ON SLIPWAYS.

BY MR. WILLIAM BOYD, OF WALLSEND-ON-TYNE

In responding to an invitation to read a short paper on the modes used for hauling up vessels on slipways, the writer wishes it to be understood that his principal object has been to give a brief description of the method in use at the Wallsend Slipways, which are to be visited by the Members of the Institution on this occasion. But, before describing the system employed there, he proposes to refer shortly to two or three others, each of which possesses certain peculiarities of its own.

Armstrong's System.—This system is in use at the Howdon Yard of the Tyne Improvement Commissioners, and can be seen during this week by Members of the Institution.

It consists of one hydraulic cylinder A, Figs. 1 to 3, Plate 78, in which works a piston X, attached to a hollow ram B., Fig. 3. Inside this ram a second ram C is placed; and by the combination of these three different powers are obtained. For light loads pressure is admitted to the inside of the ram B only, forcing out the small ram C; for intermediate loads pressure is admitted to each side of the piston X, and a power is obtained due to the area of the large ram B. For heavier loads pressure is, in the same manner, admitted to the back of the piston; but the other side is opened to the exhaust, and thus the full value of the piston area is obtained.

The mode of hauling is as follows. A wrought-iron crosshead is attached to the end of the ram C, from which two short stud-link chains pass backwards to two barrels DD, keyed on a cross shaft behind the cylinder and having the end of the chain securely fastened to them. On this same shaft are placed two chain-wheels EE, running loose on the shaft, but which can be connected at will with the chain barrels D by suitable clutch gear; round these chain-wheels are passed the chains J, leading down the slipway to the cradle. When the ram is forced out of the cylinder, the chain barrels D are made to revolve through an arc of a circle, due to the stroke of the ram, and carry with them through the same arc the chain-wheels E, round which the slipway chain J is wound; this chain, as it uncoils, drops into a pit behind. When this movement ceases, the vessel is held in position by three pawls on the pawl-wheel F, and remains stationary. The clutch which connects the wheels E with the barrels D is then withdrawn, and the drawback cylinder G coming into operation draws the ram back into the cylinder A, by causing the chain wheels D to revolve back again, through the same segment of a circle as that through which they had been made to revolve by the outward movement of the ram. The whole machinery is then in its original position, and the water being again admitted to the ram, the operation is repeated till the vessel is hauled up the slipway as far as required. The relief valve is operated by the tappet rod T, worked off the cross-head; and the empty cradle is hauled up and down the slipway by the chain K, shown at the side in Fig. 2.

2. *Hayward Tyler and Co.'s System.*—The system of haulage adopted in this case is shown in Figs. 6 and 7, Plate 79. As described in "Engineering," 11 May 1877, it consists of four hydraulic cylinders, laid parallel and in pairs, as shown. The rams of each pair are connected by a crosshead, through which the traction links A pass, and thence extend down the slipway to the cradle. On the top of each crosshead are bolted two standards B: through the upper end of each passes a horizontal shaft, with a hand-lever on the outer end. In the centre of this shaft is keyed a double segment C, one arm of which is weighted, while from the other is suspended an iron block D, which serves as a stopper, and is so placed as to drop, when the segment is depressed, between a pair of short links in the traction-rod. These pairs of short links E are placed at regular intervals corresponding with the stroke of the ram. The balance weight on the segment C holds up the stopper in the position shown on the right hand in Fig. 6, out of the way of the rods; but by

turning the lever on the end of the horizontal shaft, as shown on the left hand, the stopper is lowered into its place between the pair of short links, and against the crosshead which couples the pair of rams. The action of the machine is as follows. When the traction-rods have been connected to the cradle, and led up to the cylinders, the forward "stopper" is depressed into its position between the links, and the forward rams are put in motion, thus carrying forward the traction-rods and hauling the vessel up the slipway. Immediately before the travel of the first pair of rams is completed, the second stopper is lowered to engage between another pair of links, and the hinder rams are then set in motion, continuing the work. As soon as the strain is thus taken off the first stopper, it is raised clear of the links by the balance weight on the segment, and is lowered again only when the second pair of rams have nearly completed their stroke, the first rams having been meantime run back. Thus the work of hauling up the cradle proceeds continuously. The back travel of the rams is effected automatically by means of counter-weights, the water pressure being first relieved by the crosshead striking a stud which opens an outlet valve; or in some cases a small reversing cylinder is employed instead of a counter-weight.

