A PRACTICAL COURSE IN WOODEN BOAT AND SHIP BUILDING

VAN GAASBEEK

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A PRACTICAL COURSE

in WOODEN BOAT *and*

SHIP BUILDING

The Fundamental Principles and Practical Methods Described in Detail

Especially Written for Carpenters and Other Woodworkers Who Desire to Engage in Boat or Ship Building, and as a Text-book for Schools

By

RICHARD M. VAN GAASBEEK

Head of Department of Woodworking, School of Science and Technology, Pratt Institute, Brooklyn, N. Y.

FULLY ILLUSTRATED

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PREFACE

To meet a popular demand for a text-book to assist the great army of house carpenters and other woodworkers in transferring from their usual occupations to the wooden boat and ship building industries, now rapidly developing in this country, and especially for those men who wish to qualify for advanced positions, and for boat and ship builders who wish to broaden their experience in order that they may prepare for greater responsibilities, this work is offered.

The text is the outgrowth and development of a pioneer course organized early in the war by Pratt Institute, Brooklyn, N. Y., in response to the demand caused by shortage of skilled labor in these industries.

It was a study to know how to organize the work effectively, to select only those problems that otherwise might take years of labor in the industry for these men to solve, and to present the problems progressively and in such a way that the men would grasp the basic principles in the shortest possible time.

It has been the aim of the author to establish a fundamental course,—one that would help the ship builder as well as the boat builder; for whatever the size or type of the vessel, the general principles of construction remain very much the same in all cases.

Those who master this course can direct the labor of others, because they themselves will have learned by doing, and it is only by manipulative skill that a practical understanding of the subject can be acquired.

It was out of the question to build a full-size ship. The space and equipment necessary to handle heavy timbers, the cost of the lumber itself, and the extra labor that would be required of the men after a hard day's work, were all factors to be considered in determining the kind of instruction that would best meet the emergency situation.

We have built a full-size boat, using full-size timbers, and under exact factory conditions, and with the scarfing and adzing of heavy yellow-pine timbers and practice calking, both light and heavy, a course has developed, which, judging from the reports from the men as to their advancement and success in the industry after completing the course, has been most gratifying.

The author has not attempted to give a complete treatise on the subject and therefore offers no apology for any omissions that may be found. The first part of the work (Chapters I to IV) is strictly technical in character, giving the operations in sequence as they were performed on the job and explaining them in such a way that the average mechanic can understand. In the second part (Chapters V to VIII) an effort is made to show typical ship construction views, giving the reader an idea of the methods of handling and fastening heavy timbers.

The author wishes to express his appreciation of the generous assistance given by Messrs. Chas. Rassiga, Jr., Edward J. Weber and Harvey R. Saylor, his co-workers, and to leading wooden ship builders and manufacturers, without whose aid this work would have been impossible.

Particularly the author wishes to acknowledge his indebtedness to Mr. W. G. Hudson, District Supervisor, Wood Hull Construction, Second District, Emergency Fleet Corporation; Mr. Theodore E. Ferris; The Foundation Company, agents of the United States Shipping Board, Emergency Fleet Corporation; Messrs. Tams, Lemoine and Crane; Stetson Machine Works; Messrs. J. A. Fay & Egan Company and Messrs. C. R. Durkee & Co. for permission to use the drawings and photographs used in illustrating the second part of the work.

THE AUTHOR.

Pratt Institute,
Brooklyn, N. Y.
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CHAPTER I

THE MOULD LOFT

The principal drawing of a vessel is the sheer drawing. It is composed of three parts, mutually dependent upon each other, as follows:

Sheer Plan.—Figure 1.—A side view showing length of vessel and heights of sheer or gunwale.

Half-breadth Plan.—Figure 2.—A top view, showing a horizontal or floor plan on any water lines.

Body Plan.—Figure 3.—An end view, showing curves of the frame lines outside the timber at any point in the vessel. Frame lines forward of the midship section are on the right of the center line; aft of the midship section on the left of the center line.

TABLE OF OFFSETS

The table of offsets exhibits the distances from a center or base line. These offsets are compiled by the naval architect and are used by the mould loftsman in laying down the lines on the floor. Just how these offsets are compiled is only of pass-

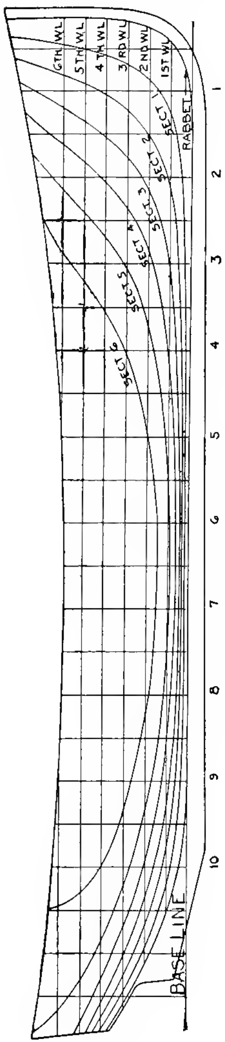


Figure 1.—Sheer Plan—Moulded Lines.

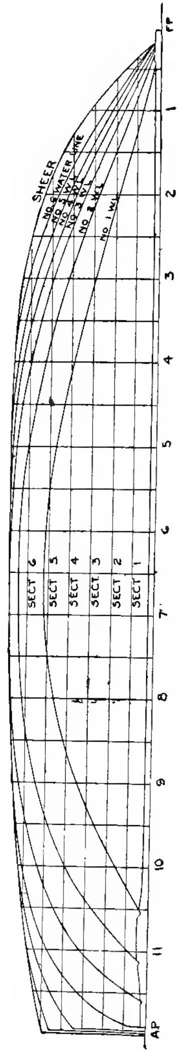


Figure 2.—Half-breadth Plan—Moulded Lines.

ing interest to the reader, as it is the purpose of this work to help the mechanic to apply them.

Model for Taking Off Offsets.—The most practical way of taking off the offsets is to make a model of wood, an invention of an American mechanic. The model must be made to an exact

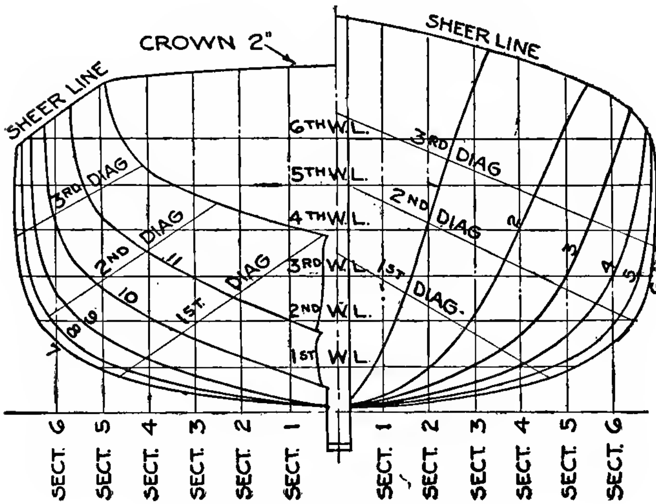


Figure 3.—Body Plan—Moulded Lines.

scale, usually ¼″ to 1′, and it is generally composed of two kinds of soft wood of different colors, such as pine and cedar, in alternate layers screwed or pinned together. The seams between the layers represent the water lines.

The model usually represents the starboard half of the vessel and has a plane side, representing the longitudinal midship plane, on which the sheer plan is drawn. Its curved side is then gradually carved, shaved, and filed to such a form as to satisfy the eye and the judgment of the designer.

It is very important, in making the model, to fair up perfectly every portion, so that one portion of it assimilates with the other. If the model is made to a small scale, the discrepancies can be more readily detected, because the whole of the model can be seen at a glance and the inequalities of one end as compared with the other will be discovered. The model must be perfectly fair, not only on all lines, but in every direction.

Station lines, rabbet line and bearding line, and all water lines are laid off to the same scale on the model. The layers can then be separated and from these the table of offsets is scaled. The accuracy with which the model is scaled will save the time of the mould loftsman in laying down his lines.

MOULD LOFT WORK

Laying Off of the Lines.—The laying off of the lines on the mould loft floor can be compared with the foreman's layout in carpenter work. (See Figure 4.) It is the name given to the process of drawing the lines of a vessel to full size in plan and elevation, in order to determine the exact dimensions of the most important and fundamental parts of the structure. The necessity for drawing to full size arises from the extreme accuracy with which the dimensions of the various parts must correspond with one another in order that when assembled there may be no irregularity or unfairness in the surface of the vessel.

If the mould loft is not long enough for laying down the vessel full length, it can be laid down in

Figure 4.—Fairing-in a Line on Mould Loft Floor.

sections, one overlapping the other, providing the sections are long enough to properly fair up the lines. If the vessel is very large, this is an important operation, for while looking at one part of the line, it may be impossible to see the other side of the same line. Figure 4 shows a section of the

TABLE OF OFFSETS

Water Lines Spaced 3 Inches	Stations Spaced 12 Center Line to Center Line				
Section Lines Spaced 3 Inches	Stem	1	2	3	4
Height of Gunwale Above Base..	2–2–0	1–11–6+	1–9–5	1–7–7+	1–6–5
Height of Rabbet Above Base...	....	0– 0–3	....	....	....
Half-Breadth of Gunwale........	....	0–10–0	1–4–2	1–7–2	1–8–2
Half-Breadth of Water Line No. 1	....	0–2–1+	0– 5–4+	0–8–7	0–11–6+
Half-Breadth of Water Line No. 2	....	0–3–5+	0– 8–4	1–0–6	1– 4–0
Half-Breadth of Water Line No. 3	....	0–4–7	0–10–3	1–2–7	1– 5–7+
Half-Breadth of Water Line No. 4	....	0–5–7	0–11–6	1–4–2+	1– 7–1
Half-Breadth of Water Line No. 5	....	0–6–5	1– 1–1	1–5–4	1– 7–6
Half-Breadth of Water Line No. 6	....	0–7–5	1– 2–3	1–6–4+	1– 8–1+
Height of Sec. No. 1 Above Base	....	0–4–4	0–1–3+	0–0–7+	0–0–6
Height of Sec. No. 2 Above Base	....	0–1–3	0–3–3	0–1–6	0–1–2+
Height of Sec. No. 3 Above Base	....	1–9–4	0–6–5	0–3–1	0–2–0
Height of Sec. No. 4 Above Base	....	....	0–1–3	0–5–1	0–3–0+
Height of Sec. No. 5 Above Base	....	....	1–7–0+	0–9–1	0–5–0
Height of Sec. No. 6 Above Base	....	....	....	1–4–2	0–9–1
	Base Line	W. L. 1	W. L. 2	W. L. 3	W. L. 4
Rabbet from F. P..............	1– 5–6	0–5–5	0–3–0	0–2–2	0–1–7
Rabbet from A. P..............	2–10–4	1–5–0+	0–9–7+	0–4–4	....
Fore Edge of Stem From F. P...	0– 5–7	0–2–3	0–1–0+	0–0–4	0–0–1+

mould loft floor at Pratt Institute, Brooklyn, N. Y. The men are fairing-in a line, as can be seen; that is, making its curve true and regular. A mechanical eye will save a great deal of labor, for much depends upon the fairing-in of the lines, as considerable injury may be done to a good design by deviating from the drawings.

THE SHEER PLAN

To lay off the sheer plan, Figure 1, first produce the base line and run the water lines in parallel

TABLE OF OFFSETS

Stations Spaced 12 Center Line to Center Line

5	6	7	8	9	10	11	Transom
1-5-7	1-5-4+	1-5-4	1-5-6	1-6-1+	1-7-0+	1-8-1+	1- 9-6
....	....	....	....	....	0-1-1+	0-5-0	0-11-5
1-8-4+	1-8-5	1-8-4+	1-8-1+	1-7-4+	1-6-5	1-5-0+	1- 2-6
1-2-1+	1-3-4	1-3-4	1-1-7	0-10-2+	0- 4-5	....	....
1-6-1+	1-7-2	1-7-2+	1-6-3+	1- 4-3	0-11-6+	0-2-5	....
1-7-5+	1-8-3	1-8-2+	1-7-7	1- 6-5+	1- 3-6	0-9-3	....
1-8-2	1-8-4	1-8-4	1-8-1	1- 7-3+	1- 6-0+	1-2-1	0- 1-7+
1-8-4	1-8-5	1-8-4	1-8-1+	1- 7-4+	1- 6-4+	1-4-2	0-10-1+
....	....	....	....	1- 7-4+	1- 6-5	1-4-7+	1- 1-6+
0-0-5+	0-0-5	0-0-5+	0-0-6	0-0-7+	0-2-3	0- 6-1	1-0-2+
0-1-1	0-1-0	0-1-0+	0-1-1	0-1-6	0-3-4	0- 7-3	1-1-2+
0-1-5	0-1-3	0-1-3+	0-1-6	0-2-4+	0-4-5	0- 8-6	1-2-3
0-2-2	0-1-7	0-1-7+	0-2-3	0-3-5	0-6-1	1-10-4	1-4-0+
0-3-2+	0-2-6	0-2-6+	0-3-4	0-5-0	0-8-0	1- 0-7	....
0-5-6	0-4-3	0-4-4	0-5-4	0-7-7+	1-0-0	....	....

W. L. 5	W. L. 6	Sheer
0-1-6	0-1-6	0-1-6
....	....	....
0-0-1	0-0-1	0-0-1

to the base line. Then strike in the station lines at right angles to the base line and equidistant apart.

The method of laying down one or two lines will suffice to give the reader enough information to enable him to complete the layout. We will assume that the vessel has been outlined and will therefore lay off the sheer line and section 5.

To lay out the sheer line refer to top line of the table of offsets. This gives the heights of gunwale or sheer above the base line. Point off these distances on the various stations from the base line. The first figure represents feet, the second inches, and the third eighths, as follows:

At the stem, 2′ 2″; on station 1, 1′ 11 6/8″; station 2, 1′ 9⅝″; station 3, 1′ 7⅞″; station 4, 1′ 6⅝″; station 5, 1′ 5⅞″; station 6, 1′ 5 4/8″; station 7, 1′ 5 4/8″; station 8, 1′ 5 6/8″; station 9, 1′ 6⅛″; station 10, 1′ 7″; station 11, 1′ 8⅛″, and at the transom, 1′ 9 6/8″.

Drive a small nail in at these points and bend a thin batten so as to approximate as closely to these points as is consistent with absolute fairness and continuity. If the batten does not spring well to these points, it is best to pass the batten inside some and outside others in order to prevent great deviation from the design in either direction.

Likewise refer to section 5 on the sheer plan and height of section 5 above base in the table of offsets. Point off on each station line as shown, namely, station 2, 1′ 7″; station 3, 0′ 9⅛″; station 4, 0′ 5″; station 5, 0′ 3 2/8″; station 6, 0′ 2 6/8″; station 7, 0′ 2 6/8″; station 8, 0′ 3 4/8″; station 9, 0′ 5″; station 10, 0′ 8″, and station 11, 1′ 0⅞″. Drive a small nail in at these points and bend a thin batten through them as described in the preceding paragraph.

HALF-BREADTH PLAN

To lay off the half-breadth plan, Figure 2, strike a line representing the center line and mark in the stations of the frames as shown. Set up from the center line on the various stations the half-breadths of the water lines and sheer lines, taking the distance from the table of offsets.

The method of laying down the half-breadths of water line No. 2 will show the reader enough to enable him to complete the layout. Refer to the table of offsets, half-breadth of water line No. 2.

Point off these distances on the various stations from the center line, namely, on frame 1, 3⅝″; frame 2, 8 4/8″; frame 3, 1′ 0 6/8″; frame 4, 1′ 4″; frame 5, 1′ 6⅛″; frame 6, 1′ 7 2/8″; frame 7, 1′ 7 2/8″; frame 8, 1′ 6⅜″; frame 9, 1′ 4⅜″; frame 10, 0′ 11 6/8″; frame 11, 0′ 2⅝″. Drive small nails at these points, and bend a thin batten through them, passing it inside some and outside others as need be in order to properly fair up the lines, as explained in a previous paragraph.

BODY PLAN

To lay off the body plan, Figure 3, first produce the base line and then the center line. Lay off the water lines parallel to the base line and the station lines parallel to the center line. Scale off from these lines on the drawing the various frame lines and transfer these locations to the mould loft floor, taking all measurements from the corresponding line. Drive in small nails at these points and bend a thin batten, fairing up the line as may be required before striking in the line.

CHAPTER II

STEM AND STERN CONSTRUCTION

The stem is made up of four members, namely, Stem, Lower Stem, Apron, and Deadwood. The stern is made up of six members, Stern Post, Stern Post Knee, Shaft Log, Deadwood, Horn Timber and Transom.

Stem.—The stem (Figure 5) is the foremost boundary of the boat, being a continuation of the keel to the height of the vessel, at the fore extremity.

Lower Stem.—The lower stem is a curved piece placed in the angle formed by the apron and the upper end of the deadwood.

Apron.—The apron is the upper member of the stem on the inboard side of the boat. It is intended to strengthen the stem and afford wood for the reception of the outside planking and the heels of the foremost timber.

Deadwood.—The deadwood is the lower member of the stem on the inboard side of the boat. The deadwood becomes the foundation against which the heels of the forward frames are abutted.

Stern Post.—The stern post (Figure 6) forms the after boundary of the frame of the boat, being the after continuation of the keel to the height of

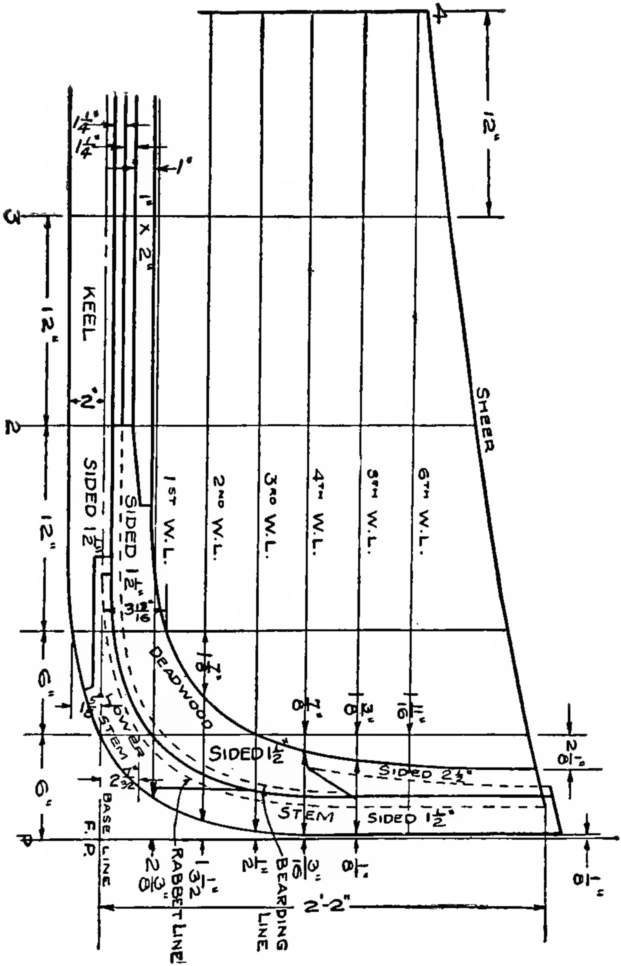


Figure 5.—Detail of Stem

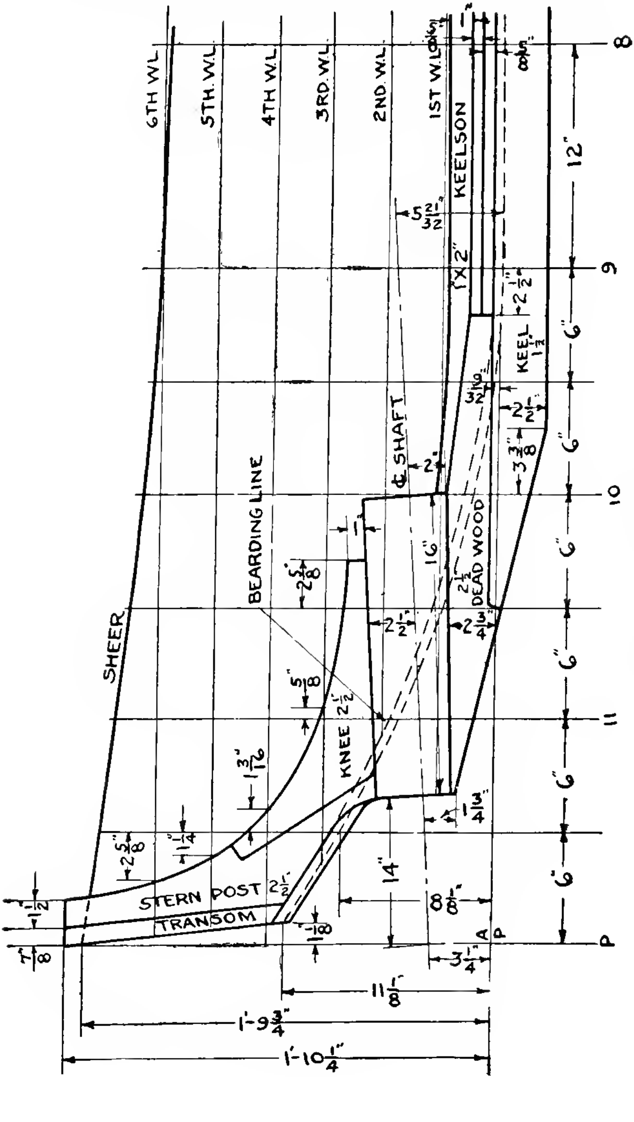


Figure 6.—Detail of Stern.

the deck, and forms a receptacle for the after ends of the outside planking.

Stern Post Knee.—The stern post knee is placed in the angle formed by the keel and stern post.

Shaft Log.—The shaft log is the member of the stern through which the propeller shaft enters.

Deadwood.—The deadwood is the lowest member of the stern, run up to the height of the floor timbers, and on it the after ends of the keelson rest.

Horn Timber.—The horn timber protects the end of the stern post and covers up the end wood.

Transom.—The transom is the last main frame of the boat and is placed square with the stern post.

These members of the stem and stern are united to each other and to the fore and after ends of the keel by scarfs, bolted together.

STEM AND STERN MOULDS

It is necessary to make a separate mould, or pattern, for each member of the stem, Figure 7, and the stern, Figure 8, on which all construction lines are transferred from the mould loft floor. These moulds are needed in locating bearding and rabbet lines and locating various points such as water lines, etc., used in setting up the timbers and fairing the structure. Accuracy in making the moulds is very necessary, in order to insure the economical appropriation of timber and to facilitate the execution of the workmanship.

Picking Up the Lines.—A simple method of

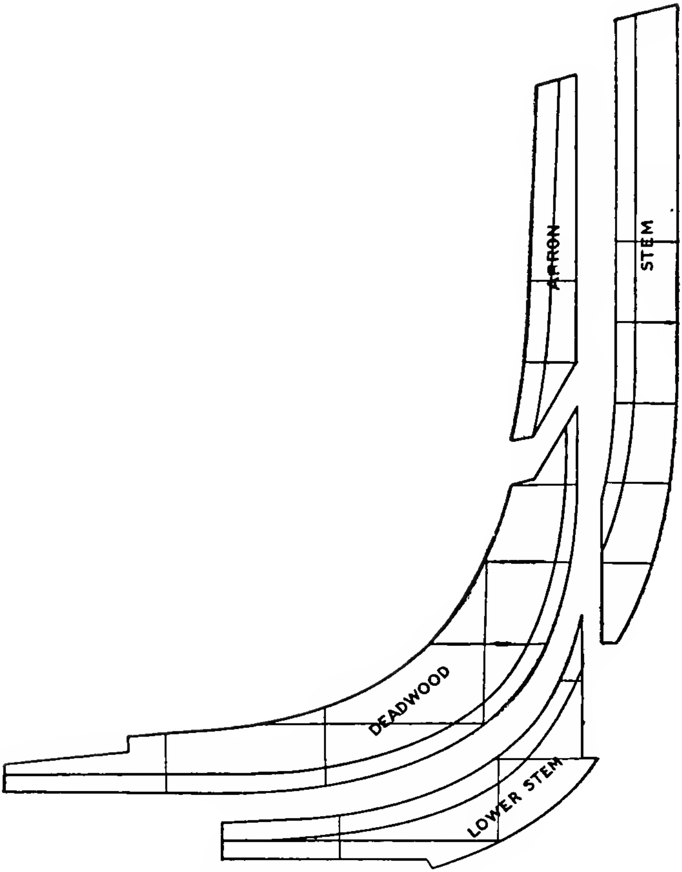


Figure 7.—Moulds for Stem.

picking up the lines is shown in Figures 9 and 10. On the floor is shown the full size layout of the stem and stern construction shown in Figures 5 and 6.

Place a series of tacks with the heads resting

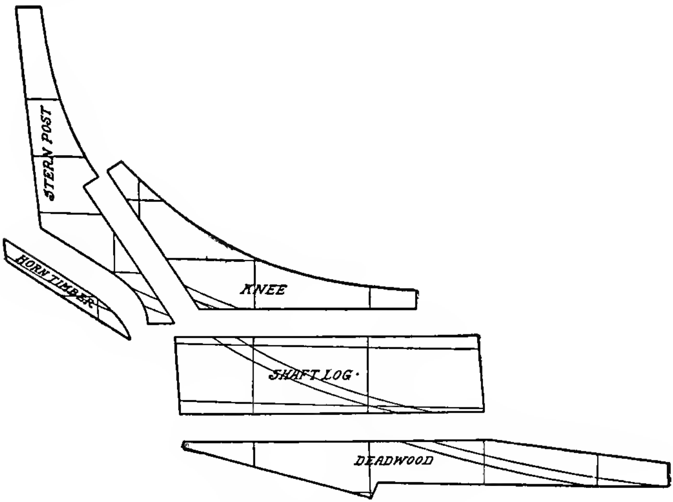


Figure 8.—Moulds for Stern.

on the required line, Figure 9. The heads of the tacks should be driven into the floor slightly, to prevent them from moving out of place.

Place a piece of stock wide enough to cover the member, with the grain of the wood running in the direction that will show the least amount of end wood (to prevent splitting when cut to shape). Give the mould several light taps with the hammer in the direction of the curve. The heads of the

Figure 9.—Picking Up Lines from Mould Loft Floor.

tacks will leave a mark into which a small brad can be driven and around which a batten can be bent. See Figure 10.

Saw the moulds on the band saw, leaving the lines full, and fair up by hand as shown in Figure 11, making a perfect fit of each piece.

Transfer the water lines and all construction lines from the floor to the mould, when the moulds will be ready for use.

The moulds are generally made of one-half inch pine. The stock for the stem, as shown in the detail, calls for 1½″ stock for all members except the apron, which is 2½″ material, and all members of the stern 2½″ stock, excepting the horn timber, which is 1½″ thick.

Cutting Out the Stock.—Apply the moulds to the stock to be used in the construction of the boat, and cut out the stock on the band saw, leaving the lines full for fairing up. If the moulds have been accurately shaped and fitted, the stock to be used can be lined up to these moulds and fitted without much trouble. They can now be riveted or bolted together.

RABBETING

It is usual and proper to cut the rabbet, or recess in the stem and stern to receive the ends of the planking, before raising them. The *bearding line,* or line formed by the curved surface of the vessel's planking with the stem, keel, and stern post, and the rabbet, or outside line of the planking, are

Figure 10.—Bending Battens and Lining-In.

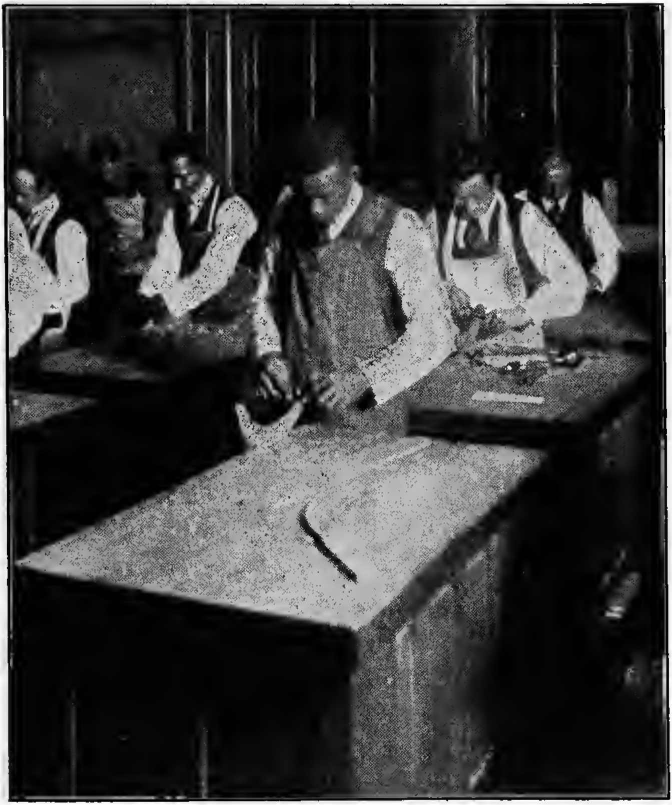


Figure 11.—Fairing Up Moulds.

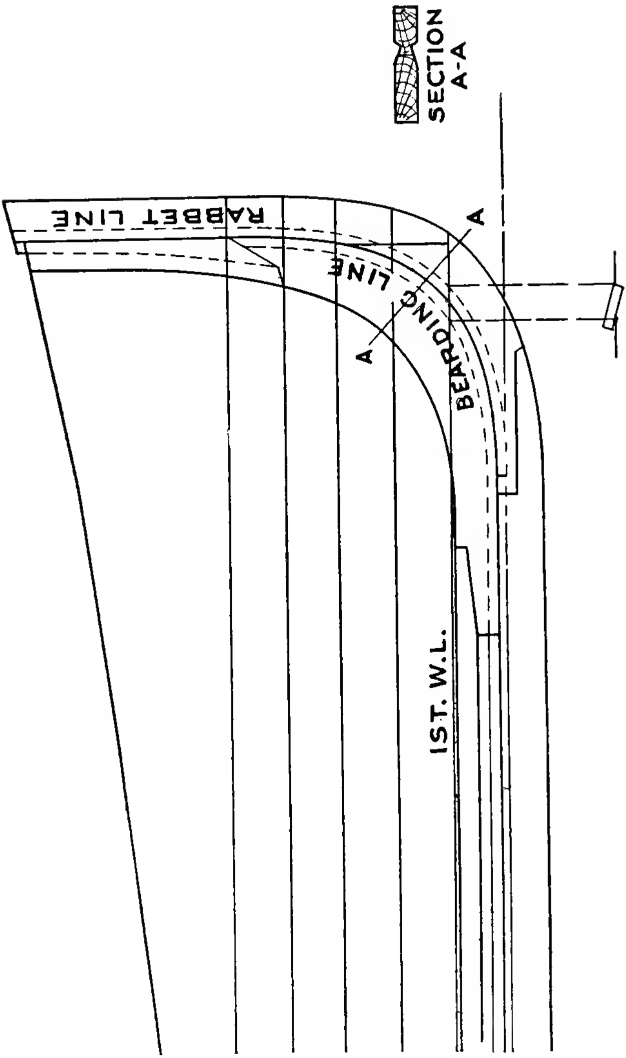


Figure 12.—Section Through Stem Showing the Development of Rabbet.

transferred from the moulds to the stem and stern, and the rabbet is cut in with a chisel.

