Laying Down and Taking Off

Desmond Charles

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Author: Desmond Charles

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Chapter I

1a. Laying Down a Small Wooden Vessel

A designer expresses his ideas of shape and construction by means of drawings and written specifications, the drawings being made to scale (smaller than full size) and in sufficient detail to convey to the builder all necessary information about shape and construction. When a set of boat or vessel drawings is received by a builder, he enlarges the *lines* drawing to full size. This is called *"laying down"* and when this is done the principal construction details are enlarged to full size, and necessary full-sized templates, moulds and patterns are made for the builders. This work is called *"taking off"*.

Laying Down and Taking Off work is done on the floor of a well-lighted room called a mould loft. This floor is usually sufficiently wide and long to "lay down" the largest sized vessel that will be built in yard. Nearly every shipyard has its mould loft, the majority being constructed in such a manner that the entire floor is free from posts and obstructions, light being admitted on all sides and from overhead.

As I desire to make my explanation perfectly clear to men not familiar with work done in a mould loft, I will first describe and illustrate the work of "laying down" a small commercial vessel to be constructed of wood and afterwards explain the work of "laying down" a vessel to be built of steel.

Fig. 1 illustrates the scale lines drawing and Figs. 2 and 3 construction drawings of wood-constructed vessel I am going to "lay down".

1a¹. Explanation of Figures in Circles on No. 1 Illustration

Figures marked in circles are placed on drawing by me to aid the reader in identifying each line and to explain the order in which the various lines are usually "laid down" by a mould's loftsman. *They are not a part of a lines drawing.*

List of Numerals in Circles and Name of Each Line

Profile View

1 Base
2 Perpendicular
3 Ordinates
4 Water-line planes
5 Sheer and top of rail
6 Bottom of keel
7 Rabbet
8 Top of deck

Half-Breadth View

9 Rabbet
10 Front of stem
11 Top of rail
12 Sheer
13 L.W.L.
14
15 } W.L. below l.w.l.
16
17
18 } W.L. above l.w.l.
19
20 Buttock lines

Body Plan

21 Center line
22 Rabbet
23 Half-width at Stem
24 Cross-section No. 7
25 " " " 6
26 " " " 5
27 " " " 4
28 " " " 3
29 " " " 2
30 " " " 1
31 " " " 8
32 " " " 9
33 " " " 10
34 " " " 11
35 " " " 11½
36 " " " 12
37 Buttocks
38 Diagonals
39 Shaft
40 Shaft line on half-breadth water-line view
41 Shaft line on profile
42 Buttock profile

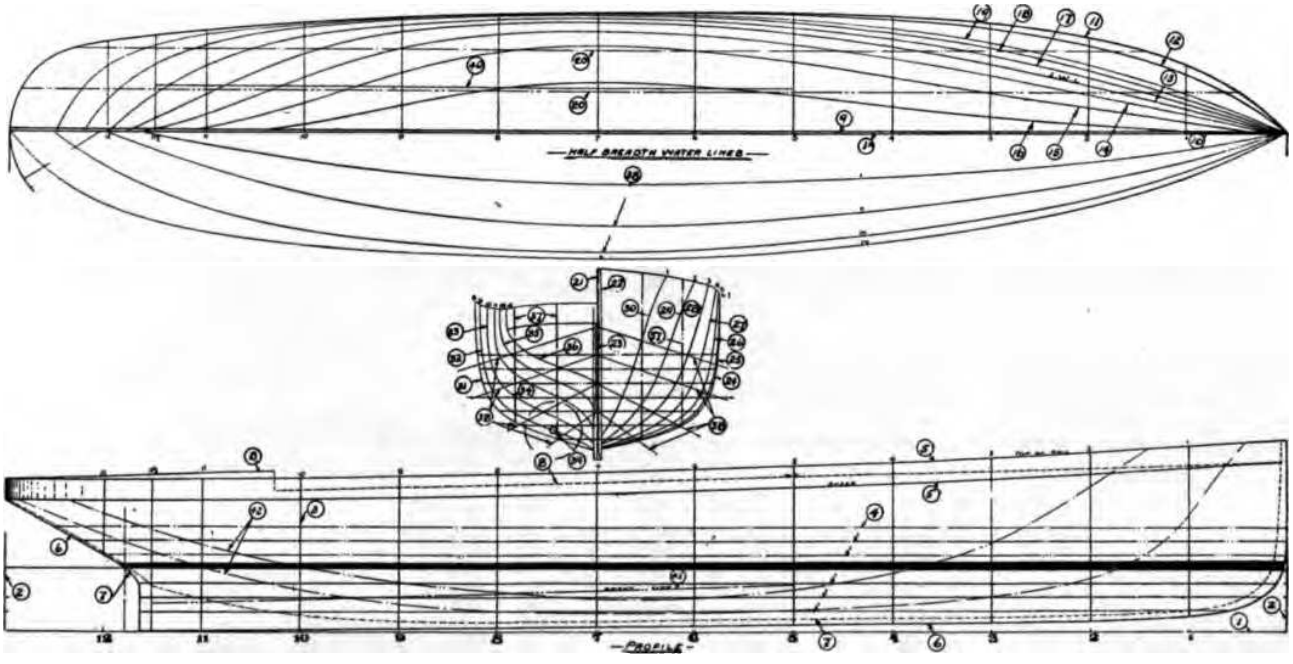


Fig. 1

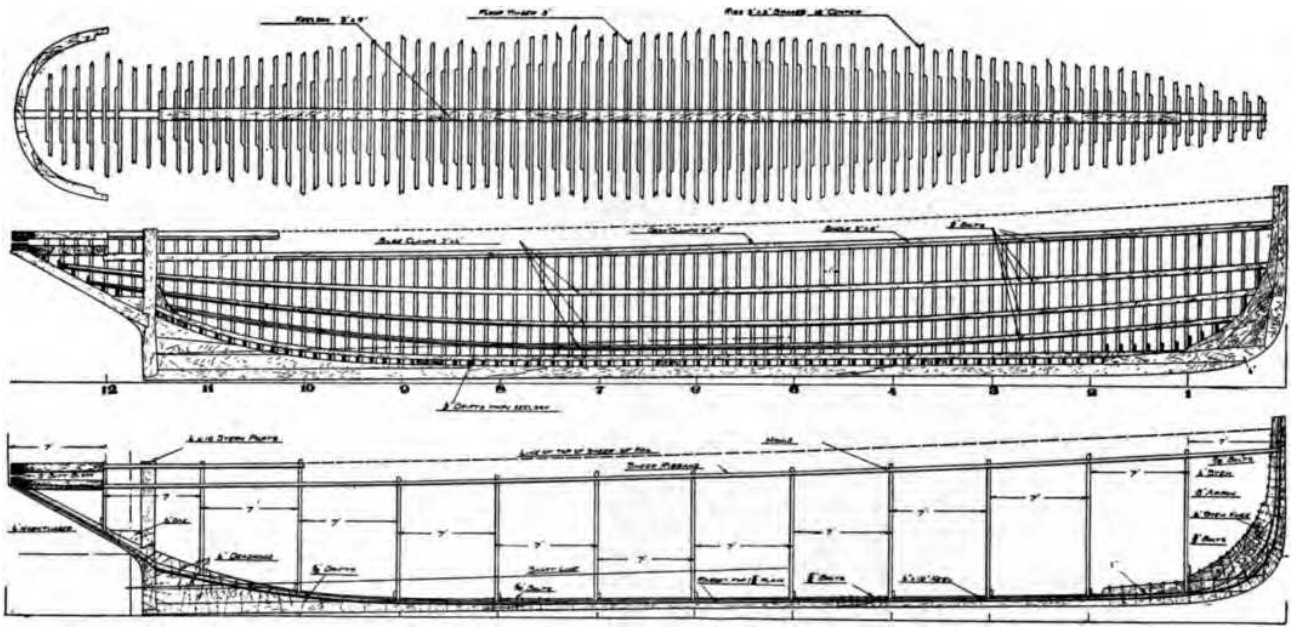


Fig. 2

1b. Description of Vessel

The design is for a small commercial power-driven vessel to be constructed of wood. Its principal over-all dimensions being:

Length over all, 91 feet.