This apparatus has been supplied by Messrs. Hayward Tyler and Co. to the Italian Government for the dockyard at Spezia, and to many other foreign ports. It seems to possess the advantage of avoiding the loss of time due to "fleeting" or interruption in the movement of the vessel, and to any retrogression of the cradle; but the first cost would apparently be very great.

3. *Day Summers and Co.'s System.*—This simple arrangement is employed by Messrs. Day Summers and Co. at Southampton, and is shown in Figs. 4 and 5, Plate 78. As described in "The Engineer," 12 September 1879, it consists of a drum B, 5 ft. 2 in. diameter, on which is wound a steel wire hawser A, 9 in. in girth, and which is driven by worm wheel and gearing connected with a small pair of engines, as shown. This drum is large enough to carry the whole length of the wire hawser without a second coil. To prevent any bruising of the strands of the steel wire against the iron drum, the

surface of the latter is covered with hard rope, tightly strained on the drum, and this protection is said to answer very well.

The spur wheel C upon the large drum B is worked by the pinion D, Fig. 5, which can slide in or out of gear with C, and when out of gear allows the small drum E to work independently of the large drum B, for the purpose of hauling up the empty cradle, and of unwinding the steel hawser A off the large drum. This is effected by taking two or three turns round the barrel E with a light chain, one end of which passes round a pulley at the lower end of the slipway, and is then brought back and made fast to the end of the wire hawser A. The drum E is then set in motion, and the light chain pulls the wire hawser off its drum and hauls it down to the cradle, where it is made fast, and is thus ready to haul up the next vessel.

As in this system there is no interruption in the onward movement of the vessel up the slipway—technically known as "fleeting,"—the work is done very rapidly; and as few hands are required, the cost is consequently small.

Thompson's System.—This system, designed by Mr. John Thompson of Newcastle, and Mr. T. B. Lightfoot, by whose firm the machinery was constructed, is now in use at the slipways of Messrs. Cleland and Co., and Messrs. Palmer's Shipbuilding Company, on the Tyne; at Penarth Docks; and at Messrs. Raylton Dixon and Co.'s Works, Middlesborough. It consists of a treble-powered hydraulic hauling apparatus, Figs. 8 and 9, Plate 80, placed at the top of the ways, and connected by means of suitable crosshead and rods to a double set of main traction links, which extend nearly to the bottom of the ways. The three powers are obtained by allowing the pressure (which may be taken either direct from a pump or from an accumulator) to act respectively on the centre ram alone, on the two outer rams, or on all three together. The rams are single-acting, and the water is admitted or exhausted by the attendant, controlling an ordinary hydraulic working valve. The return stroke is accomplished by means of a small single-acting hydraulic cylinder, on the ram R of which the pressure water constantly acts. The connection to this ram R is in some cases made by chains, Fig. 10, attached to the extreme end of the links, and carried round suitable pulleys up to the returning cylinder, which is fixed above low water. In other cases, Fig. 11, the ram R is applied direct to the crosshead of the hauling cylinders, rods or chains being taken down the whole length of ways to the bottom end of the links, so as to transmit the proportion of power required for hauling them down the ways.

With this arrangement of machinery, the attendant, by simply working one lever forwards and backwards, can cause the links to travel up and down through a distance determined by the stroke of the rams, which is about 11 ft. Suitable pawls, attached to the main timbers of the cradle, gear with the connecting plates of the links, which are spaced exactly 10 ft. apart, so that at every upward stroke the cradle is hauled 10 ft. The usual pawls, rack, and centre rails prevent the cradle from returning with the links on the backward stroke. Several sets of pawls are used, so as to distribute the strain on the cradle. The empty cradle is hauled down either by separate hydraulic purchase with ordinary chain, or by a small ram applied within the centre hauling ram, the large rams being locked back during this process.

