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OBSERVATIONS UPON SHIPBUILDING AND ENGINEERING PRACTICE ON THE CLYDE.

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In this paper it is proposed to give the impressions of the writer upon various matters, bearing more or less upon the present practice and progress in engineering and shipbuilding, formed during a recent trip to the United Kingdom, and during which he visited a good many of the most up-to-date establishments.

What first strikes the stranger from Australia, visiting any of the large and well-equipped shipyards or engine factories, is the feverish activity pervading the premises, from the principals, downwards. When trade is brisk, naturally the energy of the principals and operatives is represented by large outputs, and a constantly increasing size of premises. One man's remark in reply to one of mine seems to describe the position fully: "Yes, we try to keep up in the front of the procession, but we have to keep moving and battling all the time to do it."

The labour problem being of a uniform character mostly and wages in the various districts on a par, for time and piece work, the chief source of profit lies in economy of production. The economies of a well-managed yard lie in many directions, among which the chief are: the possession of a thoroughly practical head, with keen eyes for detail; a good drawing office staff; conveniently arranged railway sidings, into which materials can be placed in accessible positions, and with a minimum of manual labour; a wide system of light railway lines for transport of material in all required directions; a system of cranes, heavy and light, for dealing with all materials over 4 cwts.; a complete and combined system of hydraulic and pneumatic rivettinig plant, dealing with all sizes in daily use; electric and pneumatic drilling, chipping, and caulking tools; good lighting; a commodious, well-fitted, and conveniently-placed machine shed, traversed by lines of light railway, and fitted with hydraulic or electric cranes capable of handling up to 4 tons with ease. The usual joiners and blacksmith's shops fitted with the latest labour-saving devices connected with the production of the several specialties.

Most of the large and progressive shipyards, that in busy years turn out a gross tonnage of 20,000 and upwards, are so fitted; and were these conveniences not to hand, and the old system of transportation by unskilled manual labour, harnessed like mules to unwieldy barrows and trolleys, still in vogue, it would not be possible to turn out more than one-tenth of their present amount of tonnage.

It was the good fortune of the writer to do business recently with one of the most progressive of the great shipbuilding firms, and a study of their methods, even from an outsider's point of view, is a liberal education for an observant and interested person. When the building firm has laid before it a specification of work, it is generally understood that the casual rank and file of details are to be carried out according to the usual practice of the concern, and if there is any doubt on that point it is cleared up during the negotiations.

The customer gets what he wants and pays for, as regards arrangement, details being in design and scantling, more or less different from others, and have the firm's individuality. The whole of the arrangements, general and detailed, are made in the drawing office, nothing being left to chance or the option of the workman or foreman. The chief draughtsman, and under him the sub. in charge of that particular ship, prepares plans of all parts of the structure, for the use of the various departmental foremen; and should any necessary alteration, on inspection, suggest itself to those in charge of the operation, it must be altered first on the drawing.

The able chief necessarily, in the production of his plans, studies economy of labour and inter-changeability of parts wherever he can, and to this end it is advisable that little should be left to chance. All attachments are designed to be as simple and easily made as possible; obscure and inaccessible corners are strictly avoided; special attention is paid to the spacing of rivets, these being templated whenever and wherever possible, to ensure uniformity of practice, and conformity with whatever rules govern the construction. To illustrate, it may be mentioned that when the workman fits up or assembles the parts, say, of a cellular double bottom, the attachments to the centre longitudinal are made by angles picked at random from a pile of two or three hundred, all punched to one template. Frames floors, intercostals, keelsons, tank tops, and iron decking are all treated similarly, and produce a surprising economy of time in construction over old methods. Frames, floors, double bottom, bulkheads, beams, and most structural parts are made complete from the "board," and fit accurately when assembled. Not the least important part of the routine work is the piling of the raw materials, such as angle bars and plates, in such order that "first required first at hand" shall obtain, during each successive operation, and that no time be lost piling and unpiling stuff uselessly.

After a few frames and reverse bars have been bent, and punched to templates, these are assembled and attached together with a few bolts, and stacked for the convenience of the rivetting gang. This work and the transverse framing of the double bottom is all rivetted by hydraulic power before being assembled on the berth, piece work being the rule, generally speaking. The pressure for the rivetting machines is derived from a central power station, in a convenient locality, with mains led in various directions, with branches from them as required for the various appliances. The frame rivetter has at his disposal a hydraulic crane, and boy, rivetting machine, two labourers, one oil furnace and boy for heating rivets. The furnace temperature can be regulated to a full red heat without danger of burning the rivets, and 20 are always in the fire. The boy puts the rivets in the frame, usually six at a time, and they are closed at the rate of up to 1400 per working day.

After the frames and transverse members of the double bottom have been rivetted, they are assembled on the ground, and when a large vessel of, say, 8000 tons is in question, the facilities for transport become a very important factor. A line of rails is laid down on each side of the building berth, and afterwards the parts are deposited each opposite its own place. Convenient hydraulic derricks hoist them into place, where they are bolted up and shored in position.