A section through the stem is shown in Figure 12 and a full-size detail of the rabbet is shown in Figure 13, the line *A-B*, Figure 13, representing the bearding line, and the line *C-D* the rabbet line. *E-F* is the width of the rabbet on the first water line, as shown on the projection, Figure 12, and is

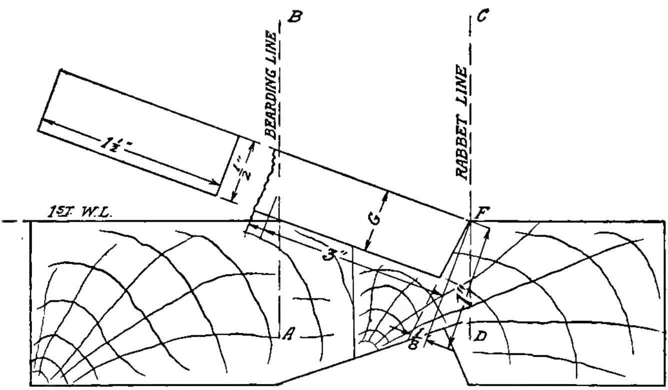


Figure 13.—Detail of Rabbet. (Section Through *A-A*, Figure 12.)

formed by the intersection of the bearding, rabbet, and first water lines.

Make a template or mould the thickness of the planking, as shown at *G*, about 1½″ wide and 3″ long, depending upon the size of the rabbet to be cut. Bevel one end as shown, about ⅛″ in 1″. Begin chiseling at the rabbet line to the bevel of the mould, and cut from the bearding line until the mould rests in the rabbet, Figure 14. The

Figure 14.—Erecting Stem and Stern and Cutting Rabbets.

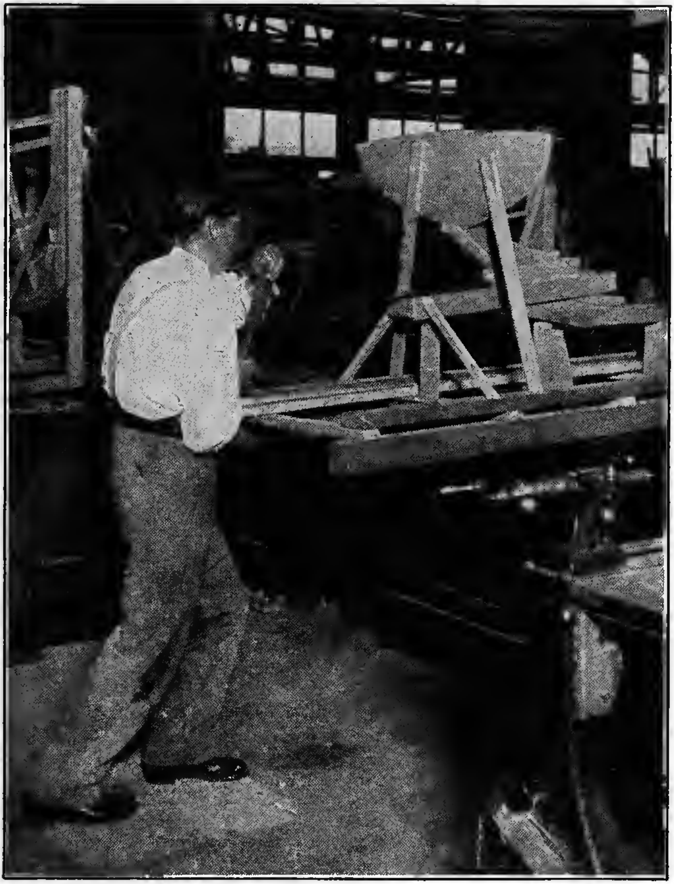


Figure 15.—Boring Through Shaft Log for Propeller Shaft.

mould being the same thickness as the planking, the outside edge must intersect at *F*, or on the rabbet line.

Stopwaters.—The stopwaters, or round pieces of wood or dowels, are driven in at all seams running inboard, to render the vessel watertight.

KEEL

The keel, forming as it does the lower boundary of the longitudinal section, is spoken of as the backbone of the vessel. The pieces are obtained in as long lengths as possible, varying in size according to the size of the vessel.

The several pieces forming the keel are joined together by lock scarfs and also scarfed to the stem and stern, bolted and riveted together. A chalk line is run from the center of the stem and stern for the purpose of lining them up with the center of the keel.

The rabbet extends along the keel to receive the edge of the first strake of planking, or garboard strake. Station lines are marked upon the top of the keel, giving the location of the various frames. See Figure 14.

Shaft Log.—As soon as the stem and stern are plumbed and united to the keel, the opening for the propeller shaft should be bored through the shaft log, Figure 15. The line of the shaft is laid out from the mould. The bit is held in position as shown in the illustration to insure the proper direction.

CHAPTER III

FUTTOCKS AND FRAMES

The futtocks, commonly called the *ribs* of the vessel, are the curved or crooked timbers giving the shape, to which the planking is fastened. Two futtocks united, right and left hand, constitute a *frame*.

FUTTOCK MOULDS

A mould should be made of each futtock of a different shape. Futtock moulds forward are shown in Figure 16. Futtock moulds aft are shown in Figure 17.

The method of picking up the lines from the mould loft floor is similar to the one described for picking up the lines of the stem and stern construction.

Another method is shown in Figure 18, using a flexible steel template. This template can be bent to any shape and is held in position by winged nut screws on the outside. Adjusting the template to the required shape on the mould loft floor, and fastening the screws, the template can be taken up and used in lining the stock to be cut.

The shape of the futtocks is taken from the body

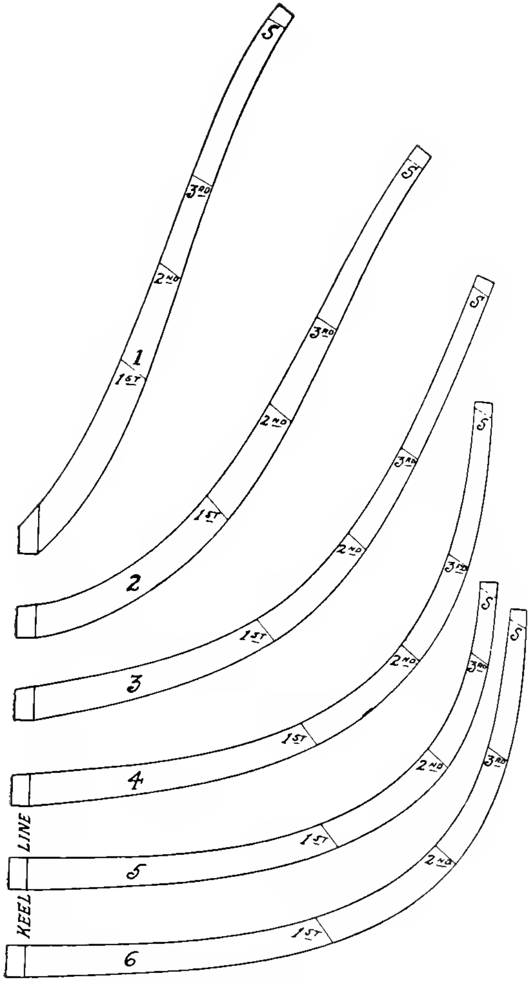


Figure 16.—Futtock Moulds Forward.

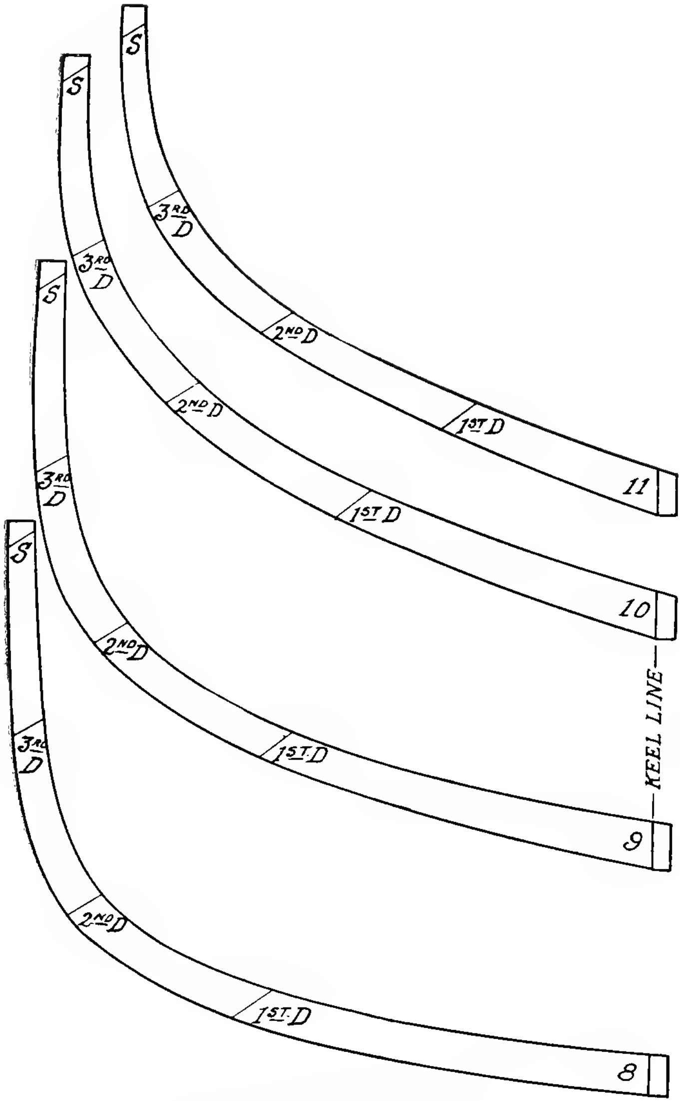


Figure 17.—Futtock Moulds Aft.

plan, Figure 3. These lines give the outside lines of the frames. The width of the frames will depend largely upon the size and the demands to be made upon the vessel.

Figure 18.—Picking Up Lines from Mould Loft Floor with a Flexible Steel Template.

Cut the moulds full of the line to allow for fairing up, finishing the mould by hand. Each mould is numbered so it can readily be placed in its proper location.

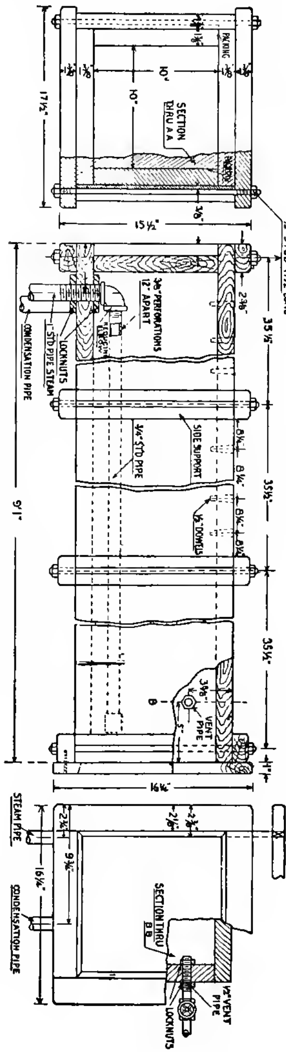


Figure 19.—Details of Steam Box.

The sheer, diagonal, and keel lines are transferred from the floor to the moulds. These lines will be needed in lining up and setting the frames, and for locating the beveling spots and running the ribbands.

Surmarks.—The marks on the moulds showing

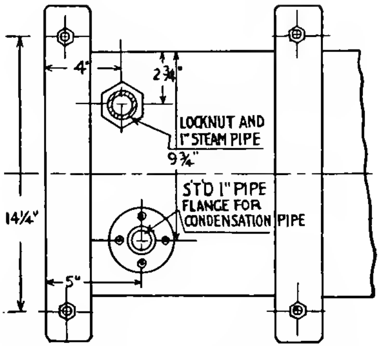


Figure 20.—Pipe Details of Steam Box.

the intermediate bevel stations, or where the diagonal lines cross the futtocks, are called *surmarks*.

STEAM BOX

The futtocks, ends of ribbands, and planking will need to be steamed in order to bend them to the required shape. The size of the steam box required is dependent upon the size of the timbers and planking to be bent.

Details of a steam box are shown in Figures 19, 20, 21 and 22. The dimensions can be varied, either enlarged or made smaller, to meet a special need.

The box is made of cypress with butted joints and calked seams. Cleats continue around all four sides, bolted together.

The steam enters at one end and runs through a perforated pipe the entire length of the box, which distributes the steam and gives an even temperature throughout. At the front end a small

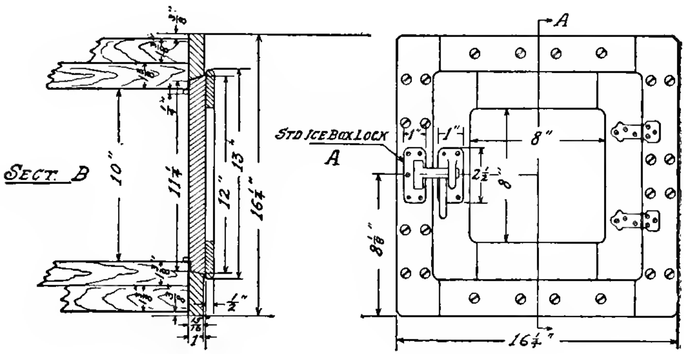


Figure 21.—Detail of Door of Steam Box.

vent pipe takes off the surplus steam and leads it out doors. At the far end there is an outlet for the condensation, leading to a water seal trap, shown in Figure 22. The water lying in the trap prevents the steam from escaping. The condensation can be drained into a pail or connected with the sewer if desired.

If the steam box is located out of doors, the condensation will take care of itself, as it can run off into the earth and the steam can escape and pass off in the atmosphere. If the steam box is located indoors, some provision of this kind should be

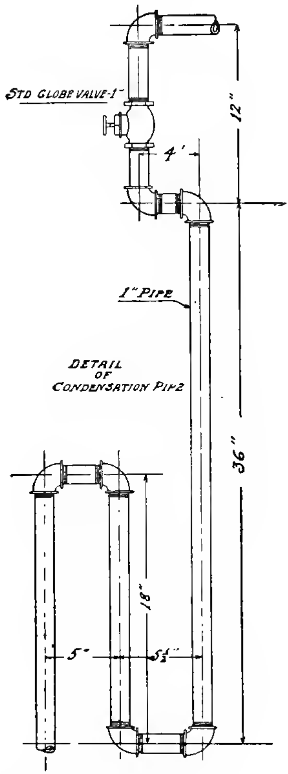


Figure 22.—Condensation Pipe and Water Seal Trap of Steam Box.

made for taking care of the condensation and surplus steam.

Packing is placed in the rabbet of the door to make it tight, the door locking with an ice-box fastener.

STEAM BENDING

Special bending stock should be used. Green or unseasoned lumber bends more readily and is not so liable to split while being bent as seasoned stock is. It would be better to put the stock into a water bath for several hours or overnight before steaming it.

The stock should be thick enough to make two futtocks, and when removed from the form should be resawed, making right and left hand futtocks, which, when fastened together, make a complete frame. The futtocks being thicker at the heel, some material can be saved and the stock will bend easier if the timbers are tapered.

Experience is the best teacher as to the length of time required to steam a piece of stock ready for bending. The greener or wetter the stock, the shorter the time required. If the stock is left in the box too long, the life is taken out of the timber and it becomes very brittle and breaks; while, on the other hand, if not left in the steam box long enough, the timber will also break.

STEAM BENDING FORM

A bending form is shown in Figure 23. The shape of the form should be made from the inside line of the moulds, and an extra allowance made for shaping and fitting, as well as for some spring in the timber when removed from the form. In other words, the form should be made to a quicker sweep than the moulds.

When the stock is ready to be bent, one piece is removed at a time from the steam box and a thin sheet of strap iron is nailed on the back of the timber, to give support to it while being bent and to insure a fairer bend.

As soon as this strap iron is fastened, one end is inserted under the bar, as shown in the illustration, and held in position by a wedge. One man bends the timber around the form and another man pulls it into place with a clamp.

The timber will retain the heat for some time, so there is nothing to be gained in forcing it to the breaking point.

As the timber is bent around the form, clamps are applied at intervals to give added support to the stock while bending. The end of the timber is held in place by a hook, which catches over an iron pipe extending the full width of the form. This can be seen in the lower right-hand corner of the form (Figure 23).

The timbers should set a day before being removed from the form, when they can be resawed and planed to the required thickness. Line up the timbers from the moulds and number each one for ready identification.

DIAGONAL LINES

The diagonal lines are drawn in on the body plan, Figure 3, standing as nearly square as possible to the frame lines. They are considered the most effectual toward fairing the body of the vessel, or making each portion of the vessel assimilate with the others. The diagonals are distinguished

Figure 23.—Bending Timbers.

as "1st, 2nd, 3rd, etc., diagonals," and give the stations or surmarks of the ribbands, which are placed around the timbers to give support to the vessel while in frame.

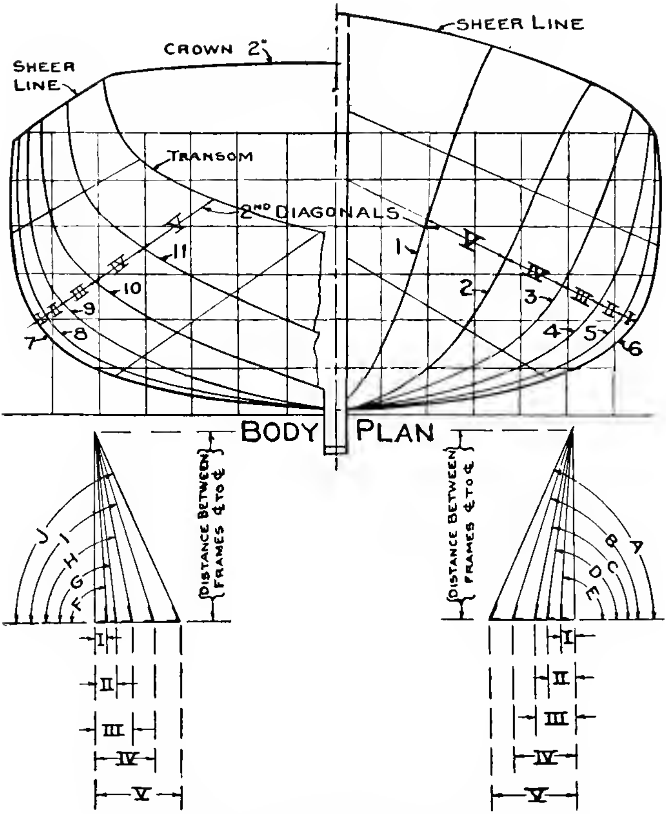


Figure 24.—Method of Developing Bevels on Diagonals.

BEVELING FRAMES

The edges of the frames must be beveled, so that when the planking is bent around them they will fit tight at all points. These bevels are developed on the diagonal lines, as shown in Figure 24.

Draw two lines at right angles to each other. Point off a distance on the vertical line equal to the distance between frames, center to center. On the horizontal line point off from the intersection of these two lines the distance between frames 7 and 8 on the second diagonal, then the distance between frames 8 and 9, the distance between frames 9 and 10, the distance between frames 10 and 11 and the distance between frame 11 and the transom.

All measurements are to be taken on the second diagonal between frames, and all measured off from the intersection of the vertical and horizontal lines. Connect these points with the point on the vertical line, as shown in the illustration. Then bevel *F* is the bevel for frame 8, bevel *G* is the bevel for frame 9, bevel *H* is the bevel for frame 10, bevel *I* is the bevel for frame 11, and bevel *J* is the bevel for the transom. All bevels are developed on the second diagonal.

Likewise with the forward frames. Draw two lines at right angles to each other, as shown to the left in Figure 24. On the vertical line measure off a distance equal to the distance between frames, center to center. On the horizontal line point off from the intersection of these two lines the distance

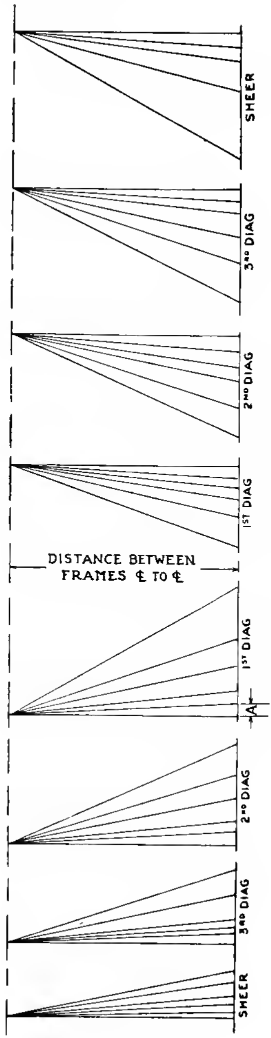


Figure 25.—Bevels on Each Diagonal.

between frames 5 and 6 on the second diagonal; then the distance between frames 4 and 5, the distance between frames 3 and 4, the distance between frames 2 and 3, and the distance between frames 1 and 2.

All measurements are to be taken on the second diagonal between frames and all measured off from the intersection of the vertical and horizontal lines. Connect these points with the point on the vertical, as shown in the illustration. Then bevel *A* is the bevel for frame 1, bevel *B* is the bevel for frame 2, bevel *C* is the bevel for frame 3, bevel *D* is the bevel for frame 4, and bevel *E* is the bevel for frame 5. Frames 6 and 7 are amidship and are square.

Bevels are developed on each diagonal as shown in Figure 25. Therefore, in this particular boat, each frame has four bevels, namely, sheer, 1st, 2nd and 3rd diagonals, one fairing into the other.

BEVELING BOARD

The mould loftsman makes a beveling board, as shown in Figure 26, giving the various bevels. These bevels are taken from the developments, Figure 25. This saves time, referring to the mould loft, when laying out the frames, as it gives all the bevels needed for the entire vessel.

In many yards, and especially in ship work, the bevels are spoken of as *degrees,* and are so listed on the beveling board. This is for the information of the mechanic operating the band saw, as he tilts his saw one way or another to a desired angle,

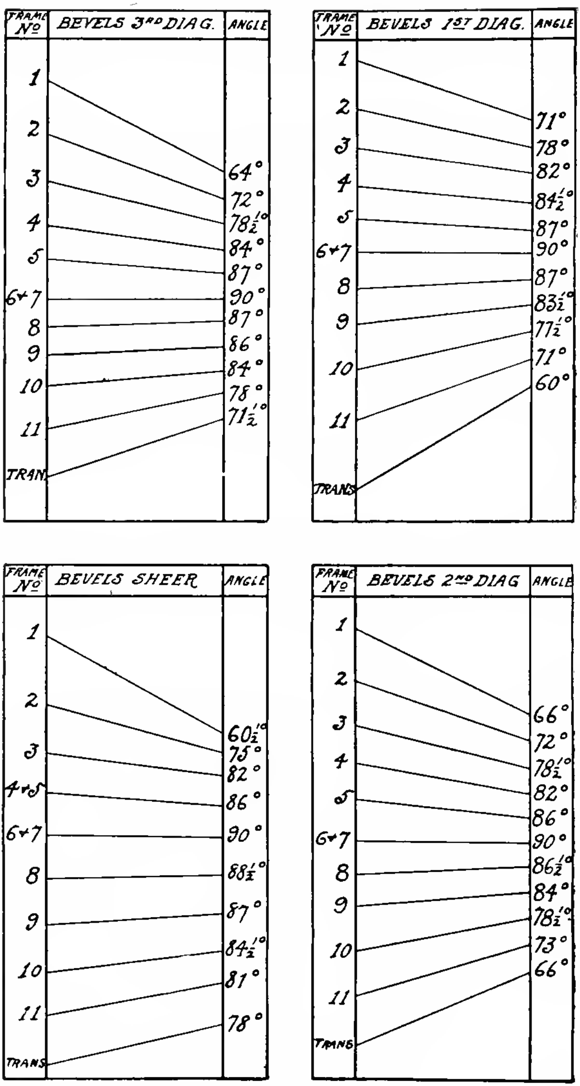


Figure 26.—Beveling Board.

which is registered on the gauge of the machine, telling the operator the angle at which the machine is cutting. These degrees are marked on the frames at the given stations. The timbers are run through the band saw, changing the angle gradually as the stock nears each bevel. See Figure 27.

FRAME CONSTRUCTION

Several types of frame construction are shown in the illustrations. In Figure 28, false frames are first installed, ribbands are run, and the vessel faired up, after which the futtocks are bent and fitted to the ribbands.

Figure 29 shows a manufactured frame; that is, the futtocks are bent and then lined from the moulds and united with the floor timbers. The frames are then raised and plumbed, after which the ribbands are run and the vessel faired up.

Figure 30 shows a built-up frame; that is, a frame made of a number of pieces and double thickness of straight stock fastened together. The stock is roughed out, fitted and fastened together, and then lined from the moulds.

Figure 31 shows a strap frame boat. This is lighter construction. False frames are first installed, ribbands run, and the boat faired up. The frames are bent around a form, the ends tied together as shown in Figure 32, immediately removed from the form and sprung in position in the boat, while hot, and fastened to the ribbands.

Cross Spalls.—Cross spalls are long pieces of

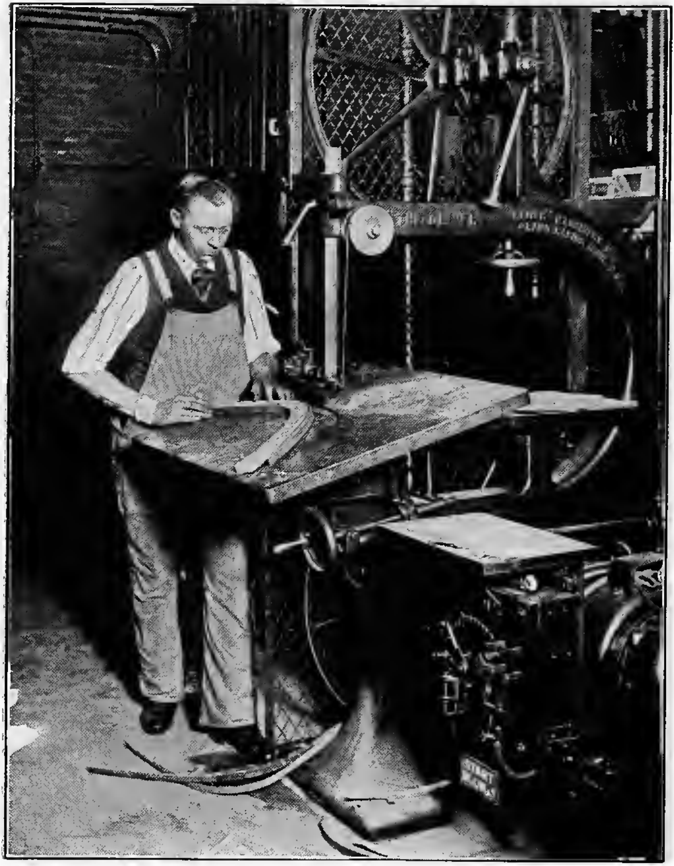


Figure 27.—Sawing Timbers.

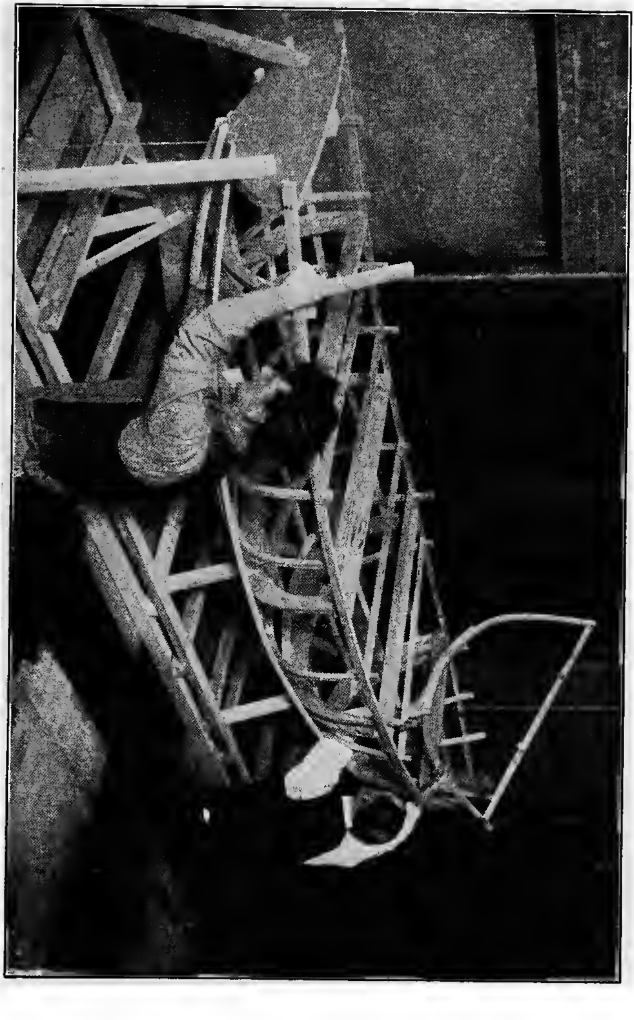


Figure 28.—Fitting Futtocks to Ribbands and Installing Frames.

plank which have the breadth of the boat at particular stations marked on them, and unite the heads of the futtocks to the required width. These preserve the form of the boat while it remains in frame and until the beams are crossed. Note Figures 28 and 30.

Floor Timbers.—The heels of the futtocks are united with a floor timber as shown in Figure 28. The bottom edge is beveled to correspond to the beveling on the futtocks, the top edge remaining square. The two futtocks thus united form a *frame.*

RAISING FRAMES

The frames should be erected at right angles to the keel and perpendicular at their respective stations. A ribband is run at the first diagonal on both sides of the boat; square each frame from the keel and fasten to the ribband, then plumb every other frame, shoring them at the first diagonal ribband.

Install the sheer ribband and space off the timber heads to the same spacing as they are at the heels, after which all the ribbands may be run on.

Ribbands.—The ribbands are thin broad battens screwed fast to the frames at given stations on the square body, usually on the diagonal lines. See Figure 29.