Breadth, extreme, 17 feet 6 inches.

Depth, extreme, from keel to top of stem head, 13 feet 9 inches.

Therefore, the dimensions of mould loft floor required to lay vessel down are:

Length not under 100 feet (a few feet more than extreme over-all length).

Breadth not under 36 feet, if vessel's lines are to be laid down in locations similar to ones on lines drawing Fig. 1, with profile view and half-breadth water-line views separated, or 17 feet if lines are to be laid down with profile and half-breadth water-line views together, the profile being laid down first with one colored crayon, and half-breadth view with one of different color on same part of floor as profile view, the base line of profile being used as center line for water-line view.

As it is a more difficult matter to lay lines down in the second manner (both views together on one portion of floor), I will explain how work is done in that manner.

When "laying down" the lines of a vessel, the profile and half-breadth water-lines are laid down first and in such positions that inaccuracies of shape which cannot be seen on scale drawings can be corrected. An important duty of the mould loftsman is to correct inaccuracies and *fair* all the lines. The cross-sections are "laid down" *after* lines shown on profile and half-breadth water-line views have been faired or corrected, and it is usual to "lay down" cross-sections on a different portion of floor, or upon a large board that can be moved from the mould loft to bending room. The reason for doing this will be explained a little further along.

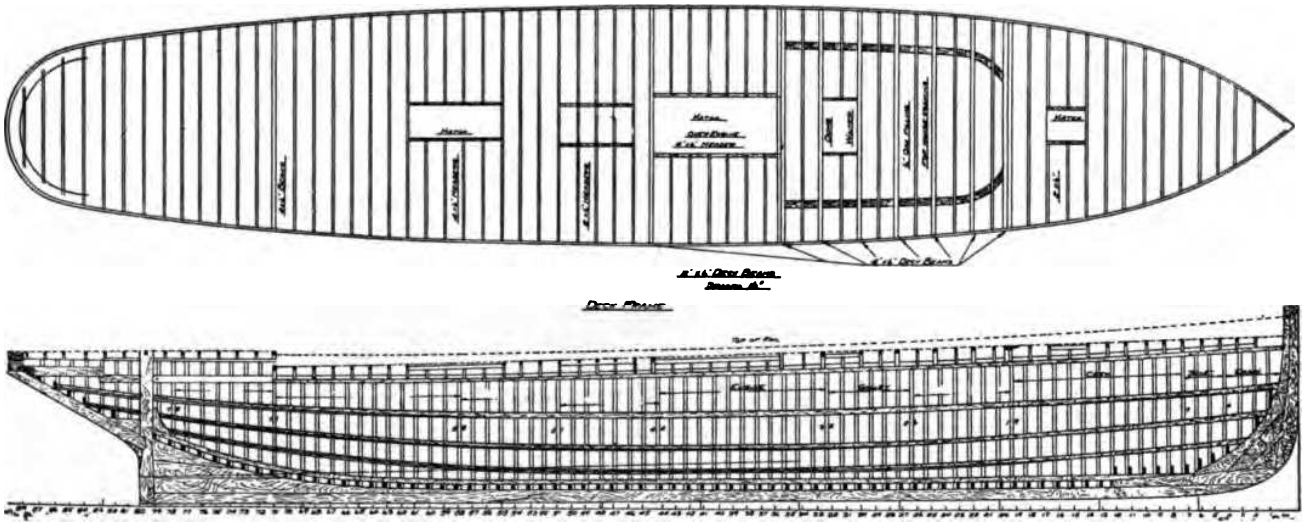


Fig. 3

1c. Fairing the Lines

It is a physical impossibility for a designer to get all lines shown on a scale drawing absolutely fair, and to take absolutely correct measurements from a scale drawing. Therefore, the mould loftsman first marks out the lines by using measurements supplied by designer and whenever a line laid down to these measures does not come absolutely fair and true he corrects it by moving any measurement point that is out of position. The mould loftsman must be careful not to materially change the shape of any line; *he only corrects inaccuracies.*

The art of fairing lines can only be acquired through practice, but in general it will be found that lines can be faired more easily if a certain definite plan of procedure is followed. I have found that it is best when laying down profile view to fair the sheer line first, the keel and stem outline next, and the rabbet next. When fairing half-breadth water-line it is best to fair deck outline first, the L.W.L. next, then water-lines below the L.W.L., beginning with one nearest to L.W.L., and last of all water-lines above water beginning with line next above the L.W.L.

The work of fairing lines really consists of two separate and distinct parts, the first or preliminary fairing being done just before each line is marked and consists of correcting apparent inaccuracies or irregularities that appear in the batten sprung to measurement points. The second fairing, done when buttock lines and diagonals are being marked in, is most important, because it is the final one made for the purpose of fairing the lines *in every direction.*

1d. Description of Mould Loft Floor

The floor of a mould loft must be perfectly level and smooth. It should be constructed of tongued and grooved strips of hard wood, and it is advantageous to have planks laid diagonal to side of floor that will be used as base line. Sometimes the floor of a mould loft is painted either a dull black or white, because colored lines show more distinctly on a painted surface.

Along lengthways edge of floor a fixed perfectly straight batten is secured, the inner edge of batten being used as a *base* line (1) when "laying down" and serving the double purpose of clearly indicating base line and also as a guide for ends of measuring battens when these are used for measuring "laying-down" lines. It is a good plan to paint base batten black and clearly mark along its top ordinate numbers and frame positions.

I will now assume that floor of mould loft with base batten is ready. (See Fig. 4.)

The first work is to mark on floor the over-all perpendiculars (2), space off ordinate or mould lines (3), and mark them across mould loft floor at exact right angles to base line.

