Fig. 8 - Steam Bent Frame

Fig. 9 - Framed and Partially Planked



Ribbands are removed as planking progresses

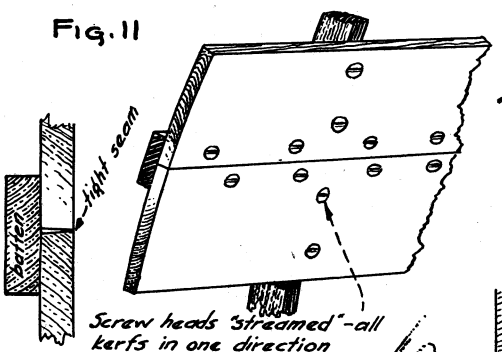




The spiling points are connected by a fair line. The resulting outline gives true shape for plank.

Fig 10 - Taking a "Spiling"

Fig. 11



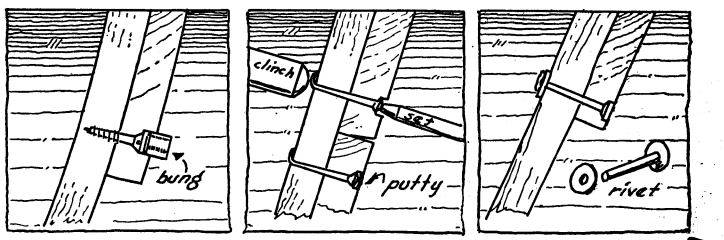


Fig. 12 - Types of Plank Fastenings

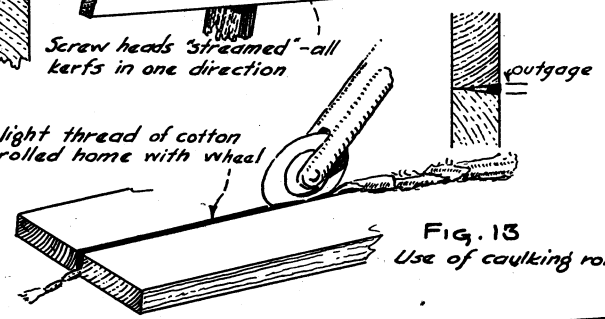


Fig. 13
Use of caulking roller

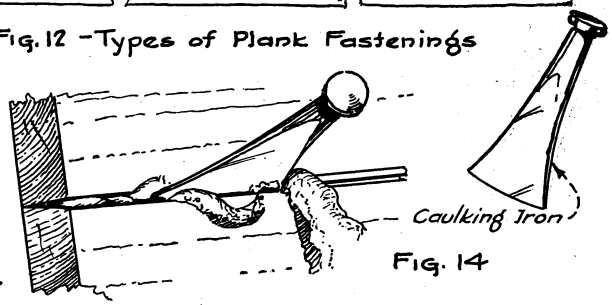


Fig. 14

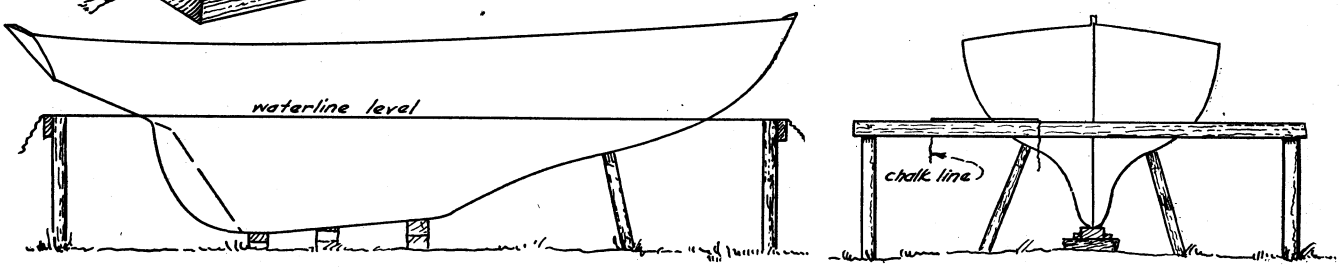


Fig. 15 – Showing use of batter boards and chalk line to strike in waterline

After the molds are set up, ribbands are streamed from stem to transom as shown in Fig. 8. Clamps are used to bring the steamed frame out to the ribbands and the frames are held to the ribbands during planking by two-headed framing nails. Fig. 10 graphically shows the principle of "spiling" a plank so it will fit.