Harpings.—The harpings are the continuations of the ribbands beyond the square frames. The ribbands and harpings are sometimes scarfed to

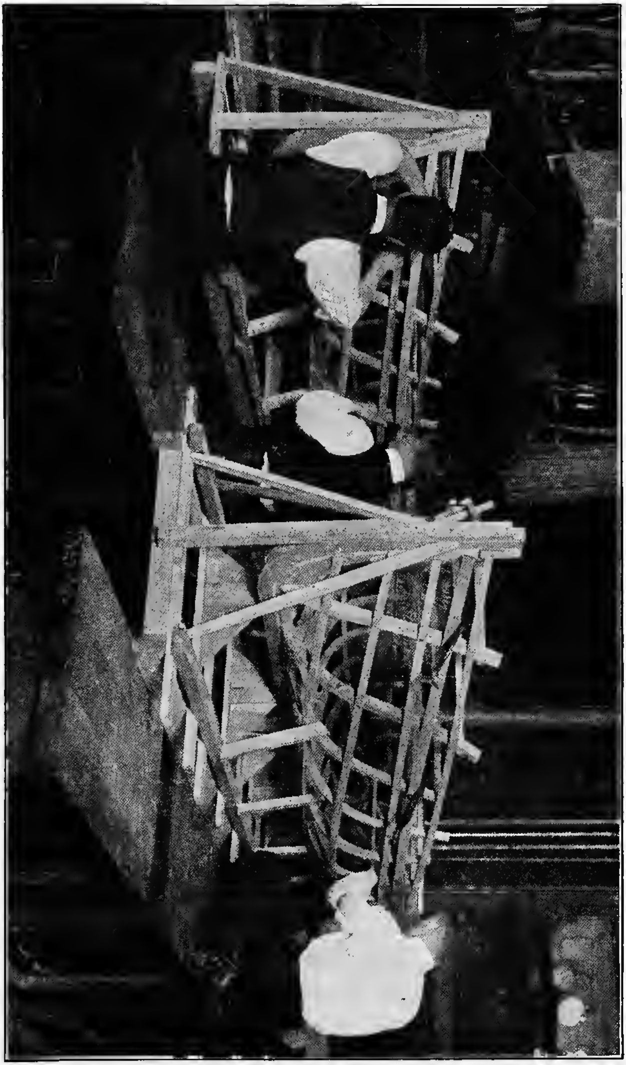


Figure 29.—Manufactured Frame Construction—Running Ribbands.

Figure 30.—Built-up Frame Construction.

each other, but the connection is more usually kept up by one length of the ribband made to overrun the other.

FAIRING UP

A great deal depends upon the mechanical eye of the builder in *fairing up,* as a good design can easily be ruined at this stage of the construction. The lines of the boat should be regular, true, smooth, and flowing.

After the planking is installed, it will be impossible to cure any defects, and the graceful lines intended by the naval architect will be lost sight of. If the laying out and the workmanship have been careful up to this point, little difficulty should be experienced in fairing up.

PROJECTION OF DIAGONALS

Figure 33 shows the method of projecting the diagonals on the sheer plan and body plan. While these lines are not essential in fairing up, still they will help to show the position of the ribbands as they are bent around the frames.

Filling-in Pieces.—The filling-in pieces, usually 2″ wider than the top of the keel, are placed in the spaces between the frames, level with the floor timbers. They are fastened to the keel and form a rabbet to receive the garboard strake.

KEELSON

The keelson may be considered as an internal keel. It unites in one mass the keel, deadwood,

Figure 31.—Strap Frame Construction.

Figure 32.—Bending Frames for Strap Frame Boat.

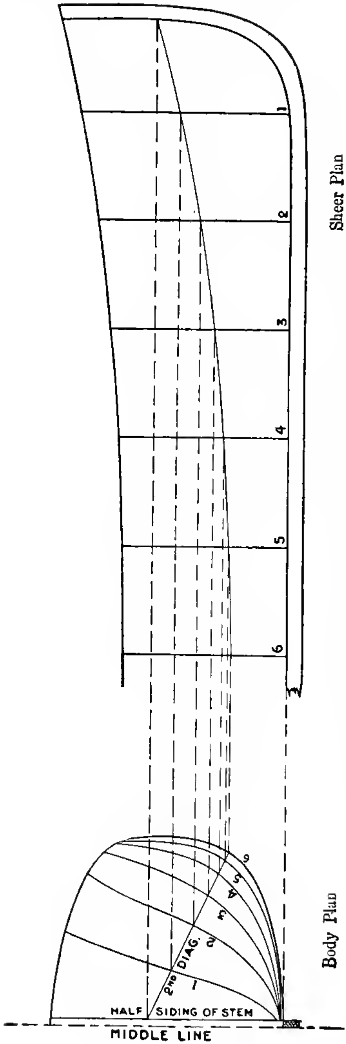


Figure 33.—Projection of Diagonals on Sheer Plan and Body Plan.

and floors, so that a compact union may be formed throughout the system. It is placed immediately above the keel, lying upon the upper part of the floors as far as they extend, and resting fore and aft against the deadwood. If the timber will permit, it should be put in in one length. If two pieces are scarfed together, care should be taken to have the scarfs properly shifted and clear of the keel scarfs.

CHAPTER IV

OUTSIDE PLANKING

The outside planking, or skin, or sheathing, of a vessel terminates abaft below the transom, in the rabbet of the sternpost, and forward in the rabbet of the stem. The strakes are not parallel, but of such a breadth as may be required by the form of the place where they are situated and the circumference of the body at any given distances upon them; narrowing at some places and widening at others, according as the body requires the form of the edges to hang or "sny."

Strakes.—The principal strakes, or breadths of planking, are: *Binding, bilge, broad, garboard, sheer* or *upper, shutter,* and *lower* strakes.

The *binding strake* is the first strake to be installed, unless the horns of the frames are long enough to raise the sheer batten high enough to permit the installing of the sheer strake.

If the vessel is large enough, a strake can be worked near each ribband; and when on and fastened, the ribbands can be removed and several gangs of workmen can be employed advantageously in getting out and working the remainder of the plank required to fill up the openings.

Before commencing to plank a vessel, it is necessary to determine the number of strakes required and their widths at midship, as well as fore and aft. If the vessel is too long for the strakes to be obtained in one length, it will be necessary to run them in, in two or more lengths butted together. The position of these butts must be determined before laying out the first plank. They should be shifted, and in no case should they be less than four strakes apart.

To find the widths of strakes, bend a thin flat batten inside of the ribbands on the midship frame and obtain the girth or distance from the keel to the sheer line. Likewise fore and aft. Lay out on this batten the number of strakes required. The width of these strakes will depend upon the material available and the shape of the vessel. This is a matter of judgment, as there is no given rule for determining the width. The *garboard* plank should be the widest.

From the garboard to where the bilge turns, the strakes gradually diminish in width, so that the bilge and topsides are the narrowest and nearly uniform in width. The sheer strake is generally a little wider than the topsides, to allow for fastening the *moulding*, or *guard*.

SHEER STRAKE

The sheer batten gives the top edge of the sheer strake. The plank as it diminishes fore and aft must bring out the uniform longitudinal plank lines.

Assuming that the sheer strake is to be 4″ on the midship frame, 3¼″ at frame 1, and 2⅞″ at frame 11, the plank can be scaled as shown in Figure 34.

Scribe a circle with a radius equal to the width of the plank on the midship frame, and strike a center line as shown. Measure up, at right angles to the center line, a distance equal to the width of the plank at frame 1, until it cuts the circle as at *A*.

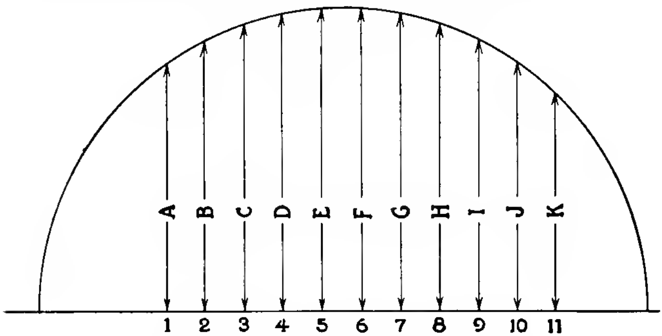


Figure 34.—Scaling for Sheer Strake.

Likewise measure up, at right angles to the center line, a distance equal to the width of the plank at frame 11 until it cuts the circle as at *K*.

Divide the distance between these two lines on the center line equally into as many spaces as there are frames, and lay off parallel lines as shown. Then the distance *A* is the width of the plank at frame 1, *B* width at frame 2, *C* width at frame 3, *D* width at frame 4, *E* width at frame 5, *F* width at frame 6, *G* width at frame 7, *H* width at frame 8, *I* width at frame 9, *J* width at frame 10, and *K* the width of planking at frame 11. These points will give a fair diminish for the lower edge of the sheer strake, and should be laid off on each frame from the sheer line, as shown in Figure 35.

BINDING STRAKE

The next problem is to cut the plank so that when bent around the frames it will fit without springing or bending it edgewise. In order to get the shape of the top edge of the binding strake, it will be necessary to take a spiling of the lower edge of the sheer strake. If material will permit, the binding strake is generally installed in one length.

SPILING

The spiling batten is a thin piece of stock 5″ or more in width and longer than the longest length of plank to be used. Secure the batten on to the frames with clamps, screws, or nails, temporarily, with its upper edge a little below the marks giving the lower edge of the sheer strake.

It is important that the batten follow the twist of the frames and lie flat against them, taking care not to spring it edgewise. See Figure 36. It is well to remember that the object is to have the batten occupy approximately the same position as the strake for which the spiling is taken.

Mark on the batten the center of the frames and take the spiling at these points, numbering each to correspond with the frame numbers, for ready identification. Spiling can be taken at any point, but reference marks must correspond on the spil-

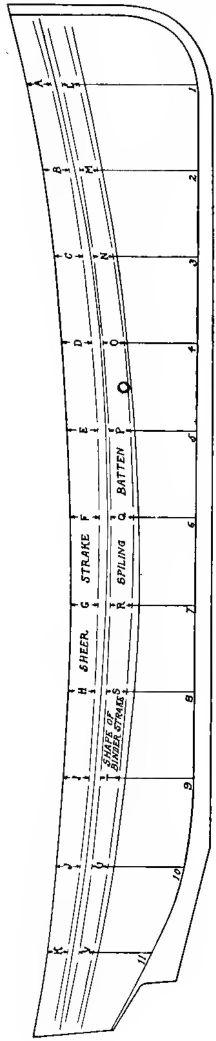


Figure 35.—Scaling and Spiling for Sheer and Binding Strakes.

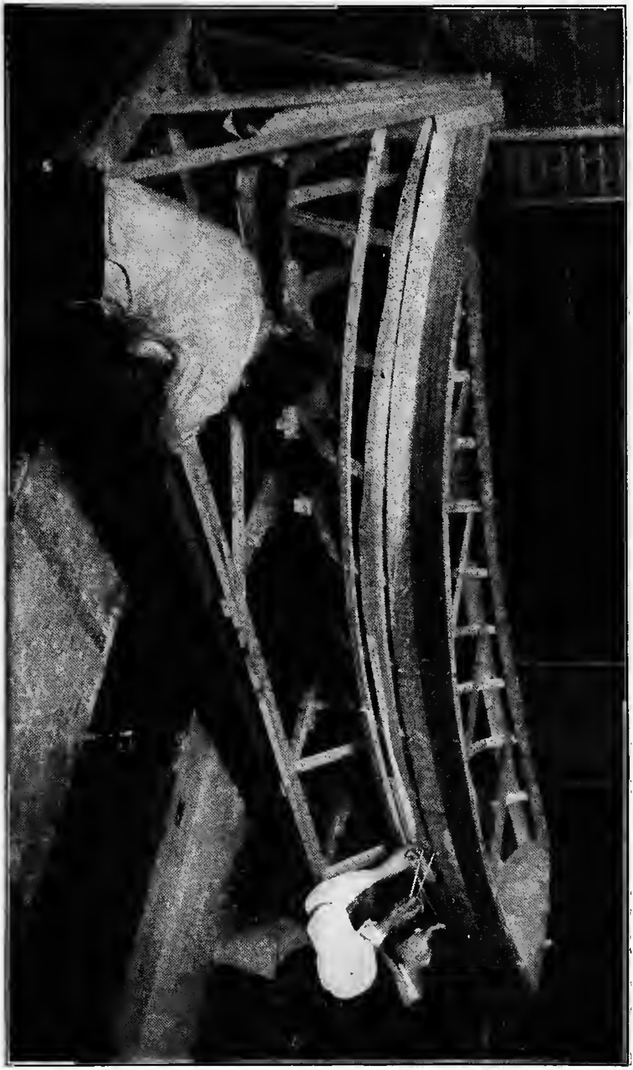


Figure 36.—Spiling for First Lower Strake.

ing batten and the point from which the spiling was taken; otherwise it will be impossible to find the locations again, after removing the batten.

Set a pair of dividers to an opening a little greater than the widest gap between the spiling batten and the marks on the frames giving the lower edge of the sheer strake. With one leg of

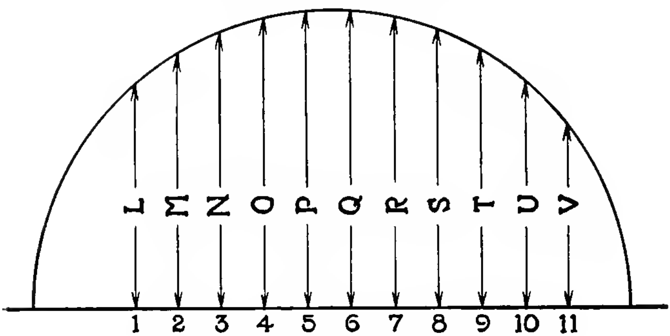


Figure 37.—Scaling for Binding Strake.

the dividers on this line, point off equal distances on the spiling batten, as shown in Figure 35. This gives the points for the upper edge of the binding strake.

Lay the spiling batten on the stock to be cut for the plank, mark the spiling spots, and transfer these points from the spiling batten to the plank to be cut.

This strake will be narrower than the sheer strake and it will be necessary to scale again for the lower edge, to get a fair diminish fore and aft.

Scribe another circle, as shown in Figure 37, with a radius equal to the desired width of the plank on the midship frame, and strike a center line. Measure up, at right angles from the center line, a distance equal to the width of the plank at frame 1, until it cuts the circle as at *L*. Likewise measure up, at right angles to the center line, a distance equal to the width of the plank at frame 11, until it cuts the circle as at *V*.

Divide equally the distance between these two lines on the center line into as many spaces as there are frames, and lay off parallel lines as shown. Then the distance *L* is the width of the plank at frame 1, *M* width at frame 2, *N* width at frame 3, *O* width at frame 4, *P* width at frame 5, *Q* width at frame 6, *R* width at frame 7, *S* width at frame 8, *T* width at frame 9, *U* width at frame 10, *V* width at frame 11.

Lay off these distances from the spiling spots on the plank to be cut, as shown in Figure 35. Bend a batten through these points, which will give a fair diminish and the shape of the binding strake.

After the plank is sawed and fitted, a mate can be lined out for the other side of the boat before it is fastened.

GARBOARD STRAKE

After determining the width of the garboard strake at midship and fore and aft, run a ribband on the frames for the top edge of the garboard, which should look fair from all directions. It is important to have a proper diminish fore and aft, to avoid trouble in installing the *shutter* strake.

Bend a thin spiling batten around the frames to approximate the position of the garboard, and take a spiling for the lower edge, as previously described. Where the rabbet rounds up into the stem and stern, the spilings should be closer together and square out from the rabbet. Transfer these points from the spiling batten to the stock to be used for the plank, and bend a thin batten through these points. Measure up from the rabbet to the ribband or top edge of the garboard at each frame. Transfer these distances from corresponding positions on the plank, and bend a batten through these points, which give the shape of the garboard.

LOWER STRAKES

After the binding strake and garboard are installed, take the girth of the midship frame between these two planks and divide the distance into the number of planks desired to side in the remainder of the boat. Likewise take the girth on frame 1 and frame 11 and divide these distances by the number of planks in order to find the width of each plank fore and aft. A spiling must be taken for the top edge of each plank and the lower edge must be scaled to get a fair diminish fore and aft, bringing out as it does the parallel longitudinal lines of the boat.

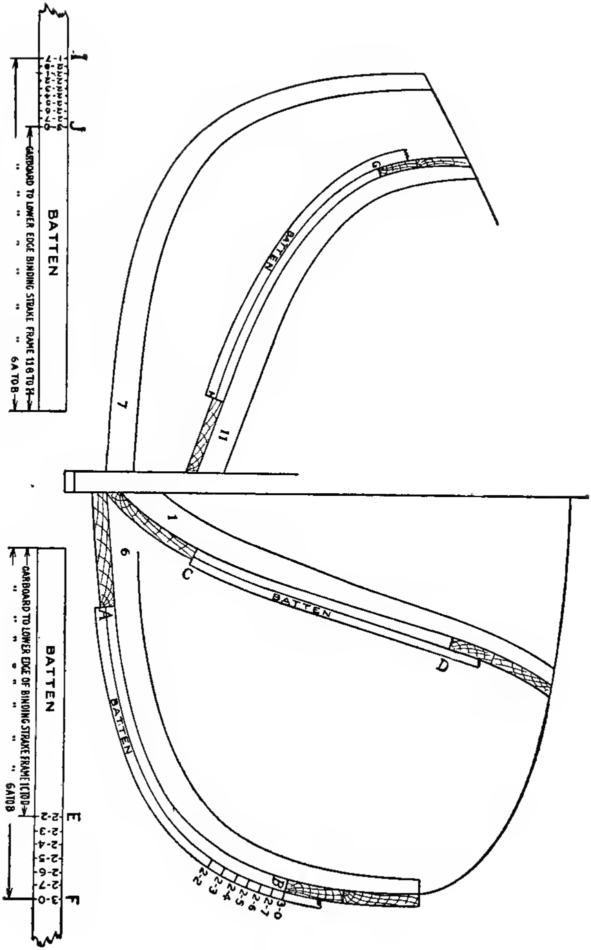


Figure 38.—Scaling for Lower Strakes.

SCALING

Bend a thin batten around the midship frame to get the girth or distance between the garboard and binding strake as shown in Figure 38, *A-B*. Likewise take the girth between the same points on frame 1, *C-D*. Square these two points across the batten, *E-F*, and divide the space up into as many equal parts as there are eighths contained in the difference between the width of the plank at midship and the desired width at the stem.

Assume that the width of the plank is to be 3″ amidship and 2-2, or 2 2/8″, at the stem. The difference between 3″ and 2 2/8″ is 6 eighths; therefore, divide the difference in the girth of the midship frame, or frame 6, and the girth, or frame 1, into 6 equal parts, as shown in Figure 38, *E-F*. Mark the distance of the girth of the midship frame on the batten 3″, the distance of the girth of frame 1, 2-2. Each division is then numbered 2-3, 2-4, 2-5, 2-6, 2-7.

It will readily be seen that wherever this scale is applied with the lower edge of the batten always resting against the upper edge of the garboard, it immediately gives the width of the plank at that particular point. The width at each spiling station should be scaled and marked on the strake for ready reference. This gives a fair diminish for the plank on the forward end only.

The after end is then scaled in a similar manner, as shown in Figure 38. Take the width of the plank at midship, as previously described, as 3″, and assume that the width of the plank at frame 11 is to be 1-7 or 1-7/8″. The difference between 3″ and 1-7/8″ is 9 eighths. Divide the difference in the girth of the midship frame and the girth of frame 11 into 9 equal parts, as shown at *I-J*. Call the girth of the midship frame 3″ and the girth of frame 11 1-7/8″, and succeeding distances 2-0, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7, 3-0. This immediately gives the width of the plank at that particular point. Scale each spiling station as before and mark on the strake for ready reference.

With the width thus determined, it is of course unnecessary to run ribbands on the frames, unless it appears that the strakes are not running fair, but a spiling must be taken for the upper edge of each plank. If the frames are curved, it may be necessary to hollow the inside of the planking to fit.

BEVELING FOR PLANKING

The planking should be beveled square from the diagonals. At the bottom edges of the seams the planks should be in contact throughout their length. After the planks are fitted, the outer edge should be beveled about 1/16″ in 1″, beveling from about the center of the plank. If the openings of the seams were of equal width throughout their depth between the planks, it would be impossible to make the calking sufficiently compact to resist the water.

CALKING

Before beginning to calk, all seams should be jacked off and all high spots removed. Begin calk-

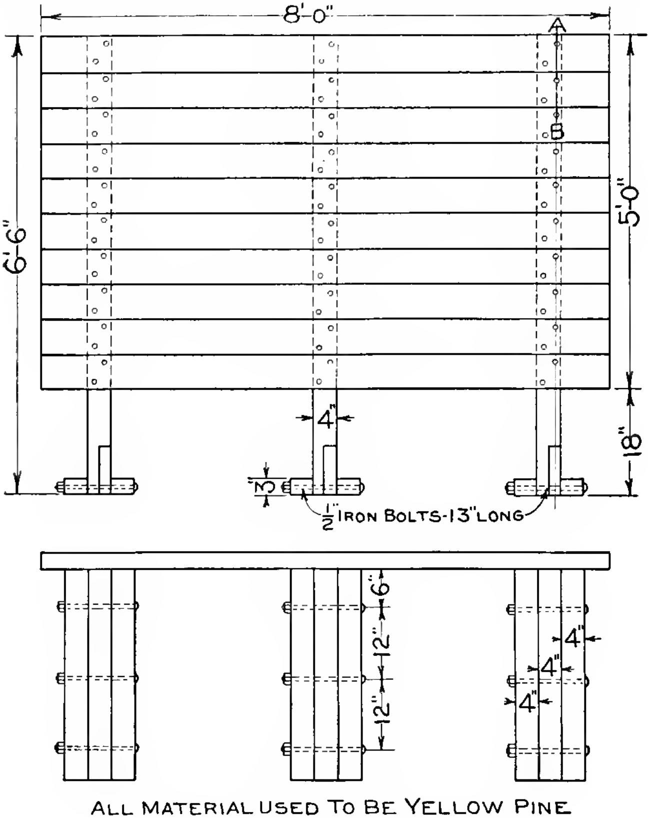


Figure 39.—Form for Practice Calking.

ing at one end and tuck a strand of cotton or oakum into the seam, then with a dumb iron gather the cotton or oakum into a small loop and drive it in; then another loop, and so on along the seam, varying the size of the loop to make just the right body of cotton or oakum to properly fill the seam.

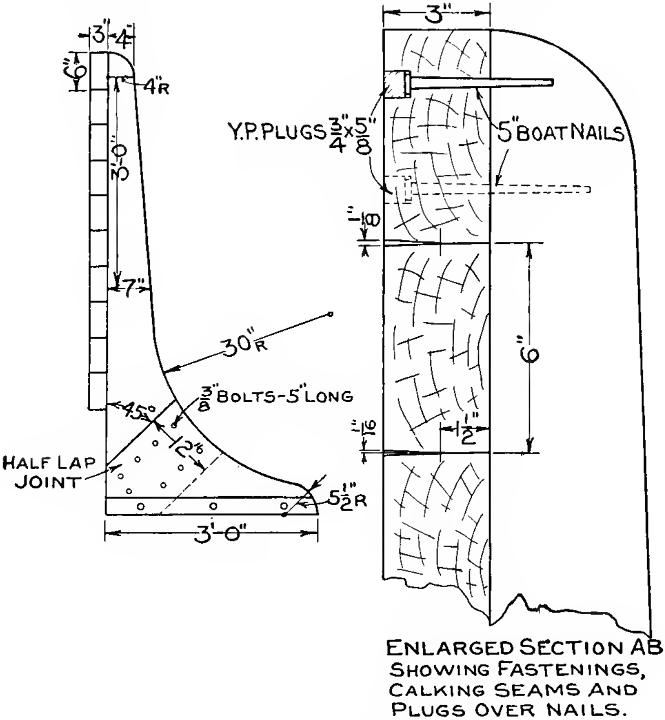


Figure 40.—Details of Form for Practice Calking.

Go over the seam again, using a calking iron, and drive the cotton or oakum home, so that room is left for the reception of the putty.

The tendency of the amateur is to drive the oakum into the planking instead of into the seam. This is very injurious and leads to leakage and to the rotting of the planks themselves.

Figure 41.—Practice Calking

A suitable calking form for practice calking is shown in Figures 39-40. In Figure 41 two men are seen calking. Experience is the best teacher, and so it is worth while to begin practicing on a form of this kind. This form can be made collapsible, and the calking readily removed for recalking.

FINISHING

After calking, the seams are painted with a moderately thick paint, working it in well, so that it covers the calking material and serves as a binder for the putty. A special narrow brush, called a *seam brush,* is made for the purpose.

After the paint is dry, the planking should again be planed, using a smoothing plane, with the iron set very fine. It should then be sandpapered, first across the grain and then with the grain. All unfair places will be very conspicuous after painting, so it is very important that particular care be used at this time.

The seams are then filled with putty, flush with the outside, and again sandpapered, ready for the painter.

CHAPTER V

SHIP CONSTRUCTION

MATERIALS AND PROCESSES

Practical shipbuilding requires a knowledge of the properties of the materials used in the construction of ships, and of the processes by which they are produced or prepared for use, so that they may be suitably selected for the services for which they were intended. It also requires a knowledge of the methods, means, and machinery by which, after delivery in the shipyards, the materials are brought to the required shape, erected in their proper relative position, connected together, and completed so as to form a structure which will fulfill the intentions of the designer.

There is an ever-increasing demand for rapid production. The revival of the wooden shipbuilding industry necessitates a vigorous and constant search for simplification of methods of work, for labor-saving and time-saving machinery, and for improved means of handling materials.

The shortage of skilled carpenters has caused engineering departments to design and construct new machines to take the place of men working on certain parts of a vessel, thus releasing a great many men for other work, where they can be used to better advantage.

In previous chapters the methods of laying down the lines and developing bevels, scaling, spiling, etc., have been taken up in detail. In the following chapters special attention is given to the methods of handling and fastening the large timbers used in ship construction.

Drawings and Plans.—The larger the vessel the more details there are to be considered. In the building of the standard wooden cargo carriers, now being built for the United States Shipping Board by the Emergency Fleet Corporation (photographs of which illustrate the greater part of this text) numerous drawings are required before the completion of the vessel.

Drawings must be made showing the general arrangement of decks, lower hold, inboard profile, midship construction section, together with lines and offsets for lofting the vessel, and framing plans. During the progress of the work plans are also required to show the drainage, heating, plumbing, sanitary system, steering gear, masts, rigging, cargo gear, electric light arrangement and wiring, together with all necessary detail hull plans.

Specifications.—The specifications are part and parcel of the drawings. They give a statement of all the particulars of the ship, including what is shown on the drawings as well as what cannot be shown on them. The quality of the materials to be used is described in detail and the scantlings, or dimensions, of the same are carefully recorded.

It is also clearly stated how parts not manufactured by the shipbuilder are to be obtained.

Any omissions in the specifications, or in the drawings, the absence of which from the construction of the vessel would be weakening or detrimental, must be furnished by the builder.

The specifications are prepared by the naval architect, but this last clause serves as a check upon him. The decision, in all cases of doubt arising, rests with the architect.

Sheer Plan.—Figures 42 and 43 give the sheer plan, or outside form of the ship, stem and stern portions, respectively. The sheer plan consists of an elevation showing the longitudinal contour, the water lines or lines at which the vessel will float, and certain other lines parallel to this and equally spaced below it, which are also called water lines. A series of vertical lines equally spaced from stem to stern, called *square stations*, and certain other details are included in the sheer plan. The necessary tables of offsets are also given.

TABLES OF OFFSETS

Preliminary offsets of standard wooden steamships are given in the accompanying tables, for half-breadths, heights above base, and diagonals, respectively.

All offset figures in these tables are to the outside of frame (inside of plank, and are given in feet, inches, and eighths).

Note that the vertical sections are spaced 13 feet apart; buttocks and bowlines 2 feet 6 inches apart; diagonals and water lines spaced as per body plan.

Dimensions.—The dimensions of the standard steamship are as follows:

Length on deck..............	281′–6″
Length bet. perpendiculars...	268′–0″
Breadth moulded	45′–2″
Depth moulded at side.......	26′–0″
Designed load draft (full)...	23′–6″

Half-breadth Plan.—Figures 44 and 45 give the half-breadth plan, showing the form of the ship at the several water lines, supposing the hull to be cut by horizontal planes at the level of these water lines.

Body Plan.—Figure 46 shows the sectional form of the ship at the square stations, supposing the hull to be cut by transverse planes at these stations. The table of offsets required follows the body plan.

Midship Construction Section.—Figures 47 to 52 show the structural arrangement of the ship and scantlings of the most important parts. The midship construction section is shown in detail in Figure 47, while miscellaneous sections appear in Figures 48, 49, 50, 51 and 52.

Figure 48 shows a section from the bridge deck to top of the wheel house, including the boat deck and boat deck house.

Figure 49 is a section through the poop to above the poop deck.

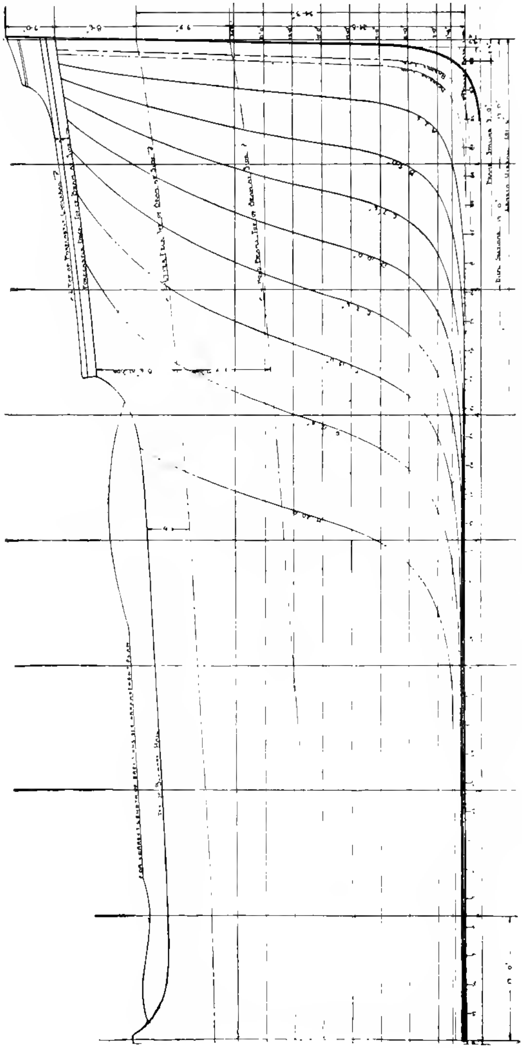


Figure 42.—Standard Wooden Steamship—Sheer Plan—Moulded Lines—Stem.

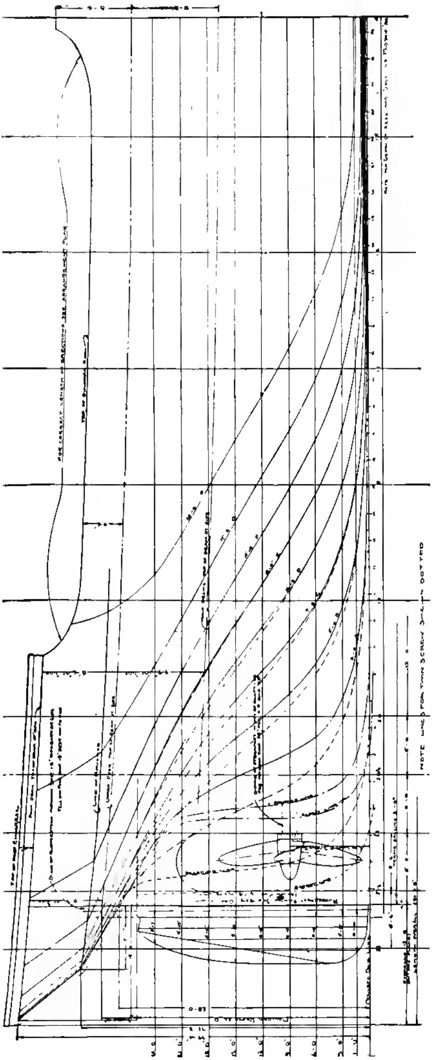


Figure 43.—Standard Wooden Steamship—Sheer Plan—Moulded Lines—Stern.