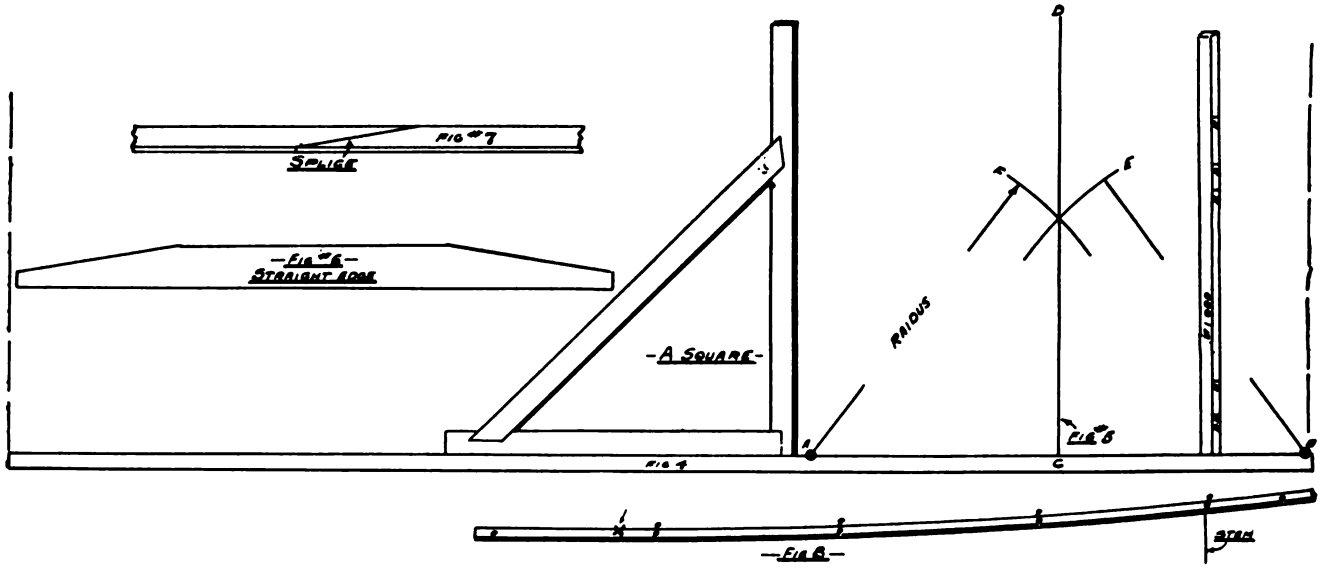
As "laying down" a vessel's lines really consists in making a full-sized reproduction of the designer's scale drawings, the mould loftsman must, before he begins his work, endeavor to clearly understand the designer's intentions as regards shape of lines.

Over-all perpendiculars (2) are marked off in this manner: A point is marked on base line to indicate where forward perpendicular is to be located and over-all measurement is taken from this point along base line. The after perpendicular is marked at point where over-all measurement reaches. These perpendicular lines must be at exact right angles to base and their length must be sufficient to enable fore and aft line of profile that is furthest from base to terminate against them. To insure that perpendiculars are at exact right angles, the mould loftsman first lays out the lines with a large A square and then proves their accuracy by checking in this manner:

1e. Explanation of Method of Proving That One Line is Drawn Square to Another

The line *A, B,* on Fig. 5, is a base line and it is desired to draw the long line *C, D,* perpendicular to it.

Place edge of one blade of A square to follow base line *A, B,* and draw the perpendicular line *C, D,* very faintly. To prove its accuracy use a pair of beam compasses, one point of which is placed at *B* and the other at *E.* Describe arc *E* and then measure from *C* towards *A* a distance equal to *C, B.* Describe arc *F* without changing compasses, and if it is found that point of intersection of the two arcs is exactly on perpendicular, the line *C, D* will be exactly perpendicular to *A, B.* If the intersection is not on line you will know that *C, D* is not exactly perpendicular.



1f. Description of A Squares Used in a Mould Loft

These are made of pine or mahogany battens about 1 to 1½ inches, glued together to form strips 4½ to 6 inches wide. The three pieces that form square are halved and glued together, great care being taken to get outer working edges of square exactly at right angles. A mould loftsman usually has one or more of these squares, the length of short blades being about two-thirds the length of long one.

On Fig. 5 an A square is shown.

When the two perpendiculars have been marked and proved, the mould loftsman proceeds to lay out ordinate lines (3), or lines that indicate positions of erecting frames. In this particular instance, the vessel being a wooden one, the ordinate lines 1 to 12 are also the lines that indicate where erecting frames, or first frames erected, are located.

Ordinate lines are laid out in this manner: The mould loftsman accurately measures along base line and makes a mark where each ordinate line (3) is located. He then places his A square at each point and marks the ordinate lines on mould loft floor, being careful to get them at exact right angles to base. The accuracy of ordinate lines can be proved by either proceeding in the manner explained by illustration Fig. 5, or by measuring from upper end of forward perpendicular parallel to base. *Note this:* If a line is drawn from forward to after perpendicular exactly parallel with base line and along this parallel line there is measured distances corresponding with ordinate point distances measured along base line, it is evident that if every perpendicular drawn from a point on base line cuts the corresponding point on upper parallel line, ordinate lines will stand at exact right angles to base.

After ordinate lines (3) are marked, the parallel water-line planes (4) shown on profile drawing are marked. These lines must be parallel with base line and the exact distance apart indicated on lines drawing. In this particular case, the lines are 12 inches apart. Water-plane lines, and in fact all long straight lines, are usually marked by means of a chalk line, and after their accuracy has been proved, they are re-marked more clearly with a crayon or pencil, using a long straight edge as a guide.

1g. To Mark the Long Straight Parallel Water-Lines on Profile by Using a Chalk Line

Measure up from base line, along forward and after perpendiculars, and mark points where each water-plane line (4) terminates. Next make similar measurements on two or three widely spaced ordinates and mark the points.

Now tightly stretch a well-chalked fine cotton line from a point on forward perpendicular to a corresponding point on after perpendicular and prove that the line is straight and parallel with base by observing that it exactly cuts points marked on widely spaced ordinate lines. When satisfied that line is correct, have one or more assistants stop the line at equal intervals by pressing it down to floor without shifting it, and then snap line section by section. If the snapping is properly done, the chalk on line will leave a perfectly straight mark on floor and you can accurately re-mark it in pencil or crayon by using a long straight edge as a guide.

1h. Description of Straight Edges Used in a Mould Loft

A mould loftsman must have one or more straight edges to help when marking straight lines of moderate length. These straight edges are generally made of several narrow strips of mahogany or pine glued together, the width of the strips being about 1 inch and total width of straight edge about 8 inches at center for a straight edge not over 16 feet in length. The ends are tapered as shown on Fig. 6.

When these lines have been marked, the profile view can be laid out. Measurements for doing this are obtained from table of offsets that is always attached to a lines drawing. The mould loftsman usually lays down profile view outline first, and in order to do this work accurately and in the quickest manner, he first transfers all measurements to a number of "taking-off" battens and then by using these "taking-off" battens in proper locations and butting one end of them against base line batten, height line measurements can be more quickly made than by using a rule.