The machinery on this system erected at Raylton Dixon and Co.'s, and at Palmer's Works, is the same in principle as the above; but instead of three distinct hauling cylinders one only is used, fitted with two concentric rams, of which the larger and outer is used for heavy, and the inner for light loads. When the smaller ram alone is being used, the larger one, which is provided with a stuffing-box and gland for the other to work through, is locked back by two removable keys.

Wallsend System.

The system at the Wallsend Slipway does not claim any special novelty, but its chief peculiarity lies in the *length* of the slips, which measure 1000 ft. from the bottom end of the rails to the upper end of the hydraulic cylinder. The machinery was constructed by Messrs. S. and H. Morton and Co., of Leith, in the year 1873: but the system was first designed by the late Mr. Morton in the year 1819, and was carried into comparatively general use in

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succeeding years. About the year 1832 a Select Committee of the House of Commons awarded Mr. Morton a considerable sum, for the great advantage his invention had been to the shipping interest of the country. The general arrangement of the slipway is shown in Figs. 12 to 14, Plate 81. The foundations are shown in the section Fig. 12, and consist mainly of slag. For the first year or two after the slipways were in operation, some settlement took place, and the longitudinal balks had to be wedged up from the cross-timbers; but of late no trouble has been experienced from this cause. The inclination of the slipways is $\frac{5}{8}$ in. to a foot, or 1 in 19.

Machinery.—As will be seen from Figs. 15 and 16, Plate 82, and Fig. 19, Plate 84, the cradle consists of a main body of timber framing, 173 ft. long, and extended by "ekes" E, along the centre of the slipway, to 284 ft. long. These "ekes" are balks of timber surrounding a wrought-iron bar, and running on wheels on the centre rail.

On the top of the longitudinal timbers, Fig. 19, Plate 84, which are supported by transverse balks resting on the slag foundation, are fixed cast-iron rails, Fig. 20, weighing 3 cwt. per running foot for the centre rails, and 1 cwt. per running foot for the outer rails: on the latter there run two extensions or continuations of the main cradle framing, and upon these rest the transverse wrought-iron arms A, Fig. 19, which support the sliding bilge-blocks B. The weight of the whole cradle, arms, &c., is about 160 tons. When a vessel is "relieved," as described hereafter, these arms swing on strong centre pins into a longitudinal position, and allow the cradle to be removed entirely from under the vessel. The motive power for each slipway consists of a hydraulic cylinder, the ram or plunger of which is 15 in. diameter and 10 ft. stroke, corresponding with the length of the traction links. Water is forced into the cylinder by three pumps, each $3\frac{1}{2}$ in. diam. and 12 in. stroke, making in quick gear 50 strokes per min., and in slow gear 25 strokes per min. The general arrangement is shown in Figs. 17 and 18, Plate 83. Attached to the outer end of the ram is a strong crosshead A, and connected to it are two wrought-iron rods, passing backwards outside the cylinder; these are again joined together by a second crosshead B, to which the series of successive links C, leading down the slipway to the cradle, are attached. These links, shown enlarged in Figs. 21 and 22, Plate 84, are of wrought iron, each 10 ft. long from centre to centre of the eyes, and $3\frac{3}{4}$ in. diam., giving a sectional area of 11·04 sq. in. The pins are of steel of same diameter. The pumps, Figs. 17 and 18, are driven from the engine through the pinion D (which can be shifted in or out of gear as required), and one or other of the loose wheels E F, which can be connected to their shaft by a clutch. This same shaft also drives through the intermediate gearing G the chain sheave H. This sheave works an ordinary short-link chain, called the "back chain," which is used for pulling up the empty cradle after a vessel is launched; and also for pulling it down into its lowest position, to receive a vessel coming on for repairs.

