TO PLACE TWO CRANKS UPON A SHAFT SO THAT ONE SHALL STAND AT A RIGHT ANGLE TO THE OTHER.

By JOSHUA ROSE.

It is obvious that the keyways in both the crank and the shaft must be cut accurately in their proper positions, because it is a tedious operation to file out the sides of the keyways when the cranks are placed upon the shaft. To mark the keyways in the absence of any tools or appliances specially designed for the purpose we proceed as follows: Placing the shaft upon a marking-off table, we plug up the centres upon which the shaft has been turned, by driving a piece of lead in them, leaving the surface level with those of the shaft; and then from the perimeter of the shaft we carefully mark, upon the lead plugs, the centres of the shaft. From this centre we describe a circle whose diameter will be equal to the required widths of the keyway, and then taking a square we place its stock upon the face of the marking-table, and bringing the edge of the blade even with the edge of the circle, we mark a perpendicular line upwards from the circle to the perimeter of the shaft, and then draw a similar line on the other side of the circle, as shown in Fig. 1, in which A

represents the shaft and B the circle, C the perpendicular line struck on one side of the circle, and D the square placed upon the marking-table E, in position to mark the line on the other side of the circle, F and G being wedges to keep the shaft A from moving its position upon the table. We next mark with a scribing-block or surface gage, the depth of the keyway as denoted by the line H, and the marking at that end of the shaft is completed. Passing to the other end of the shaft we find the centre of the shaft, and describe around it a circle equal in diameter to the required width of keyway, and from the edges of the circle to the perimeter of the shaft draw two lines with a scribing-block, as shown in Fig. 2, A

representing the shaft, B the circle, C and D the breadth of the keyway, E the marking-off table, F and G the wedges, and H the depth of the keyway, which must, in this case, be marked with a square resting on the table. We have now marked off on the end faces of the shaft a keyway at each end, one standing at a right angle to the other, but it must be borne in mind that we have paid no attention as to which crank shall lead; that is to say, suppose in Fig. 3 A and B

represent cranks placed upon the shaft C, and running in the direction of the arrow D, it is evident that the crank B leads in the direction in which the engine is to run, and hence the keyway E stands in advance of the keyway F, in Fig. 3; and therefore, as shown in Fig. 3, the right-hand crank leads. To have made the left-hand crank lead, when the engine runs in the direction of the arrow D, we should, supposing the keyway F to be already cut, have to cut the keyway E on the directly opposite side of the shaft; or, what is the same thing, supposing the keyway E to be already cut, the keyway F would require to be cut on the diametrically opposite side of the shaft. It is obvious that if the engine ran in the direction of the arrow G, the left-hand crank would lead, supposing in each case the cylinders to stand at H. Here it may be necessary to explain the manner of determining which is the right and which the left-hand crank. Suppose then that Fig. 3 represents a locomotive crank, the cylinders being at H, then as the engineer stands in the cab and faces his engine, A will be the left and B the right hand crank. It is usual in locomotives to make the left-hand crank lead when the engine is running forward, the practical difference being, that if the workman were by mistake to make the right crank lead, the engine would run forward when the reversing lever was

placed to run backward, and *vice versa*. It makes no difference whether the shaft can be turned end for end or not: if the right or left crank is required to lead when the crank is required to revolve in a given direction the keyways in the shaft must be marked off in the relative positions on the shaft necessary to obtain that result.

To proceed. We have now to carry the lines of the keyways along the circumference of the shaft, and this we accomplish as follows: If the ends of the shaft are flat, or square, as it is commonly termed, we may carry the lines along by placing a square with the stock against the end face of the shaft, and the blade running along the circumference, bringing the edge of the blade exactly level with the lines at the perimeter. If, however, the end of the shaft is rounding, we may mark the keyway Fig. 1 as shown in Fig. 4, in which A represents the shaft with the keyway marked on the end, and B represents an angular piece of metal made true and straight (of any required length), so that when placed upon the circumference of a turned or straight shaft its edges will stand true and parallel with the length of the shaft; as shown in Fig. 4, the angle-piece is placed in position to mark off the side C of the keyway, by drawing with a scribe a line along the edge E of the angle-piece B.

The keyway marked parallel with the face of the marking-table, as shown in Fig. 2, may be carried round on the circumference with the scribing-block at the same time that the lines C and D in that figure are marked.

