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Sir J. W. BAZALGETTE, C.B., Vice-President, in the Chair.

(*Paper No. 1878.*)

"The Design and Construction of Repairing Slipways for Ships."[1]

By THOMAS BELL LIGHTFOOT, M. Inst. C.E., and JOHN THOMPSON.

THE history of slipways, like that of all modern mechanical appliances, is one of evolution, and dates back to a period prior to the present era.

Taking advantage of a conveniently sloping gravelly or sandy shore, the method of beaching was no doubt practised in very early times by the ancient Egyptians, in order to effect repairs to their vessels, which even then were constructed of sawn planks, and had sails as well as oars. Later, at ancient Carthage, the war galleys were drawn up a sloping shore on timber ways or slips, and this, the most primitive form involving the use of any artificial contrivance, has by gradual transition been developed into the modern slipway, with its powerful hydraulic hauling-apparatus capable of dealing with the largest and heaviest vessels.

Without considering the various stages of development, it may be stated that the earliest slipway, of the type proposed to be treated of in this Paper, was introduced in the year 1819 by the late Mr. Morton, of Leith. It consisted of ways, which were generally longitudinal balks of timber, carrying cast-iron rails, laid at any convenient inclination on a foundation of rough stones, of a cradle on rollers with adjustable sliding bilge-blocks, upon which the vessel was placed and drawn up, and of hauling gear, at first actuated by hand, and later by steam or hydraulic power. Since then the improvements introduced have been entirely in the details of the apparatus, which, from being at first merely required to deal with the light wooden ships in use at the commencement

[1] The discussion upon this Paper occupied portions of two evenings.

of the present century, is now constructed for speedily withdrawing from the water the largest existing iron vessels.

A general plan and side elevation of a modern slipway for vessels up to about 300 feet in length, and 2,500 tons gross weight, are shown in Plate 5, Figs. 1 and 2. Such a slipway consists: first, of a foundation, the nature of which must, of course, be specially decided by the engineer for each particular situation; secondly, of longitudinal timbers on cross-sleepers carrying cast-iron rails (Plate 5, Figs. 3 to 7); thirdly, of a cradle provided with cast-iron rollers and sliding bilge-blocks for receiving the vessel; and fourthly, of the hauling machinery. The modes of construction of the foundations, ways and cradle, present little variation in slipways of different systems; but the hauling gear, though now generally actuated by water-pressure, is subject to variation according to the ideas of the manufacturer or designer.

It is proposed to consider briefly each of the four sections, and to describe the operation of working when it is required to take on a vessel for repairs.

After deciding upon the construction of a slipway, it first devolves upon the engineer to fix the inclination of the ways. This can generally be at once determined by a consideration of the amount and value of land at his disposal, by the depth of water it is necessary to provide over the cradle when at its lowest position, and sometimes by the natural slope of the ground. As a rule, gradients of from 1 in 15 to 1 in 22 have been adopted; but these by no means form a limit, as it is obvious that no special engineering difficulties attend the introduction of either a greater or less inclination. The most suitable description of foundation can only be arrived at after a careful survey of the ground, and it is of course best to take borings from top to bottom of the site. In some cases no further preparation than mere surface-dressing will be wanted, while in others it will be necessary to provide a bed of concrete or stone filling, or even to drive piles under the ways. As a rule, however, the foundation of a slipway is not a difficult or an expensive matter, as the weight of the vessel and cradle is spread over such a large area that the pressure per unit of surface is very little, not more indeed than from 7 to 8 tons per lineal foot of way. The Authors are of opinion that piling should never be resorted to except in cases where it is absolutely necessary, and even then only with great caution, unless the whole length of way is to be piled. When part of the ways are supported on natural ground and part on piles, a difficulty is very likely to arise at the junction, for, the ground being more or less yielding, the cradle, drawn on to the more rigid piled-portion, is subjected to excessive local stresses, which would probably cause breakage of rollers, carriage or rails. What is to be aimed at is to have a uniform support for the ways throughout their entire length, and where the formation of the ground varies, this uniformity must be obtained by excavation and filling-in with suitable materials.

The longitudinal timbers or rail-bearers, disposed as in Plate 5, Figs. 3, 4 and 5, are supported by transverse sleepers 12 inches wide by 6 inches deep, placed close together. The cluster of timbers forming the centre-ways for a slipway, such as is now being considered, consists of three balks of Memel or sawn pitch-pine, each 13 inches square, all with scarfed and keyed joints, while the outer bearers, which are spaced about 25 feet apart from centre to centre, having but little weight to carry and distribute, are composed of single timbers also 13 inches square. After the first starting of a slipway slight settlements are sure to take place, but are easily compensated by wedging up the rail-bearers where required.