1i. Description of "Taking-Off" Battens

"Taking-off" battens are straight pieces of pine having either flat or triangular cross-section and sufficiently long to enable the greatest height or width measurement to be transferred to them. One end of each batten is finished perfectly true and square, so that it can be butted against base-line batten and held there while a measurement is being transferred from "taking-off" batten to mould loft floor. On illustration Fig. 5 a "taking-off" batten with rectangular cross-section is shown, and on it I have marked a series of lines to indicate just how a mould loftsman marks measurements on such battens. The batten illustrated has marked on it all necessary height measurements for No. 1 ordinate. The lower mark indicates height bottom of keel is above base; the next mark indicates height of rabbet above base; the next mark indicates height of sheer above base; the next one height of center of deck line above base, and upper one height of top of rail. Thus, by placing this batten against base line at No. 1 ordinate position and having it follow ordinate line, the mould loftsman can quickly and accurately transfer measurement points for all profile height measurements on No. 1 ordinate.

All measurements for profile view are made from base line (1), and all measurements for half-breadth water-line view are made from center line (1a), in exactly the same manner that they are made by the architect when preparing the lines drawing.

The usual method of marking points of measurement on a mould loft floor is to mark a small dot or cross and enclose it within a circle, the center of dot or cross indicating the exact point of measurement and the point where pinning nail for guiding batten is driven. For this vessel the mould loftsman will require four battens for "taking-off" height measurements of profile view. This is because each batten has a rectangular cross-section, therefore, a separate series of measurements can be marked on each face. Thus, the first batten will have marked on it measurements for Nos. 1, 2, 3, and 4 ordinates, the second for Nos. 5, 6, 7 and 8 ordinates, the third for Nos. 9, 10, 11 and 12 ordinates, and the fourth heights for stem and stern.

I will now assume that all profile height measurements have been marked on battens and transferred to the mould loft floor. The mould loft floor will now have the appearance shown on Fig. 9, and the mould loftsman can proceed to mark in the profile outline. I will explain how this is done, but before doing it I will briefly describe the battens used in a mould loft for drawing long curved lines.

1k. Description of "Laying-Down" Battens Used in a Mould Loft

These battens are made of clear pine in long lengths, and if one length of material is not sufficiently long, two or more pieces are carefully spliced together, the usual method of splicing being a long tapered glued splice as shown on Fig. 7. By making a splice of this kind the batten will bend to a true curve. Three kinds of battens are used: (*a*) Battens that have the same cross-section area from end to end. These are used for guiding the pencil when drawing long lines that have a regular curvature from end to end, such as a sheer line. (*b*) Battens that taper towards one end. These are used for guiding the pencil when drawing lines having a curvature that changes at or near one end, such as the after end of a load water-line. (*c*) Battens that taper towards their center. These are used for guiding the pencil when drawing lines having an abrupt change of curvature some distance from end, such as the forefoot of a stem. In a mould loft there is always a large number of battens of each kind, the dimensions of cross-section varying. Some of the battens have a square cross-section varying in size from 1½ by 1½ inch down to ¾ by ¾ inch. Another kind of batten used very frequently is one having its width greater than its thickness. It is usual to make these battens two times as wide as they are thick, some being 2 inches wide and ⅞ inch thick and others various sizes down to ⅝ inch wide by ⅛ inch or less thick. The very small battens are used for guiding the pencil when drawing very abrupt curves.

1l. Explaining the Way to Use Battens for Guiding the Pencil When Drawing Long Curved Sheer and Other Lines on a Mould Loft Floor

For the sheer and top of rail lines (5) the mould loftsman selects a rectangular cross-section batten that is sufficiently stiff to require a little pressure to bend it to the measurement points. This batten should, if possible, be sufficiently long to extend from end to end of line, but if this length of batten is not available a shorter one can be used; but it is important to remember great care has to be taken, when using a shorter batten, to prevent a flat spot appearing in line at points where end of batten reaches to. The mould loftsman drives a wire finishing nail, a little longer than width of batten, through the center of each sheer measurement point, and when this has been done he bends batten against the nail and holds it in place by driving additional nails against the other edge of batten. Frequently with the batten resting against all measurement point nails there is some slight irregularity in the curve. Irregularities must be corrected, by the mould loftsman, without making any radical change in line, so as soon as sheer batten is bent, the mould loftsman looks along it, notes any irregular spots and has his assistant move nails here and there until the line is fair and batten is moved *as small a distance as possible* (average) from the original measurement points.

It is very important to remember that whenever a long batten is bent to a curved line the tendency is for ends of batten to assume a flat shape. The mould loftsman, knowing this, always lets the ends of a batten extend several feet beyond the termination points of a curved line and he puts sufficient tension on the extended portions to obliterate any flatness. This same method is followed when using a batten that is not sufficiently long to reach from end to end of a line. The last several feet of such a batten is not used as a guide for marking, but as an end for the purpose of eliminating flatness of curve. Fig. 8 shows a short batten in position for marking a portion of sheer line of design being laid down. Note the extension of batten ahead of stem, also note *X* mark, which indicates where marking of line must terminate until batten is moved to a position that will enable the line to be continued aft in a fair curve. I have shown a short batten in use because I desire to call your attention to the importance of allowing the ends of such a batten to extend.

The whole of sheer line (5) is marked and then nails are driven at points along outside of keel line (6), batten is bent, fastened in place, faired if necessary, and outside of keel line (6) is marked. It is usual to commence to mark this line from stern and work forward, a fairly stiff batten being used for portion of line that extends from stern-post to No. 2 ordinate, and then a center tapered batten that is sufficiently limber to bend around the forefoot up to stem head. Small battens are used for bending around curves of stern-post and horn-timber. After profile outline is marked, nails are driven along rabbet (7) line points and rabbet line is marked very faintly. This line is marked faintly because a little later it may be found necessary to change its shape at various points, especially along forefoot. I will explain later the reason why this change may be found necessary.

The center of deck line (8) is next "laid down".

After profile outline and rabbet are marked the mould loftsman lays down the half-breadth deck and water-line view. Measurement points for this view are obtained from offset tables and are marked on taking off battens in exactly the same manner that measurements for sheer were marked. You will remember I mentioned that it is my intention to explain the way to lay down half-breadth water-lines on same space that profile is laid down, therefore, base line for profile now becomes middle line for half-breadth water-line view and ordinate lines used for profile become ordinate lines for half-breadth view.

To avoid possibility of confusing the points and lines of profile with those of half-breadth water-lines I use a different colored crayon for each set of lines. My usual practice, on a white painted floor, is to use Dixon's black crayon for perpendiculars, ordinate lines, parallel straight water-lines on profile, sheer and profile outline, rabbet and bearding line.

Blue crayon for deck outline and water-line of half-breadth water-line view.

Red crayon for buttock lines on both profile and half-breadth view.

Green crayon for diagonal lines.

Thus each set of lines stands out clear and distinct, and it is an easy matter to follow any selected line.

When all half-breadth measurement points are transferred to mould loft floor the mould loftsman marks the lines that indicate half-width of rabbet (9) at stem, keel and deadwood, on half-breadth water-line view. This line extends from forward to after perpendiculars and is drawn the distance out from center line of keel that rabbet is away from center line. This is usually half siding of keel, stem and deadwood. In this design the line is parallel to center line of keel, but frequently in small vessels the width of rabbet increases at shaft-log. Measurements for rabbet widths at each ordinate are obtained from offset table. He next marks lines at

stem and stern, to indicate half-widths of each water-line at its points of termination (10).