Rivetting the inter-costals and fore and afters in a ballast tank was, before the advent of pneumatic tools, an exceedingly tedious operation, and if the space were limited, the work would be none too good. The air tools are now used throughout the cellular spaces, and whereever a man can get his head and shoulders in, he can also use the air hammer, which does excellent work. The holding-on hammer has a series of telescopic rods adapted for air pressure, and of a length varying according to the space available. These are placed against the hot rivets, a small handle turned, and the rod shoots out against the opposite wall and holds the rivet solid until it is closed up. Two men and a boy can close up from 350 to 400 ¾in. rivets per working day in the confined cellular spaces, where 180 to 200 rivets used to be considered a good day's work closed by hand.

The caulking process, on shell plating, bulkhead, tanks, etc., is entirely done by means of the pneumatic tools, and 400 running feet of seam per working day is considered only a fair performance for a man.

Next in usefulness and adaptability is the electric drill, used extensively for drilling sheer-strake doublings, and other places where high-class girder work is necessary. This appliance weighs about 400lbs., and is usually slung from a traveller above, either of wood or iron, and which is shifted along the posts as the work progresses. Although weighing so much more than the pneumatic drill, it has certain advantages of quick setting that only it possesses. No time is lost in adjustment, as the electric magnets are put into work by the simple movement of a switch, and the apparatus adheres to the ship's side with a force equal to about a ton. This machine also acts as a motor for cutting round holes for side lights, ventilators, etc., and does the work of ten men, with one attendant.

The lifting appliances on the building berths are good, and mostly capable of dealing with weights up to about 5 tons. These consist chiefly of mast derricks with swinging jibs, each within reach of the other, and worked on the usual hydraulic system, the cylinder and two sets of sheaves being neatly fixed at the root of the mast vertically.

One of the very large yards has erected expensive gantry cranes over its chief building berths, and doubtless it sees a good return for the investment; but a series of properly arranged masts seem to answer equally well, and cost very little in construction or up-keep. There are very few heavy lifts during the construction of a modern liner on the stocks, with the exception of the stern-tubes and tail-end shafts; these generally being taken in through a space left in vessel's bottom.

The apparatus and appliances above mentioned seem to the writer to contribute in a chief degree to the expeditious production of the iron-work; and in a minor degree the devices in the machine shed help, by more prompt dispatch, to reduce the standard time needed for each particular operation.

For instance, I noticed that the plate edge planers had hydraulic pistons instead of the old-fashioned screw and cross handle for fastening the plate in position. The plate is lined up to its marks, and on the turning of a handle all the pistons come down at once and hold the plate rigidly till planed. Another machine punches manholes through ballast tank floors, say, 18in. x 14in., in five seconds. Ordinary flanging or bending operations performed on keel plates and others are now done cold by hydraulic machines, which in principle may be compared to a blunt pair of scissors, and which act in a precisely similar way.

There is now in most yards a machine or two for joggling shell plates, these being of different design. The most popular is one with two stiff overhung rolls, with the suitably shaped space and an adjusting screw. These turn out the work a good deal quicker than can the hydraulic joggler, which works as a press, with the plate shifted along step by step. Piece work in every department is the generally adopted system of labour, the yard, of course, finding all material and appliances. The unskilled labour is paid by the contractor. Each man has a direct interest in the amount of work turned out satisfactorily; faulty work has to be made good at his own expense.

With the plating squads, the facilities for transport of the materials is of the first importance. They have to handle plates up to 32 feet long by 4ft. 6in. wide and 1 inch thick, weighing 2½ tons.

The templating has to be done with the extreme of dispatch, more particularly in damp or wet weather, which chiefly prevails. If a new template were taken off one day and applied the next to the plate, the holes would be more than half blind, owing to the expansion of the wood by absorption of damp; therefore, this operation is always completed without interruption. The plates are taken from their stack, put through the various rolling, punching, planing and countersinking processes with astonishing celerity, chiefly due to the ease with which they can be put on the bogie cars, by means of handy and swift cranes, and shunted along to their destination without delay. It is not unusual to complete the plating of an 8000-ton steamer in 5 to 6 weeks; and at the end of that time, if the rivetters have been following the platers closely, the hull begins to assume a definite appearance. Tack rivetting is adopted in all the first-class establishments—that is, the butt straps, or lap joints of the plate ends are rivetted with half their number of rivets, immediately after being formed. This system applies more particularly to shell plating for two-thirds the length amidships, and the steel work of the upper decks similarly, its objective being to keep the whole structure in shape until completely fastened. Shoring is strictly attended to, but is insufficient in itself without reliable fastenings, as the weight accumulates.