In order to obtain sufficient depth of water to permit vessels of the desired capacity to float over the cradle when run down, it is necessary to carry the ways a considerable distance into the water. For this reason, except in situations where from the great range of tide the construction of the lower portion can be entirely effected at low water, the employment of divers is necessary. To avoid this increased expense various proposals for shortening the slip have from time to time been made and carried out. The simplest and usual plan is to make the cradle telescopic, that is, in several divisions attached to each other by sliding lengthening-bars which permit the various sections to close up when the cradle is run down for taking on a vessel, and to open out as soon as the hauling-up commences. This arrangement is successfully adopted in several slipways worked on the Authors' system. Another plan, applicable in situations where there is sufficient range of tide, is to enclose the upper part of the slip within water-tight walls, provided at the bottom with gates, which being shut at low-tide exclude the water. This method was selected in the case of a slipway on the River Tees, also worked on the Authors' system, but the gates are not now used. When it is necessary to employ the aid of divers in constructing the lower submerged portion of a slipway the work is generally carried out in the following manner. The rail-bearers are first of all framed together on land, on a continuous platform of transverse sleepers (Plate 5, Figs. 3 and 4). The rails are then fixed, and, the land end of the bearers being properly scarfed to join the last length laid from shore, the platform is floated out as nearly as possible over the position it is intended to occupy, the bed having been previously prepared by dredging, or by sinking and levelling up a sufficient quantity of stones, or by both. Guide-piles being driven, the platform is loaded with stones and sunk, after which the ends are keyed to the shore timbers, and the stone-weights, which are to be permanently left, adjusted, sights being taken from time to time from the top of the way to check the correctness of the work during sinking, and before it is finally left.

The rails already alluded to (Plate 5, Figs. 5 and 6) are of cast iron. The outer ones are single, about 5 inches deep and 5 inches wide, while those at the centre are double, of nearly the same sectional dimensions, and connected to each other by a plate on which is cast a strong rack of about 6 inches pitch, for receiving the holding pawls on the cradle. These pawls are introduced to prevent the cradle running down the way in the event of an accident happening to the hauling gear. In the Authors' system wings are cast on each side of the centre rail, to support and guide the hauling links, which extend nearly to the bottom of the ways. The rails must be accurately cast, and are laid on the timbers with an intervening layer of felt to ensure a good bed. The joints must be carefully made, and throughout this work it is absolutely essential to avoid all inaccuracies, as they would be certain to lead to breakages of rollers, carriages or rails, which, though not endangering the safety of the vessel, would seriously interfere with the efficient and economical working of the plant.

The cradle, Plate 5, Figs. 1, 2, 5, 6 and 7, is a structure of timber, generally American oak, so constructed as to receive and maintain the vessel in very nearly the same trim as that in which it floats. It consists of a strong tapered centre rib, about 280 to 300 feet long, of several balks securely bolted and fastened together, forming the rest for the keel blocks, and of two lighter side ribs corresponding in position with the side ways. From the centre rib to each of the sides stretch transverse pieces of iron or of wood, carrying sliding bilge-blocks, worked by ropes-and-gear from the deck of the vessel or from jetties. These jetties as a rule, extend either on one side or both sides of the ways (Plate 5, Figs. 1 and 2), for the purpose of affording convenience in placing the vessels on the cradle, and for superintending the whole operation, which it is important to complete without loss of time. The sliding bilge-blocks are trimmed with supplementary loose blocks, shaped to suit the size and description of vessel to be hauled up. The cradle-ribs are carried on numerous cast-iron rollers, in cast-iron carriages

(Plate 5, Figs. 5, 6 and 7), those at the centre being placed as close together as possible, while those for the sides, where the pressure is small, may be spaced some distance apart. About ten of the centre-carriages are formed to receive the cradle-holding pawls, previously referred to. It is also usual to provide two or three short independent cradles or ekes, which may be attached to the top of the main cradle, according as the vessel to be repaired is long or short. The other adjuncts of the cradle are—wrought-iron ploughs at the aft end of each rib for removing silt or mud, or any other obstruction that may accumulate on the lower portions of the rails; hinged iron rods for guiding the keel of the vessel properly on to the centre of the cradle, one pair of rods being placed at the top for the bow, and a second pair at the bottom for the stern; besides sundry gear for working the bilge-blocks, and for lifting and lowering the pawls.

The hauling machinery usually consists of one or more direct-acting hydraulic cylinders placed at the top. Water is forced into the cylinder, and the motion transmitted from the rams to the cradle by means of strong forged-iron rods or chains. In some cases engines with gearing are used, especially if the slip be for small vessels.

The mode of working is as follows:—The general size and description of vessel to be taken on having been ascertained, the bilge-blocks on the cradle are trimmed to fit the ship as nearly as possible, and the guide-rods and other fittings looked to and put in proper position. The cradle is then run down into the water by its own weight, assisted, if necessary, by a down hauling chain worked by an independent apparatus at the top, arranged also for quickly drawing up the empty cradle after launching a vessel. The extreme end of the cradle may project 30 to 50 feet over the end of the rails, the main ribs being made strong enough for this purpose. The vessel is now floated into position as accurately as possible, being guided by hawsers manipulated from the jetty or shore, and also by the fore-guides fixed at the front of the cradle, which are drawn up into a vertical position by ropes afterwards secured on the vessel. The hauling-up then commences, the ship all the time settling on the keel-blocks placed on the centre rib, and being guided at the stern by the aft guides. At the proper time the sliding bilge-blocks are drawn in by ropes previously taken up to the jetties or on board the vessel, and so the operation proceeds until finally the ship is drawn up out of the water, safely seated on the cradle, and supported uniformly over the whole length of keel as well as by the bilge-blocks on each side.