Working with this machinery, the mode of operation is as follows. The cradle is run down into the water by its own weight, assisted occasionally by the back chain, which is sometimes rendered necessary by the accumulation of mud lying at the lower ends of the slipways, into which the cradle has to force its way; or again, in the case of large and long vessels, the lower end of the cradle is often pulled 40 or 50 ft. beyond the rails, and rests on the hard mud bank existing outside. The vessel to be taken on the cradle is then guided into an approximate position, by ropes carried to capstans on the jetties, Plate 81. Attached to the upper end of the cradle are two long iron rods I, Fig. 15, Plate 82, a few inches on each side of the centre line of the cradle, and each hinged at the lower end, so as to enable them to be raised from a horizontal to a vertical position: the outer ends of these rods are buoyed, and when the vessel is approximately in the proper position light ropes fastened to the rods are passed on board ship and hauled up tight. The iron rods, thus raised to a vertical position, form two guides between which the vessel can be accurately placed on the keel-blocks, guided by the controlling ropes on shore. The cradle is then hauled slowly up the ways by the hydraulic ram, till the stem grounds and settles on the foremost "eke," the stern being still afloat. Two similar rods to those described above are attached to the lower end of the cradle, and the stern of the ship is in like manner guided between them, till by the concurrent upward movement of the cradle the whole length of the keel rests on the line of keel-blocks. The moment this operation is complete, the bilge-blocks B, sliding on the transverse arms A, Fig. 19, are hauled into position against the bilge of the vessel by ropes passed on to the nearest jetty, and when pulled home the ropes are passed on board the vessel and there made tight. The vessel is then safely and securely seated on the cradle.

The operation of hauling up now commences. The length of each traction link is 10 ft., corresponding with the stroke of the hydraulic ram, as before described. Each time the ram with its crosshead is forced by the pumps out of the cylinder, the cradle with its burden, and the connecting series of links, advance up the ways through the length of one link or 10 ft. The outlet valve of the cylinder is then opened, the water escapes, and the vessel falls back on to pawls attached to the underside of the cradle, which catch into teeth cast on the centre rail, Fig. 20. A counterbalance weight brings the ram back into the cylinder; the first link is removed by means of a small travelling crane, and a new attachment is made between the crosshead of the ram and the next link of the series. This process is repeated until the cradle and the vessel thereon are pulled clear of the water.

When a vessel is to be launched, the reverse process takes place. All the pawls, except one or two at the fore end of the cradle, are tied up; these two are worked by hand till the vessel is lowered far enough down the slipway to allow of launching, when these in turn are also tied up, and the vessel rests for a short time on one single pawl or "dagger." The lowest link is then disconnected from the fore end of the cradle, and the dagger being knocked away, the cradle with its burden runs down the ways. As deeper water is reached, the vessel floats away from the cradle. The back chain before alluded to is then connected to the chain sheave H, Fig. 18, at the head of the slipway, and by its means the empty cradle is pulled up the slipway till it is again required.

Speed of Working.—When the vessel is once fairly seated on the cradle, and the hauling up process can commence without interruption, the rate of movement is as follows:—

For light vessels	in quick gear	2 min.	per link or rod 10 ft. long.
„ heavy	„ slow	„ $3\frac{1}{2}$	„

Owing however to the time occupied in the successive removal of rods, the actual rate of progress up the slipway is not so fast, and is about as follows:—

Single rods, for light vessels	in quick gear,	$2\frac{1}{2}$ to 3 min.	per rod.
„ heavier	„ slow	„ $4\frac{1}{2}$ to 5	„

When the size and weight of the vessel exceed a certain limit, a double tier of rods is laid, Fig. 21, Plate 84, connecting the crosshead of the hydraulic ram with a similar crosshead attached to the foremost eke. Hence, although when the vessel is actually moving the rate of progress remains as stated above, yet owing to the longer time occupied in the removal of the successive pairs of rods the total time is about as follows:—

Double rods, comparatively light vessels,	quick gear,	5 min.	per rod.
„ very heavy vessels,	slow „	6 to 7	„

The total distance traversed by the cradle from the point where it first receives its burden is about 420 ft.; and the time occupied may be taken as about two hours with single rods, and three and a half hours with double rods, exclusive of course of the time required to place the vessel on the cradle, which is usually about three-quarters of an hour.

Comparison with Dry Docks.—An impression exists in some quarters unfavourable to slipways, as compared with dry docks, on account of the supposed greater safety of the latter. As to this, the writer can state that 714 vessels have been taken on the Wallsend slipways from their opening in January 1874 to 30 June, 1881, a period of $6\frac{1}{2}$ years, and not a single accident of any kind has happened to any one vessel by reason of defect or insufficiency in the system employed.