To mark off the keyways in the cranks, we place a centre-piece in the bore of the crank, as shown in Fig. 5, in which A

represents a crank having a centre-piece of sheet-iron, B, placed in the bore. On the face of this centre-piece we mark the centre of the hole into which it fits, and from that centre we describe the circle C, which must be of the exact same diameter as the crank-pin if it is in its place, or otherwise of the crank-pin hole. We then draw the lines D and E, using as a guide a straight-edge placed one end upon the crank-pin journal, or even with the edge of the crank-pin hole, as the case may be, and the other end (of the same edge of the straight-edge) exactly even with the circumference of the circle C. From D and E we find the centre of the circle F, which must be central between D and E, and whose diameter must be exactly equal to the required width of keyway; and we then mark the circle G, describing it from the centre of the hole, and therefore of the circle C. By drawing the lines H and I, which must be even with the circumference of the circles F and G, using a straight-edge as a guide, we shall obtain the correct position for the keyway K, and the whole of the keyways may be cut, care being taken to cut them quite true with the lines, and of an exact equal width.

In putting the cranks on we proceed as follows: We first provide a temporary key, a close fit on the sides, but clear top and bottom, so that it will bind just easily on the sides of the keyways in both the shaft and the crank. The shaft must be placed and wedged with its keyway downwards, so that in putting the crank on, the pin end may hang downwards, which will render it more easy both to put on, handle, and adjust. As soon as the shaft has entered the crank, say a quarter of an inch, we must insert the temporary key (which may have its end edges well tapered off to assist the operation of entering it) sufficiently far into the keyway of the shaft that it will not fall out, and we may then proceed to put the crank on the shaft to the necessary distance, keeping the temporary key sufficiently far in the keyway to enable it to act as a guide; that is to say, up to at least half the length of the keyway.

To put on the second crank, we first place the shaft so that the crank already on, stands exactly horizontal, setting it by placing a spirit-level, as shown in Fig. 6, in which A repre-

sents either the crank-pin journal or the crank-pin hole in the crank, and B a circle struck on the end face of the shaft and from its centre, the diameter of the circle B being exactly the same as that of A. If then we so adjust the position of the crank that a spirit-level applied to the exact circumferences of the circles A and B stands level, the crank will stand level, and we have only to put the second crank on with its centre-line standing perpendicular, and the two cranks will be at a right angle one to the other. We now proceed to put on the second crank, pursuing the same method employed in putting on the first one, save that the temporary key need not be inserted so far into the keyway, because, if the keyways have been cut the least out of true, it will make a great difference at the crank-pin, because of the latter's increased distance from the centre of the crank-shaft. As soon as the second crank is placed to its position on the shaft we must ascertain if it stands vertical, which we may do by applying the spirit-level as shown in Fig. 7, bringing its edges exactly fair with the edges of the circles A and B, and moving the

being taken that, if the crank last put on had to be moved to adjust it, the sides of the keyways be filed even, otherwise drawing the key will tend to move the crank. In fitting the keys let them be a snug fit on the sides, and bear equally well all along the bottom and top, drawing them in and out during the fitting process, and easing them on the spots which show by the marks to have borne hardest in the keyway, but taking care not to drive them so tightly during the fitting as to bend them in drawing them out, which is very apt to occur in cases where a drift can not be inserted into the back end of the keyway. When a drift is used, the key should have its end edges well chamfered off, so that it will not swell from the effects of the drift, and then bind tightly in the keyway. Care should be taken to slightly oil the key before driving it in and out, otherwise it will be apt to cut and bind fast in the keyway. In case it becomes difficult to extract the key, and a drift at the small end of the key can not be used, it is necessary to hold a hammer under the projecting end of the key, to prevent it from bending from the effects of the blows, and to render the blows more effective.

CELLULAR SYSTEM FOR SHIPS OF WAR.*

By H. J. BOOLDS.