In launching, the reverse process takes place. The vessel is lowered by the machinery to within a convenient distance of the water. The cradle is then disconnected from the links and, the holding pawls being raised, is left supported entirely on one special single pawl or dagger at the top. The dagger is now knocked out by a blow from a hammer, and the cradle with its burden runs down the way till it reaches the water, and the vessel floats off. The empty cradle is drawn up by the supplementary hauling chain, and after trimming is ready to take on another ship.

Having now generally described the construction and working of a slipway, it is intended to consider some improvements lately introduced in the cradles, and to enter more fully into the various systems of hauling gear.

A method by which a single slipway can be made available for repairing two or more vessels at one time is of obvious importance, the single set of expensive hauling-up machinery, and the single cradle doing double or treble work, and so reducing the amount of capital invested, in proportion to the value of the repairs effected. This improvement, which has been introduced of late years, is called relieving, and is accomplished in the following manner:—

The transverse arms of the cradle connecting together the centre and side ribs, and carrying the sliding bilge-blocks, instead of being permanently fixed, are hinged at their outer ends to the side ribs, and are thus capable of being swung round parallel with the side ribs, upon which they rest when in this position. After the vessel to be relieved has been hauled up, strong balks of timber are placed between each pair of transverse arms, to act as bilge-blocks, capable collectively of eventually carrying the whole weight of the vessel. Commencing at the top, and simultaneously on each side, these new blocks are tightly wedged against the bilge of the vessel, the weight being in this manner relieved from each old bilge-block and taken by the new ones resting on the ground. All the old blocks are thus relieved, and slid out on the arms, the vessel resting on the new blocks and on the keel blocks on the cradle. These latter are now relieved by placing under the keel, at proper intervals, hydraulic presses connected with the pumps. Water under pressure being introduced into these presses, the vessel is raised just sufficient to permit the keel-blocks to be knocked out, after which on exhausting the water from the presses the ship sinks back and is entirely carried by the new blocks supported on the ground. The cradle is now clear and relieved from the vessel, and so soon as the hinged transverse arms are swung round into a longitudinal position, can be moved down the ways, and is ready to be used for another vessel. In this manner lengthening can be readily carried out by cutting the vessel before taking it off the cradle, and relieving each part separately, the second part being moved down the way upon the cradle for a distance corresponding with the additional length required. As a matter of arrangement, it is, of course, necessary to place those vessels requiring the longest time for repairs at the upper part of the ways.

A new method of relieving (Thompson and Cooper's patent) has just been brought out by one of the Authors, and Mr. George Cooper, the late manager of the Penarth Slipway Company, Limited. It is shown in Plate 6, Figs. 8 to 11, and may be thus described:—Instead of employing one cradle, two are used, constructed in such a manner that a vessel having been hauled up to a certain point upon the main cradle, can be transferred to the auxiliary one, the main cradle being thereby set free to receive a second vessel. With this object in view the main rails of the slipway are constructed in the ordinary manner, and at the ordinary inclination, but of such additional length as may be required for the working of the auxiliary cradle. Alongside the upper portion of the main rails, and parallel with them, is placed a second set of ways upon which the auxiliary cradle travels. The slope of these rails is greater than that of the main ways, in order that when a vessel has been hauled up until it is over the auxiliary cradle, and new bilge-blocks have been fitted, the heaving up of the two cradles simultaneously may cause the vessel to be gradually lifted up by the auxiliary cradle from the increased inclination of its rails, so leaving the main cradle free to be lowered down the ways for receiving a second vessel, after the transverse arms have been swung round into a longitudinal position.

When the ship is to be launched, the main cradle, with its arms swung round and resting on the side ribs, is hauled up under the vessel, the arms are then put into position and the bilge-blocks run in, and the main and auxiliary cradles simultaneously lowered down the ways. The greater slope of the rails of the auxiliary cradle causes the vessel gradually to approach and seat itself on the resting blocks of the main cradle, and the bilge-blocks on the auxiliary cradle being removed, the vessel, now supported entirely by the main cradle, is run down the ways and launched.