TABLE OF OFFSETS, STANDARD WOODEN STEAMSHIP—HEIGHTS ABOVE BASE

	A	B	C	D	E	F	G	H	Upper dk.	P. B. & F.
Stem.	....	....	....	....	....	....	....	....	31- 3-0	42- 9-0
2	1- 4-2	5-11-6	25-3-1	34- 6-1	39- 7-2	....	....	....	32- 2-3	40- 8-7
2	6- 2-1	0- 5-7	1-6-7	4- 4-7	16- 4-0	30- 7-3	37-10-4	....	30- 9-5	39- 3-4
4	0- 1-7	0- 2-7	0-4-0	0- 8-1	1- 6-5	4- 2-0	17- 7-7	....	29- 7-5	38- 1-4
5	0- 1-4	0- 2-7	0-3-5	0- 4-7	0- 5-7	0-10-0	1-11-3	9-4-0	28- 7-7	....
6	0- 1-0	0- 2-5	0-3-3	0- 4-5	0- 5-6	0- 6-7	0- 8-7	1-9-5	27-10-2	....
7	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	27- 3-5	....
8	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	26- 9-0	....
9	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	26- 4-4	34-10-4
11	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	26- 1-0	34- 7-0
13	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	26- 1-0	34- 7-0
14	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	26- 2-0	34- 8-0
15	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 8-7	1-7-1	26- 3-7	34- 9-7
16	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-4	0-10-3	1- 8-7	4-1-6	26- 6-7	....
17	0- 0-6	0- 2-3	0-4-0	0- 8-5	1- 6-3	3-10-7	5- 5-6	10-1-7	26-11-0	....
18	0- 2-1	0- 2-7	1-4-7	3- 0-0	5- 4-4	8- 8-0	12- 6-6	17-9-2	27- 3-3	....
19	0- 8-1	2- 2-5	5-9-7	9- 9-3	13- 2-7	16- 5-4	19-10-4	27-1-0	27- 9-0	....
20	6- 0-7	11-11-2	16-6-0	19- 1-0	21- 3-2	23- 8-5	27- 5-1	....	28- 3-3	36- 9-3
20½	14- 4-7	19- 3-0	21-0-7	22- 8-0	24- 5-0	26- 6-5	33- 9-7	....	28- 7-7	37- 1-7
21	23- 4-7	24- 0-7	24-9-7	25- 9-6	27- 2-0	29- 4-6	....	....	29- 1-2	37- 6-4
21½	27- 2-6	27- 7-2	28-1-7	28-10-3	29-11-2	36- 6-7	....	....	29- 8-5	37-11-2
22	31- 0-3	31- 2-2	31-6-3	32- 3-2	36- 0-6	....	....	....	....	38- 5-5
Taffrail.	....	....	....	....	....	....	....	....	....	39- 4-3
Twin screw 19	0- 6-2	2- 4-6	5-7-7	9- 6-4	13- 1-7	16- 5-4	19-10-4	27-1-0	....	Knuckle.
Twin screw 20	2- 8-5	10- 0-3	15-6-0	18- 7-1	21- 1-0	23- 6-5	27- 3-1	....	....	29- 8-7
Twin screw 20½	7- 2-7	17- 1-7	20-5-0	22- 5-3	24- 3-4	26- 6-5	33- 9-7	....	....	30- 0-5
Twin screw 21	19- 6-2	23- 2-0	24-6-6	25- 8-6	....	....	....	....	....	30- 5-4
Twin screw 21½	27- 2-0	....	....	....	....	....	....	....	....	31- 0-6
Twin screw 22	30-11-1	....	....	....	....	....	....	....	....	31-10-7

TABLE OF OFFSETS, STANDARD WOODEN STEAMSHIP—DIAGONALS

	No. 0	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Stem.	...	...	...	...	...	...	...	...	...	...	...
2	9-1-6	8-3-2	7-8-0	7-2-7	6-10-7	6-8-0	6-6-0	6-4-6	6-0-5	5-5-0	4-3-0
3	15-2-6	14-6-4	14-1-3	13-8-4	13-4-1	13-1-6	12-10-7	12-5-7	11-5-0	9-7-0	6-5-0
4	19-1-5	18-10-0	18-7-7	18-6-7	18-5-2	18-4-1	18-0-0	17-0-6	15-0-2	11-7-1	6-9-2
5	21-3-2	21-4-6	21-6-0	21-8-3	21-9-5	21-11-3	21-9-0	20-2-3	16-11-0	11-10-2	6-9-2
6	22-3-3	22-6-1	22-9-6	23-2-2	23-7-4	24-1-4	23-11-2	21-7-6	17-1-1	11-10-2	6-9-2
7	22-7-3	23-0-0	23-3-7	23-9-0	24-2-5	24-9-6	24-10-0	22-1-1	17-1-1	11-10-2	6-9-2
8	22-8-2	23-0-5	23-4-4	23-9-7	24-3-3	24-10-6	24-10-7	22-1-2	17-1-1	11-10-2	6-9-2
9	22-8-2	23-0-5	23-4-4	23-9-7	24-3-3	24-10-6	24-10-7	22-1-2	17-1-1	11-10-2	6-9-2
11	22-8-2	23-0-5	23-4-4	23-9-7	24-3-3	24-10-6	24-10-7	22-1-2	17-1-1	11-10-2	6-9-2
13	22-8-2	23-0-5	23-4-4	23-9-7	24-3-3	24-10-6	24-10-7	22-1-2	17-1-1	11-10-2	6-9-2
14	22-8-2	23-0-5	23-4-4	23-9-7	24-3-3	24-10-6	24-10-7	22-1-2	17-1-1	11-10-2	6-9-2
15	22-7-3	22-11-3	23-2-7	23-7-6	24-0-3	24-6-1	24-4-2	21-8-0	17-1-1	11-10-2	6-9-2
16	22-5-0	22-9-2	23-0-2	23-4-4	23-7-7	23-7-7	22-8-3	20-3-0	16-8-5	11-10-2	6-9-2
17	22-2-3	22-5-3	22-7-2	22-8-5	22-4-7	21-5-7	19-10-7	17-9-3	15-1-2	11-5-7	6-9-2
18	21-7-3	21-10-4	21-8-4	20-11-0	19-6-4	17-9-7	15-11-7	14-2-2	12-3-3	9-8-5	6-3-2
19	20-4-5	20-2-7	19-3-5	17-5-0	15-1-5	13-0-1	11-2-4	9-10-2	8-5-4	6-10-7	4-11-4
20	18-6-1	17-5-0	15-1-4	11-11-2	9-1-2	7-1-0	5-8-6	4-11-0	4-3-2	3-7-7	2-11-3
20½	17-4-1	15-7-2	12-2-4	8-3-3	5-4-1	3-6-2	2-8-0	2-4-2	2-0-7	1-10-0	1-6-6
21	16-0-1	13-1-3	8-0-5	2-1-7	...	...	...	...	...	...	...
21½	14-2-3	8-5-4	0-7-1	...	...	...	...	...	...	...	...
22	9-3-0	...	...	...	...	...	...	...	...	...	...
Taffrail.	...	...	...	...	...	...	...		...	...	...
Twin Screw 19	...	...	19-3-5	17-5-0	15-1-7	13-1-6	11-3-7	9-11-6	8-7-3	7-1-4	5-2-1
Twin Screw 20	...	...	15-1-5	12-1-5	9-6-7	7-1-1	5-8-7	5-8-1	4-11-2	4-2-7	3-5-0
Twin Screw 20½	...	...	12-2-6	8-10-1	6-4-3	4-10-0	3-11-3	3-6-5	3-1-7	2-9-0	2-4-6
Twin Screw 21	...	...	8-4-2	4-7-0	2-10-0	2-2-0	1-10-6	1-9-2	1-7-1	1-10-4	1-5-1
Twin Screw 21½	...	...	...	...	...	...	...	...	...	...	...
Twin Screw 22	...	...	...	...	...	...	...	...	...	...	...

TABLE OF OFFSETS, STANDARD WOODEN STEAMSHIP—HALF-BREADTHS

	1′-6″	3′-0″	6′-0″	9′-0″	12′-0″	15′-0″	18′-0″	21′-0″	24′-0″	Upper dk.	P. B. & F.
Stem.	0- 8-0	0- 8-0	0- 8-0	0- 8-0	0- 8-0	0-8-0	0-8-0	0- 8-0	0- 8-0	0- 8-0	0- 8-0
2	2- 7-4	3- 9-2	4-11-0	5- 5-0	5- 8-7	6-0-3	6-4-4	6- 9-3	7- 2-4	9- 1-7	13- 5-0
3	7- 4-3	9- 4-0	10- 8-0	11- 4-7	11-10-3	12-3-3	12-8-7	13- 2-5	13- 8-4	15- 0-2	18- 2-3
4	12- 3-1	14- 1-2	15- 9-0	16- 4-7	16-10-4	17-3-1	17-7-1	17-10-7	18- 2-6	18-10-3	20- 3-2
5	16- 9-0	18- 4-0	19- 6-3	19-11-0	20- 2-4	20-4-0	20-7-1	20- 9-0	20-10-5	21- 0-1	...
6	19- 5-0	20- 9-6	21- 8-2	21-11-1	21-11-4	22-0-0	22-0-0	22- 0-2	22- 0-5	22- 0-7	...
7	20- 4-0	21- 9-0	22- 5-6	22- 6-3	22- 6-3	22-6-3	22-6-3	22- 6-3	22- 6-4	22- 6-4	...
8	20- 4-7	21-10-0	22- 7-0	22- 7-0	22- 7-0	22-7-0	22-7-0	22- 7-0	22- 7-0	22- 7-0	...
9	20- 4-7	21-10-0	22- 7-0	22- 7-0	22- 7-0	22-7-0	22-7-0	22- 7-0	22- 7-0	22- 7-0	...
11	20- 4-7	21-10-0	22- 7-0	22- 7-0	22- 7-0	22-7-0	22-7-0	22- 7-0	22- 7-0	22- 7-0	...
13	20- 4-7	21-10-0	22- 7-0	22- 7-0	22- 7-0	22-7-0	22-7-0	22- 7-0	22- 7-0	22- 7-0	...
14	20- 4-7	21-10-0	22- 7-0	22- 7-0	22- 7-0	22-7-0	22-7-0	22- 7-0	22- 7-0	22- 7-0	...
15	19- 8-0	21- 2-5	22- 2-0	22- 3-4	22- 4-1	22-4-5	22-5-1	22- 5-3	22- 5-7	22- 6-0	...
16	16- 8-4	18-11-7	20-10-3	21- 7-3	21-11-3	22-1-5	22-2-2	22- 2-7	22- 3-4	22- 3-5	...
17	12- 4-1	15- 1-0	17-10-2	19- 6-1	20- 7-4	21-3-4	21-8-1	21-10-3	21-11-5	22- 0-0	...
18	7- 5-0	9-11-5	12-11-5	15- 2-1	17- 1-5	18-9-2	20-0-7	20-10-5	21- 4-1	21- 5-2	...
19	3- 6-1	5- 2-5	7- 6-7	9- 4-7	11- 5-6	13-8-7	16-1-3	18- 1-7	19- 4-4	20- 0-3	20- 4-0
20	1- 5-2	2- 1-1	3- 1-5	3-11-5	4-11-2	6-5-0	8-9-5	12- 2-1	15- 4-0	17-10-0	18-10-3
20½	...	0-11-0	1- 5-0	1- 9-4	2- 1-3	2-7-1	4-1-7	7- 2-2	11-11-0	16- 6-2	17-10-3
21	...	...	...	...	...	...	...	...	4- 6-7	14-10-0	16- 7-7
21½	...	...	...	...	...	...	...	...	...	11-10-2	15- 2-7
22	...	...	...	...	...	...	...	...	...	...	13- 4-3
Taffrail.	...	...	...	...	...	...	...	...	...	...	...
Twin screw 19	3-10-0	5- 6-3	7- 8-6	9- 6-3	11- 6-7	13-9-0	16-1-3	18- 1-7	19- 4-4	as	Knuckle
20	1-10-0	2- 7-0	3- 8-7	4- 7-6	5- 8-6	7-1-7	9-4-0	12- 4-4	15- 4-6	above	18- 2-6
20½	1- 2-1	1- 6-7	2- 3-0	2- 8-7	3- 3-0	4-0-3	5-5-3	8- 1-5	11-11-0	...	17- 0-6
21	...	0-11-0	1- 1-7	1- 4-1	1- 6-2	1-8-3	2-1-0	3- 1-3	6- 3-7	...	15- 9-0
21½	...	...	...	...	...	...	...	...	...	...	14- 0-5
22	...	...	...	...	...	...	...	...	...	...	9- 9-0

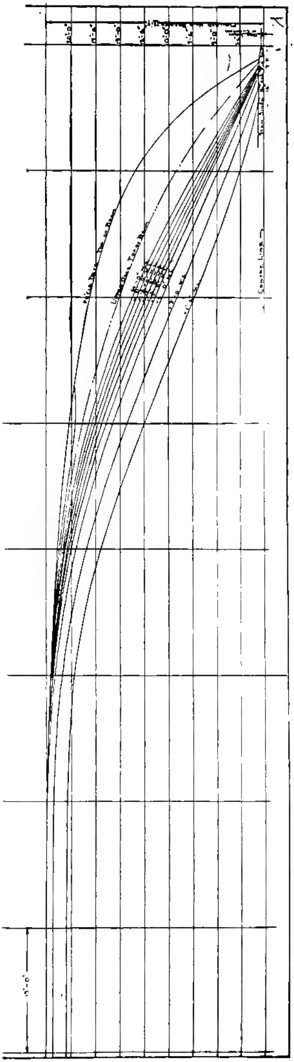


Figure 44.—Standard Wooden Steamship—Half-breadth Plan—Moulded Lines—Stem.

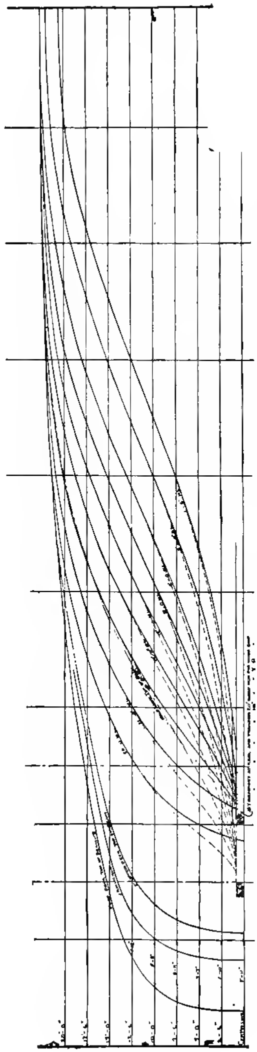
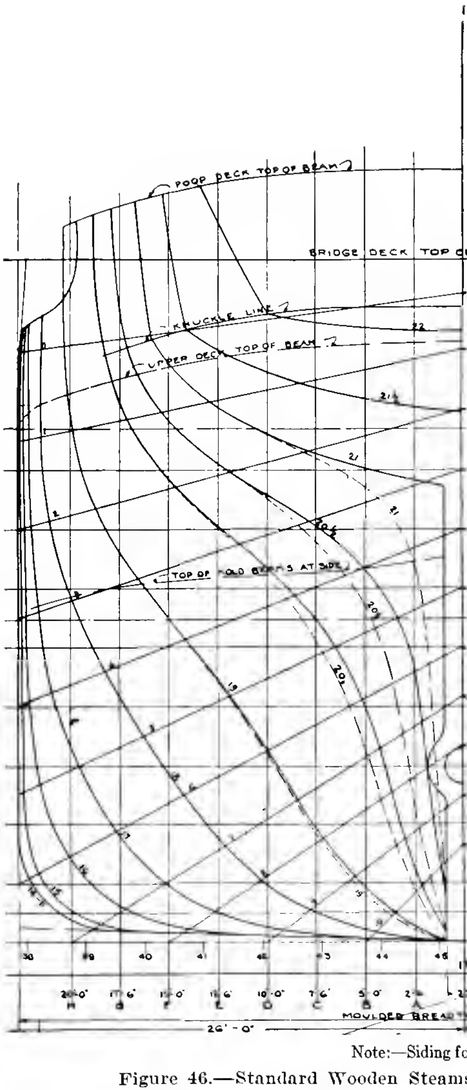
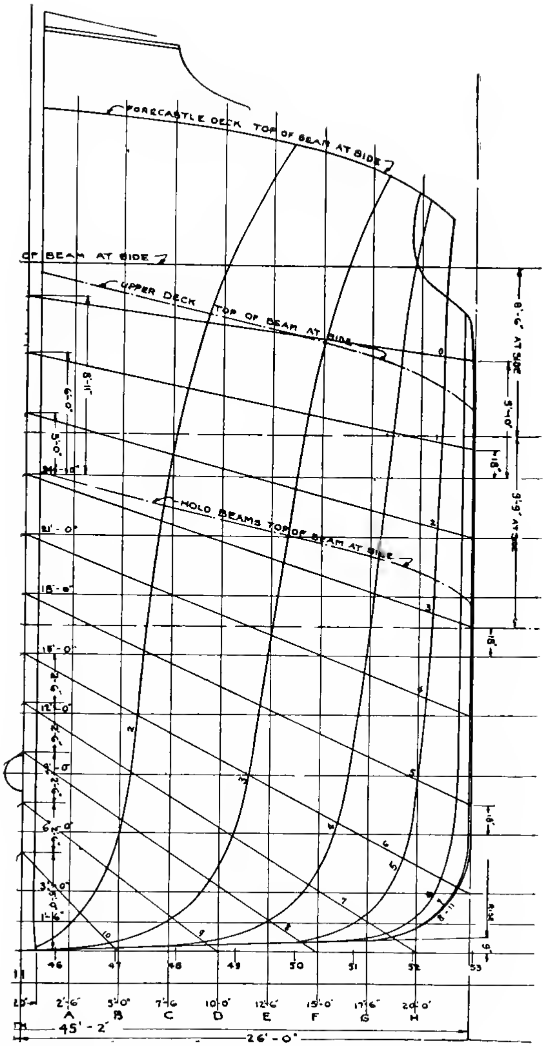


Figure 45.—Standard Wooden Steamship—Half-breadth Plan—Moulded Lines—Stern.



Note:—Siding for Fir

Figure 46.—Standard Wooden Steamship



Wood 20″, for Y. P. 16″.

Moulded Lines—Body Plan.

Figure 50 shows the section through the engine foundation, looking forward. One-third of the engine holding-down bolts are put through to the bottom of the foundation keelsons. The remaining two-thirds of the holding-down fastenings are heavy lag-screw bolts.

Figure 51 is a section through the shaft tunnel, looking aft, and Figure 52 shows the section through the forecastle.

SCANTLINGS

The following are the scantlings, or dimensions, for various parts of the standard wooden steamship:

Stem.—Sided 16″, moulded 20″, yellow pine.

Apron.—Double 16x16″, yellow pine.

Knightheads.—Sided 20″, moulded same as frame, yellow pine.

Sternpost.—Sided 28″ in way of shaft log, 16″ at keel and head, moulded 24″, white oak substitution; built up in four sections; white oak inner stern post of yellow pine, of same dimensions as main post.

Rudder Post.—Sided 16″, moulded 18″, white oak.

Rudder Stock.—18″ diameter, best white oak.

Rudder Blade.—Built up, yellow pine.

Deadwood Knees.—16″ sided, hackmatac or oak.

Horn Timbers.—White oak.

Stern Framing.—Yellow pine.

Forward Deadwoods.—16″x18″ yellow pine.

After Deadwoods.—16″x18″ yellow pine.

Shaft Log.—14″x14″, in four pieces, white oak.

Hull Bulkhead Planking.—3″x8″ double diagonal, yellow pine.

Hull Bulkhead Studding.—8″x12″ yellow pine.

Pointers.—3″x12″ yellow pine.

LOFTING THE SHIP

The lines are laid down on the mould loft floor full size, as previously described. See Figure 53.

If space will not permit the laying down of the full length, it can be laid down in two or three sections, one overlapping the other. The sections must be long, however, so that the lines may be properly faired up.

All sections are laid down and the lines proved before getting out the moulds. It is not an easy task to properly fair in these lines, for while looking at one portion of the ship, it is impossible to see the other end; yet much depends upon the accuracy of the mould loftsman in getting out his moulds, in order to conserve the labor of the carpenter in dubbing off and fairing up the scantlings while in frame.

Moulds.—The moulds are prepared by the mould loftsman, having plainly marked on them the various beveling stations, water lines, and other means of identification, for ready reference when assembling. All have to be plainly numbered and show the number of pieces required. These are

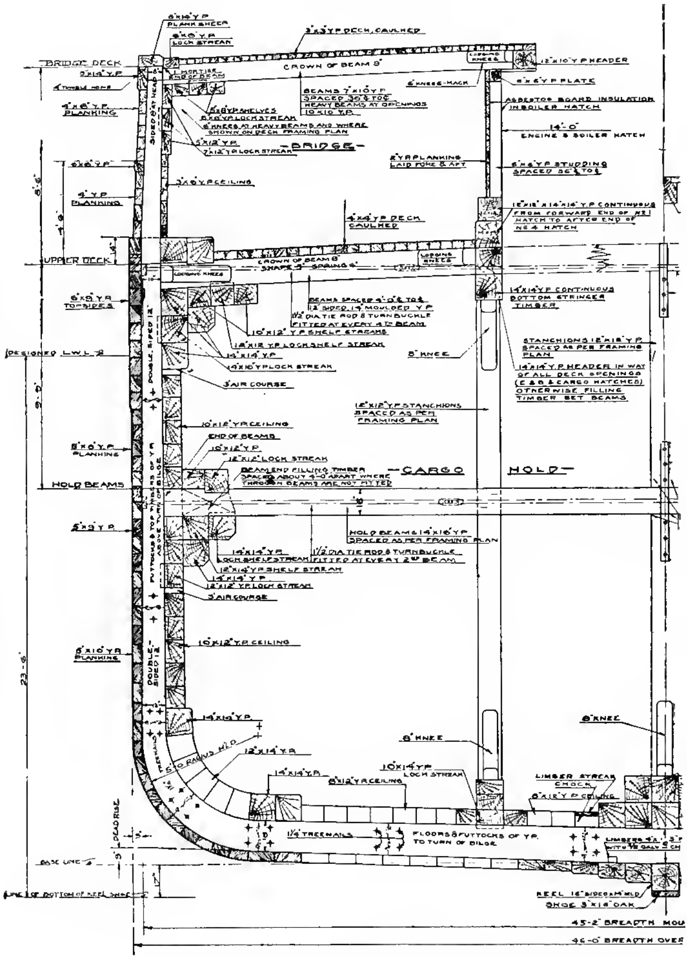
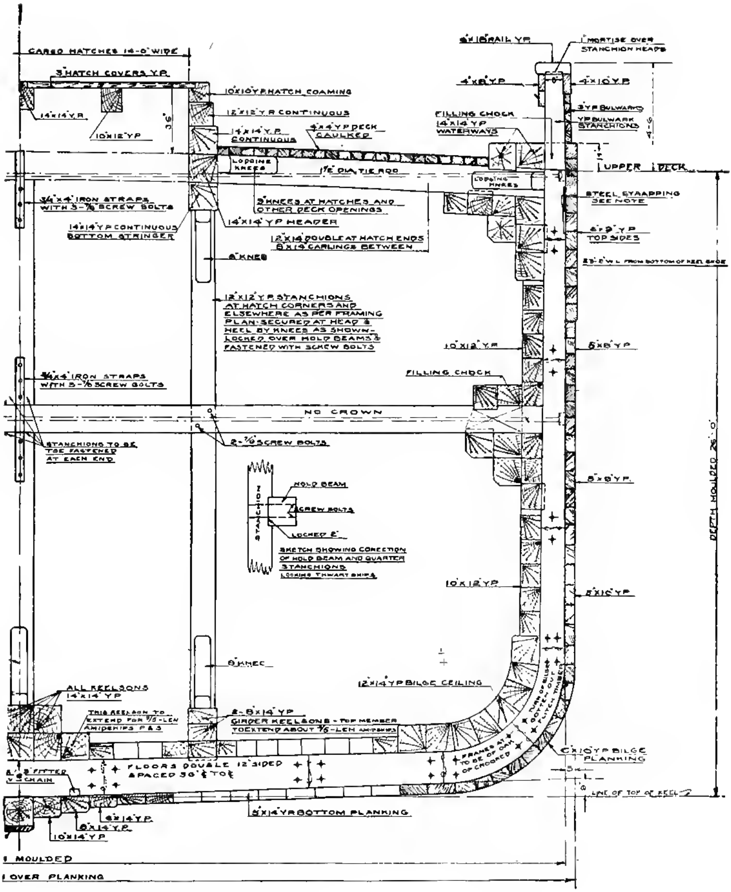


Figure 47.—Midship Section of



Standard Wooden Steamship.

given to the mill superintendent, and from them he lays out his parts.

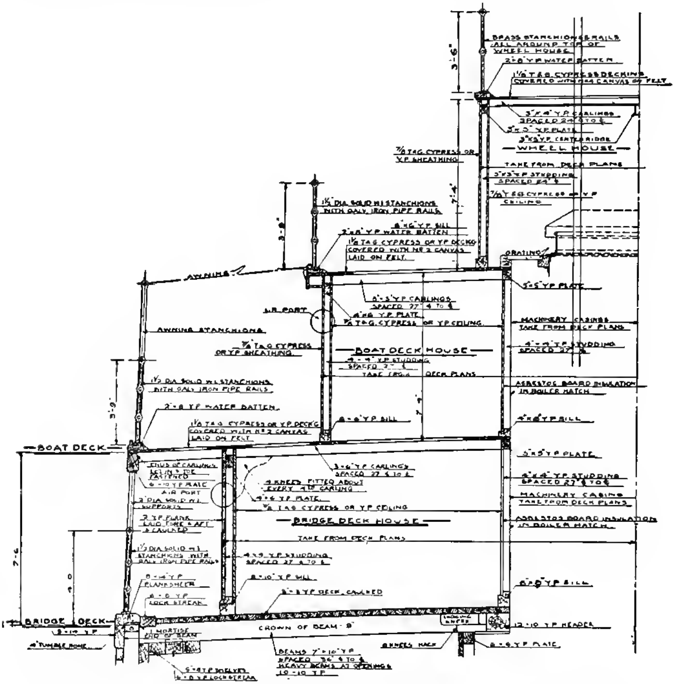


Figure 48.—Section from Bridge Deck to Top of Wheelhouse of Standard Wooden Steamship.

FRAMES

The frames are double sawed, spaced 36″ center to center, separated at the butts with 2-inch chocks, and each butt fastened with 1¼″ treenail.

The frames are laid out from the moulds, as

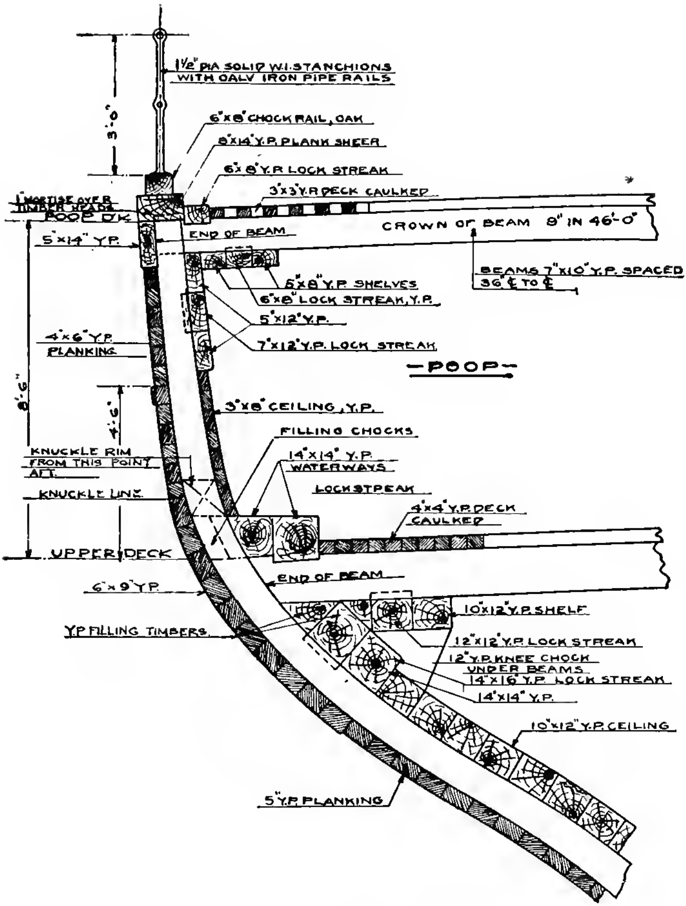


Figure 49.—Section Through Poop.

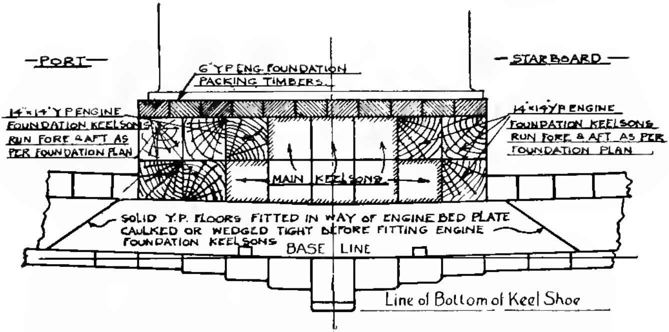


Figure 50.—Section Through Engine Foundation, Looking Forward.

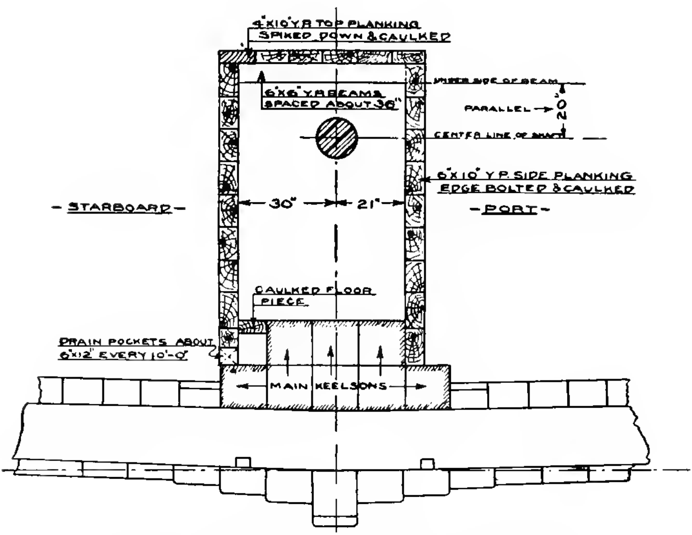


Figure 51.—Section Through Shaft Tunnel, Looking Aft.