If you look at bow of any vessel you will see that the extreme forward end of stem does not taper down to a knife edge but has some width. On the design being laid down this width is 1 inch at stem head, therefore, the half-width of deck at extreme forward end of stem is ½ inch, and this ½ inch width is carried down to where water-line No. 3 cuts stem, and from this point it begins to increase in width until at a point about 1 foot aft of No. 1 ordinate it becomes the same as that of keel.

The width of front of stem is shown on half-breadth water-line view by a line drawn the proper distances out from center line of keel (10). On Fig. 1 illustration this (10) and the rabbet line (9) are clearly shown.

The mould loftsman transfers termination points of water-lines and rabbet in this manner (bear in mind that base line is now also center line of half-breadth view):

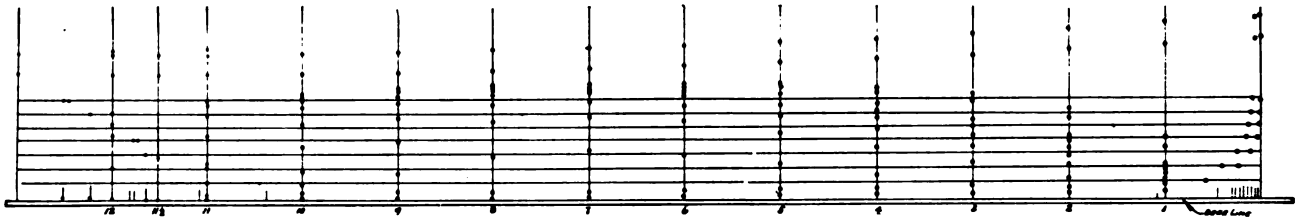


Fig. 9

He uses a square, placing one edge against base batten and other edge to cut point where one of the parallel water-plane lines crosses stem or stern outline of profile, or rabbet, as the case may be; the standing edge of square is then used as a guide and a line drawn from point on profile down to line that indicates half-width of front of stem, or of stern, or of rabbet, as the case may be. This line is drawn faintly because it is not a portion of laying-down lines.

Fig. 9 illustrates appearance of mould loft floor when profile and half-breadth view measurement marks have been transferred, and Fig. 10 illustrates appearance when lines 1 to 19 have been marked on floor ready for fairing.

The mould loftsman when laying lines down to measurement points such as these are makes the longitudinal lines fair to the eye by correcting irregularities due to evident mistakes in measuring offsets from scale

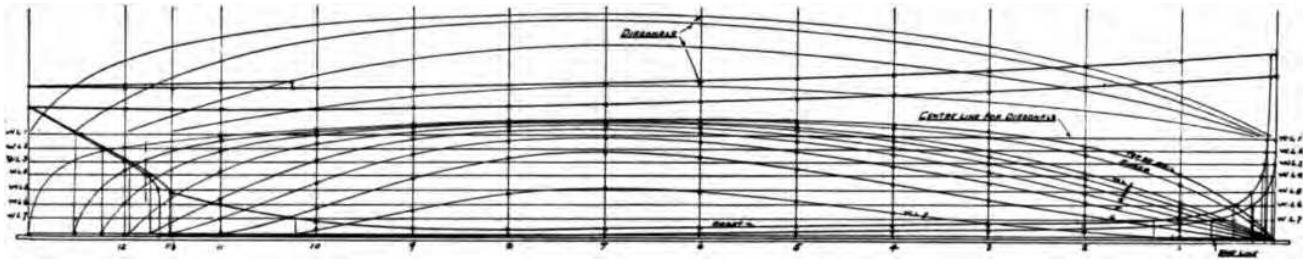


Fig. 10

Forward and after points of termination of all water-lines are drawn and transferred in this manner and after this has been done points where each water-plane line crosses rabbet line are transferred down to half-width of keel line (rabbet).

After the points of termination water-planes and of rabbet have been transferred, the top of rail outline (11), deck outline (12), L.W.L. (13), and half-breadth water-planes (14 to 19), are marked, the various lines being laid down in the order indicated by numerals. The preliminary fairing of these lines is an important detail.

I will assume that top of rail (11) and deck outline (12) have been laid down and found to be accurate. The next line to lay down is the L.W.L. (13). Now let us assume that when batten is bent to measurement points of L.W.L. it is found that there is an irregular spot in line between Nos. 1 and 2 ordinates. This irregularity can be removed by either moving batten out at No. 1 ordinate and letting it remain in its place at No. 2, or by moving batten in at No. 2 ordinate and letting it remain in its place at No. 1. The question for mould loftsman to decide is which of the two methods of correcting the irregularity is best. The irregularity may only be a small one, but it is very important to correct it in such a manner that the designer's intention as regards shape of lines be adhered to. Bear in mind that in the majority of instances an alteration in the shape of one water-plane will affect one or more of the water-planes immediately above and below the one that is changed, and thus the designer's ideas of form can be changed very materially by a mould loftsman unless he is very careful. Fairing a line should always be done in such a manner that shape remains as nearly like the drawing as it is possible to have it.

drawing, leaving the final fairing of lines until body plan has been laid down and buttocks and diagonals drawn. *Accurate fairing cannot be done without the use of buttock and diagonal lines.*

1m. Laying Down Body Plan

The body plan is next laid down on a portion of floor entirely apart from longitudinal profile and half-breadth water-lines. The floor is prepared by marking base, center line and parallel water-plane lines, and then measurements for cross-sections are taken, on measurement battens, *from the profile and half-breadth lines already laid down* and transferred, because by doing the work in this manner cross-sections will be laid down to corrected measurements of lines already laid down and not to original measurements given on table of offsets. You

must bear in mind that when laying down lines it is necessary to have corresponding measurements alike on all views, therefore, whenever a line is changed on one view, a similar change must be made on all other views of same line.

Fig. 11 shows appearance of floor after straight parallel water-plane lines, center line and base line for cross-sections have been laid down, and Fig. 12 its appearance after cross-section outlines have been marked.

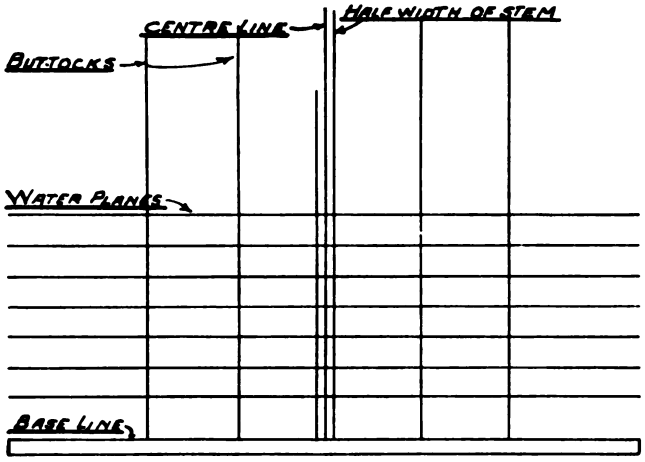


Fig. 11

The cross-section outlines are at this time marked on floor very faintly, because later it will no doubt be found necessary to make corrections, and in addition to this it will be necessary to take off the thickness of planking after cross-section shapes are faired.