The form of hydraulic hauling-gear so successfully introduced by the late Mr. Morton has had very extended application. It consists of a single direct-acting hydraulic cylinder with one ram having about 10 feet length of stroke. On the outer end of the ram is a crosshead, and to this crosshead are attached two wrought-iron bars, one bar passing on each side of the cylinder. These two bars are connected at their lower extremities to a second crosshead, to which wrought-iron links for hauling up the cradle are secured. Plate 3, Figs. 12 to 14 show the general arrangement of this gear. In hauling up a vessel, after the ram has made one outward stroke, it is necessary to pause to disconnect and remove one of the links, which are made in lengths to suit the stroke of ram. This having been accomplished with the assistance of a small hand-crane, the ram is run back by a constantly acting weight and a new attachment made between the links. The ram then makes another forward stroke, drawing up the cradle another 10 feet, and the process of disconnection and connection is repeated until the vessel is hauled up a sufficient distance. With the heaviest vessels two lines of links are generally used, as shown in Plate 7, Fig. 14, and two links have therefore to be disconnected and connected at each stroke. The great objection to this system is the delay and labour incurred by the removal of the links, and it was to obviate this that the Authors designed the form of hydraulic gear shown in Plate 7, Figs. 15 and 16, which has been successfully at work in several slipways since the year 1874. In place of working the press directly from the pumps, a small accumulator is introduced for the purpose of accumulating water pumped during the act of reversing the rams, and as the water-pressure is constant a set of treble-powered cylinders, or a cylinder with two or more concentric rams, is used for giving the variable power. A crosshead is actuated by the rams, and is connected to a second tail-crosshead by two forged bars. From this tail-crosshead a double set of links, shown in Plate 5, Figs. 5 and 6, extends nearly to the end of the ways, resting upon the wings cast on the centre rails, and being guided thereby. To the top crosshead is attached a ram working in a cylinder always open to the water-pressure. The action is as follows:—

Water from the accumulator having been admitted to one or more of the main hauling-rams, according to the weight and position of the vessel on the ways, the crosshead is pushed up, forcing the ram into the returning cylinder and drawing up the links. On reversing the valve-lever, the pressure is shut off and the main cylinders opened to exhaust, so that the constant-pressure ram reverses the stroke, forcing in the main rams and pushing down the links to the position from which they started. A definite upward and downward travel, equal in length to the stroke of the rams, can therefore be given to the links by the forward or backward movement of the hand-lever. From Plate 5, Figs. 5 and 6 it will be seen that the links are jointed with rectangular flat plates, and as all links and plates are made of equal length, it follows that if suitable pawls are fixed to the cradle, and arranged to gear with the ends of the joint-plates, the cradle will be drawn up at each upward stroke of the rams, while during the downward motion of the links the pawls will slip, the cradle remaining in its highest position, being held by the pawls in gear with the rack cast on the centre line of rails. The hauling pawls, of which several sets are used, are shown in elevation in Plate 1, Fig. 6, and are made of forged iron secured to the main rib by cast steel or malleable cast-iron brackets. With this system no disconnection or removal of links or bars is required. The only loss is the time occupied in the return stroke, which however is not great, as, owing to the small size of the ram, it is forced out much more rapidly than are the hauling-up rams, the respective areas being approximately as 1 to 19. During the short time the links are stationary, *i.e.*, at the reversal top and bottom, water under pressure is accumulated, to be given out so soon as the rams are permitted to travel in one direction or the other.

It is obvious that several modifications of this hauling machinery can be made, all involving the upward and downward movement of the links as described, and in some cases the rams might be worked direct from a set of force pumps. The accumulator is, however, convenient not only as a means of economising time, but as a safety-valve to present shocks, and as a regulator for adjusting the speed of the engine or the working of the pumps, according to the demand for water.

A few years ago Messrs. Hayward, Tyler and Co. constructed a hydraulic hauling-gear with a double set of cylinders and rams. These were so arranged that while one set was in upward motion the other was returning. By attaching the hauling links first to one set of rams and then to the other the cradle was drawn up by an almost continuous motion. This arrangement would seem to be very costly in machinery and foundations, and would occupy considerable space, which the Authors venture to think would not be compensated by any advantage over their cheaper system.

More recently Messrs. Day and Summers have made hauling machinery in which an engine, working through gearing on to a large drum, rolled up a wire rope led from the cradle. This plan will no doubt answer well for moderate weights, but it is open to objection when applied to vessels of large dimensions, both on account of the difficulty in making gearing to withstand such enormous strains, and in obtaining wire rope sufficiently large, pliable, and durable.

The stress required for hauling up a vessel varies very much according to the efficiency of the ways. If everything was rigid it would be found by the following formula:

$$S = \tan \theta\,(w + w_1 + w_{11}) + \frac{(w + w_1)\,r_1}{r} f + w_{11} f_1 \quad . \quad . \quad (1)$$

where S is the total pull on the links, w the weight of the vessel, w_1 that of the cradle, and w_{11} that of the links, all in tons, θ the angle made by the rails with the horizontal, r the radius of the rollers, r_1 the radius of the roller-axle, f the coefficient of friction between the axle and its bearing, and f_1 that between the links and the rails. The total amount of pull to be provided in the hauling cylinders, supposing the Authors' gear to be used, would be this quantity S, added to the total pressure on the returning ram, and what is required to overcome the friction of the hydraulic apparatus.