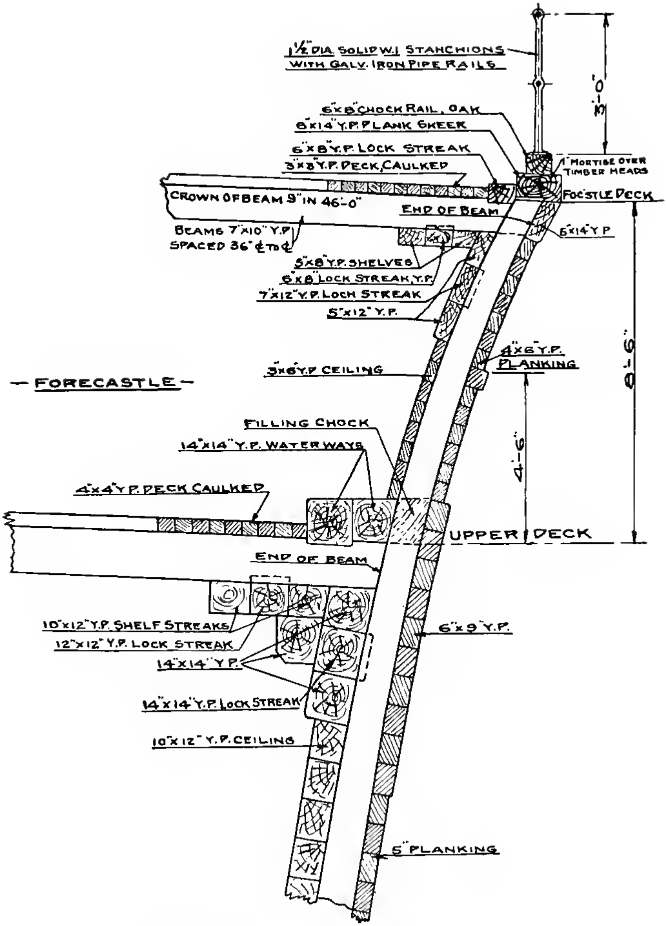


Figure 52.—Section Through the Forecastle.

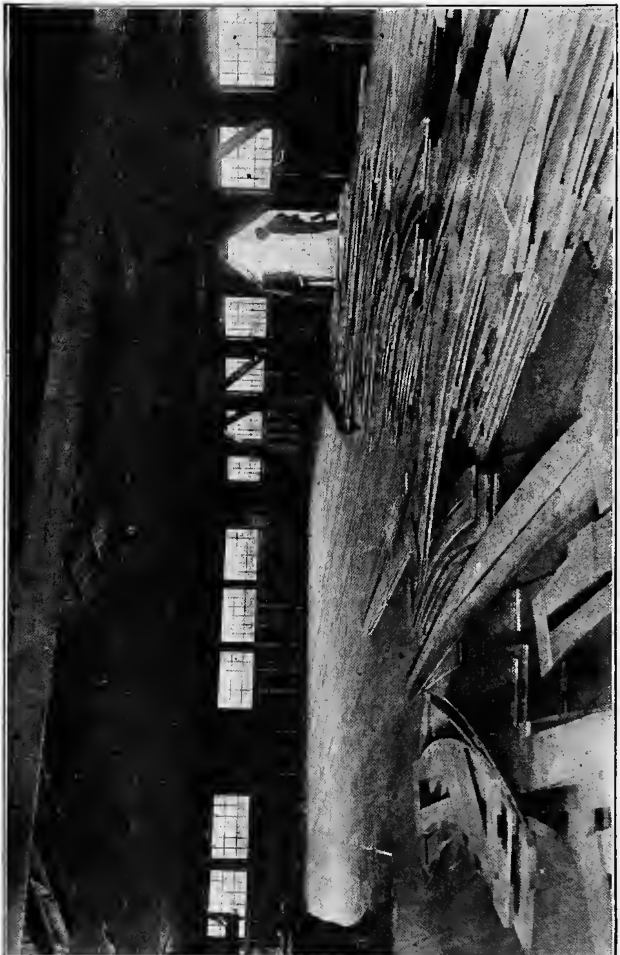


Figure 53.—Mould Loft.

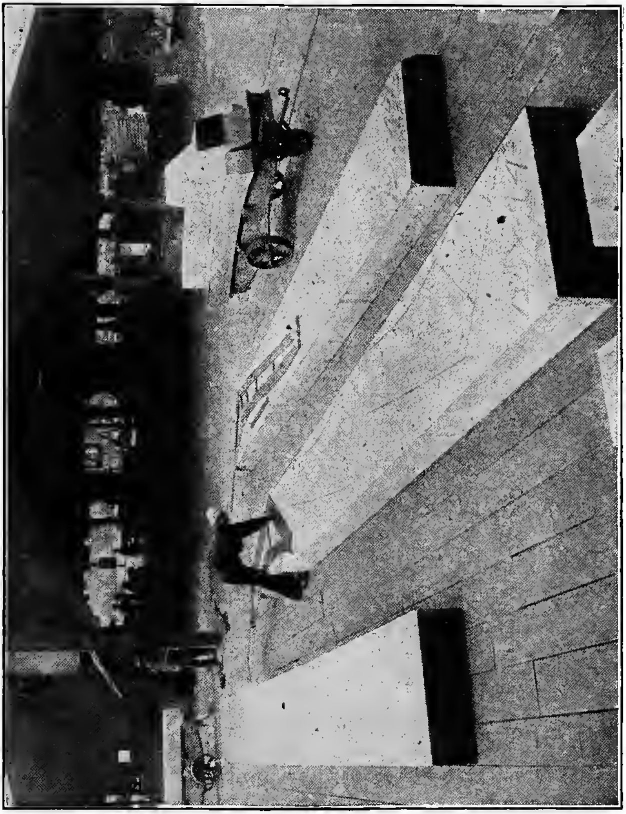


Figure 54.—Applying Mould—Laying Out Timbers.

shown in Figure 54, and cut to the required bevel on the band saw. See Figures 55 and 56. The gauge on the side of the machine registers the angle at which the saw is cutting.

The man guiding the stock through the saw

Figure 55.—Beveling Frames on the Band Saw.

announces the various degrees or bevels as he nears the mark on the timber, while the operator at the wheel gradually tilts the saw one way or the other, as the case may be, fairing one bevel into the other as the degrees change.

Mill Floor Carriages.—In the well-equipped plant the mill floor is made up of sectional carriages, as shown in Figure 57. On the top of the carriages are a series of rolls.

The tops of the rolls are level with the working table of the machines, so that a heavy timber can

Figure 56.—Cutting a Straight Timber on the Band Saw.

be passed through a machine and moved about with but very little exertion on the part of workmen. The timbers are then put on trucks and distributed to the assembling platforms at the head of each "way." See Figure 58.

Ways.—The set of heavy timber sills upon which a ship is built, and upon which the vessel slides in launching, is called a *way*. Launching ways sup-

Figure 57.—Sectional Carriages in Mill for Handling Heavy Timbers.

port the cradle of a ship, and form the track on which it descends into the water. See Figures 99, 100.

Figure 58.—Assembling Platform.

CHAPTER VI

MACHINES AND LABOR-SAVING DEVICES

Sawing and Handling Large Timbers.—Special machines and labor-saving devices have been designed to partially offset the shortage of labor. Figure 59 shows the method of sawing a heavy timber in a large modern mill. The first slab has been removed and the second cut is being made. The timber rests on a carriage which slides back and forth, and is controlled and held in position by a series of hooks operated by a lever on the carriage. The finished timbers are moved about in the yard on trucks, as shown in Figure 60.

Bevel and Edging Machines.—One of the latest machines to be designed is a bevel and edging machine used for beveling ceiling and planking (including calking seams), and forecastle deck beams; also for faying knees, rounding edging of waterways, main rails, pin rails, etc.

In Figure 61 is shown a timber starting through the machine at an angle of 11 degrees to the right, and in Figure 62 the other end is shown coming out of cut at an angle of 11 degrees to the left, the angle continually changing as the work was done.

The finished timber as it left the machine is shown in Figure 63.

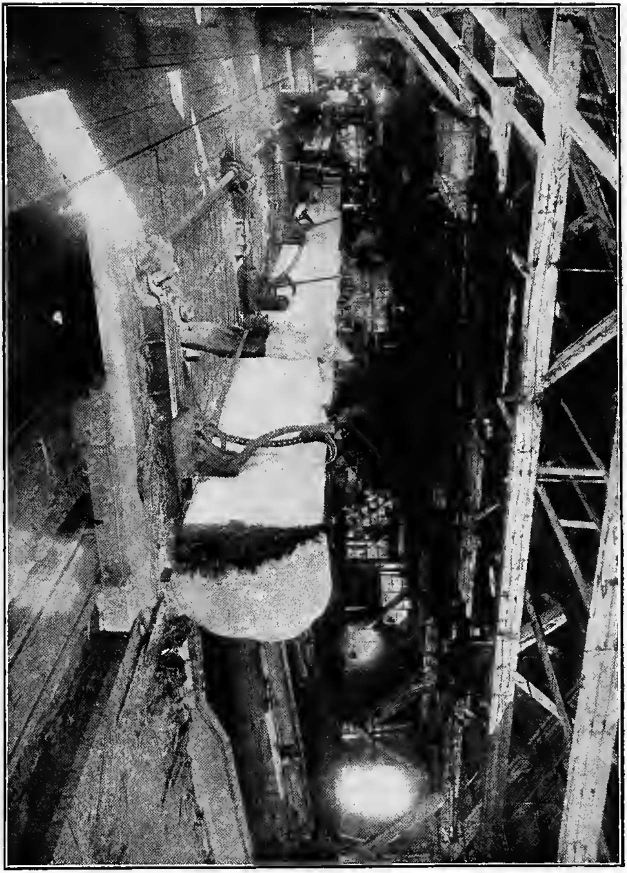


Figure 59.—Sawing a Heavy Timber in a Modern Mill.

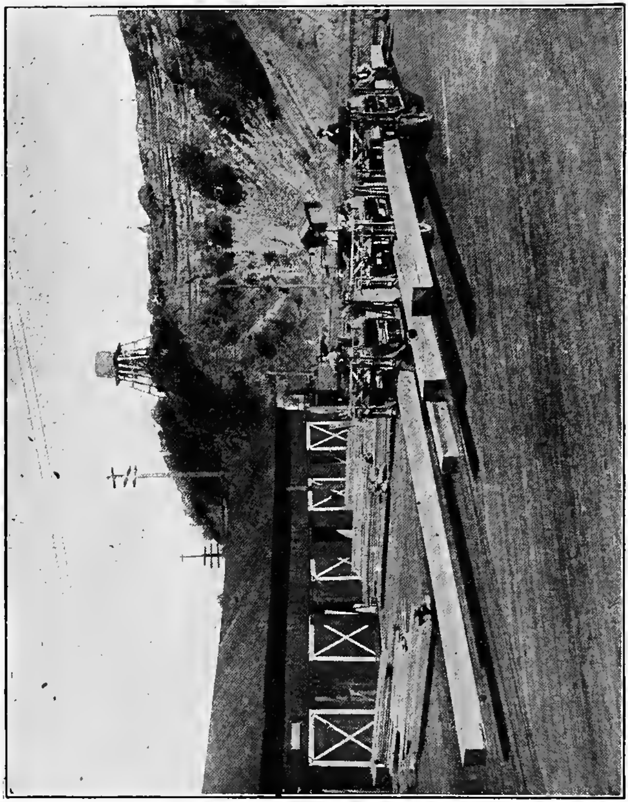


Figure 60.—Handling Heavy Timbers in the Yard.

In beveling ceiling planking, a complete strake can be laid out at a time; battens are nailed on each timber, and the timbers placed on roller skids alongside of the machine, from which they can quickly and easily be placed on the carriage and run through. The collar of the machine rests against the batten, and this regulates the depth of the cut and the shape.

Surfacing Knees.—The method of surfacing knees is shown in Figure 64. Eleven knees are shown after having been surfaced two sides. These eleven knees were loaded on the carriage, surfaced one side, turned over and surfaced on the other side, the complete operation requiring only fifteen minutes.

"Faying" the knees is a simple operation, as shown in Figure 65. A small platform is placed on the carriage, and a batten is nailed on the knees in the same manner that is used in working ceiling and planking. To illustrate the work accomplished the carriage was reversed and the machine stopped.

Working Rudder Stock.—The working of the rudder stock shows another possibility of this machine. Formerly all the work was performed by hand, while the surfacing of the various parts is now done on the machine.

In Figure 66 the rudder stock (iron bark) is placed on blocks sawed to hold it at 45 degrees, the carriage of the machine is run forward, and the cutting done on the top beveling head.

Figure 61.—Starting a Cut at an Angle of 11 Degrees to the Right.

Figure 62.—Finishing the Cut at an Angle of 11 Degrees to the Left.

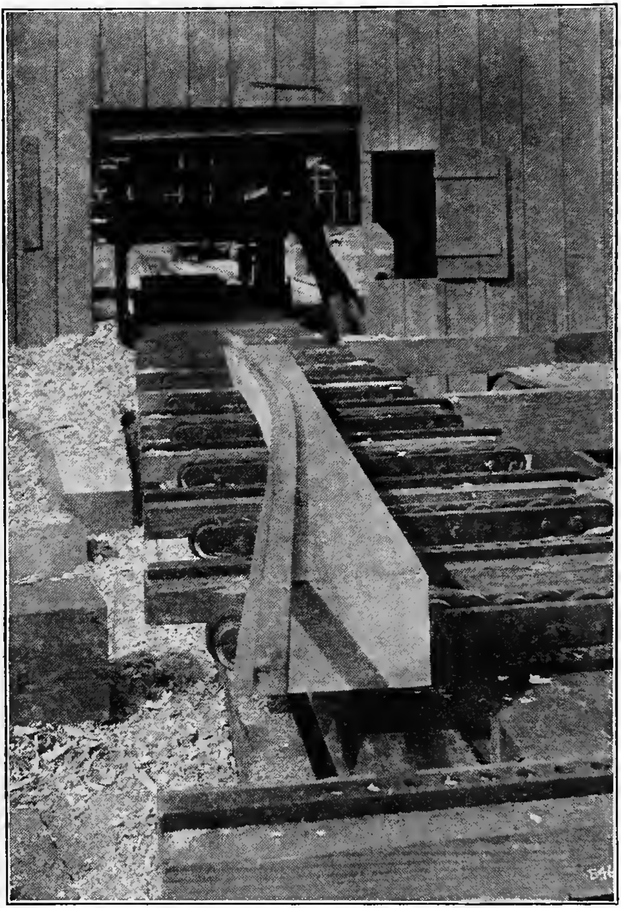


Figure 63.—The Finished Timber.

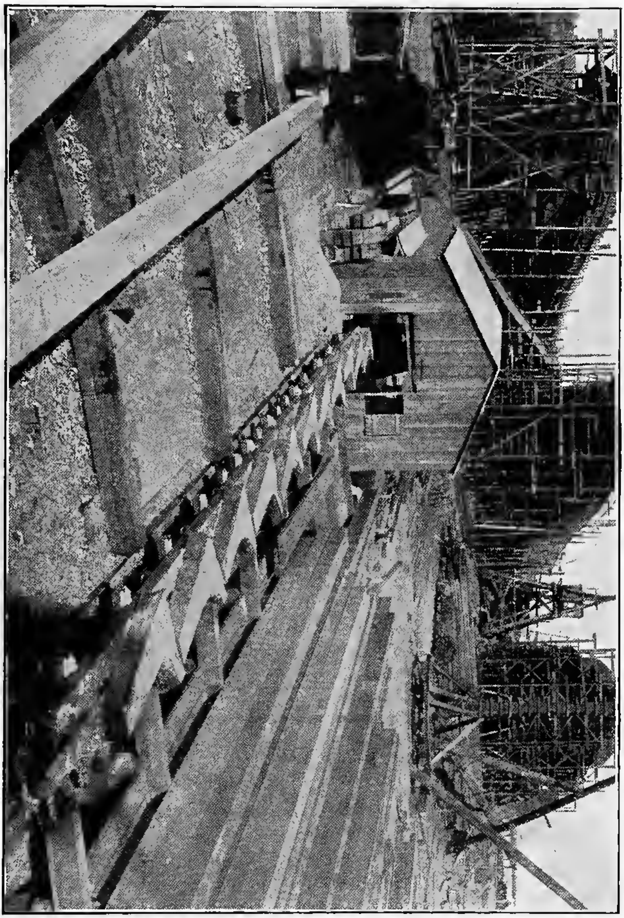


Figure 64.—Surfacing Knees on a Special Machine.

As it is especially hard wood, comparatively light cuts are made, and each time the carriage is reversed the beveling head is lowered slightly by power (the dial indicator showing the exact posi-

Figure 65.—Faying Knees on a Special Beveling Machine.

tion) and another cut is taken. This operation is continued until the timber is cut to the desired depth. The rudder stock is then placed in such a position that another corner can be cut down in the same manner.

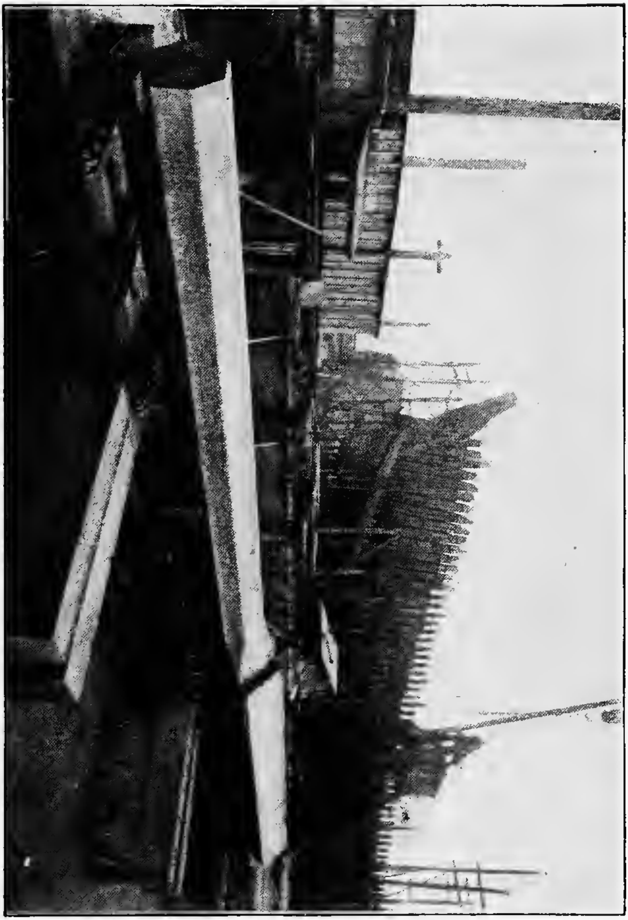


Figure 66.—Shaping the Rudder Stock on the Beveling Machine.

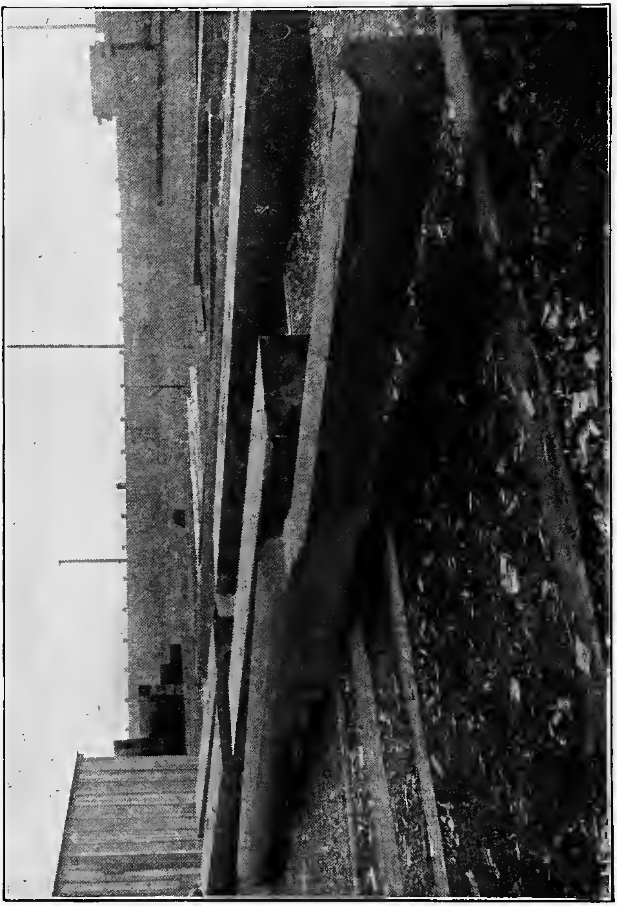


Figure 67.—Shape of a Rudder Stock After Sixteen Cuts Have Been Completed.

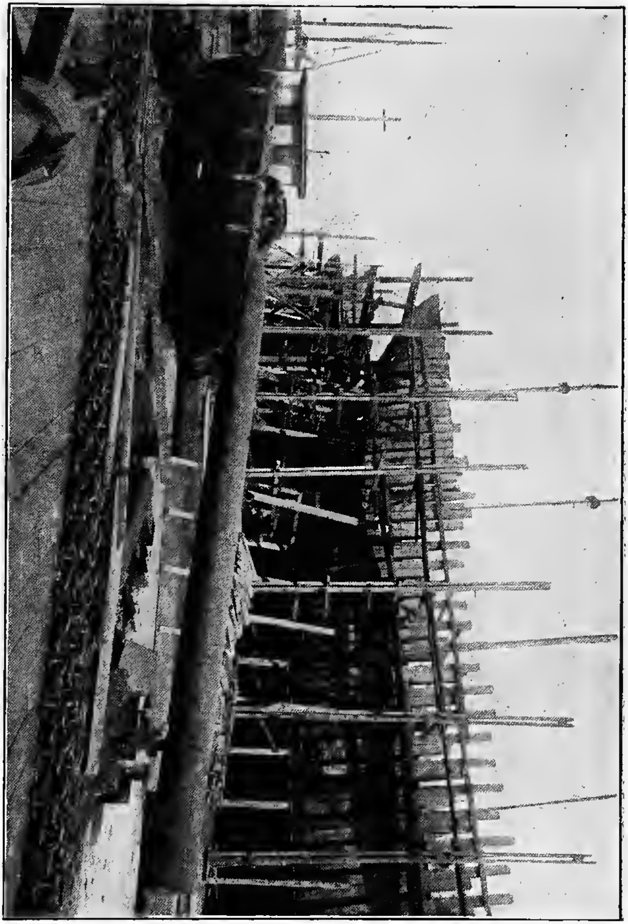


Figure 68.—The Rudder Stock Requires But Little Time with Hand Tools to Complete the Work After Leaving the Machine.

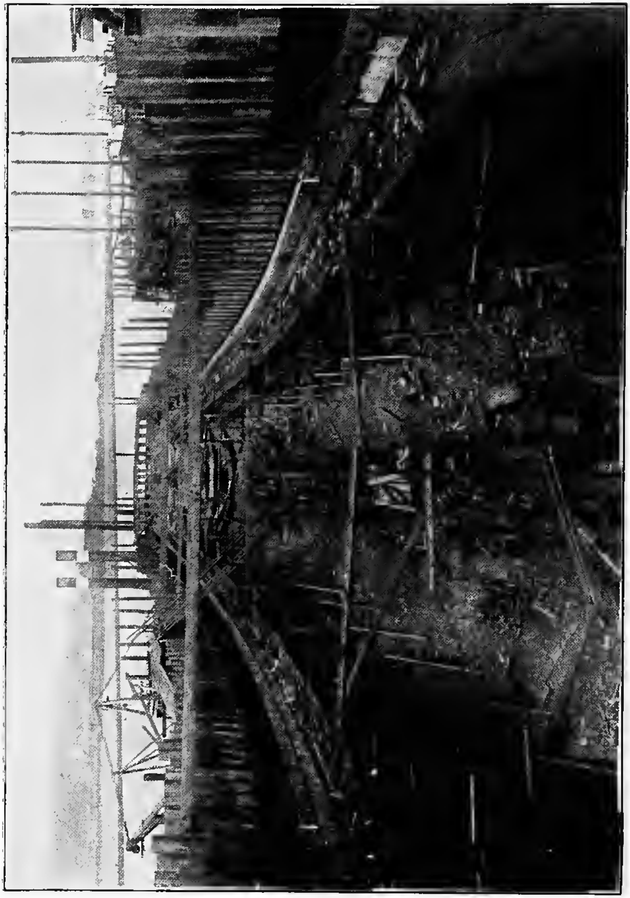


Figure 69.—No Hand Tools Were Used in Beveling the Ceiling in This Ship.

Figure 67 shows the same piece after sixteen cuts have been completed, the lower part beveled two ways, and the sides surfaced. It leaves the machine as shown in Figure 68, practically finished, requiring comparatively little time with

Figure 70.—Record Keel Laid in Ten Minutes in a Prominent Yard on the Atlantic Coast.

hand tools to complete the work as shown in the illustration.

Every piece of ceiling used in the ship shown in Figure 69 was beveled on this machine, no hand tools being used. Even the back of the ceiling at the turn of the bilge was beveled, using the top beveling head of the machine, thus showing the amount of hand labor that may be saved.

Setting Up the Keel.—The keel, Figure 70, is made of yellow pine, 16 by 14 inches, in lengths of

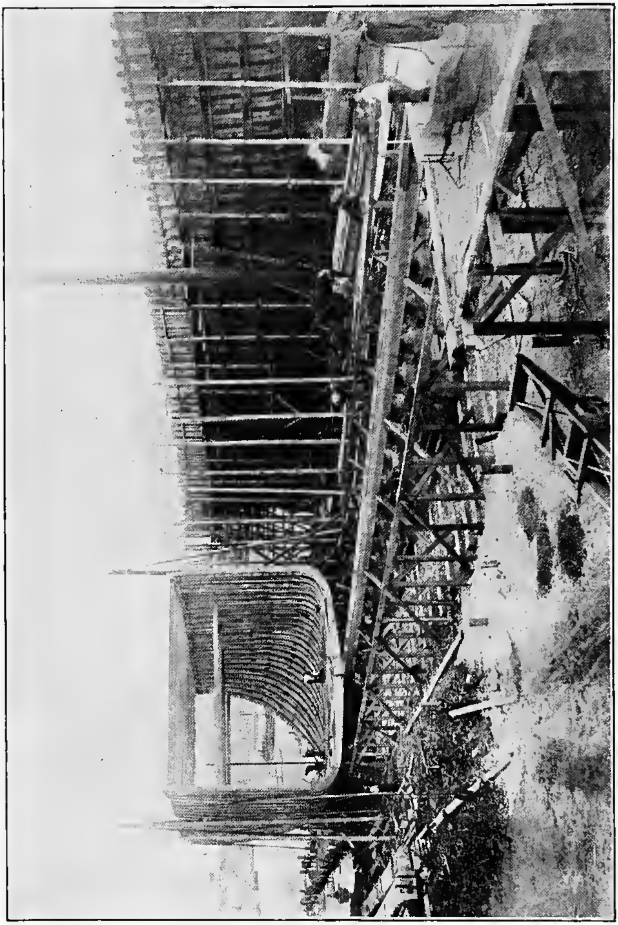


Figure 71.—Assembling Platform, Showing Ways and Square Framing.

about 40 feet, scarfed together with 7-foot scarfs. Each scarf is fastened with eight $1\frac{1}{4}''$ bolts set up over clinch rings at both ends. The keel is set up on the keel blocks, wedged and shored in position. The keel shown in Figure 70 probably holds the

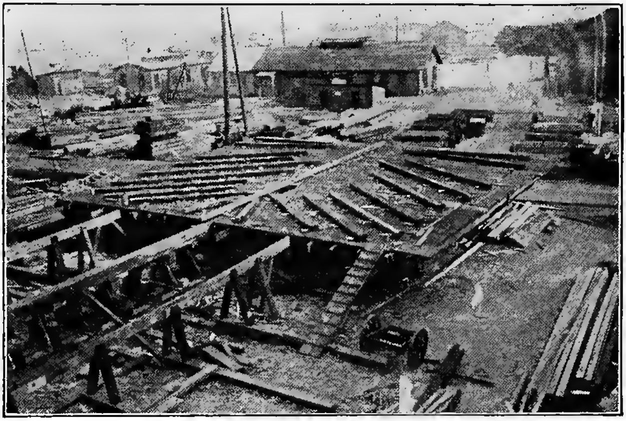


Figure 72.—Assembling Platform, Showing Diagonals.

record, having been laid in 10 minutes in an Atlantic Coast shipyard.

Assembling Platform.—At the head of each way is an assembling platform as shown in Figure 71. Timbers are fastened to the platform on the diagonal lines, and upon these timbers the frames are assembled as in Figure 72.

Fitting and Fastening Frames.—If the diagonal lines and other reference lines have previously been transferred from the moulds to the frame timbers before sawing, they will readily find their proper location. The timbers come already shaped from the band saw, so that very little hand work is required at this stage of construction.

After the joints are fitted, the frames are fastened together with 7/8-inch drift bolts and 1 1/4″ treenails. The holes are bored with an automatic auger bit, followed up by a man putting in the treenails as fast as the holes are bored, and again followed up by two men driving in the treenails, so that by the time the last hole is bored the frames are practically ready to raise.

CHAPTER VII

RAISING THE FRAMES

As soon as the carpenters finish a frame, the riggers take charge in raising it into position. In Figure 73 is shown a frame about to be raised.

Two tracks are placed on either side of the ways, running from the assembling platform the entire length of the ways, and on these tracks the frames are run to their positions. Chocks are placed against the previous frame raised, to give the proper spacing of the frames and serve as a stop as the frame slides down the ways.

Figure 74 is a nearer view of the frames in position ready to raise, and in Figure 75 a frame is being raised.

As soon as the frame leaves the platform, the next frame is begun, and in that way both riggers and carpenters are kept busy. While one assembles, the other group raises.

Figure 76 is a near view of the frames in position. Figure 77 shows the same ship a short time before, the ways having been lowered while the ship was on them, as shown in Figure 76.

CANT FRAMES

The cant frames are the half frames at the fore and aft of a ship. It is usual to dispose the transverse framing of a ship entirely in planes perpendicular to the trace of the load water line, with the longitudinal plane of symmetry of ships.

This practice leads to a large and varying bevel being given to the frames at the ends of a ship with a very bluff bow or stern, and it becomes a prac-

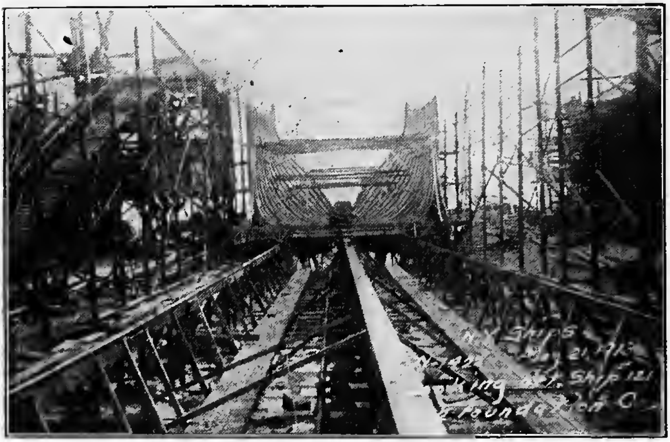


Figure 73.—The Frames Are Run on Two Tracks, One on Either Side of the Ways.

tical question whether it would not be better at such parts to dispose the frames in planes which are more nearly normal to the general surface of the ship, and which need not be perpendicular to either of the three planes of reference.

It is of great economical value and highly important that the timber frames be all square or nearly square sections, thus eliminating great bevels. Most of the bevels in wooden ship timbers do not exceed 10 degrees, very few exceeding 15 degrees.