The vessels in question have of course been of all sizes and tonnages. The heavest vessel yet attempted was H.M. Troopship "Tyne," measuring 320 ft. long × 34 ft. beam, gross registered tonnage 2169 tons, displacement weight 1700 tons. She contained besides 300 tons of pig metal ballast, making a total weight hauled up of 2000 tons.

The slipway system has moreover the following manifest advantages.

(1.) The height of the vessel from the ground allows a free current of air under the bottom, which is thus quickly dried; by the time the dirt and adhering scale are removed, it is always perfectly dry, and ready to receive a new coat of paint.

(2.) In case of heavy repairs to the bottom of a vessel, this height gives ready access to the plates or frames which have to be removed and repaired; and the workman can act with much greater efficiency than in a dry dock, where the bottom of the vessel is only a foot or two above the floor.

(3.) The process of repairing is never interrupted by the hauling up of another vessel; whereas interruption constantly occurs in large dry docks, from the necessity of letting in the water to admit another vessel behind the first.

(4.) An advantage of obvious importance to the capitalist is that the cost of construction of slipways able to contain four vessels at one time, as is often the case with the two Wallsend slipways, is considerably less than the cost of a dry dock with its pumping appliances, capable of giving equal accommodation.

Relieving.—This last consideration leads very naturally to a description of the mode by which the upper portions of the slipways are made available, and which enables two vessels, each say 300 ft. long, to be "slipped" one behind the other on each slipway clear of the water.

It has been already stated that the slipways measure 1000 ft. long from end to end. When it is required to use the upper portion of the slipways, *e.g.*, when extensive repairs or alterations are in question, or when a vessel is to be lengthened, the cradle carrying the vessel is hauled, in the manner before described, right up to the top of the ways, leaving space for another vessel between it and high water. When in this position the operation of "relieving" is undertaken.

This is commenced by placing between each pair of transverse arms A, Fig. 19, Plate 84, (and in most cases also forward of the foremost arm) strong blocks of timber as bilge-blocks, capable eventually of carrying the whole weight of the vessel. Commencing just forward of the foremost arm, and simultaneously on the port and starboard, these new bilge-blocks are very tightly wedged against the bilge or underside of the vessel; the weight of the vessel is thus removed from the bilge-blocks B sliding on the arms A, and taken by the new bilge-blocks resting on the ground. The bilge-block on the first arm is then slid out from under the vessel, and the arm is free to be turned from a transverse into a longitudinal position. This process is continued till all the arms on each side of the vessel are free of it; and the ship now rests solely on the new bilge-blocks, and on the keel-blocks upon the cradle.

These latter are disconnected in their turn in the following way. Along the centre line of the cradle are a series of short hydraulic lifting presses PP, Plate 82, which are connected with the pumps used for the hydraulic cylinder by pipes laid beneath the surface of the ground. These being set going, water is forced into all these presses simultaneously, and the whole vessel is raised very slightly, but sufficiently to allow of the removal of the centre keel-blocks. When the pressure is relieved, the vessel sinks gradually back on to the new bilge-blocks just described. The whole cradle is now clear, and free of the superincumbent vessel. The cradle is then allowed to move down the slipway, and is ready to be used for the reception of other vessels for painting or slight repairs, till the heavier work upon the "relieved" vessel is completed. She is then placed again on the cradle by a process exactly the converse of that just described, and is lowered down the slipway for launching.

It will be seen that the relieved vessel rests entirely on the new bilge-blocks, which are further supported by side shores, and that under the line of the keel the slipway is perfectly clear, so that the rods required for the use of the cradle in its lower position can be run up or down without hindrance. Further, in the event of any one or more of the new bilge-blocks coming in the way of a damaged plate that requires removal, this block can be readily removed and rebuilt, in any way rendered necessary by the work to be carried out.

Several vessels have been very readily lengthened on these slipways by this method. The fore body of the ship is relieved in the manner just described, leaving the after body resting on the cradle. The separation of the vessel into two portions is then made in the usual mode; and when this is complete the cradle is slowly lowered down the ways for a distance corresponding with the additional length which it is proposed to give to the vessel. The after body is then in its turn relieved, and the whole cradle removed from under it. The new part of the ship is then built, and when the whole is complete the vessel is replaced on the cradle and launched.