As in practice the values of f and f_1 are difficult to determine, and vary according to the state of lubrication, and as there is besides another unknown element in the shape of the extra pull to overcome the effects produced by deflection of the ways, it is usual to estimate the hauling power in a much more empirical manner. The following rule, constructed from actual observations, is fairly accurate for ways of an inclination of about 1 in 20:

$$S = s + \frac{w + w_1 + w_{11}}{8} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

s being the total pressure on the returning ram. For other inclinations some allowance must be made on one side or the other, but as the friction due to the weight of vessel and cradle and of the hauling gear does not vary with change in gradient, the total pull is not as a rule subject to great alteration for a given size of vessel. It also depends as much on the efficiency of the ways as on the average inclination. The time occupied in placing a vessel upon the cradle may be taken at about one hour, while the hauling up as a rule will occupy two hours, but this of course will vary according to the system employed, the length of way, and the engine power at disposal. In a slipway on the Authors' plan at Penarth, the length of ways is 867 feet, and the expense of placing and hauling up a vessel weighing 2,300 tons may be taken as the wages of sixteen men for one hour and three men for two hours, while with Morton's system, in which the links had to be disconnected, at least another hour and a half would be taken in hauling up, and the labour of twenty men would be required during the whole operation, lasting four and a half hours. The engine power at Penarth is about 40 indicated HP., the water being supplied from the hydraulic pumping engine at the adjacent docks. Since the slipway was set to work in 1879 no less than one hundred and thirty ships have been hauled up and repaired, without the slightest accident, beyond the breakage of a few rollers at first starting.

Whatever form of hauling gear be adopted, it will generally be of advantage to have a supplementary engine and crab, with chain for traversing the empty cradle quickly up and down, especially in positions where there is likely to be an accumulation of mud at the lower end of the ways, in which case the empty cradle when run down would not acquire enough velocity to overcome and remove the obstruction.

This Paper would be incomplete without some statement as to the cost of constructing such works as have been described; but the Authors have much difficulty in giving any general estimate which is not likely to be misleading. It may, however, suffice to state that a slipway such as that shown in Plate 5, Figs. 1 and 2, could be constructed for about £25,000, including the foundations, 850 feet of ways, cradle, and appurtenances, hauling machinery with links, and one timber side jetty, but exclusive of land. The gradient is 1 in 19; and the machinery is sufficiently powerful to haul up a vessel of 2,500 tons gross weight. The slipway could accommodate two vessels, each about 280 feet long, at one time.

In conclusion it may be mentioned that the Authors do not advocate the indiscriminate adoption of slipways in every case where it is desired to set up a ship-repairing establishment. They believe that the choice of the plant, whether it is to be a graving dock or slipway, a floating or hydraulic-lift dock, must rest entirely with the engineer after a careful survey of the locality and a consideration of his resources. In very many situations, however, there can be no doubt that as regards first cost and facility in execution the slipway possesses advantages which should specially recommend it to capitalists, while from the shipowner's point of view the better ventilation around the vessel when it is withdrawn from the water, the ample opportunity afforded for inspection, and the short time occupied in hauling up and launching, neither of which operations is necessarily dependent on the tide, except in very special situations, are all important features. It is probably the combination of these advantages which has led to the financial success that the Authors believe has attended the working of every well-constructed and conveniently-placed slipway; while on the other hand there is, unfortunately, little room for doubt that in many instances graving and other repairing docks have been a source of considerable loss; though, as was pointed out by Mr. T. Stevenson, M. Inst. C.E., in his work on "The Design and Construction of Harbours," they largely tend to raise the character of a port, and hence almost all harbours of any importance have them.[1]

In this Paper only such methods as are generally in use have been dealt with, and no attempt has been made to describe the obvious designs of greater or less utility which might be desirable under special circumstances. Such are the hauling up of the vessel broadside, as has been carried out at Bordeaux by Mr. Labat, and the provision of a traversing carriage for shunting from the main ways, to enable several vessels to be slipped where length cannot be obtained to accomplish it in the usual manner. Reference should, however, be made to the combined floating dock and slips as first carried out in 1851 at Philadelphia and afterwards at Portsmouth, U.S.A., and at Cartagena and Pola.[2] The dock at Philadelphia was designed for lifting vessels up to 2,800 tons gross weight and about 300 feet long. There were two slipways placed side by side, each served by the dock, and capable of berthing one vessel, but the cradles were not provided with rollers. The time occupied in operating on a vessel was two hours for lifting and seven hours for hauling on the slip, while the launching took nearly as long. The total cost of dock and slipways was about £163,000.

It might be worth mentioning that by having two slipways side by side, each complete in itself and capable of dealing with two ordinary vessels, they could be arranged, if necessary, to act together so as to haul up jointly one large ship such as an ironclad.

The Paper is accompanied by several diagrams from which Plates 5, 6, and 7 have been prepared.