11. Taking Off the Thickness of Planking

The lines of this vessel are drawn to *outside* of planking, and as it is necessary to use patterns of cross-section shapes as guides for shaping frames, the mould loftsman, after lines have been faired, takes off the planking by marking lines the exact thickness of plank inside cross-section shape lines. This is done by setting a pair of carpenter's compasses to exact thickness of planking, bending a batten to follow outline of the section and then by letting one leg of compasses follow along inside edge of batten, the other leg, with pencil point attached, will scribe a new line the thickness of plank inside cross-section outline.

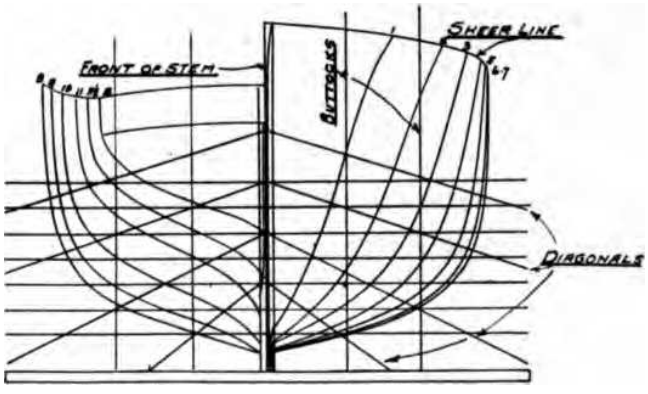


Fig. 12

On Fig. 13 I show an enlarged view of two cross-section outlines after thickness of planking has been taken off. To aid you in understanding the drawing I have shown original outlines in broken lines and outlines after thickness of plank has been taken off, in full. This illustration will be described after I have explained how lines are faired.

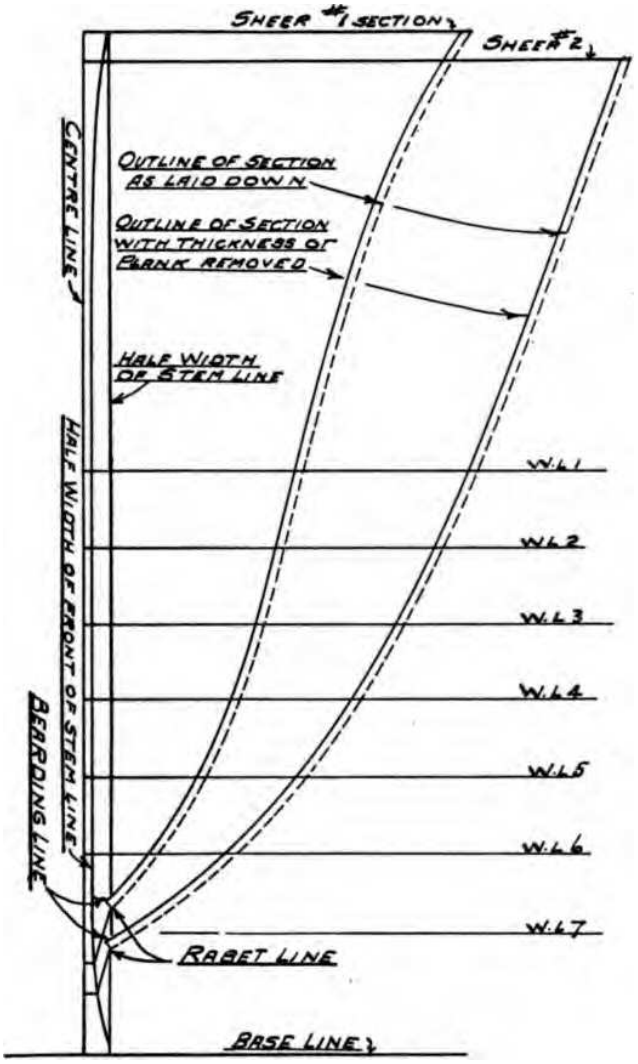


Fig. 13

10. Fairing the Lines

I will assume that all profile longitudinal lines, half-breadth water-lines and cross-section shape lines have been laid down, and that measurements on all views correspond. To fair these lines it is necessary to make use of buttock and diagonal lines, because fore-and-aft and transverse lines may look fair when viewed as they must be on a mould loft floor as plane surfaces taken at right angles to each other, but when viewed from other angles irregularities may be apparent. Therefore to fair the lines, which really means proving they are fair, buttock straight lines are marked on both cross-section and half-breadth water-line views, and then by making measurements on cross-section view and transferring them to proper places on longitudinal profile view, points are obtained for the curved buttock lines on profile. Some ad-

ditional points for getting buttock lines shaped at ends of profile are obtained by marking verticals from points on half-breadth water-line view to corresponding water plane on profile. Fig. 14 shows an enlarged view of forward portion of longitudinal profile and water lines, with buttock transfer lines and buttock shapes marked. For the purpose of making the illustration clearer, I have marked half-breadth water-lines in broken lines and buttock outlines and transfer lines in full.

It may be found that when a batten is bent to points marked for buttock curved lines some points will be out. When this occurs it is necessary to look over longitudinal and cross-section lines very carefully and determine change necessary to make buttock line fair. One of the best ways to fair is to let buttock line batten bend to a fair curve, paying no attention to the point, or points, that is out, and then measure from batten to where buttock does not cut its measurement point, transferring this measure to corresponding buttock line on cross-section plan, and ascertain if a fair curve of cross-section can be obtained when cross-section shape is altered to cut the new point. If it can be obtained, transfer corrected cross-section measure to half-breadth water-line view and note if, when water-line is changed to meet this point, the water-line shape will be fair. If it is fair to look at, you can be reasonably certain that the change should be made. In practice it will be found necessary to make several changes before all lines are fair and measurements on all views correspond. Take one buttock at a time, beginning with buttock nearest keel.

After buttocks have been marked and corrected, the final fairing is done by means of diagonals.

1p. Final Fairing by Using Diagonals

Straight diagonal lines (38 on cross-section view) are marked, measurements are taken along them and transferred to mould loft floor immediately above longitudinal profile view, the upper water plane of profile view being used as center line for diagonals. Bear in mind diagonal measurements are taken from center line of cross-section view along diagonal straight lines to where each cross-section outline crosses a diagonal. Measurement battens are used.

On Fig. 10 I have drawn the diagonal curved lines and indicated the line on profile view used as center line when laying down these lines.

Diagonal curved lines indicate the approximate path of travel of water around and under a vessel, and if lines of vessel are fair, the diagonal curved lines will be fair curves from end to end. Any irregularity in one of these lines will indicate a flat spot or a bulge in form, and of course it is necessary that mould loftsman correct diagonal, cross-sections and half-breadth water-line at any point where diagonal shows any irregularity.

The fore-and-aft, and cross-section lines have now been laid down and faired, but before making the templates, it is necessary that shaft line be marked, that correctness of rabbet be proved, and that bearding line be marked at its proper distance from rabbet of keel, stem, deadwood and stern.

To mark shaft line use measurements given on table of offsets, mark points where forward and after ends of shaft line terminate, stretch a chalk line from point to point, and then prove that line is correctly located by making an intermediate measurement along an ordinate the line crosses and checking it with measure for that ordinate given on table of offsets.