In conclusion the writer appends a Table showing the power actually required to haul up a number of vessels (of which he has been able to obtain the exact displacement weight), as ascertained by the registration of the gauge attached to the hydraulic cylinder, compared with the theoretical power required, as obtained by calculation.

The formulæ employed are seen to be simple, and the comparison of the "actual" with the "theoretical" power is interesting. It will of course be at once evident that the excess of the former over the latter is caused by variations of weather, inequalities of the slipway, more or less perfect lubrication, and the many other conditions of actual working.

APPENDIX.

THEORETICAL CALCULATION OF POWER REQUIRED TO MOVE VESSELS UP SLIPWAY.

Power required for Weight (*Formula* A).—The formula here is :—Power = R × slope of incline = R × $\frac{1}{19}$, where R is the total weight, which in the case of the vessel No. 22 is made up as follows :—

Weight of Vessel =	1500 tons
Weight of Cradle =	160 „
Weight of Links =	13 „
Total Weight	1673 „

Hence Power for Weight = $\frac{1673}{19}$ = 88 tons.

Power required for Friction of Cradle, &c. (*Formula* B).—Here the formula is :—

$$\text{Power} = \frac{\text{coeff. of friction on axles} \times \text{diam. of axle} \times \text{weight of vessel and cradle}}{\text{Diameter of wheel}}$$

For No. 22, Power for Cradle Friction $= \frac{0{\cdot}2 \times 2{\cdot}5 \text{ in.} \times 1660 \text{ tons}}{10 \text{ in.}}$

= 83 tons.

Power required for Friction on Leather Collar of Ram (*Formula* C). Here the formula is :—

Total pressure = pressure per sq. in. × depth × circumf. of collar
= 2800 lbs. (in case of No. 22) × 1 in. × 47·5 in.
= 59 tons.

Power = Total pressure × coefficient of leather on iron in motion *
= 59 tons × 0·56
= 33 tons.

* Leather on iron in repose gives coefficient of friction 0·80,
„ „ in motion „ „ 0·80 × 0·70 = 0·56.

POWER IN TONS REQUIRED TO HAUL UP VESSELS.

Number of Vessel.	Gross Register Tonnage.	By Calculation.					By Gauge.	
		Actual Weight of Slip.	Power for Weight.	Power for Friction of Cradle.	Power for Friction of Collar.	Total Calculated Power.	First time on Slip.	Second time on Slip.
			Formula A	Formula B	Formula C			
		Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1	932	630	42·26	39·5	18	99·7	120	120
2	902	650	43·4	40·5	19	103	125	
3	866	670	44·4	41·5	20	107	130	140
4	971	800	51·2	48·0	21·8	121	145	
5	1374	820	52·3	49·0	21·8	124	145	140
6	1531	920	57·5	54·0	21·4	133	140	150
7	1261	920	57·5	54	22·8	134	150	160
8	1323	920	57·5	54	22·8	134	150	
9	1250	930	58	54·5	22·8	135	150	
10	961	1000	61·7	58	30	149·7	200	
11	1613	1010	62·2	58·5	27·5	148	180	
12	1469	1030	63·3	59·5	28·7	151·5	190	
13	1571	1040	64	60	22·8	146·8	150	180
14	1568	1040	64	60	24·2	148	160	
15	1727	1040	64	60	25·3	149	170	170
16	1498	1070	65·4	61·5	22·8	149·7	150	180
17	1683	1220	73·3	69	31·7	175	210	
18	1646	1220	73·3	69	33	175	220	
19	1913	1340	79·6	75	31·7	186	210	
20	1879	1340	79·6	75	30	184·6	200	
21	1873	1350	80	75·5	30	185·5	200	
22	2141	1500	88	83	33	204	220	

SLIPWAYS.

Armstrong's System.