The shape of each plank is obtained by *spiling*. This is the name for the mechanical process of determining the run of the seam edge on a twisted, or snyed plank and converting this seam run to the flat board from which the plank will be cut.

It is obvious that you cannot just cut a straight edge in a piece of lumber, call it a plank, and then slap it on a hull and expect it to fit. The plank has sny to it, and a straight edge will, when the plank is fastened down, take a violent sweep up or down.

In Fig. 10, I have taken the planked V-bottom boat for simplicity of illustration. You will notice that a thin sheet of template lumber, usually about ⅛ to 3/16 or ⅜, has been tacked down flat to the sny or twist of the hull. This template sheet is straight on a flat surface, but when bent will sweep as shown. Use dividers, rigidly set, to transfer a fixed distance from the edge of the rabbet to the spiling template.

When you remove the template, join the points by a line which will have what appears to be a peculiar sweep. Then tack this spiling template on the plank lumber and saw out the spiled line. When planed, you have the garboard plank to just the right shape that will bend over the hull and fit the rabbet landing. Usually one or two initial tries will enable the novice to get the hang of the thing.

On round-bilged hulls, all planks are spiled. On V-bottom hulls, after the garboard is screwed home, the distance from the seam edge to the middle of the next batten will serve as a guide for initial fitting, but if you want to get your shape right the first time, spile 'er.

USUALLY the V-bottom boat is screw fastened. This is done either by running the screws flush to plank face and planing afterward, which is Fancy Dan stuff for bright finished boats, or by countersinking about ⅛" as the screw is driven, plugging with white lead putty or some patented seam gunk before sanding.

In high quality boats, such as mahogany runabouts, the screw hole is counterbored for mahogany bung plugs. These are wooden dowels of the same wood as the planking and about ½" long. Dipped in shellac, with the grain running with the plank, they are softly tapped home and the shellac allowed to harden before the bung is clipped flush to plank with a sharp chisel. Bungs can be bought in all sizes from marine supply houses. Here also you can buy drills that will pre-drill for screws and countersink for bungs all in one go.

Invariably the screws in all boat construction must be pre-drilled to the root diameter of the screw, and from ½ to a full ¾ of screw length to avoid splitting. A split from a driven screw is a leak that's hard to find.

Fig. 11 shows the standard method of fastening planks to V-bottom boats. There are variations, of course, according to local custom and shop, but the method shown is usual.

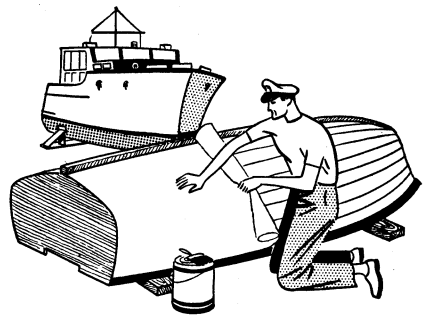
The novice will build his boat with planking too wide. This is not good. Strakes of *narrow* width will last longer and stay tighter. *Four or five inches at the widest, perhaps six, and two or three at the narrowest* is the usual professional rule.

In round-bilged boats there is great latitude in fastening. Some of the more usual methods are shown in Fig. 12. These sectional views are self explanatory. Further detailed description is carried in any of the encylopedic boat manuals, and the beginner should arm himself with at least one copy.

How is a hull kept tight? Either by caulking with seam gunk as in the case of the lightly-built plywood type of boat, or by a compressed seam which is often used in seam-batten boats, or by good, old-fashioned cotton caulking rolled in with a wheel, as at Fig. 13. The inner edge of the seam is fitted tight, and an outgage of from 1/16" to ⅛" is provided to lightly roll in a thread of cotton, after which the seam is puttied and sanded. In larger hulls with thicker planking an outgage of from ⅛" to 3/16" is provided, on planking from 1" to 1¼" thickness, and cotton is caulked in lightly with a caulking iron, as shown in Fig. 14. All seams get the putty treatment.

Waterlines often stump the beginner. Fig. 15 illustrates the best way to get a straight, true waterline before launching. Batter boards are set up level, and chalk string used to snap a line which can then be graved in with a hook knife, called a race knife. This then, rounds out the basic steps usually unknown to the novice.

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