The important thing to bear in mind when laying out shaft line is to have line at engine location sufficiently above top of keel to allow engine to be installed without having to cut away any construction material, and to have line at propeller wheel location sufficiently below water to insure that propeller will be properly immersed and clear hull.

As this vessel is to have twin screws, the shaft line passes through hull at some distance out from center line; this does not alter method of laying down shaft center line, but it makes it necessary to mark lines on both profile and half-breadth water-line views.

1q. Rabbet and Bearding Line

The rabbet indicates line where outside of planking butts against keel, stem, etc., and bearding line indicates

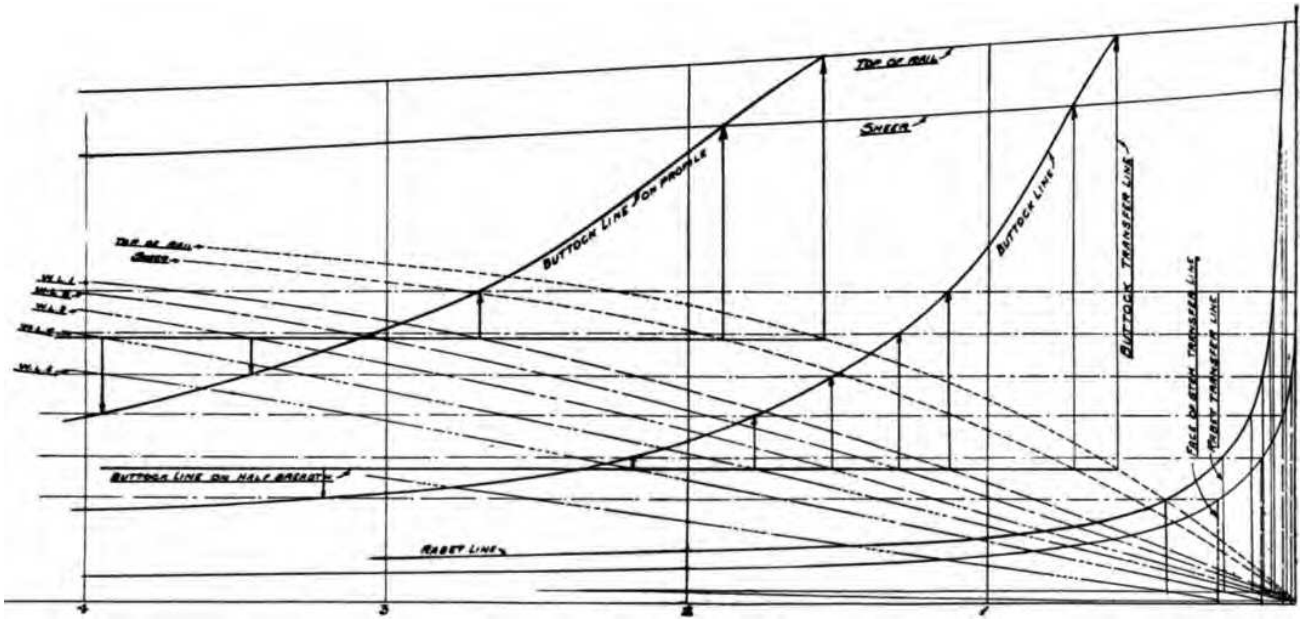


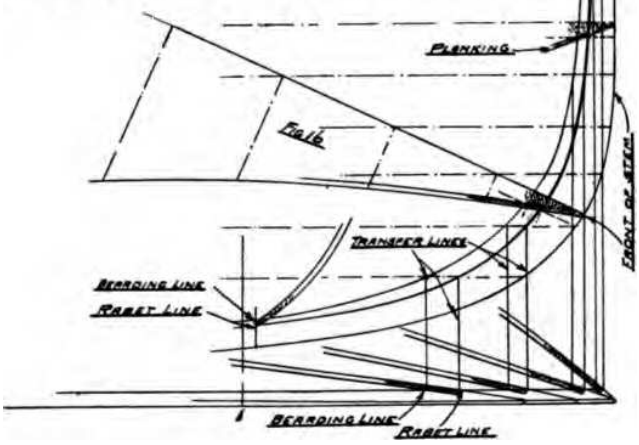
Fig. 14

where inside surface of planking touches wood of keel, stem, etc., therefore, the two lines ***must*** always be at least the thickness of planking apart at points where frames are "dead flat", and must, of course, move further apart as inclination of bottom of frames becomes more vertical. To find the measurement points for bearding line proceed in this manner:

11. Obtaining Measurement Points for Bearding Line

The mould loftsman has already marked on the cross-section plan outlines of section shapes to outside of plank and of shapes with thickness of planking taken off, and there is also marked on this view half-thickness of keel and stem lines (22) drawn parallel with center line (21).

As the bearding line is located where *inside* of planking touches wood of keel, to obtain points for bearding line along keel, all that is necessary is to measure up from base line on cross-section view to where each inside of plank cross-section shape outline (the heavy lines on Fig. 13) touches half-width of keel line and transfer these meas-



Figs. 15 and 16

ures to proper ordinate on profile view. A batten bent to cut these measurement points will, if rabbet line is fair, bend to a fair curve and indicate the exact shape and position of bearding line along keel. Measurement points taken from cross-section shapes will only enable bearding line to be drawn from No. 1 section aft to No. 12, therefore, it is necessary to obtain additional measurement points for marking bearding line along stem and stern. These points are obtained in the manner indicated by Fig. 15 illustration.

Fig. 15 is an illustration of stem and on it is shown rabbet and bearding lines and cross-section shape of stem at various points. There is also shown lines to indicate method of transferring points for obtaining shape of rabbet and bearding lines on profile view. The bearding line indicates where inside of plank touches wood of stem, keel, etc., therefore, if a line to indicate thickness of planking is drawn inside of and parallel with each water-line where it crosses the half-width of stem line, points for bearding line are obtained, and by measuring distance each point is away from rabbet line and transferring measurements to water-line planes on profile points for position of bearding line at each water plane can be obtained. The easiest method of transferring both rabbet and bearding line points to the profile view is by drawing verticals in the manner shown on Fig. 15.

On the Fig. 15 illustration some of the water planes have been omitted from the half-breadth water-line view. This has been done to avoid confusing you by having too many lines.

When points are marked on profile a batten can be bent to cut them and shape of bearding line from No. 1 section position to stem head marked. This mark should be drawn faintly at first, because it will no doubt have to be corrected along the portion where outline of stem is not at right angles to water plane.

If you look at Fig. 15, you will note that outline of stem near where three lowest water planes are drawn does not lie at right angles to the water planes. It therefore is necessary to prove the accuracy of bearding and rabbet lines at these points. This is done by drawing diagonal lines on profile at right angles to stem contour, measuring widths and marking outline shape of diagonal.

On Fig. 16 I show one of these diagonal lines and have marked at its forward end the thickness of plank line and cross-section of stem.

It will generally be found that at points where contour of stem stands at an angle that is much greater or less than a right angle (like at two water-lines on illustration) some correction to both rabbet and bearding lines will have to be made.