THE whole business of a war ship is to keep herself afloat while she sinks or otherwise destroys her antagonist; but, while the science of naval warfare has been directed to destruction by every means, and protection only from shot and shell, nothing is done for protection from the ram or torpedo. The power of the gun has been so much increased that the thickest armor that can be made and carried afloat is comparatively valueless for protection from shot, and worse than valueless for protection from sinking. If, therefore, a ship, even without armor, could carry her guns and fight without risk of being sunk, she would be a much more formidable antagonist than any ship of war now in existence. With the exception of the machinery, which necessarily occupies large spaces, and perhaps of coals, which may require to be frequently taken in and consumed in large quantities, there is no part of the stores of a ship of war that may not be stowed in the smallest separate compartments into which I propose to divide such ships without being in any way inconvenient to get at in emergency; even the machinery may be so divided that it may be in several watertight compartments instead of as at present usually all in one, and there is no particular reason why coals may not be stowed away in smaller separate compartments than customary, which may be emptied in detail, and closed watertight when empty. All iron ships have some bulkheads, usually limited in sailing ships to one collision bulkhead at the bow; screw-steamers have, in addition, one or two whole or partial bulkheads at the stern to protect the body of the ship from danger through accidents to the screw, shaft, or pipe; and two bulkheads generally enclosing the machinery, boilers, and coals. These are all that are considered absolutely necessary against usual sea risks; the holds being required to be as large free spaces as possible for general cargo purposes. In large and long vessels the two principal holds may be again divided by bulkheads into two spaces before and two abaft the engine-room; thus separating the largest ships into seven, or at most eight water-tight compartments, injury in any one of which is usually sufficient to cause a total loss. In the larger ironclads, partial protection from bottom injuries is obtained by an inner skin of iron, riveted and made watertight upon the inner edge of the floors and frames to the height of the upper part of bilge or lowest deck. The value of this inner skin has been proved in the cases of the Great Eastern and the Agamemnon. It appears to me self-evident, that it would be an immense practical advantage to the ship if the spaces into which it is absolutely necessary to separate the stores of every kind by divisions, which are now of no other use than simply as partitions, and which only add their own weight to the weight of the stores for no benefit to the ship, were enclosed by regularly divided and permanent watertight partitions, which would serve all the purposes for which tanks, store-rooms and magazines are now required, and contribute, in proportion to their number and arrangement, to the strength and safety of the ship, instead of being, as at present, merely dead weight, increasing the risk of her destruction. In the accompanying drawing I have shown, firstly, the composite cruiser, designed to illustrate my paper of eleven years ago on "Cellular Ships of War;" and, secondly, the Vanguard, with the lower holds altered and divided on the cellular system, to show how easy it would have been to have rendered that ship unsinkable, and how easy it would still be to make the rest of our ships of war much stronger and unsinkable, without impairing their efficiency otherwise in any respect. In the Vanguard plan I have shown the orlop beams lifted about 2 ft. to bring this deck about 1 ft. above the load line, and made a complete iron deck. The inner skin is carried up the inside of the frames and attached to this iron deck, making a complete inner ship. A longitudinal bulkhead is run through the centre line of ship from the keel to the gun-deck, or deck next above the load line. All the principal transverse bulkheads are carried up to this deck, and additional bulkheads are put in, dividing the holds into spaces 24 ft. long, making the spaces between the gun and orlop decks about 24 ft. square. Below the orlop deck the holds are again sub-divided by longitudinal and transverse bulkheads into spaces about 12 feet square, all fitted and caulked watertight between the deck and the inner bottom, and from each

* Institution of Naval Architects.

BOOLD'S CELLULAR SYSTEM FOR SHIPS OF WAR.

other, there being no openings into these cells except by an iron water-tight door on the orlop deck, each space between the gun and orlop decks opening into four cells. In an original design it would be intended to carry each of these 24 ft. cellular spaces to the outer skin, thereby confining the water between the two skins to that space, with one water-tight opening in the inner skin for access to the frame spaces for cleaning and painting. The engine-room—from the design as a twin screw-steamer—occupies one 24 ft. space each side of central line, the next space before that being four coal cells, each 12 ft. square; then a 24 ft. boiler space, then four coal cells, then 24 ft. boiler space, and then 12 ft. cells from that to the bow, those next the forward boilers being used for coals; each cell will hold 50 tons of coals, and each group of four will hold 200 tons. Three groups on each side will hold 600 tons, or 1,200 tons of coal in all, with very little more inconvenience in trimming than ordinary bunker arrangement for such ships. The after end of the ship would be subdivided in the same way, the cells through which the screw-shafts pass being made tight around the shafts by stuffing boxes; the lower part of the cells through which the shafts pass can also be floored over the shaft, with access from the cells. All the cellular divisions are large enough for store-rooms for all purposes, and being water-tight, will serve as tanks for water and can be filled in groups wherever required for that purpose. The whole of the bulkhead cellular divisions in such a ship as the Vanguard would not exceed 500 tons weight, and as the weight of armor above necessitates as large an amount of ballast in such ships, the whole of this ballast would be saved, and the strength and safety of the ship would be immensely increased, without adding anything to the draught of water or displacement. The point A on the plan is assumed to be the place where the Vanguard was struck by the ram of the Iron Duke, as the worst possible place on which she could be struck to do the greatest injury, upon or so near a principal bulkhead that the space before and abaft would fill with water. As a cellular ship, according to the drawing, the water would be confined to the one engine-room and one or two cells adjoining; but even assuming that all the bulkheads of the adjoining cells were so much started as to make them leak and fill, the whole of the water in 48 ft. of length, half the breadth, and the height of the orlop deck would not exceed 650 tons, and would not sink her more than 2 ft. deeper in the water; while, with one engine and all her boilers intact, she would be perfectly safe to go anywhere for repair; and even had the Iron Duke been an enemy, would have been able to continue the contest without immediate fear for safety or victory. Five hundred tons of iron judiciously expended, as I have shown, on each of the ships of our present navy, at an expense of £20,000 each, would put twenty-five of them beyond the risk of such summary accidents either in peace or war, at a cost not exceeding the price of the Vanguard, which, for want of this small addition, now lies at the bottom of the Irish Channel.—*The Engineer*.