Fig. 1. *Elevation.*

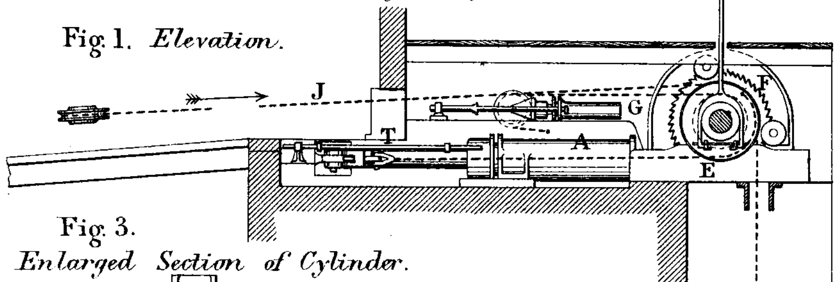


Fig. 3.
Enlarged Section of Cylinder.

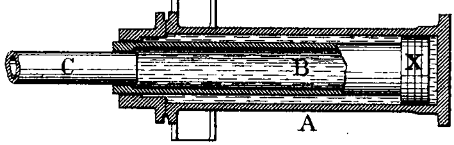
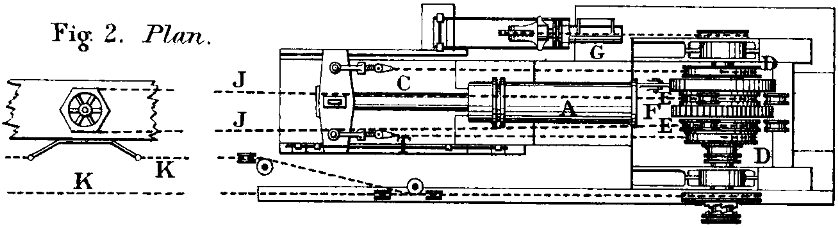


Fig. 2. *Plan.*



Day Summers & Co's System.

Fig. 4. *Elevation.*

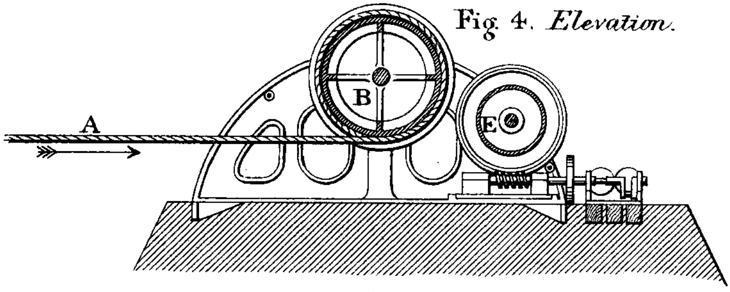
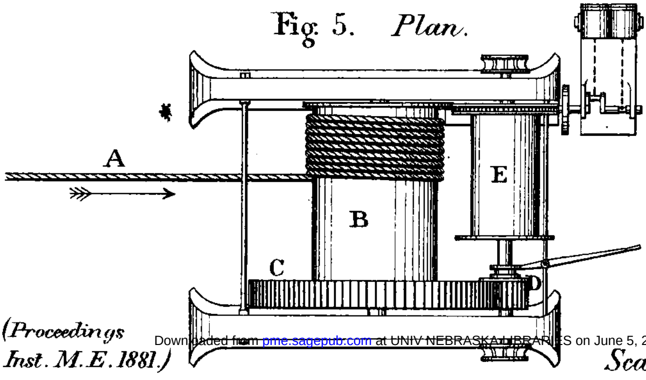


Fig. 5. *Plan.*



Scale 1/96th.

SLIPWAYS.

Hayward Tyler and Co's System.

Fig. 6. Elevation.

Scale 1/96 th.