The cardinal principle of laying down lines of this kind is to first mark shapes by using measurements given on offset or transferred from other views and then correct as required.

You will note by referring to Figs. 1 and 2 that rabbet line runs in a fair sweep aft to stern-post and then, after the slight jog at stern-post is past, it again runs in a fair line aft to stern. The rabbet line can, therefore, be accurately marked when laying down the longitudinal and body plan lines, and bearding line can be marked from measurement points obtained from body plan after planking is taken off. As there is no shaft log, the after deadwood, outside of rabbet, is practically one thickness from rabbet to keel and stern-post. The fairing of stern is done by running in two or three additional short buttock lines (beginning about No. 10 ordinate position) and outlining one or two additional cross-sections between No. 12 ordinate and stern. By transferring measurements taken along these additional buttocks and cross-sections points for fairing stern can be obtained and the accuracy of stern outline proved.

It is necessary to mark rabbet and bearding line along fashion pieces of stern (the curved pieces of timber that form the stern). The way this is done is described below.

The sheer line (5) and top of rail line indicate location of upper and lower bounding lines of fashion pieces of stern, and the space between these lines indicates width of planking that continues around curved face of fashion piece. This being the case the thickness of plank around outside of fashion piece is "taken off" by drawing a line the exact thickness of plank inside line that indicates outside shape of fashion piece of stern. This line will touch bearding line of horntimber at its after termination point and will indicate bearding line around fashion piece. The outside of plank line around fashion piece is the rabbet line.

A sufficient number of lines have now been laid down and faired to permit the mould loftsman to lay out construction details.

1s. Laying Down Construction Details

Builders have learnt that the easiest and least costly method of getting shapes of the numerous pieces of material that compose a hull is to make wood templates, or patterns, of each piece and use them as guides for marking and shaping the pieces of material that will be used for constructing the hull.

Making templates is comparatively easy, and providing the lines have been properly faired and template maker does his work properly, the templates will enable the shipbuilders to accurately shape the pieces at far less cost of labor than if they worked directly from measurements taken from the lines marked on mould loft floor. It has been estimated that every cent expended for mould loft work saves *fifty* cents of labor.

Templates made by mould loftsmen are usually made of wood. For templates of a small craft, like this one, basswood is an excellent material because it is light in weight, tough, and not easily split by nails or tacks. For small templates that will be used as patterns material about ⅛ or 3/16-inch thick is correct. Moulds that will be used as guides when setting up steam-bent frames must be made of heavy material (from 1 to 2 inches thick) because they must have strength enough to withstand strains caused by ribs bearing against the longitudinal ribbands that are fastened to mould templates of this kind.

In this craft transverse framing below deck is composed of steam-bent ribs to which sawed floor timbers are attached, and therefore mould templates of heavy material must be made.

I will, before proceeding further, explain the two usual methods (steam-bent and sawed) of constructing transverse framing of small craft and ships.

1t. Steam-Bent Framing Described

The transverse framing of boats and small commercial or pleasure craft is usually steam-bent to shape. After keel, stem, stern, etc., are set up a certain number of temporary frames (called moulds), made of rough lumber and shaped exactly like body plan outlines laid out on mould loft floor, are set up at indicated points (the points 1 to 12 shown on Fig. 1 are points for erecting temporary moulds), and then a number of longitudinal ribbands are run outside these moulds and securely fastened to them, to stern and stem rabbet, and to deadwood. These ribbands are made of rather heavy material because they have to withstand the outward strain of frames until they are properly secured.

When these ribbands are fastened to the moulds their inside faces accurately follow the shape that outside of frame of vessel must be because the moulds to which they are fastened are sufficiently close to properly guide the ribbands, and the outside edge of moulds is exactly like the shapes laid down on mould loft floor. Of course the ribbands must run in fair, unbroken sweeps from bow to stern. Lower view on Fig. 2 shows moulds in position with sheer ribbands in place. In a craft of this size about fifteen ribbands will be run in the space between sheer and keel.

To frame a boat, or vessel with steam-bent ribs the builder softens each rib with steam, and while hot bends it to shape over a properly shaped form. When a rib is cold and set to its shape it is removed from the form, beveled, fitted in its place, and secured temporarily, by driving nails through the ribbands into rib. You can readily understand that when a rib touches all ribbands it crosses the builder knows that it is shaped correctly. Several ribs are located between each two moulds.

The limit of size of rib that can be bent without the use of special bending apparatus is about 3 by 4 inches sided and moulded dimensions.

The bottom ends of ribs of this kind are secured to keel, and each pair of ribs is tied together by riveting, or bolting, a sawed floor timber to them.

When a boat or vessel, is framed in this manner it is only necessary for the mould loftsman to lay out shape of boat at each mould position; to do more than this would be a waste of effort. The templates, or patterns, of floor timbers can readily be made, after ribbands are in place, by the builders marking location of each floor on keel and then cutting out thin templates to fit in each floor position.

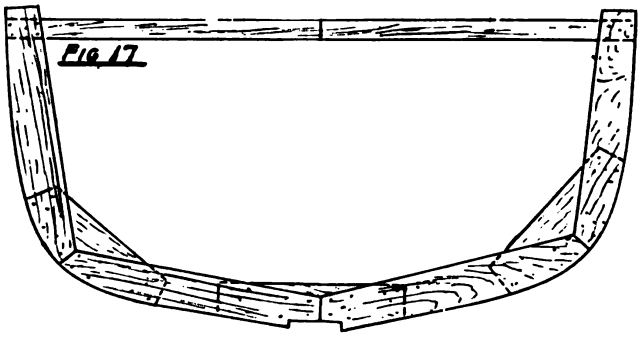
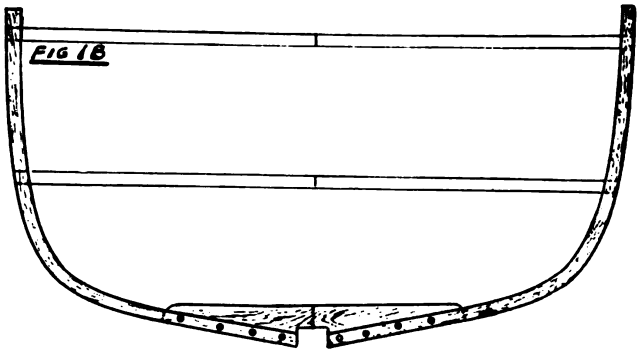


Fig. 17 shows a mould template put together and ready to fit in position, and Fig. 18 shows a pair of steam-bent ribs fastened together with a floor timber.



1u. Sawed to Shape Framing of Vessels

The transverse framing of vessels having frames made of material that is too heavy to steam bend is sawed to shape, each frame being composed of several pieces of material fastened together with bolts or rivets.

As frames of this kind have to be cut out of straight grained material the curvature of frame must be considered and the several pieces that compose a frame must be cut and secured in such a manner that short grain, which cannot be entirely avoided at ends of each piece, will not weaken the frame when it is assembled. To achieve this end it is usual to make each frame double (of two sets of pieces fastened side by side) and place the short grain portion of one piece alongside the long grain of an adjacent one. Thus when the several pieces are fastened together the frame is of equal strength from end to end.