DOUBLE-SCREW TUG-BOAT.

Constructed by Messrs JAMES HOWDEN & Co., Engineers, Glasgow.

WHEN it is of sufficient diameter and is properly immersed, a single-screw propeller is probably a more effective instrument for towing than the feathering paddle-wheel; but with a screw vessel of the ordinary form, a much larger hull, or, at least, a much greater displacement is required to give sufficient immersion to a screw propeller of the size necessary for utilizing the very considerable power of a towing steamer than is demanded by a paddle steamer of the same power. Twin screws can be applied on a less draught of water, but as usually arranged they are not so efficient for towing purposes as a single-screw propeller.

If the power can be sufficiently well utilized, the hull of a towing steamer should not have a greater displacement than is necessary for carrying its machinery and coal and for safety at sea, because the smaller the amount of power used in its own propulsion the greater will be the amount left for

keel. In consequence of this arrangement the hull of the vessel need be made of no greater displacement than is required for its purpose as a towing steamer, while each of the propellers is of larger diameter than the single screw of a hull of the same displacement if built of the ordinary form. The result, therefore, is that a large engine power can be most effectively used in a comparatively small vessel. The peculiar advantage of the arrangement, however, is not only that the propellers are of large diameter, but in the fact that there are two of them, each of which acts against an independent column of water.

When the steamer is only propelling itself the advantage of the two resisting columns of water is not brought into play unless the vessel is running against a strong head wind; but whenever the tug is attached to a heavy vessel outside itself, the advantage of the two screws is stated to be at once apparent—the actual effect in hauling (so far as can be ascertained without testing it by a dynamometer) being twice that obtained from the same engine power working a single screw of the same diameter and placed in the stern as usual. These results agree very fairly with those arrived at by Mr. Robert Griffiths, whose experiments on the use of bow and stern screws we have on several occasions referred to in this journal.

It has been found by trying one propeller only in Mr. Howden's tugs, alternately in the bow and stern, that the bow propeller gives the best hauling effect. In all probability this arises from the fact that the bow propeller works in solid or unbroken water, while the stern propeller works in the "slack-water" of the vessel.

Three of these screw tug-steamer are now at work on the Clyde—one has been in use for upwards of eighteen months, and two for about nine months. They have been built by Messrs. James Howden & Co., Glasgow, for the Screw Tug Company (Limited), and are steadily working their way into favor. So thoroughly satisfied are the directors of the company with the results obtained by the vessels, that they have unanimously resolved to recommend the shareholders to grant powers for the addition of several similar vessels to their fleet.

The vessel which we illustrate—the Clyde—was the first built of the three. It will be seen that it has both its ends alike, as it was intended principally for work in the river. The other two steamers, which are named the Forth and the Tay, have their bows formed in the usual manner, but with the screw aperture conveniently arranged and protected by means of an outguard running to the bow on the line of the

rubbing belt. It will be observed that the Clyde has the screw aperture frames lower than the keel. As she never requires to take the ground this is no inconvenience. In the case of the Forth and Tay, they have a sort of double keel running straight in a line with the screw apertures at the ends. In conclusion we may remark that a thorough series of dynamometrical experiments on the performances of these tugs under different conditions would have great interest and value.—*Engineering*.

DOUBLE-SCREW TUG-BOAT.

hauling the vessels to be towed. The arrangement of hull and propellers we now illustrate is designed to give the most favorable conditions as to the hull, and at the same time to utilize the engine power for towing to a greater extent than has heretofore been accomplished. This result is effected by constructing the vessel so as to admit of a screw propeller of large diameter being used at each end, bow and stern, and giving the proper amount of immersion to both of them by depressing the screw frames below the ordinary level of the