Bolting the Frames.—The lower ends of the cant frames are let into the deadwood 1 inch and bolted with six bolts in each half—four $1\frac{1}{4}''$ and two $1\frac{1}{8}''$. At least two of the $1\frac{1}{4}''$ bolts extend through

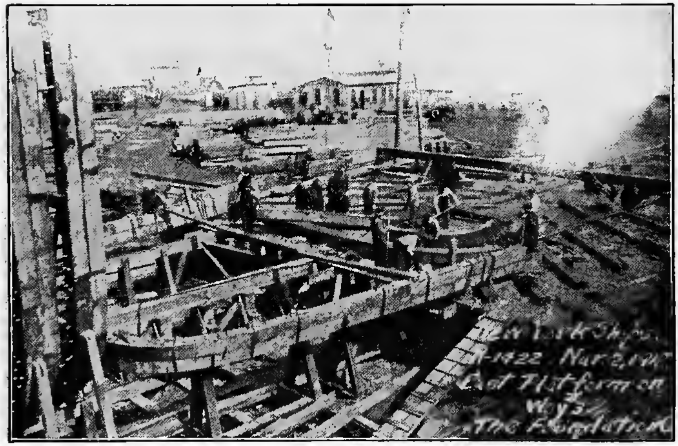


Figure 74.—Frames in Position Ready to Raise.

the half frame, through the deadwood, and set up over clinch rings.

The cant frames are built up in a similar manner to the main frames. Figures 78 and 79 show the heels of the cant frames fore and aft of the same ship. In Figure 79 the flooring is being laid and the illustration shows the long treenails in position ready to be driven in. A number are set up at one time and then the operation of driving them

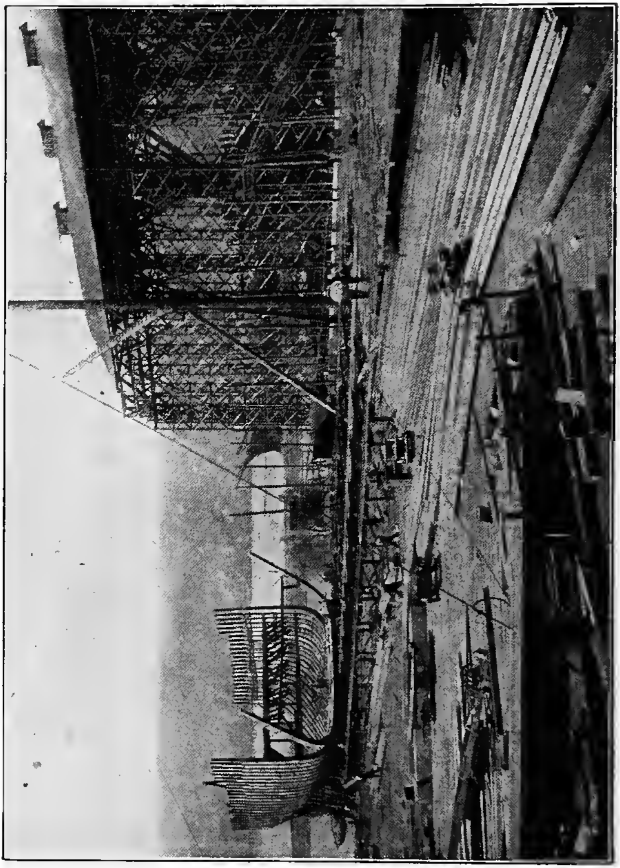


Figure 75.—Raising the Frame.

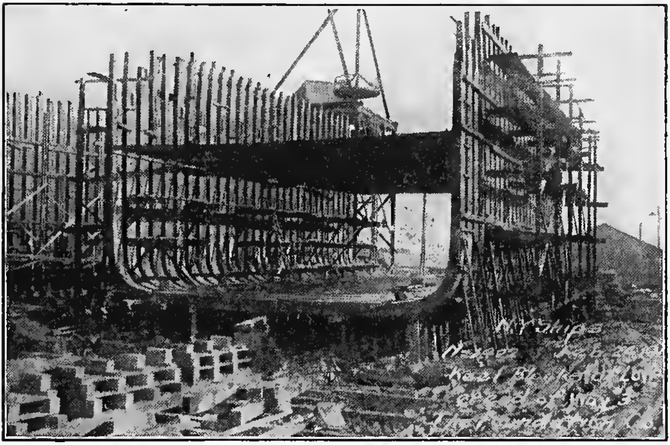


Figure 76.—Frames in Position.

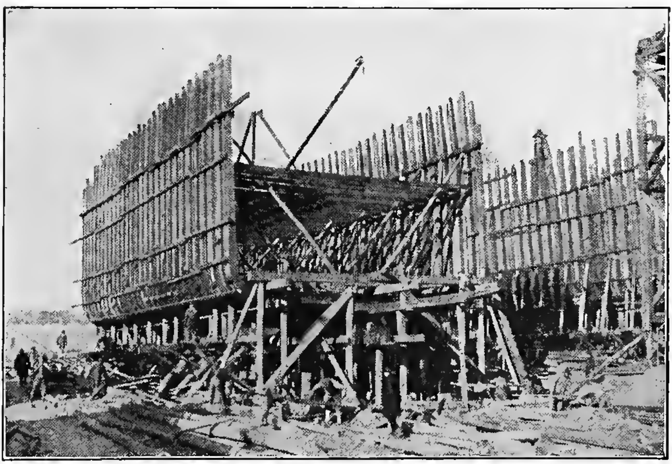


Figure 77.—These Ways Were Lowered While the Ship Was in Frame.

is performed at one time. Figures 80 and 81 show the heads of the same frames.

Keelsons.—The keelson timbers are eight in number, as shown on the midship section, Figure 47. These are put in in lengths not less than 48

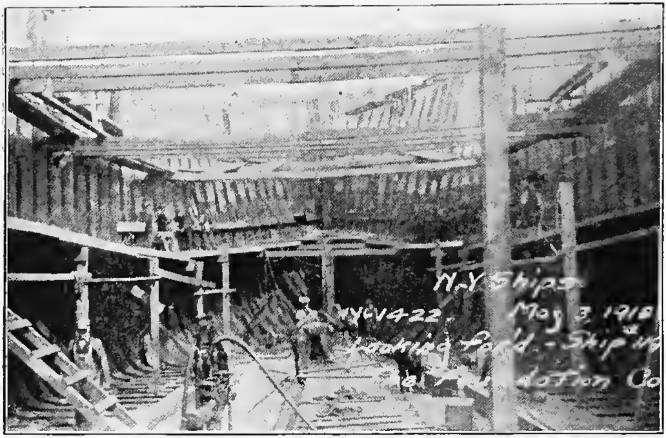


Figure 78.—Cant Frames Looking Forward, Showing Heels of Timbers.

feet long, connected with 7-foot scarfs, care being taken to get the best shift of scarfs possible.

Figures 82 and 83 show the keelsons being installed. At the lower left-hand corner of Figure 83 an opening is seen in the frame work. This opening is made after the frames are in position, and leads to a chute through which the heavy timbers of the keelson are hauled into position.

Fairing-up Work.—The framed body of the ship should be properly ribbanded and shored to

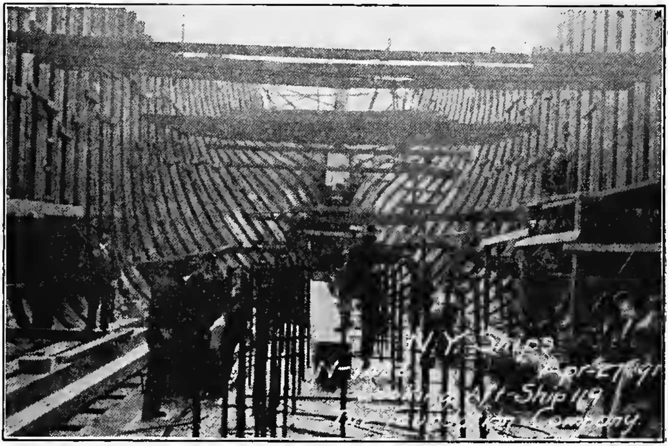


Figure 79.—Cant Frames Looking Aft, Showing Heels of Timbers.

Figure 80.—Looking Forward—Heads of Timbers.

retain shape. The inside surface of the forms should be dubbed with an adze, so as not to leave over 10 per cent of the sawed surface on the frames. The outside of the frames should be dubbed for each strake of planking, and the outer surface of planking rounded to conform to the shape of the

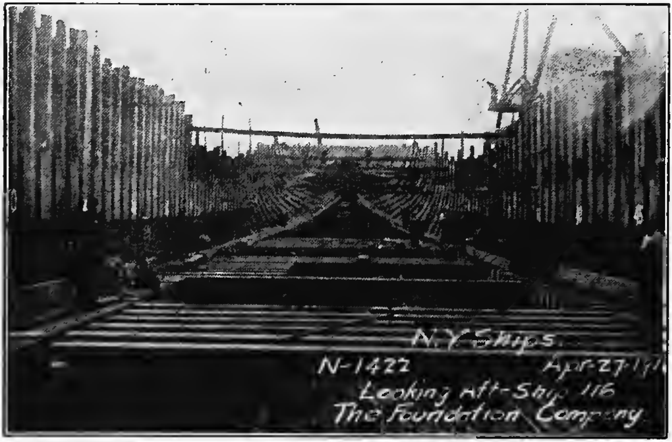


Figure 81.—Looking Aft—Heads of Timbers.

ship. The thick ceiling is rounded on the back, so as to fit the frames.

Iron Strapping.—The entire frame work is braced and reinforced by a system of iron strapping. A top belt of 3/4″ by 8-inch iron extends from about 12 feet from the forward end to about 12 feet from the aft end of the ship, fastened to each frame by 1-inch by 10-inch countersunk bolts staggered. Diagonal straps of 1/2-inch by 4-inch iron

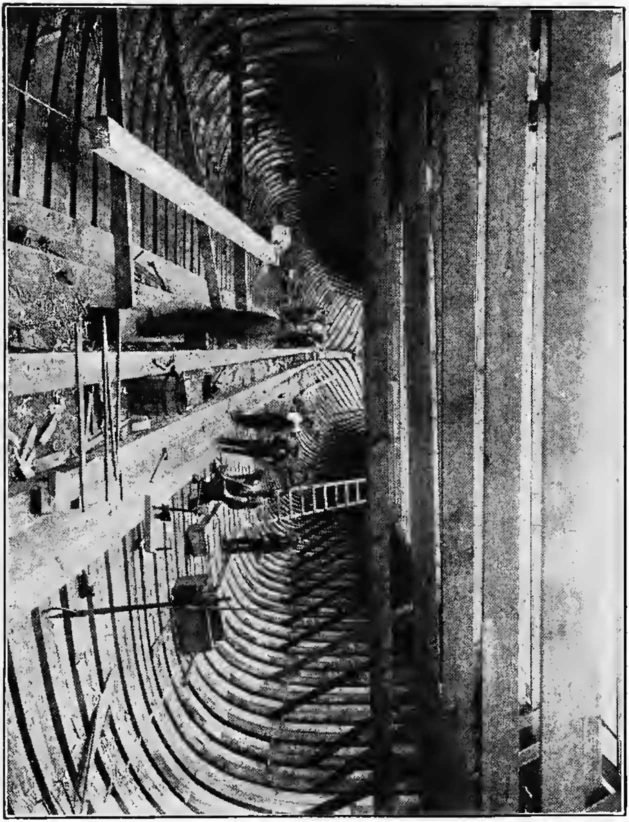


Figure 82.—Installing Keelson.

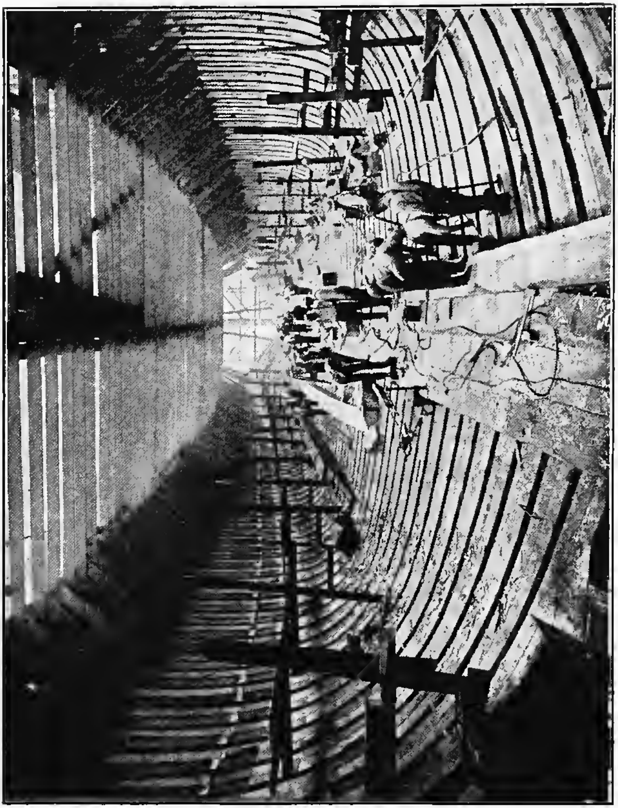


Figure 83.—Another View of Keelson and Timber Chute.

are let into the outside of the frames and inclined at an angle of 45 degrees each way.

The diagonals are connected to the top belt by two 7/8-inch rivets and at each crossing by one 1-inch rivet, and also fastened to each frame timber by one 1-inch countersunk bolt. They should be carried well down and wrapped around the bilge far enough to overlap the ends of the floor timbers.

The iron straps should be painted with two coats of red lead and oil before planking.

CHAPTER VIII

PLANKING AND FINISHING

Layout of the Ship.—Before going into the details of planking it will be well to refer to the

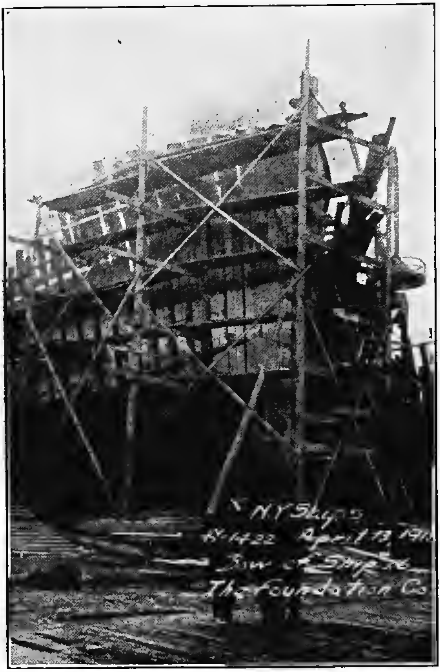


Figure 84.—Bow of Ship Ready for Planking.

illustrations to get the general layout of the ship before planking and in the finished state.

Figure 84 shows the bow of a ship ready for planking. Figure 85 shows the same bow planked, with the staging still in position. Figure 86 is a closer view of the details of the bow construction.

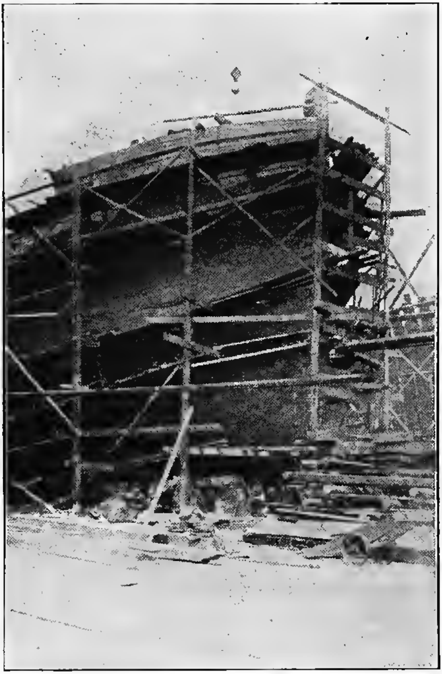


Figure 85.—Bow of Ship Planked, Showing Staging.

Preparations for Planking.—Figure 87 shows the starboard side of the ship ready to plank. Note the escaping steam, showing the location of the steam box used in bending the planking. Figure 88 shows the ship partially planked. In Figure

89 it is completely planked just before launching, and in Figure 90 the finished ship is seen after launching.

Material.—The planking and ceiling throughout is made of yellow pine lumber. The ceiling is put

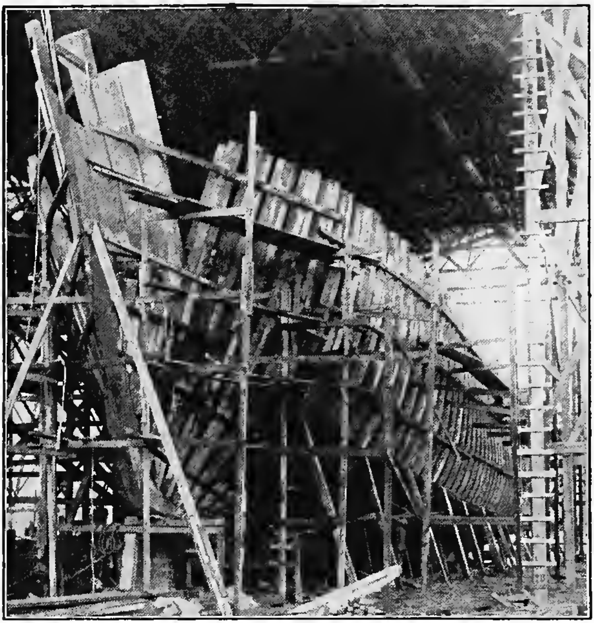


Figure 86.—Close-up View of Ship, Showing Detail of Bow Construction.

in in lengths 30 to 50 feet long, and the planking in lengths 24 to 40 feet, averaging 32 feet long. The bottom planking is 5 inches thick and 14 inches wide, bilge planking 6 inches by 10 inches, the planks narrowing as they reach up the side of the

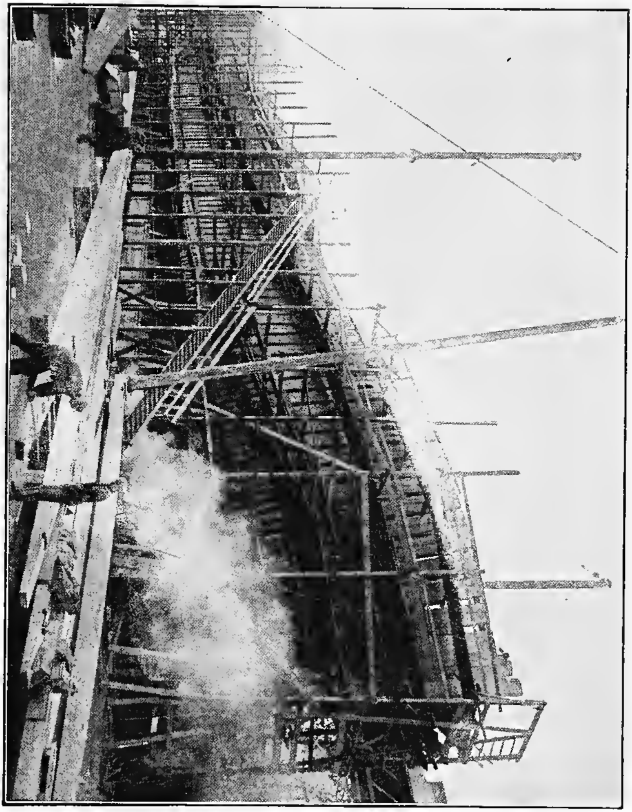


Figure 87.—Wooden Ship Framed Up Complete, Ready for Planking.

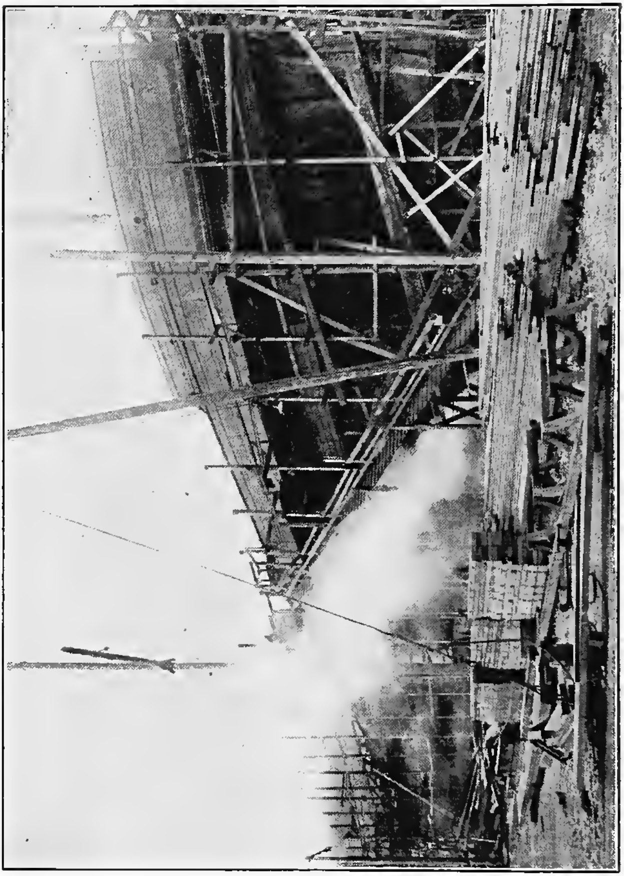


Figure 88.—Partially Planked.

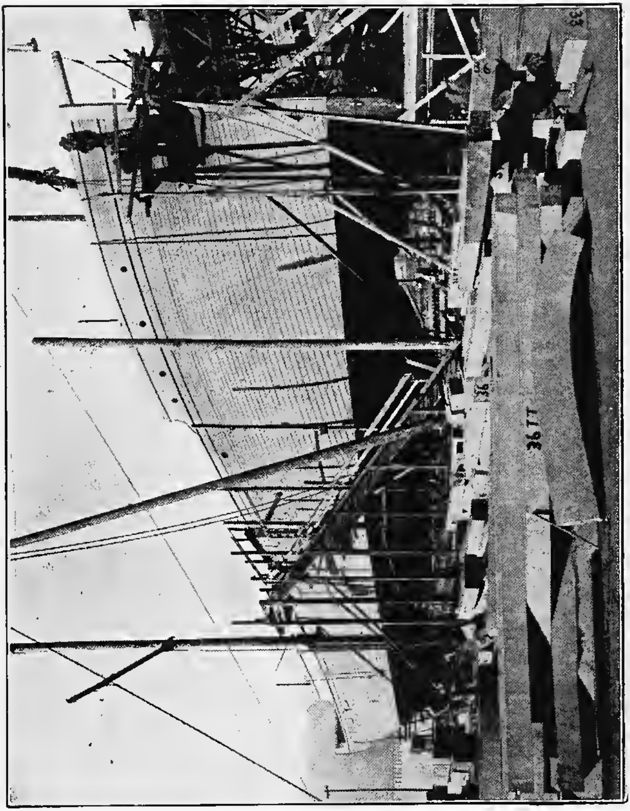


Figure 89.—Planked Ready for Launching.

ship, beginning with 5-inch by 10-inch, then 5-inch by 9-inch, and 5-inch by 8-inch, the topside planking being 6-inch by 9-inch.

The lengths of the planking are jointed with square butts on the frames, with the seams out-gauged for calking.

The circle of the stern between the knuckle line and poop deck is planked vertical, as shown in Figure 91.

Figure 92 shows the interior construction of a standard wooden steamship, looking aft. Figure 93 gives a close-up view of a framing platform.

Steam Box.—The steam box for bending the ceiling planks is located inside the ship, while the boxes for bending the outside planking are located at the head of the ship or the most convenient place possible.

The steam boxes are made in lengths about 8 feet long and about 30 inches square inside the box. A number of these lengths are bolted together to get any length of steam box desired.

The timbers are cut to the required shape before steaming them. All joined surfaces throughout the construction of the hull should be treated with a wood preservative before installing.

Clamps and Wedges.—When ready to install, one end is fastened and held in position by a clamp, and as the plank is bent in position, a hook is fastened around the frames at intervals and a short timber is placed between the hook and the outside of the planking. Wedges can then be driven to

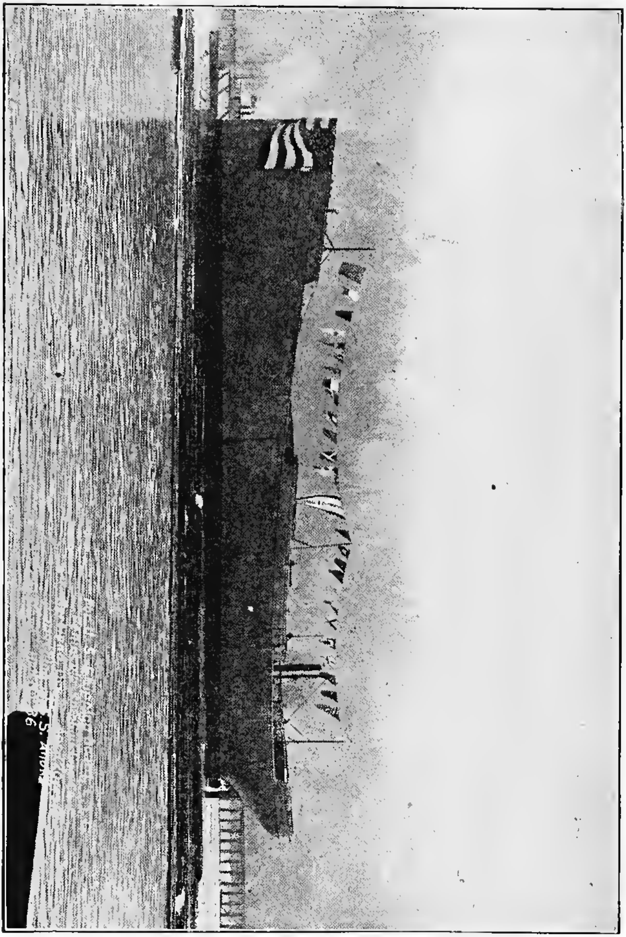


Figure 90.—The Finished Ship.

bring the planking up tight against the frames. These hold it in position until fastened, when the wedges are removed.

The garboard strake is fastened to each frame

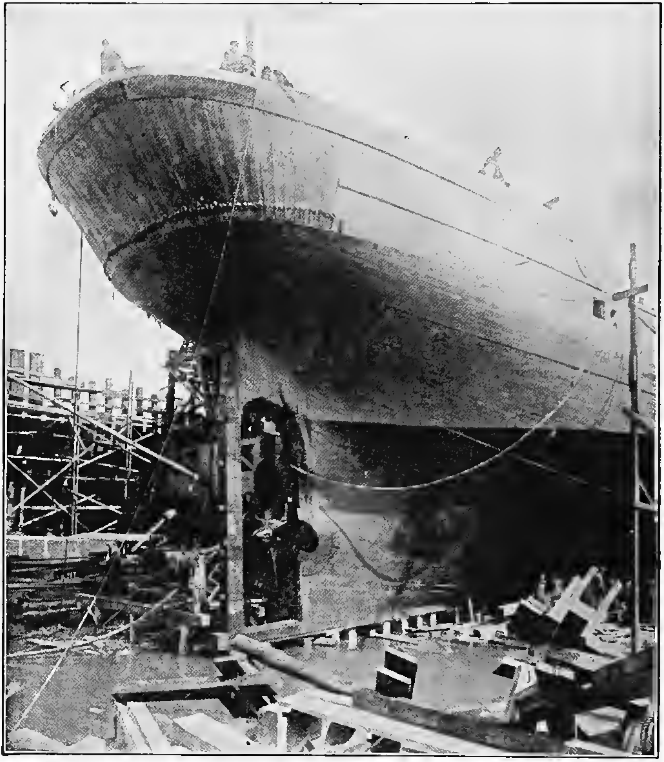


Figure 91.—Stern of Ship, Showing Vertical Planking.

with four 1-inch bolts 18 inches long, and edge bolted to the keel with 1″ by 36-inch bolts every second frame spacing.

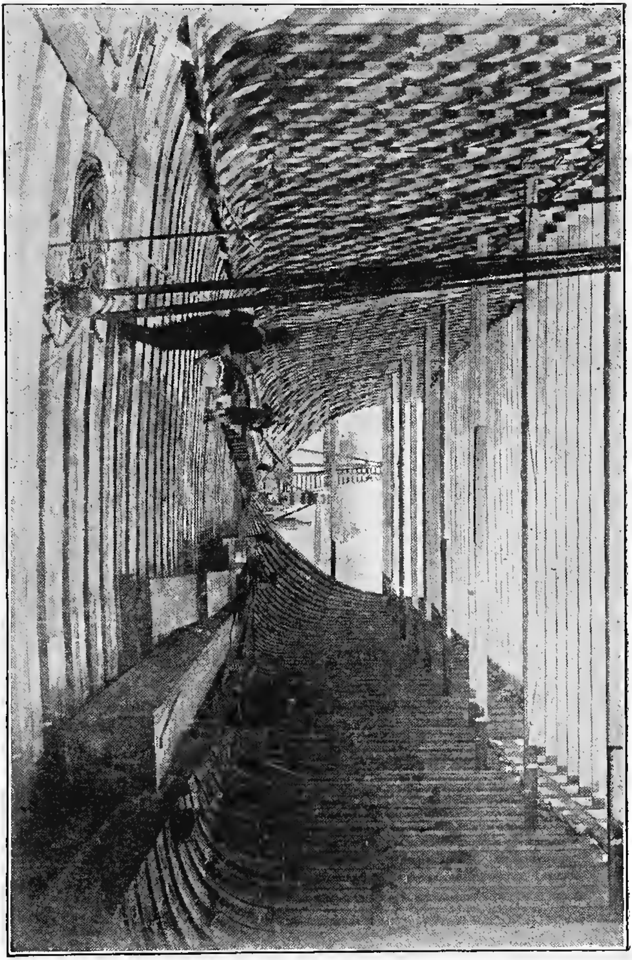


Figure 92.—Interior of Hull, Looking Aft.

Bottom, Bilge, and Side Planking.—The bottom, bilge, and side planking is fastened with 5/8-inch bolts driven over clinch rings. These rings should

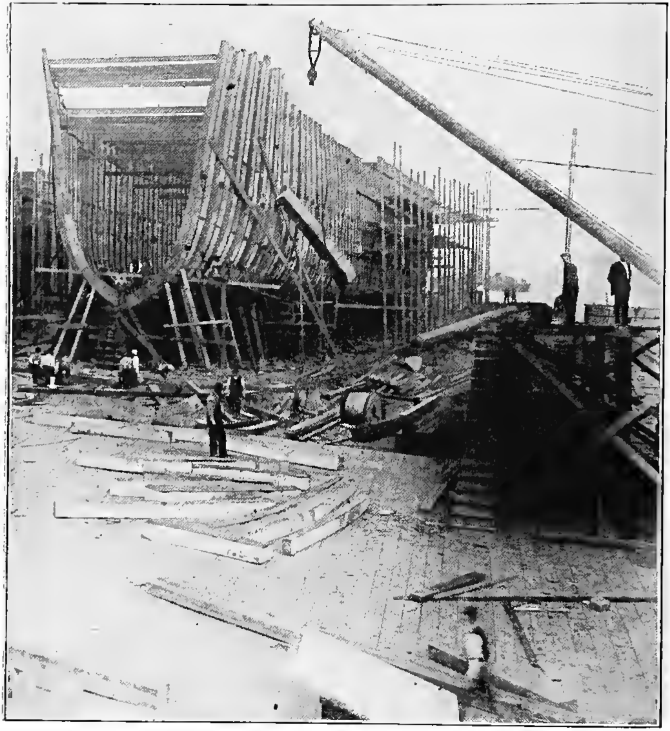


Figure 93.—View of Framing Platform.

be countersunk and the holes plugged, with the grain of the wood running in the same direction as the grain of the wood in the planking.