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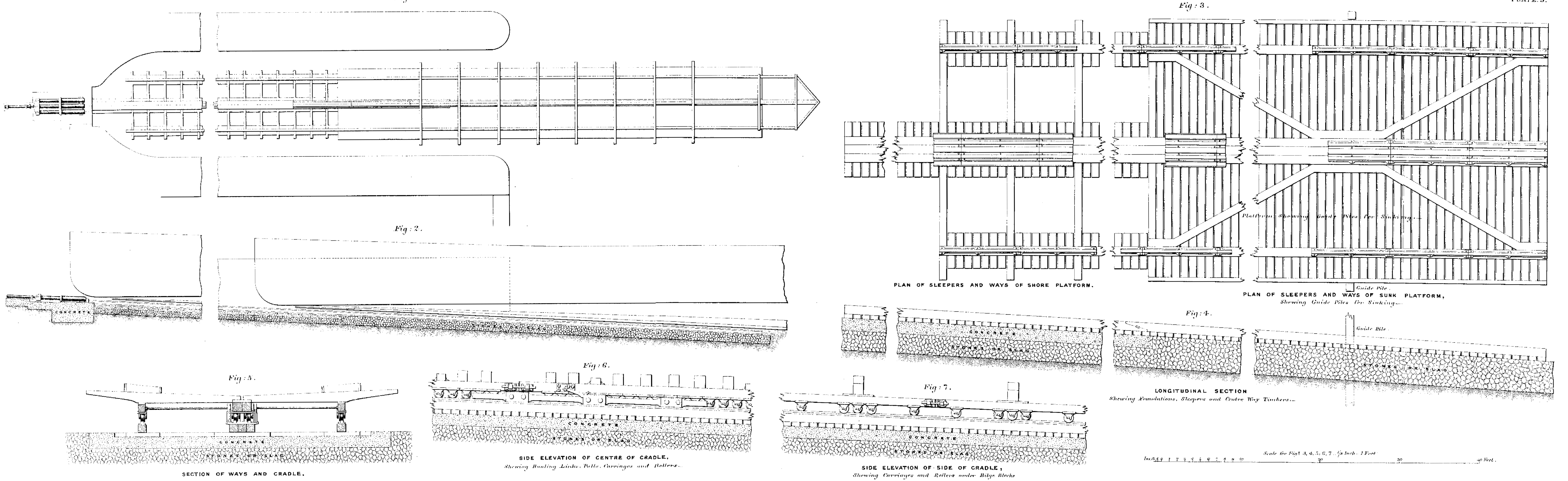
[1] Second Edition, p. 164.

[2] Minutes of Proceedings Inst. C.E., vol. xxxi., p. 295; and xxxii., p. 65.

SLIPWAYS FOR REPAIRING SHIPS.



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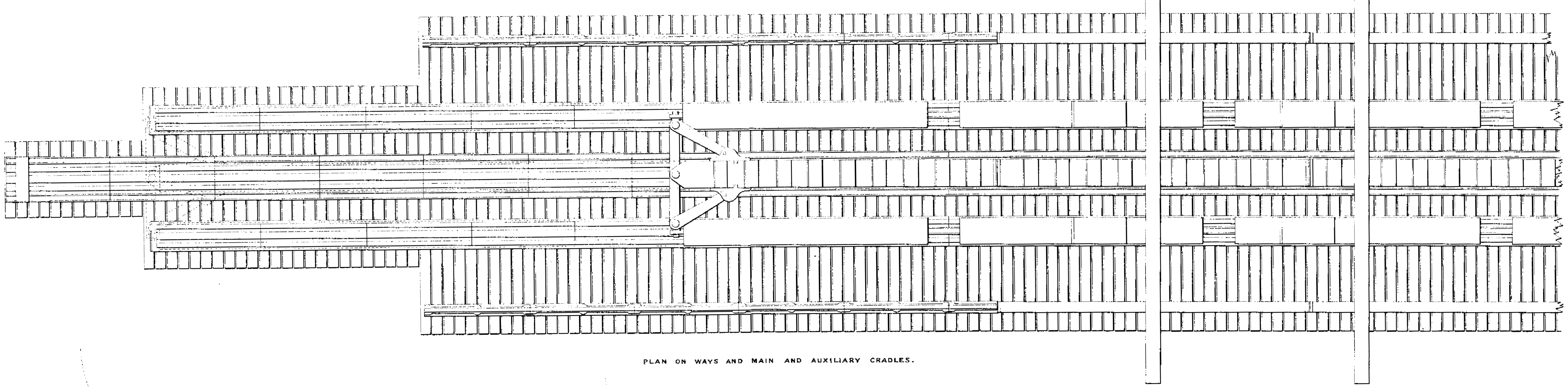
THOS KELL & SON, LITH. 40, KING ST. COVENT GARDEN

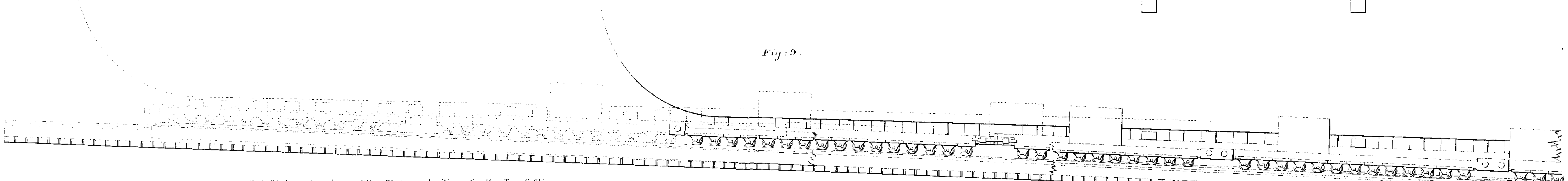
SLIPWAYS FOR REPAIRING SHIPS.

Fig: 8.



PLAN ON WAYS AND MAIN AND AUXILIARY CRADLES.

Fig: 9.