The question of corrosion, internal or external, does not much concern the shipbuilder, who will, of course, supply what is specified in the way of paint protectives. The work is hurried on, as a rule, at such a rate as precludes the possibility of the whole of the paint-work being of a reliable character. Steel plates and other materials come from the mill covered with a coat of hard black oxide known as "mill scale," which looks a good protective, but is not, it flaking off after a few weeks' exposure to damp weather. This oxide being electro-negative to steel in presence of salt water acts as a strong corrosive, and wherever present causes rapid and extensive pitting. It is, therefore, always supposed to be removed, either by weathering, hammering, or the application of a weak solution of sal-ammoniac, and afterwards a hard wire brush or sandstone, before the anti-corrosive is applied.

Of all the many specifics recommended by interested parties as a first-class coating for ships' bottoms outside, nothing seems quite as good as a mixture of red-lead and white zinc paint, provided same is applied in dry weather to dry surfaces. Inside the hulls, where subject to action of bilge water, with its exhalations of sulphuretted hydrogen and carbonic acid, decay is as a consequence rapid. The asphaltum compounds are rapidly coming into favour, instead of the long-established wash and plaster of Portland cement. These compounds are of a more or less elastic nature, and do not crack as Portland cement does, but accommodate themselves to a good deal of rough usage before losing a grip of the plate, and allowing corrosion to begin between the surface of the iron and protective. The above protectives are now largely applied to bilge, floors and bunkers, where corrosion and wasting is most active. The base of these preparations is bitumen or natural asphalt, and they are undoubtedly of great value as protectives. For ships' inside bottoms the bitumen is melted in a convenient boiler, and applied hot, solidfying as it cools; the thinner preparations, applied in the same way as ordinary paint, being merely the natural product reduced in a convenient solvent, such as spirits of turpentine, naphtha, or carbon bisulphide. Most of the liquid preparations are highly inflammable, and have to be carefully handled.

As to design, there seems to be little modification within the last ten years, of either principles or practice. The hollow water line, thin fore foot and heel, great rise of floor, outside keel are practically obsolete, and the 'midship section of the present-day ship closely approximates a rectangle with a short radius of curvature at the bilges, even in vessels with a speed up to 20 knots and over, with no more rise of floor than is necessary to drain the bilges properly. For many years it was considered impossible to obtain high speed, say over 14 or 15 knots, with a rectangular 'midship section, but experiment and trial have demonstrated the superiority of modern methods; also, that to obtain high speed at a reasonable expenditure of power, it is necessary to get the finer water-lines required from an increase of length. The former thin knife-like fore foot, and "deadwood," which were generally filled up solid with cement, and added considerably to the displacement, are now replaced by U-shaped structure, which has enough buoyancy to be self-supporting. The writer spent an interesting and profitable day inspecting the experimental tank at Dumbarton. This tank was designed by the late Wm. Denny, and has been of immense benefit to the firm and the profession generally. It is about 300 feet long by 20 feet wide, and has usually some 10ft. of water in it. There is a delicately governed engine at one end, which supplies the towing power, drawing a carriage with the model attachments and registering apparatus along on a railway suspended from the roof at a convenient distance above the water level. The test models are made of paraffine to a scale which brings them out about 12 or 14 feet long, are carefully shaped to exact form, and polished, and when afloat are ballasted to the required draught with bags of shot. After the traction engine is started and the required speed adjusted, all the particulars are registered graphically on a drum, the speed and pull being shown at a glance.

Mirrors are arranged so as to show the position of the waves created with relation to the entrance and run, and is specially looked into with regard to paddle steamers, the position of the 'midship wave being of great importance as regards the immersion of the floats.

The relation existing between the models and the full-sized vessels has been found, as regards speed, to closely approximate—

$$\frac{S}{s} = \sqrt{\frac{L}{l}}$$ where L equals length of ship
l ,, ,, ,, model
S ,, ,, ,, ship
s ,, ,, ,, model

The resistance of the model to traction, or the pull in pounds as registered, bears also a definite relation to the indicated thrust, about as—

$$\frac{P}{p} = P\left(\frac{L}{l}\right)^3$$ where P. and p. are the corresponding resistance of ship and model.

The approximate power thus obtained makes no account of friction of machinery, and a larger wave making effect of the ship over the model; but the allowance made is deduced from the builder's practice, who soon finds out his own relation of E.H.P. to I.H.P. This tank, although rather expensive in first cost, justifies its existence, as Denny is now able to give the speed paid for, and saves the cost of putting in any more power than is necessary. Some builders give good measure in speed, which may be satisfactory to owners, but certainly is expensive to themselves if the extra is more than, say, 1/4 of a knot. This, among first-class builders, is looked upon as a satisfactory margin.

The modern passenger steamer may be, without any exaggeration, fairly contrasted with a first-class hotel in its appointments for convenience, comfort, and luxury; and much thought and money is expended by all concerned in the production of a satisfactory article. The chief consideration of an extensive passenger accommodation is the ventilation, and all arrangements are made now-a-days (or should be) subject to plenty of fresh air currents and as much light as possible.

Ventilation is chiefly arranged so that it will be as nearly automatic as possible, and nothing left to the discretion or memory of attendants. The air currents between decks are induced chiefly by means of skid or