In addition to the bolts the wide planks have four treenails in each frame and the narrow planks two treenails, all driven in full length, wedged on outside of planking and inside of ceiling with oak wedges.

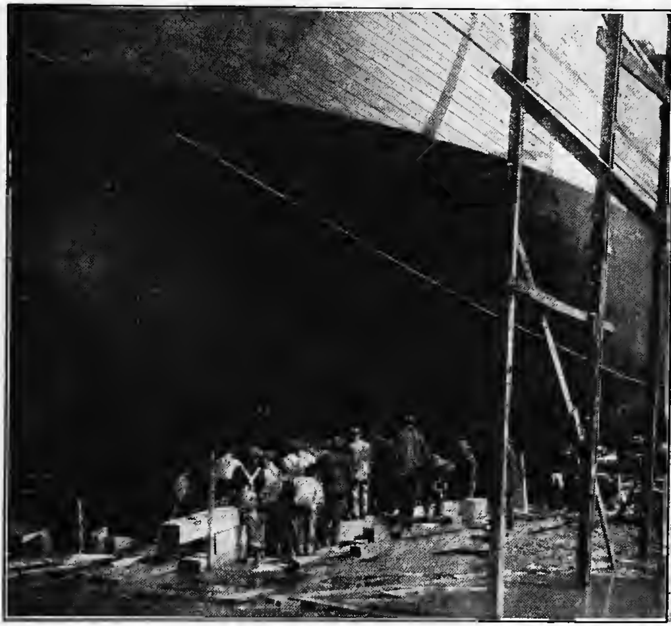


Figure 94.—Ready to Launch.

The wedges are placed across the grain of the wood through which they are driven. The holes for the treenails are bored with long, power, ship auger bits.

The head of each treenail is protected with an

Figure 95.—Framing the Poop Deck.

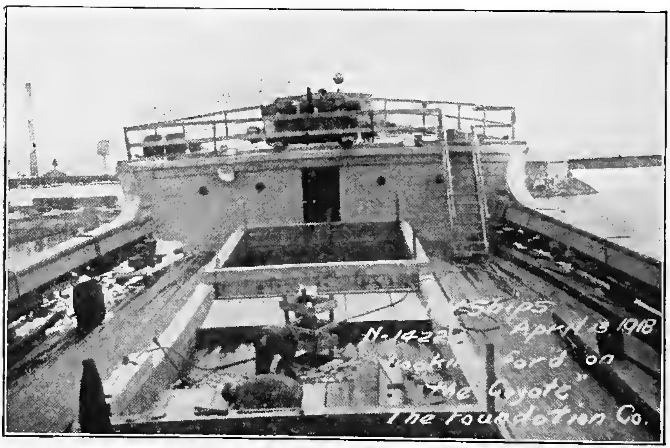


Figure 96.—Poop Deck Completed.

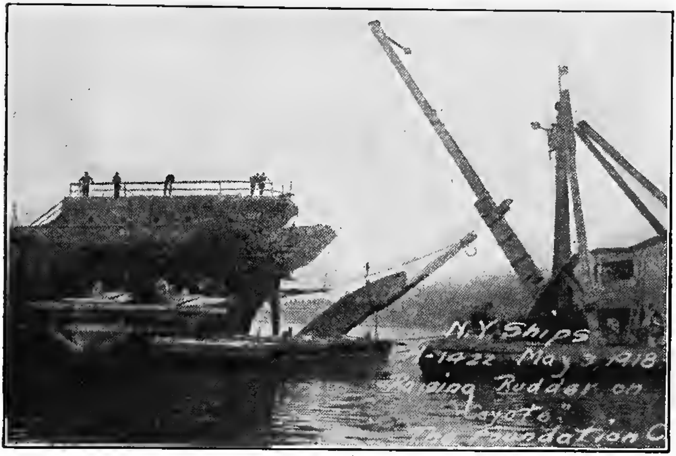


Figure 97.—Raising the Rudder.

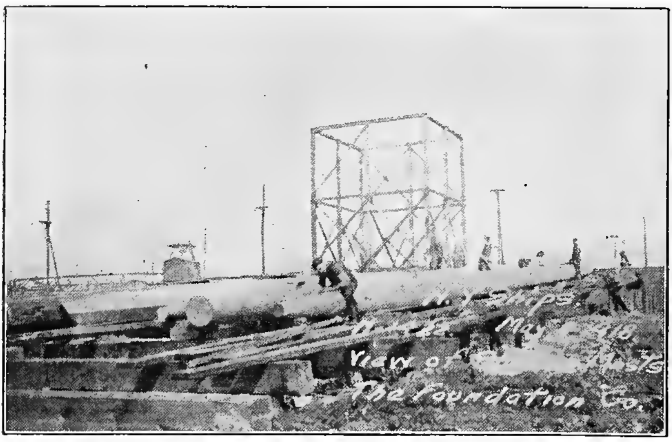


Figure 98.—Shaping the Masts.

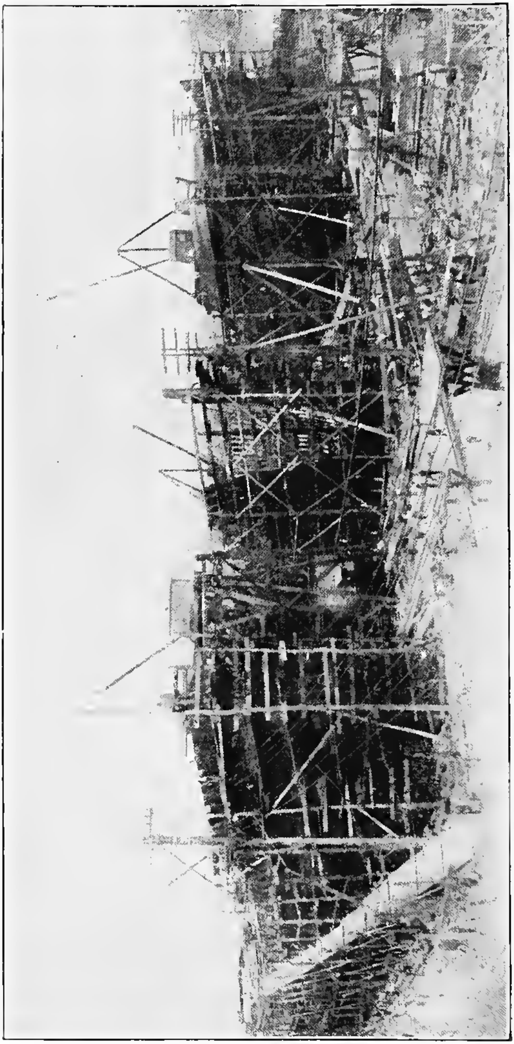


Figure 99.—Panoramic View of a Prominent Shipyard on the Atlantic Coast

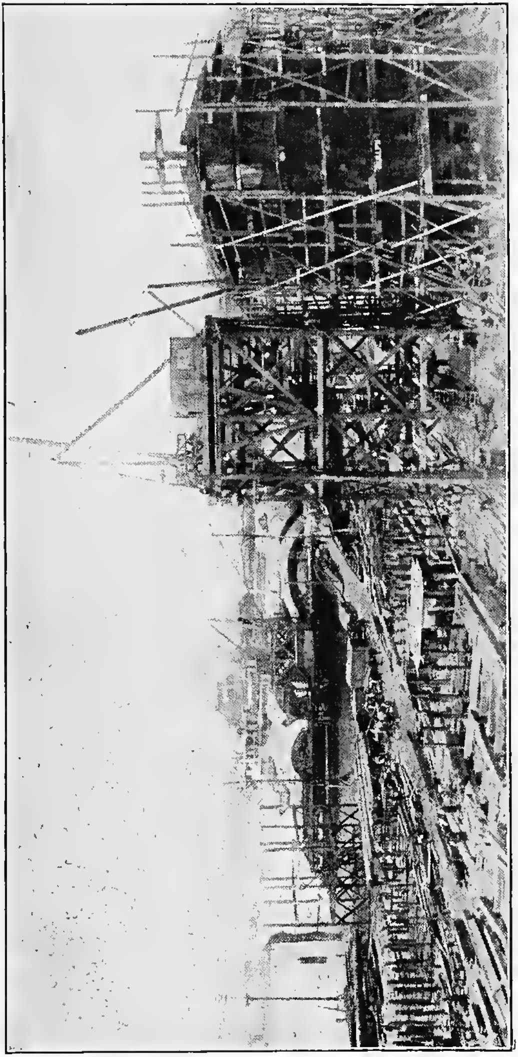


Figure 100.—Continuation to the Left of Shipyard Scene in Figure 99.

iron cap to take the blow of the sledge while being driven in, to prevent it from splitting.

After the planking is fastened, the outer surface is rounded to conform to the shape of the vessel and joined so as to properly take the paint.

Calking.—The seams in the hull are opened up with a dumb-iron where it is necessary to enlarge them to make room for the oakum. Beginning with the garboard, which should be calked with at least eight threads of oakum, the number of threads is reduced up to the five-inch planking, which should be calked with at least four threads of oakum, double horsed. The oakum is kept in the store room as it comes in bales, and is spun into threads for the calkers.

Cementing Seams and Painting.—The outside planking seams up to the 18-foot water line should be filled with cement, and the remainder of the outside seams painted with a white-lead paint and linseed oil.

The bottom of the vessel is painted with three coats of copper paint up to the light water line, and above the light water line a priming coat and two coats of pure lead and linseed oil.

As soon as the hull is completed the vessel can be launched, thus releasing the ways for the laying of another keel. The hull is then turned over to the shipfitters to complete. Figure 94 shows the hull of the vessel just before launching.

Shipfitting.—Most of the difficult technical problems arising in ship work are found in the con-

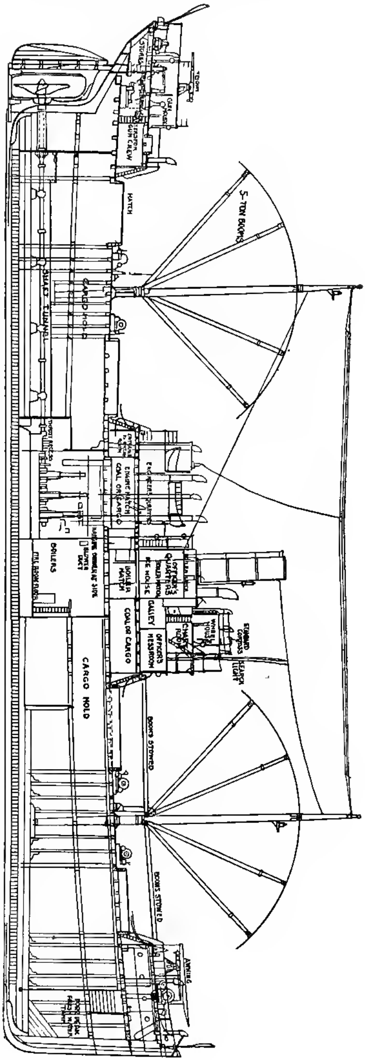


Figure 101.—Inboard Profile of Standard Wood Steamship for the U. S. Shipping Board.

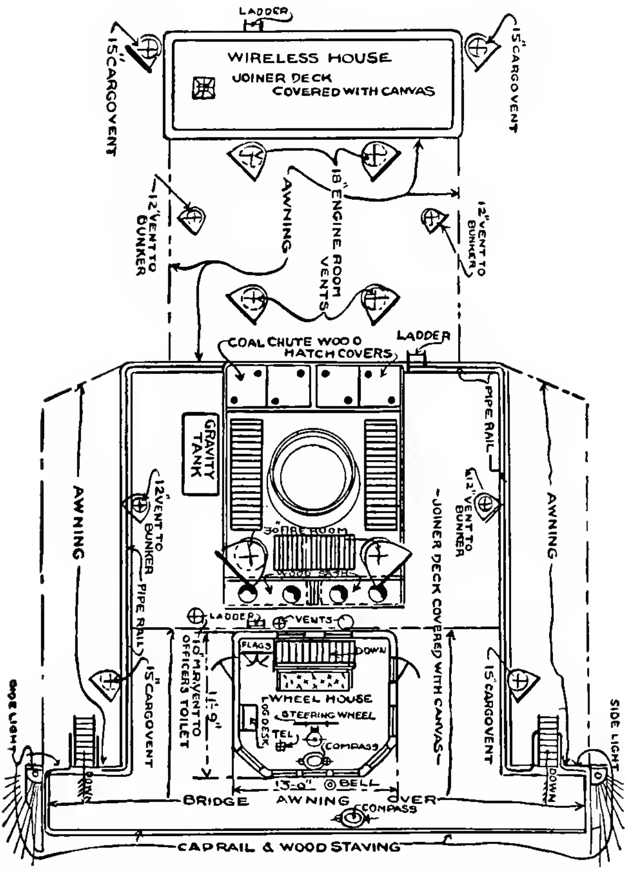


Figure 102.—Wheel House and Navigating Bridge

struction of the hull. When the shipfitters take charge, as is shown in Figure 95, framing the poop deck, the work takes on the nature of house construction, with the ordinary problems that may confront the average carpenter. Figure 96 shows the poop deck completed.

Raising the Rudder.—The methods employed in getting out the rudder stock have been shown in Figures 66, 67, and 68. Figure 97 shows the method of raising the rudder in position.

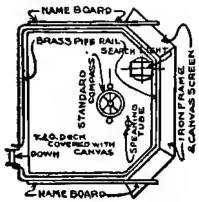


Figure 103.—Top of Wheel House.

Shaping the Masts.—Each ship (standard carrier) is fitted up with two wooden pole masts, fitted with cargo booms. Figure 98 shows the shaping of the masts. These masts were completely shaped by hand, the rough cuts being made with an adze and finished with a hand plane.

Shipyards and Ways.—Figures 99 and 100 give a panoramic view, taken June 12, 1918, of a prominent shipyard on the Atlantic Coast. Five ships are seen in course of construction and five ways are shown to the left of Figure 100, which is a continuation to the left of the view in Figure 99.

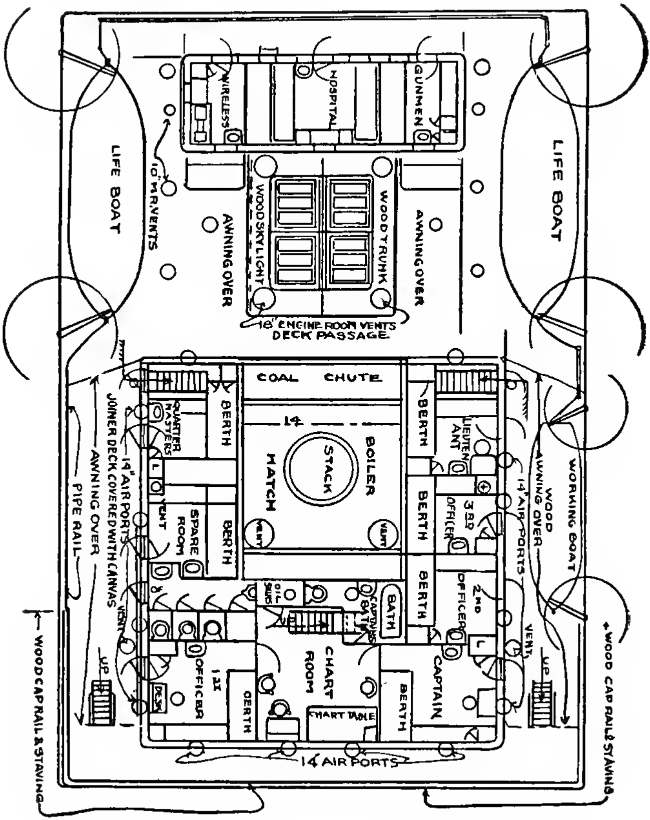


Figure 104.—Boat Deck, Standard Wood Steamship.

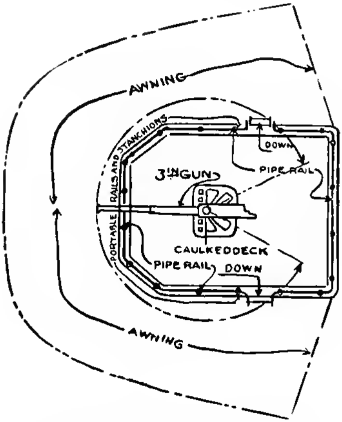


Figure 105.—Top of Gun House.

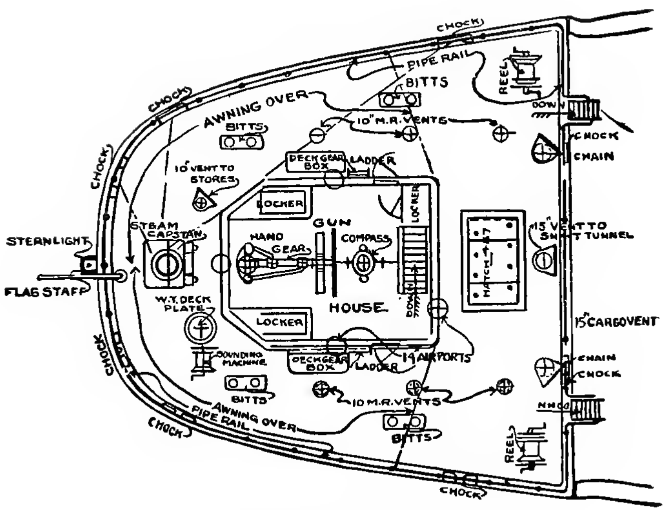


Figure 106.—Poop Deck.

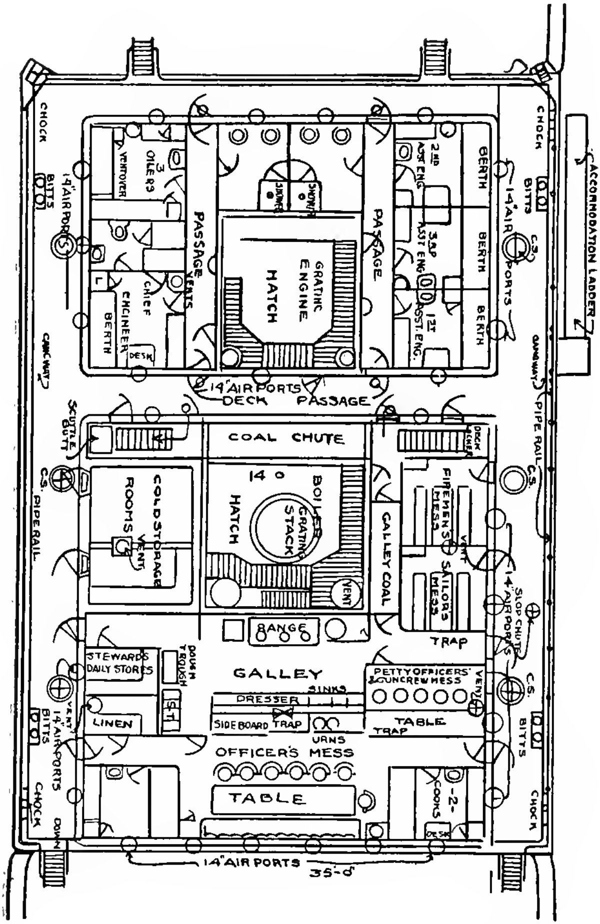


Figure 107.—Bridge Deck, Standard Wood Steamship.

This makes a total capacity for ten ships. In the distance is seen the fitting-up wharf, showing a ship with the painted camouflage effect, or protective coloring adopted for use in wartime.

STANDARD WOOD STEAMSHIP

Plans and sections of the standard wood steamship built for the United States Shipping Board,

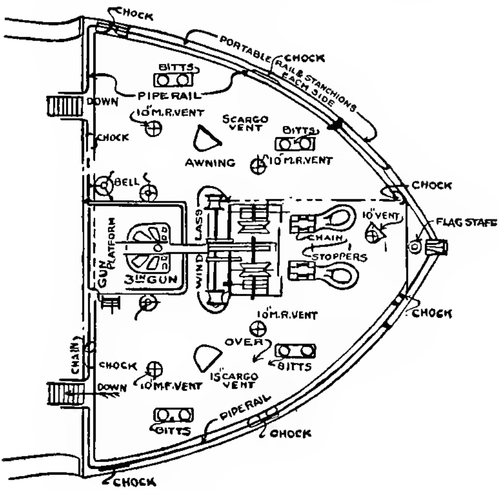


Figure 108.—Forecastle Deck.

Emergency Fleet Corporation, are shown in Figures 101 to 111 inclusive. An inboard profile of the ship is seen in Figure 101, and the arrangement of the decks and numerous other details appear in the remaining illustrations. Figure 102 shows details of the wheel house and navi-

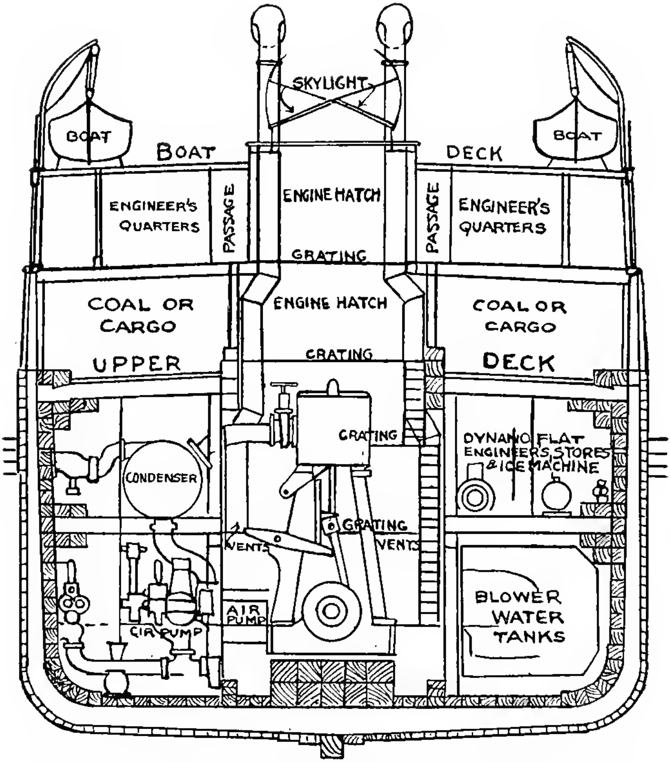


Figure 109.—Section Through Engine Room, Looking Forward.

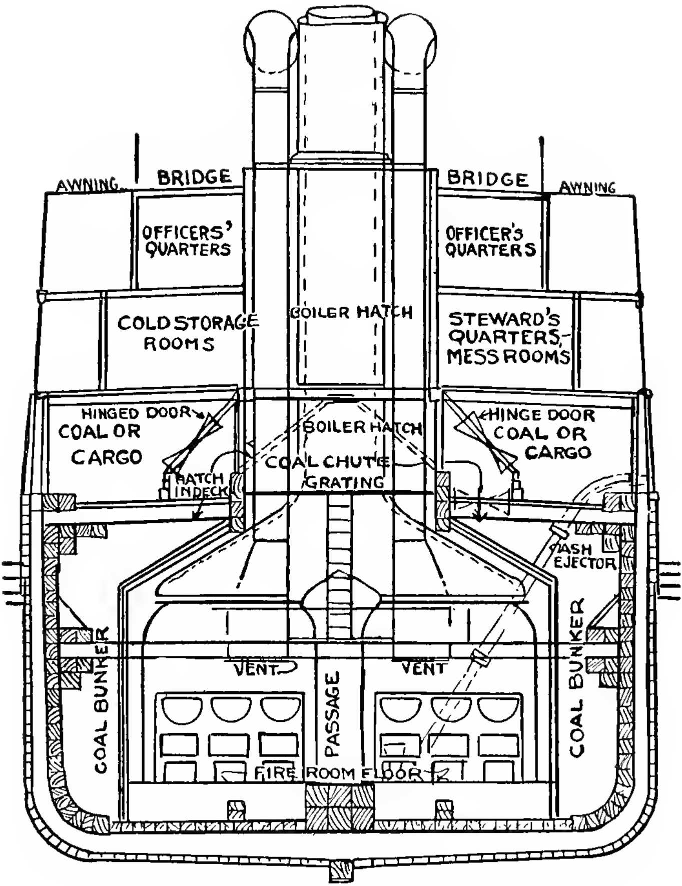


Figure 110.—Section Through Boiler Room, Looking Aft.

gating bridge, and Figure 103 the top of the wheel house. The layout of the boat deck is seen in Fig. 104, and the top of the gun house in Figure 105. Figure 106 shows the poop-deck arrangement, and Figure 107 the bridge deck. The forecastle

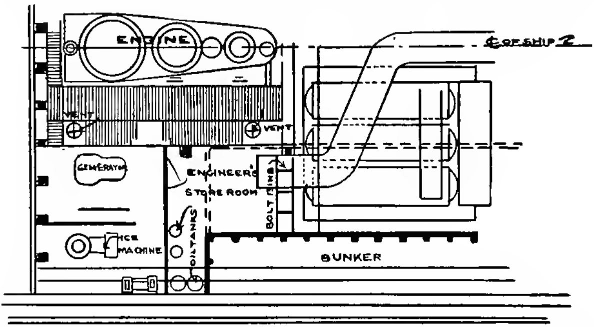


Figure 111.—Plan View at Dynamo Flat and Engineer's Store Room.

deck plan appears in Figure 108. Figure 109 shows a section through the engine room, looking forward, and Figure 110 a section through the boiler room, looking aft. Figure 111 is a plan view at the dynamo flat and the engineer's store-room.

CHAPTER IX

HAND TOOLS

Among the special hand tools used in wooden boat and ship building, the most important are the *adze,* the *broadaxe, calking irons,* the *calking mallet,* and *ship auger bits.* A description of each of these and their respective uses is given below.

A complete list of the hand tools used by the ship carpenter and boat builder is as follows:

Adze—lipped

Axe—plain broad

Bevel—ship carpenter's

Bits—
- extension
- screwdriver (large and small)
- ship auger with spur ¼″ to 1″

Brace—ratchet

Burr set

Calking irons

Calking mallet

Chisels—
- Cape
- cold
- slice, 2½″
- wood, ¼″ to 2″

Dividers

Draw knife

Gauges—
- marking
- wood, ¼″ to 2″

Hammers—
- ball pein
- claw

Oilstone

Pinch bar, 20″

Planes—
- baller, for hollowing plank
- bilge, for smoothing side of hull
- compass
- fore
- jack
- rabbet
- smoothing

Pliers—end cutting

Plumb bob

Rasp—wood

Reamers—wood, ½″ to 1½″

Saws—
- compass
- cross cut
- hack
- panel
- rip

Spirit level

Spoke shave

Squares—
- large steel
- small try square, 7½″

Adze.—Figures 112, 113. The adze is a tool resembling a hoe and is used in much the same manner for shaping large parts where the wood to be removed is too much for the chisel or the plane. The lipped adze has the extreme ends of the blade turned up and is by far the best kind, as these lips insure a clean cut and prevent raising splinters. For the best results the cutting should be across the grain. See Figure 114.

For converting large material when machinery is not available, the roughing is done with a broad axe; the adze is next used to get close to the finish dimensions, and then the work is smoothed up with a plane.

Broad Axe.—Figure 115. This axe differs con-

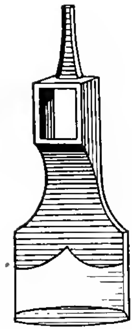


Figure 112.—Plain Adze.

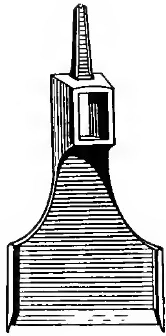


Figure 113.—Lipped Adze.

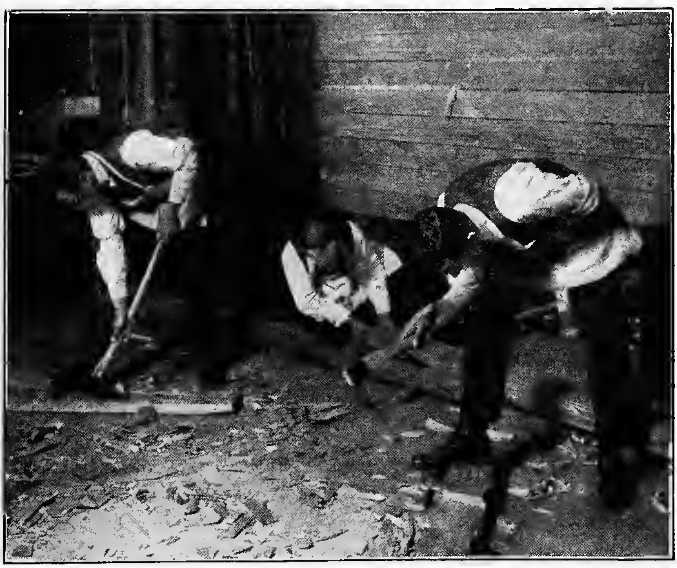


Figure 114.—Scarfing Timber with an Adze.

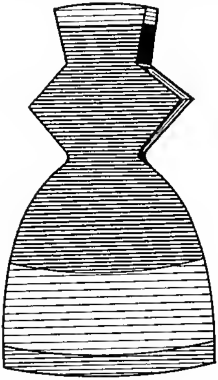


Figure 115.—Broad Axe.

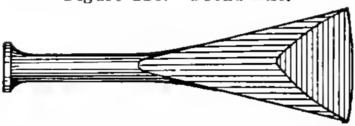


Figure 116.—Dumb or Deck Iron.

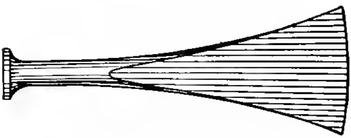


Figure 117.—Calking or Making Iron.

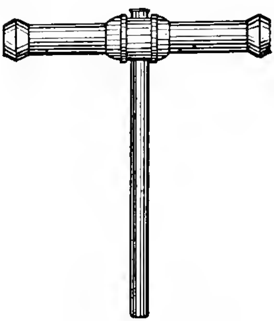


Figure 118.—Calking Mallet.

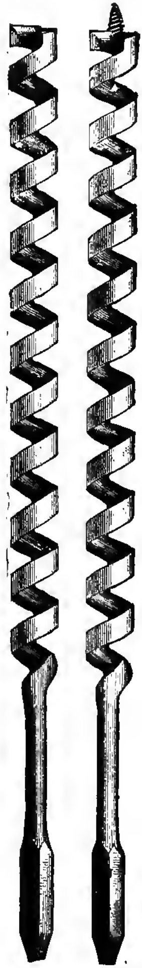


Figure 119.—Ship Auger Bits.

siderably from the ordinary axe used for chopping. The blade is wide and is sharpened by beveling one side more than the other, somewhat like a chisel. Both blade and handle are offset, the whole form and hang being adapted to hewing on the side of large pieces of timber.