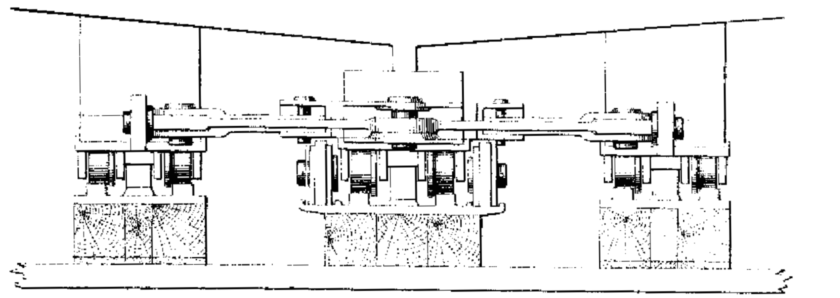
Vessel lifted off Keel Blocks, and Resting on Bilge Blocks, on Auxiliary Cradle, Top of Slipway.

ELEVATION OF WAYS AND CRADLES.

Vessel Resting on Keel Blocks, and Taking Bilge Blocks on Auxiliary Cradle, 50 Feet from Top of Slipway.

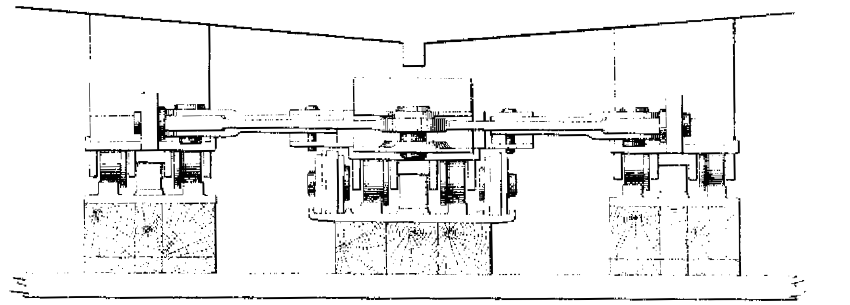
Scale 1/8 Inch = 1 Foot.

Fig: 10.



END VIEW OF CRADLES, 50 FEET FROM TOP OF SLIPWAY, SHOWING VESSEL RESTING.

Fig: 11.



END VIEW SHOWING VESSEL LIFTED FROM MAIN CRADLE.

Scale 1/2 Inch = 1 Foot.

Fig: 12.

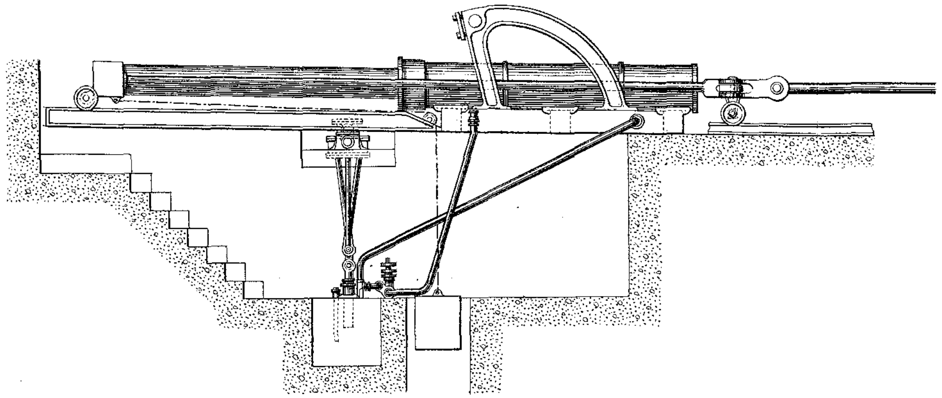


Fig: 15.

