CHAPTER XL.

MAST MAKING, LAYING-OFF THE STERN, MOULDINGS.

Art. 637. The building of masts, yards, etc., requires exceptional skill, and, consequently, it is not every plater who can turn out satisfactory work. The draughtsman who designs the spars makes an elevation, section, and expansion plan of each one. The expansion (which need only be for one strake, all strakes being alike) shows the breadths of the various plates, and is obtained by measuring the diameter of the spar at various points, multiplying by 3·14 to obtain the circumference, dividing by two or three according as there are two or three strakes, and adding the breadth of the landing. For the guidance of the plater the breadths of the finished plates so obtained are marked on the plan, but as the fairness of the spar is dependent on the accuracy of these measurements, it is usual to check them by making a full-size expansion of one strake, as shown in Fig. 12, Plate 93. This is conveniently done on the mould loft floor, but usually the plater does it himself, for which purpose he lays out the plates, end to end, so that they may serve as a sort of drawing board, on which he sets off the breadths and draws in the outline with a long batten. According to some procedures the plates are laid out in this way for marking purposes, but in the procedure about to be described each plate is marked separately, and quite independently of those adjoining. Most spars have a rounded or barrel taper, and it follows that the edges of the strakes and of individual plates are also rounded, but as the amount of curvature in each plate (mast plates are not usually longer than 10 feet) does not usually exceed about $\frac{1}{8}$ inch, it is generally neglected, which simplifies the work and does not appreciably affect the fairness of the spar. Having noted (from the full-size expansion) the precise breadth at each end of each plate, the various plates may be marked forthwith for cutting and punching, in the manner described below.

Consider the procedure of **preparing the plates** of the yard shown in Fig. 13, Plate 93, composed of two strakes with overlapped end joints. The three middle joints are butted, with inside straps, to permit of the sling hoops being slipped over them. One strake is here an outer one, and if it were necessary that the longitudinal seams should fall symmetrically with a diameter, it would require to be broader than the other, for it has a larger radius; in practice, however, to simplify the work, all strakes are made of the same breadth. Proceeding to mark one of the plates, its breadth at either end is first set off. Now, from the expansion just made, only one breadth was obtained at each joint, and it is evident from Figs. 5 and 6 that the same breadth cannot be used for the ends of both plates, for as one overlaps the other it has a larger radius and must be broader. If the breadths obtained from the expansion are taken to represent those of the overlapping ends, those for the underlapping ends must be reduced. As the circumference of a full circle is 6·28 times its radius, any increase or reduction made in the latter is accompanied by 6·28 times as great an increase or reduction in the former. In the case illustrated in Fig. 6, which represents a section through an overlapped joint, the radius of the inner plate is $\frac{5}{16}$ inch smaller than that of the outer one (measuring to the neutral axis in either case), and consequently its breadth, or girth, is $\frac{5}{16}$ inch by $\frac{6{\cdot}28}{2}$, or practically 1 inch smaller. In Fig. 5 the same plates are shown flattened out, and the difference in breadth is here apparent; the breadths of the plates, when bent as in Fig. 6, are the same as when they are straight, if in the former case they are measured on the neutral axis of the plates.

Proceeding with the marking of the plates: The breadth at either end (one of which is amended as just described) having been set off, the two edges and the centre line are struck in with chalk (as a rule, of course, only one side need be sheared), after which one end is marked square to the latter line, with a tee square, as shown in Fig. 25, Plate 93. The next operation is to mark the edge holes; this is done with a pattern template (rather longer than the plate and the breadth of the landing) in which rivet holes are accurately bored 5 diameters apart, as shown. Its ends are cut 1 diameter clear of the terminal holes, and when adjusted to the edge of the plate, one end is placed coincident with the end of the plate as just marked. Having marked the holes in both edges, the other end of the plate is struck in, 1 diameter beyond a rivet in either edge, the plates being ordered with a sufficient margin of length. The edges of all plates are marked in this way, and it is evident that as the spacing of the holes is identical and continuous throughout the length of the spar, all holes must coincide when the two strakes are put together.

The next operation is the marking of the holes in the ends of the plate for the lapped joints. The three rows, for treble riveting, are placed in line with three of the edge holes just marked (this is convenient but not essential), and cross lines are now struck in, touching the sides of the latter, as shown in Fig. 25, Plate 93. The pitch of the rivets is here, as in the seams, 5 diameters, and a pattern template, having holes accurately bored at this pitch, may be conveniently employed for marking them. Now, it is evident that if the holes are spaced 5 diameters apart in, say, the overlapping end of each plate, they must be spaced closer together in the underlapping end. In any particular case the necessary modification is obtained by dividing the difference in the breadths of the two plates[1] by the number of spaces between the holes across the joint. Thus, in the case illustrated in Figs. 5 and 6, the difference in the breadths of the two plates is 1 inch, and this divided by 8, the number of spaces, gives $\frac{1}{8}$ inch; *i.e.* the rivet pitch in the inner plate must be $\frac{1}{8}$ inch less than that in the outer. The modification must, of course, be made in such a way as not to disturb the symmetry of the holes about the centre line. To avoid the necessity of making frequent computations and accurate measurements, a stock of pattern templates may be kept, suitable for plates of different thickness and for spars having two and three strakes. The same principle must, of course, be observed when marking doubling plates and buttstraps.