Calking Irons.—These are made of steel in various shapes and sizes. The two in general use are the dumb-iron (Figure 116), which has a tapered blade almost sharp, and the making-iron (Figure 117), which has a small blunt end with a channel in it, used for going over the cotton in the seams after it has been driven in by the driving-iron. The dumb-iron is employed to open the seams that are too tight.

Calking Mallet.—Figure 118. This is a tool used in connection with calking irons for driving cotton or oakum into the seams, to make them watertight. The head, which is long and small in diameter, is usually made of live oak and fitted with iron rings to add weight and prevent splitting. Several sizes are made, the smallest being suitable for boat work.

Ship Auger Bits.—Figure 119. These are used for boring long holes. They are of different shapes and are made with and without the feed screw, or spur. Those without the spur, sometimes called "barefooted," are preferred for very long holes, as they are not so readily deflected from a straight course. The commercial bits are often too short, but it is a small job for a blacksmith to weld in a piece, making any length required.

CHAPTER X

WOODEN BOAT AND SHIP TERMINOLOGY

After-timbers.—The timbers abaft the midship section of a vessel.

Air-port.—An opening in a ship's side for air, closable by a shutter, sidelight, or deadlight.

Apostle.—A knighthead or bollard-timber on a deck, for belaying hawsers and heavy ropes.

Apron.—An upper member of the stem on the inboard side of a boat.

Arch-board.—The part of the stern over the counter, under the knuckles of the stern timbers.

Auger-bit.—A boring-bit with a twisted shank, which clears the chips out of the hole.

Balance-frames.—Those frames of a ship which are of equal area and equally distant from the ship's center of gravity.

Balcony.—The stern gallery of a ship.

Batten.—A thin strip of wood used in fairing lines.

Beak.—The part of a ship forward of the forecastle, fastened to the stem and supported by the main knee.

Beam.—One of the curved transverse timbers of a vessel, supporting a deck.

Beam-line.—The line indicating the intersection of the top of the beams with the frame.

Bearding-line.—The line made by the curved surface of a ship's skin with the stem, keel and stern-post.

Bend.—One of the strong planks on a vessel's sides to which the beams, knees, and futtocks are bolted.

Bending-strakes.—Two strakes worked near the coverings of the deck, running fore and aft a little thicker than the rest of the deck, and let down between the beams and ledges so that the upper side is even with the rest.

Bevel.—Any angle in a timber except one of 90 degrees.

Beveling.—The angles which the sides and edges of each piece of a frame make with each other.

Beveling-edge.—The edge of a ship's frame which is in contact with the skin.

Bilge.—The flat portion of a ship's bottom, or the point at which the frames turn from the bottom to the sides.

Bilge-planks.—Strengthening planks of the inner or outer skin, at the bilge.

Bilge-way.—The foundation of the cradle supporting a ship upon the sliding-ways during building and launching.

Binding-strakes.—Thick strakes, planking, or wales, at points where they may be bolted to knees, shelf-pieces, etc.

Body-plan.—An end elevation of a hull, showing the water lines, buttock and bow lines, diagonal lines, etc.

Bolt-strake.—The strake or wale through which the beam fastenings pass.

Bow-lines.—Curves representing vertical sections of the bow end of a ship.

Break.—An abrupt change of level, as of a deck. The *break* of a poop-deck is where it ends forward.

Bridge.—A partial deck running from side to side of a vessel amidship.

Building-block.—One of the temporary structures resting upon a slip and supporting the keel of a ship while building. They consist of blocks of timber so arranged as to be removable by knocking out the key-pieces or wedges.

Building-slip.—A yard prepared for shipbuilding. It includes one or more *slips,* or inclined planes on which a vessel in its cradle is supported while on the stocks in the process of construction, or upon which a ship is hauled for repair.

Bulge.—The flat portion of a ship's bottom; the bilge.

Bulkhead.—A partition in a ship which divides the interior space into compartments, which may be made watertight. The bulkheads affording the greatest protection are those placed a few feet from the stem and stern respectively, the forward one checking the inflow of water through a damaged stem, and the after one averting the danger of any accident that might arise to the sternpost or rudder-braces, or to the tube of the shaft of screw-vessels. The water taken into these compartments would only slightly impede the way of the ship by throwing her out of trim, as the quantity would be comparatively small. The bulkheads more amidships assist in strengthening the vessel, and serve to prevent fire from spreading beyond the compartment in which it started. In case of a leak they confine the water to the compartment which it enters. Watertight bulkheads have been used for ages in Chinese shipbuilding, but in this country are more generally employed in iron than in wooden vessels. In small vessels they can only be used transversely, but in larger ones they may be applied longitudinally as well.

Butt.—The meeting joint of two planks in a strake. The joint between two strakes is a *seam*.

Buttock.—The rounded-in, overhanging part on each side of a ship's stern in front of the rudder. It terminates below by merging into the *run*.

Buttock-lines.—The curves shown by a vertical longitudinal section of the after part of a ship's hull, parallel to the keel. A similar section forward shows the *bow-lines*, and a continuous section through the whole length of the ship exhibits the buttock and bow lines.

Calking.—The process of filling the seams between the planks of vessels, and of spreading the ends of the treenails, by driving in cotton or oakum, to make the seams watertight. Oakum is made by cutting old ropes and cables into short lengths called *junk* and picking that to pieces. The seam is opened with a dumb-iron or deck-iron, driven with a calking mallet, and the threads of oakum driven in, one after another, with a calking iron or making iron. It is then payed with melted pitch.

Camber.—A curvature upward, like the rise or crown of a deck amidships, or of a bridge or a beam; the curve of a ship's plank. This shape is given to increase stability.

Cant.—An angle, bevel, or slope.

Cant-frames.—Bow and stern frames canted from vertical position for the purpose of eliminating greater bevels.

Cant-timber.—A ship timber that is not square with the keel, or that makes an angle with the keel of less than 90 degrees.

Cat-beam.—The longest beam in a ship; the beak-head beam.

Ceiling.—That portion of the inside skin of a vessel between the deck-beams and the limber-strakes on each side of the keelson. It is also called the *foot-waling.* The strakes of the ceiling immediately below the shelf-pieces which support the deck-beams are called *clamps.* The outside planking is called the *skin.*

Center-line (*C. L.*).—The central, longitudinal, vertical section of a vessel's hull.

Chain-plate.—One of the plates of iron bolted below the channels, for the attachment of the dead-eyes to which the shrouds and backstays are secured.

Channel.—A corruption of *chain-wale.* A flat ledge of wood or iron projecting outward from the ship's side, for spreading the shrouds or standing rigging at each side of the masts, and protecting the chain-plates. The channels are at the level of the deck beams.

Chock.—1. A block, usually wedge-shaped, driven behind the props of a cradle to prevent it from slipping on the ways before the ship is ready to launch.

2. A piece of timber, framed into the heads and heels of a ship's timbers at their junctions, to act as a lap to the joint and make up the deficiency at the inner angle, as in the stem-piece and the main piece of the head; also in the deadwood, etc.

Clinker-built.—A term applied to boats in which the lower edge of each plank overlaps the one next below it, like the weather-boarding of a house, or the shingles or slates of a roof. In such boats the lower edge of each strake of plank overlaps the upper edge of the next strake below. They are not built upon frames, but upon temporary transverse sectional moulds, two, three, or four in number, which are fixed at their proper stations on the keel. The strakes are then put on, beginning with the garboard strake, and bent to the figure given by the moulds. Each strake is fastened to the next below it by nails, driven from the outside through the laps or *lands*, or by screws. When two or more lengths of plank are used in a strake, they are scarfed to each other, the outside lap of each scarf pointing aft.

Coal-bunker.—One of the spaces provided in a ship, convenient to the furnace-room, for keeping the fuel.

Coamings.—Also spelled *combings.* The raised border or frame of a hatchway, to prevent the water on deck from flowing below. The fore and aft pieces of a hatchway frame are *coamings,* those athwart ship are *head-ledges.* The former rest on *carlings,* which extend from beam to beam, and the latter rest on the deck beams.

Companion.—A wooden covering over the stairway to a ship's cabin; a companion-hatch. The staircase is the companion-ladder, or companion-way.

Counter.—That part of a ship's stern which hangs over the stern-post. The counter-timbers spring from the *wing-transom,* which extends across between the *fashion-pieces,* crossing in front of the stern-post, near its head. At the top of the counter-timbers is the *taffrail.*

Cradle.—The frame in which a ship lies on the ways, and which accompanies her into the water in launching, separating from the ship by the act of floating. In its simplest form, the cradle consists of three longitudinal timbers, united by ribs or crosspieces. It is also used in hauling out a ship for repairs.

Cross-beam.—A beam in a frame laid crosswise.

Cross-spalls.—Cross timbers uniting the heads of two futtocks.

Cutwater.—The forward edge of the stem or bow of a vessel; that which divides the water right and left. It is fayed to the forepart of the stem.

Deadwood.—The lower member of the stem or stern on the inboard side of a boat; also the solid mass of built-up timbers at the narrow portions of the extremities of a ship's frame, fore and aft, above the keel, and continued as high as the *cutting-down* line. In vessels designed for service in arctic waters, the deadwood is in unusual quantity, to give solidity to a structure liable to contact with ice-floes and drifts.

Dead-works.—The parts of a vessel above the load water line.

Deck.—Any floor in a ship above the bottom of the hold. Decks may run from stem to stern, or be only partial. In three-decked ships the decks above the water-line are known as the upper, main, and lower decks. The deck next below the water-line is known as the orlop deck. The upper may be known as the spar deck, with the forecastle as its foremost part and the quarter deck aft. The *waist* is the space amidships. A transverse deck extending across the middle of the vessel is called either a hurricane-deck, a bridge-deck, or the bridge. Detached structures on a deck are called deck-houses.

Deck-transom.—A horizontal timber under a ship's counter.

Diagonal.—1. A timber brace, knee, plank, truss, etc., crossing a vessel's timbers transversely.

2. A line cutting the body plan diagonally from the timbers to the center line.

3. An oblique brace or stay connecting the horizontal and vertical members of a truss or frame.

Diagonal-built.—A term applied to boats in which the outer skin consists of two layers of planking making angles of about 45 degrees with the keel in opposite directions. Such boats are built, like clinker-built boats, upon temporary transverse moulds. After setting up and fixing the moulds upon the keel, the gunwale, a shelf-piece, and a series of ribbands are temporarily fixed in the moulds. Two layers of planking are then put on, bent to fit the moulds and ribbands, and fastened to each other and to the keel, stem, sternpost, shelf, and gunwale with screws or nails, driven from the outside, and clinched inside upon small rings, called *clinch-rings* or *roves*. The gunwale is then shored, to keep it in shape. The moulds and ribbands are taken out, and floors, thwarts, etc., are put in as in a clinker-built boat.

Diagonal-lines.—Lines showing the boundaries of various parts, formed by sections which are oblique to the vertical longitudinal plane, and which intersect that plane in straight lines parallel to the keel.

Displacement.—The weight of water displaced by a vessel floating in it, this weight being equal to the weight of the ship.

Diminishing Stuff.—Planking worked under the strakes and thinned to correspond with the thickness of the bottom plank.

Dog-shore.—One of the two struts which hold the cradle of the ship from sliding on the slip-ways when the keel blocks are taken out. The lower end of each dog-shore abuts against the upper end of the ribband of the slip-way, and the upper end against the *dog-cleat,* which is bolted to the side of the bilge-way. Beneath each dog-shore is a small block called a *trigger.* In launching, the triggers are removed, the dog-shores knocked down, and the ship-cradle freed, so that, carrying the vessel, it slides down the slip-ways. A time-honored signal for launching is "Down dog-shores!"

Double Futtocks.—Timbers in the cant-bodies extending from the deadwood to the run of the second futtock-head.

Drift-piece.—One of the upright or curved pieces of timber that connect the plank-sheer with the gunwale.

Dubbing.—Dressing a timber smooth with the adze.

Entering-port.—A port or opening cut in the side of the vessel to serve as a door of entrance.

Expansion.—The expansion of the skin of a ship, or rather of a network of lines on that surface, is a process of drafting to facilitate the laying-off of the dimensions and positions of the planks of which that skin is to be made.

Fair.—To make in true curves or proportions;

to make regular, true, smooth, or flowing the lines of a boat or ship.

False Keel.—A set of timbers worked onto the main or true keel out-board, and intended to prevent leeway, also to protect the true keel in case of grounding.

Fay.—To fit close together, as two pieces of wood or timber.

Faying Surface.—The face or end of a piece of timber which joins another similar surface so closely as to leave no interstice.

Filling.—Pieces of material or a composition fitted in between the frames of the hold, to increase the watertightness, resist conpression, and prevent the accumulation of dirt, bilge-water, and vermin. Blocks of wood, bricks, mortar, cement, and asphalt have been used.

Flat.—One of a number of ship's frames of equal size and forming a straight middle body; also a timber which has no curves, as the floor-timbers of the *dead-flat* amidships.

Floor.—The bottom part of the hold on each side of the keelson; the flat portion of a vessel's hold.

Floor Timbers.—Cross timbers uniting the heels of two futtocks.

Flush Deck.—A deck running the whole length of the ship, from stem to stern, without forecastle or poop.

Forecastle.—(Pronounced fōke'sl.) The part of a ship forward of the foremast; a forward part of the space below decks, for the accommodation of seamen; in flush decks, a part of the upper deck forward of the after fore shroud; or a short upper deck forward.

Forefoot.—The forward end of a vessel's keel, on which the stem-post is stepped.

Fore-hook.—A strengthening piece in the stem, binding the bows together; also called a breast-hook.

Foremast.—The mast nearest the bow in vessels carrying more than one mast.

Frame.—A built-up rib of a wooden vessel. Two or more futtocks united form a frame.

Frame Mould.—A pattern or template for the frame of a boat or ship.

Freeboard.—That part of a vessel's side which is included between the plank-sheer and the water-line.

Furring.—Double planking of a ship's side.

Futtock.—One of the curved or crooked timbers in a built-up or compound rib or frame of a vessel. A timber of the dimensions and form for a frame of a ship cannot be procured in one piece; the frame is built up of pieces scarfed together. The number required is according to the length of the sections of the requisite height. They are known as the first, second, or third futtock, terminated by the top-timber. The term futtock is also applied to the complete half of a frame.

Futtock-plank.—The first plank of the ceiling next to the keelson; also called the *limber-strake.*

The first plank of the skin next to the keel is the *garboard-strake.*

Gallery.—A balcony projecting from the after part of a ship, as the quarter-gallery or stern-gallery.

Galley.—1. A clinker-built boat for ship's use, from 28 to 36 feet long, rowed by ten or twelve men.

2. The cook-house on board ship, which is on deck or in a forward part of the vessel.

Gangway.—An opening in the bulwarks of a vessel by which persons come on board or disembark.

Garboard Strake.—The row or strake of planks nearest to the keel on the outside of a ship's bottom. The rabbet to receive the garboard strake is made along the upper edge of the keel.

Ground Timbers.—The timbers which lie on the keel and are bolted to the keelson.

Ground-ways.—The large blocks and planks which support the cradle on which a ship rests and is launched.

Gunwale.—The upper planking covering the timber heads around the topside of the ship; also the piece of timber around the topside of a boat, and having rowlocks for the oars.

Half-breadth Plan.—A plan or top view of one-half of a ship divided by a vertical longitudinal section in the line of the keel. It shows the water lines, bow and buttock lines, and diagonal lines of construction.

Half-Floor.—One of the timbers of a frame, the heel of which is over the keel, while on its head rests the heel of the second futtock. It lies for half its length alongside the cross-timber, with the other half alongside the first futtock.

Half-timber.—One of the short futtocks in a cant-frame.

Harping.—A continuation of the ribbands beyond the square frames, moulded to the shape of the hull and used for proper spacing of cants and futtocks. The term harpings is also applied to the plank wales of the bow, which are of extra strength. Also spelled *harpin.*

Hatch.—An opening in a deck or floor, or the covering for the same.

Hatchway.—One of the large rectangular openings in the deck of a ship by which freight is hoisted in or out, and access is had to the hold. The coverings are *hatches,* and these are fastened down by *battens.* There are four pieces in the frame of a hatchway, including the coamings and head-ledges. The hatchways are called fore hatch, or main hatch, or after hatch, as the case may be, according to the size and character of the vessel.

Hawsehole.—A hole in the bow through which a cable or hawser may be passed. In large ships the hawseholes are four in number.

Hawse-piece.—One of the cant-frames standing next to the knightheads, and fitted close together, so as to form a solid mass of timber for the passage of the hawseholes; also a plank or strake on the ship's bow which is pierced by the hawsehole.

Head.—1. The fore part, beak, bow, or stem end of a vessel.

2. The upper part of a timber in a frame. The other end is the *heel.*

3. The forefoot of the keel.

Heel.—The lower end of a timber in a frame; the after end of a ship's keel.

Hog-frame.—A fore-and-aft frame forming a truss in the main frame of a vessel, to assist in giving vertical rigidity to the structure.

Hold.—The interior part of a ship, in which the cargo of a merchant vessel is stored. The portions are distinguished as the fore, main and after holds.

Horn Timber.—A small timber to protect the end of the stern-post and to eliminate end wood.

Hull.—The body of a ship or boat, exclusive of the masts, yards, sails, and rigging.

Hurricane Deck.—A raised platform extending from side to side of a ship, above deck amidships; a bridge or station for the officer in command.

Inboard.—Inside a ship's hull.

Inner Post.—A piece brought in at the fore side of the main post, and generally continued as high as the wing transom to seat the other transoms upon.

Keel.—The lower longitudinal beam or member of the framework of a vessel, serving as the backbone of the entire frame. When a ship is to be built the keel is first *laid*, upon blocks of which the upper surfaces form an angle of about three degrees with the horizon. These are called *keel-blocks* and are usually about three feet high and spaced about four feet apart. White oak is a favorite material for the keel.

Keelson.—A beam running lengthwise above the keel, and bolted to the middle of the floor frames, binding them to the keel, in order to stiffen the vessel.

Knee.—Any one of the angular pieces of timber or iron connecting the beams and the frames of a vessel.

Knighthead.—One of the first cant timbers on each side of the stem, rising obliquely from the keel and passing on each side of the bowsprit, to secure its inner end.

Limber.—A passage on each side of the keelson for bilge water. It is covered by a movable plank called a limber-board, the edges of which rest respectively upon the keelson and the limber strake.

Limber Strake.—The strake of the inner skin of a ship which is nearest to the keelson.

Lines (on a Drawing).—The principal lines of a ship plan or drawing are as follows:

(a). Base Line.—A horizontal reference line from which vertical measurements are taken.

(b). Center Line—A vertical line in the center of the body plan, perpendicular to the base line.

A horizontal line on the half-breadth plan through the center of the vessel.

(c). Diagonals—Lines running diagonally from the center line to frame lines.

(d). Frame Lines—Outlines showing the shape of the frames of the vessel.

(e). Water Lines—Horizontal lines parallel to the base line in the body plan; horizontal lines parallel to the base line in the sheer plan; curved lines in the half-breadth plan.

Lines Plan.—A drawing showing the general outline or form of the vessel. The lines plan comprises three plans:

(a). Sheer Plan—A side view showing the length of the vessel and heights of the sheer or gunwale.

(b). Half-breadth Plan—A top view showing the horizontal or floor plan on any water lines.

(c). Body Plan—An end view showing the curves of the sides or frame lines at any point in the vessel. Frame lines forward of the midship section are on the right of the center line; those aft of the midship section on the left of the center line.

Load Water-line.—The line of flotation of a ship when it has its full cargo aboard.

Loftsman.—A man who lays out and makes moulds for a vessel.

Mast.—A long spar placed amidships, nearly perpendicularly upon the keelson, and serving to support yards, sails, and rigging, or in steam vessels for signaling, hoisting, and other purposes. The lower end, or heel, of a mast rests in a *step* on the keelson.

Mast-hole.—A framed hole in the deck to receive a mast. It is made of larger diameter than the mast by twice the thickness of the wedges which hold the mast in position.

Mould.—A full-size pattern of the same figure and dimensions as the moulding-side of the piece which it represents. The mould may be of skeleton form and may serve for several frames. It is usually a thin plank cut to the form of a ship timber and serves as a template for scribing the members for the workmen, who saw, hew, and adze them into shape.

Moulding.—The depth or dimension (of a piece of timber) which lies in the moulding-plane.

Moulding-edge.—That edge of a ship's frame, which comes in contact with the skin and is represented in the plan. The other edge is the *beveling-edge.*

Mould Loft.—A large open room on the floor of which drawings and moulds of a vessel are laid out full size.

Planking.—The skin, or wooden covering of plank on the exterior and interior surfaces of the ribs or frames, and on the beams of a vessel. A line of planking is a *strake,* and is named from its position, as garboard strake, sheer strake, etc.

Planking-clamp.—A clamp used for bending a strake against the ribs or frames of a vessel and holding it until secured by bolts or treenails.

Plank-sheer.—A plank resting on the heads of the top timbers of the frames or ribs; the gunwale.

Poop.—A short deck built over the after part of a vessel, also called poop-deck; the aftermost, highest part of the hull.

Port.—1. A framed opening in a ship's side, closed by glazed lids, called *sidelights,* or by water-tight shutters, called *deadlights.* An airport is an opening through the side below decks for ventilation.

2. The left side of a vessel to a person standing on deck and facing forward; formerly called *larboard.*

Port-hole.—An embrasure in a ship's side.

Pump-well.—A compartment extending from the ship's bottom to the lower or the upper deck, as the case may be, to contain the pump-stocks, etc.; used to remove bilge water which collects in the limbers, or in the event of a leak.

Quarter.—The side of a ship, aft, between the main channels and the stern.

Quarter-deck.—A deck raised above the waist and extending from the stern to the mainmast in a full-rigged ship.

Rabbet.—The recess cut in the keel, stem, and stern to receive the ends of planking.

Rail.—The top of the bulwarks of a ship. The part continued round the stern is the taffrail.

Rake.—The forward pitch of the stem of a vessel, or the backward slope of the stern, that is, the degree in which it overhangs the keel. The rake of a rudder is that of the stern-post.

Reaming-iron.—A blunt chisel used for opening the seams between the planking of a ship, before calking them with oakum.

Rib.—One of the curved side timbers of a ship or boat, to which the wooden planking and the interior sheathing is treenailed or pinned. These frames are called ribs from their resemblance in form and function to the ribs of the human body. They are fastened to the keel or backbone of a ship in much the same manner as the human ribs are articulated to the spine. For wooden vessels of considerable size, timber of the required dimensions and form cannot be procured to make a rib of one piece, so each rib or frame is made of sections scarfed together. These sections are called *futtocks*.

Ribband.—A temporary lengthwise strip following a vessel's curves and bolted to its ribs on the square body to hold them in place until they receive the planking or plating. A number of these are fastened at different distances from the keel.

Ribband Lines.—Oblique longitudinal sections of the hull.

Ribband Shore.—A strut to support the framework of a ship while building. The head rests against the ribbands and the base on the slip or way.

Rider.—A rib within the inner sheathing, bolted through the latter into the main ribs and planking, for the purpose of stiffening the frame. The riders extend from the keelson to the orlop-deck beams.

Riding-bitts.—Two strong upright timbers near the bows of a ship, to which the cable is secured; they extend through two decks, are connected by a crosspiece, and braced against the strain of the cable by horizontal standards bolted to the deck beams.

Rising-line.—A curved line on the plans of a ship, marking the height of the floor timbers throughout the length, and thereby fixing the sharpness and flatness of the vessel's bottom.

Risings.—Thick planks supporting the timbers of the decks.

Rudder.—A contrivance, usually consisting of a flat frame, hung to the stern-post of a vessel, to afford a means of steering. The *pintles* of the rudder are hooked upon the eyebolts of the stern-post, thus giving an axis of oscillation as the rudder is moved to and fro by the *tiller.*

Rudder-port.—The hole in a ship's counter for the passage of the rudder-head, or upper cylindrical end.

Scaling.—The process of developing the proper diminish of a plank fore and aft.

Scantling.—The dimension or size prescribed for any part of the hull of a ship, especially the transverse dimension of pieces of timber.

Scarf.—A lapped joint made by beveling off, notching or otherwise cutting away the sides of two timbers at the ends, and bolting or strapping them together so as to form one continuous piece, usually without increased thickness. Also spelled *scarph.*

Scupper.—A hole or tube leading through the ship's side, to carry away water from the deck.

Scuttle.—A small opening in a ship's deck or side, closed by a shutter or hatch.

Seam.—The space between two planks of a ship's skin, made water-tight by calking.

Shaft-alley.—A passageway between the after bulkhead of the engine room and the shaft-pipe, around the propeller shaft and affording a means of access thereto.

Shaft-log.—A member of the stern of a wooden vessel through which the propeller-shaft passes.

Shaft-pipe.—The pipe or tube in the stern of a vessel through which the propeller-shaft passes inboard. It occupies a hole bored through the stern-post and deadwood.

Sheathing.—A covering, usually thin plates of copper or of an alloy containing copper, to protect a ship's bottom.

Sheer.—The rise or upward curvature of the lines of a vessel's hull toward the bow and stern.

Sheer-line.—The line of the deck at the side of the ship.

Sheer Plan.—The plan of elevation of a ship, showing the outboard features of the vessel, lines of stem and stern, strakes, water lines, etc., also the hang of each deck inside. A vertical, longitudinal midship section of a vessel, on which are shown the features similar to those of an architectural elevation, including water lines, level lines, diagonal lines, buttock and bow lines, the topside line, the cutting-down line, etc.

Sheers.—An apparatus, usually mounted on a wharf, for placing the masts in a ship, hoisting in and taking out boilers, etc. It consists of two masts, or legs, secured together at the top, and provided with ropes or chains and pulleys for hoisting purposes.

Sheer Strake.—The strake under the gunwale in the topside of a vessel. It is generally worked thicker than the rest of the topsides, and is scarfed between the drifts.

Shore.—One of the wooden props by which the framework of a vessel is externally supported while building; or by which the vessel is laterally supported on the stocks.

Siding.—Dressing the timbers of a ship to the required thickness; also the timbers so dressed. The thickness of a timber in a direction perpendicular to the moulding plane.

Skeg.—A knee which unites and braces the stern-post and keel of a boat.

Skin.—The inner or outer planking of a ship. The inner skin is commonly called the ceiling.

Sliding-way.—One of the structures on each side of and parallel with the keel, supporting the bilgeways of the cradle on which the vessel rests in launching. The sliding-ways are the inclined planes down which the vessel slides, and are made of narrow planks laid on blocks of wood.

Slip.—An inclined plane on which a vessel in its cradle is supported while on the stocks building, or upon which it is handled for repairs.

Sny.—The trend of the lines of a ship upward from amidships toward the bow and the stern; a gentle bend in timber curving upward.

Snying.—Curved planking set edgewise in the frame of a vessel at the bow or stern.

Spiling.—The edge-curve of a plank or of a strake in a vessel's hull.

Spiling Batten.—A batten on which shapes of planking, or other scantlings, are laid out to proper shape.

Spilings.—Dimensions taken from a straight-edge or rule to different points on a curve.

Stanchion.—A post for supporting the deck-beams of a vessel.

Standard Knee.—A bent timber having one branch fastened against the upright side of a beam and the other against the ship's side. One fayed vertically to the vessel's side, above or beneath a beam, is called a *hanging knee.*

Starboard.—The right-hand side of a vessel, looking from aft forward; in contradistinction to *port,* the left-hand side, formerly called *larboard.*

Stem.—The foremost boundary of a vessel, being a nearly vertical continuation of the keel, into which the lower end is scarfed. The forward ends of the various strakes are united to the stem, and its advanced edge is the *cutwater*.

Stem-knee.—A knee at the junction of the stem with the keel.

Stemson.—A knee-piece with its horizontal arm scarfed to the keelson and its vertical arm fayed into the throats of the transoms.

Step.—The recessed block in which the foot of a mast is placed.

Stern.—The after part of a vessel, from the taff-rail down to the junction of the stern-post with the keel.

Stern-knee.—A knee uniting the stern-post and the keel.

Stern-post.—A slightly raking straight piece, rising from the after end of the keel.

Stern-sheets.—That part of a boat between the stern and the aftermost thwart.

Sternson.—A binding-piece above the deadwood in the stern, and practically forming an extension of the keelson, on which the stern-post is stepped.

Stocks.—The framework of blocks and shores on which a vessel is built. It slopes gently down toward the water, and is usually a timber frame which, as the work of construction proceeds, assumes the form of a cradle. This rests on *ways*, on which it eventually slides, bearing the vessel into the water at launching. The vessel is supported laterally by *shores*, while the cradle is held by *struts* and *chocks*. In launching the ship, the shores are removed, so that the vessel rests altogether in the cradle; the ways are greased, the struts are knocked away, the chocks knocked out, and the vessel slides down the ways into the water, where the cradle becomes detached and floats clear of the ship.

Stopwater.—A piece of wood driven into a hole at a scarf joint in a vessel's timber to render it watertight.

Strake.—A breadth of planking or plating, especially one continuous from stem to stern on a vessel's hull. Strakes are named as follows:

(a). Binding Strake—The first plank directly below the upper strake and generally installed in one length if material permits.

(b). Bilge Strake—A strake passing over a vessel's bilge.

(c). Broad Strakes—All planks below the shutter strake and the garboard strake.

(d). Garboard Strake—The extreme lower plank, next to the keel.

(e). Sheer or Upper Strake—The extreme upper plank.

(f). Shutter Strake—The last plank of the bottom to be installed.

(g). Lower Strakes—All planks below the binding strake and above the shutter strake.

Stringer.—An inside strake of plank, secured to the ribs and supporting the ends of the beams; a shelf-piece.

Surmark.—1. A mark drawn on ship timbers at the intersection of the moulding edge with the ribband line; the stations of the ribbands and harpings being marked on the timbers.

2. A cleat temporarily placed on the outside of a rib, to give a hold to the ribband by which, through the shores, it is supported on the slip-way.

Taffrail.—The uppermost part of a ship's stern; the rail or topside of the bulwarks around the stern.

Topside.—The upper part of a ship's side.

Topside Line.—A sheer line drawn above the top timber at the upper side of the gunwale.

Top-timber.—The timber next above the futtocks in a built-up frame or rib.

Top Breadth.—A line in the sheer plan drawn to the sheer of the ship fore and aft, at the height of the under side of the gunwale amidships.

Transom.—A beam bolted across the stern-post, supporting the after end of a deck and giving shape to the stern.

Transom-knee.—A knee bolted to a transom and after-timber.

Treenail.—A cylindrical pin of hardwood, used for securing planking to the frames, or parts to each other. Treenails are from 1 to 1¾ inches in diameter, and are tightened in their places by wedges driven into each end.

Trimming.—The final shaping of ship timbers, etc., after the rough shaping has been done; also called *forming*.

Waist.—The middle portion of a ship's deck, between the forecastle and the quarter-deck.

Wale.—A wide plank at certain portions of a ship's side, extending from stem to stern and following the curve of the *strakes.* The various wales are known as the *gunwale, main-wale, channel-wale,* etc.

Water Lines.—The lines of a ship drawn parallel with the surface of the water, at varying heights. In the sheer plan they are straight and horizontal; in the half-breadth plan they show the form of the ship at the successive heights marked by the water lines in the sheer plan.

Way or Ways.—The timber sills or track upon which a ship is built, and upon which she slides into the water in launching.

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