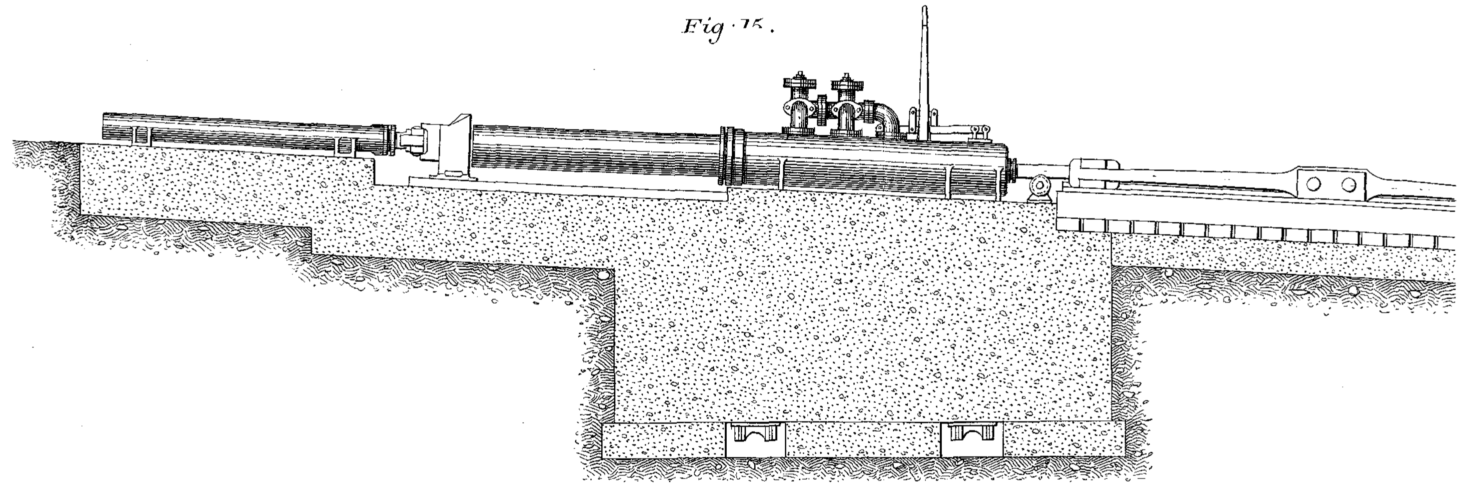


Fig: 16.

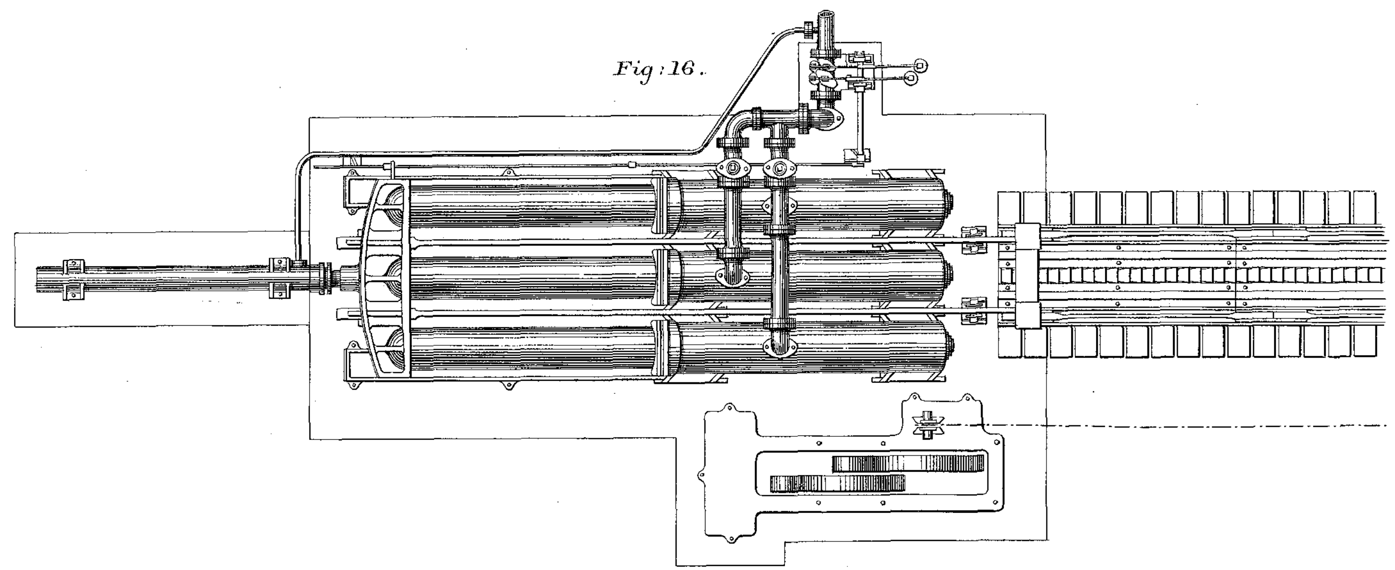


Fig: 13.

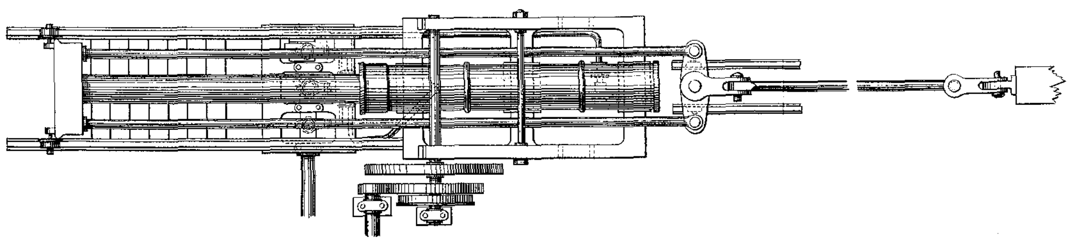
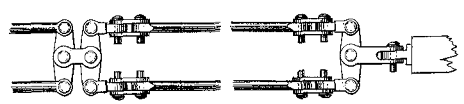
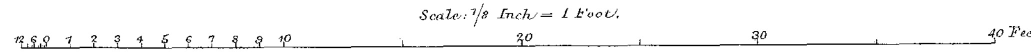


Fig: 14.



Scale: 1/8 Inch = 1 Foot.



T. B. LIGHTFOOT, DEL^T.

THOS KELL & SON, LITH. 40, KING ST COVENT GARDEN.