All plates having been marked in the foregoing manner, they are cut, punched, and countersunk. It is common to punch all plates from the inside, for, when a small die is employed and the plates are thin, this does not appreciably affect the efficiency of the riveting. The edges of the outer plates must be sheared from the outside, so as to secure close seams, and for this purpose the lines are reversed—by nicking the ends of the plates in way of them. As masts, etc., are not usually caulked, the edges of the plates need not be planed, except, of course, at the end joints if these are butted and connected by inside straps.

The next operation is the **rolling of the plates.** For this purpose a section at each end of each one is drawn with a pair of large compasses on a board (the diameter of the spar being given on the plan at each joint), and when any particular plate is about to be rolled, a couple of light set-irons are bent to the shape of its ends as so drawn.

Small bending rolls are employed for spar making. In design they are practically the same as ordinary plate-bending rolls, except that the top roll is

[1] The difference is 6·28 times the thickness, divided by 2 or 3, according as there are two or three strakes; if the plates are of different thickness, their average thicknesses should be taken.

raised or lowered by hand gear, and the upper part of the standard carrying one end is made portable, to permit of tube-like plates being withdrawn from it endwise. Few machines are capable of dealing with plates longer than 10 feet, for if the top roll—which must be of small diameter—were longer than this, it would bend too readily. This roll is of forged steel, and its diameter does not usually exceed 10 inches, but a smaller one may be kept for special work.

The plates are always bent hot, for the pressure required to bend them cold would be so great as to cause the small top roll to spring, so that the ends would have a smaller radius than the middle. Care must be taken to roll them square to the centre line, for, if twisted, the edge holes would not correspond with those in the contiguous strake. With tapered plates this is accomplished by first passing them through parallel to one edge, and then back parallel to the other, a simple method, because a plate tends naturally to enter the rolls with its leading edge parallel to their axis. The curvature is tested from time to time by applying the set-irons, and it is carried out to the extreme edge by inserting a convex bar of iron, as shown in Fig. 9, Plate 95, and by subsequent hammering. Before the plates are quite cold their inner surface should be coated with red lead (Art. 576).

The bolting together of the various plates and the subsequent **riveting** are operations requiring considerable care, for if carelessly done the completed spar may be crooked. Whatever the size of the spar, it is screwed up complete by the plater to check the accuracy of his work; and if angle stiffeners are required they are now fitted, by applying a long template to the outside and marking it by striking it over each hole (punched for the purpose in each plate) with a hammer, or if the spar is sufficiently large, a boy may mark the holes from within. When the diameter is as large as 18 inches, it may be riveted when screwed up complete, the holder-up working within, with a long-shafted hammer used lever fashion (Fig. 19, Plate 47), and in such cases large holes (about 1½ inch diameter) are usually provided at intervals (or a plate may be left off, or loose, here and there), through which the hot rivets may be passed to a boy within, who inserts them in the holes over the holding-up hammer. Small spars must be put together and riveted plate by plate, the holding-up work being done from the outside, and the spar growing gradually in length. During the riveting of a spar it is rolled over as required, so that the joint in process of riveting may be on the top; and care must be taken to keep it quite straight during the riveting, otherwise it will not be so when finished.

Art. 638. The form of the outer surface of the hull is not that of any well-known geometrical solid; amidships it is cylindrical, but forward and aft it becomes complex, partaking of the character of a paraboloid. The **stern plating,** however (above the *knuckle line* and abaft the transom, Fig. 4, Plate 94), is an exception, in that, unless of the so-called cruiser type, it is practically always cylindrical in form, being formed by the rolling of a cylinder in a curved path. A cylinder in process of rolling out the stern is depicted in Fig. 4. The reason for assigning this form to the stern is that the plating is then developable, *i.e.* it may be flattened out, or expanded; consequently, it is readily **laid off in the mould loft,** and its actual construction is simplified; further, the method admits, as required, of considerable variation in the appearance of the stern. The ordinary transverse frames, being parallel to one another, may all have their true form scrived down on the boards. The **stern frames,** however, being disposed radially, cannot be so treated; in their case, therefore, their true form is supplied to the workmen by means of outline moulds, made in the loft. And similarly in the case of the stern plating, its expansion in the loft permits of template moulds being made to the form of each plate, so that these may be cut, punched, and rolled, ready for erection at the same time as the stern frames.

As the work of **expanding the stern** is of constant recurrence in the shipyard, it will now be described.