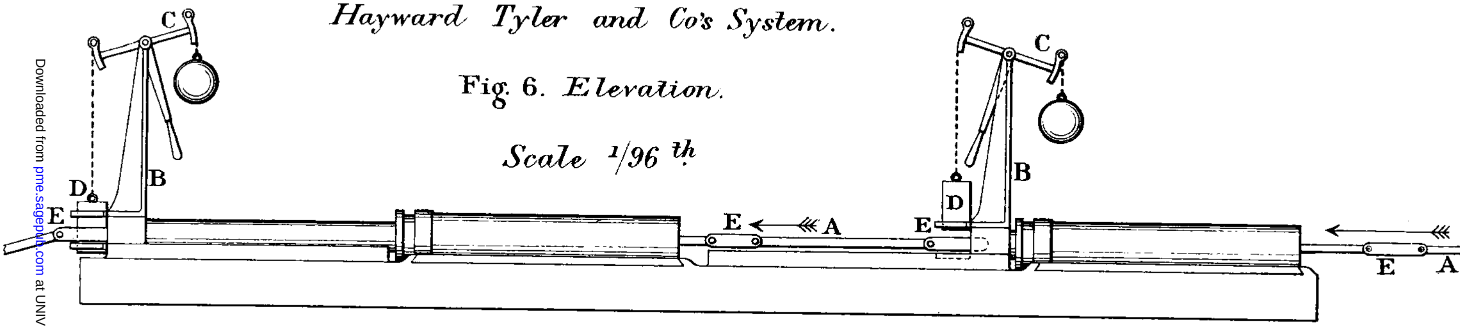
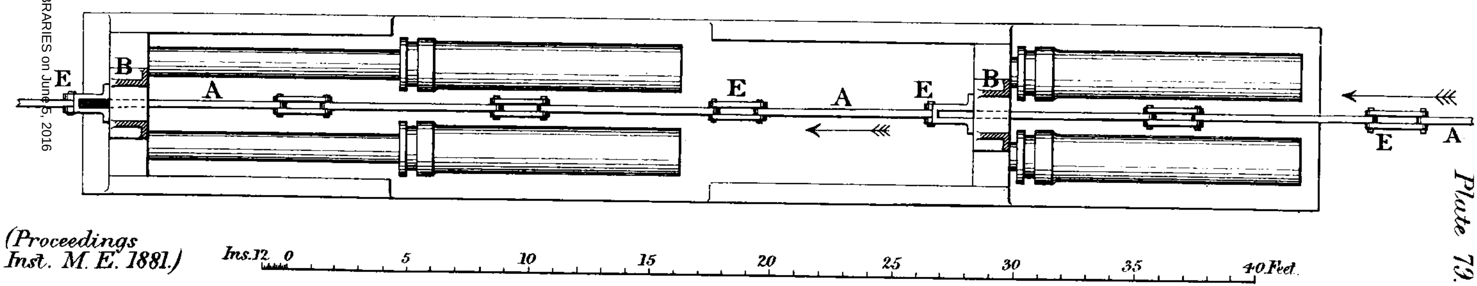


Fig. 7. Plan.



(Proceedings Inst. M. E. 1881.)

SLIPWAYS.

Thompson's System.

Fig. 8. *Elevation.*

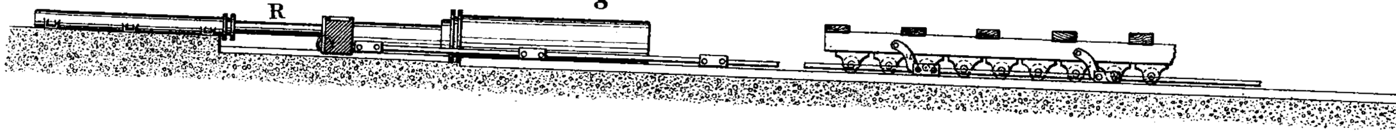
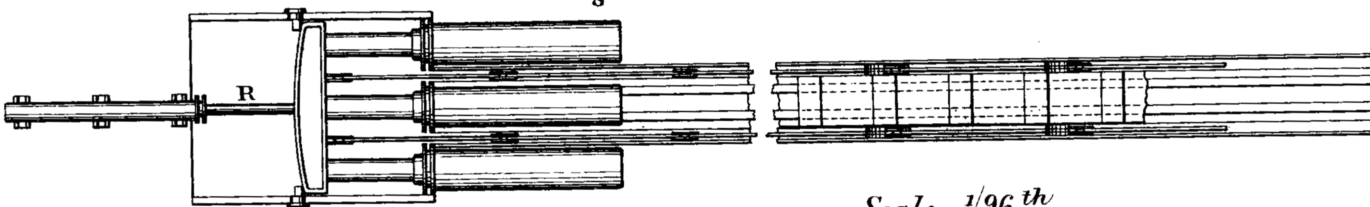
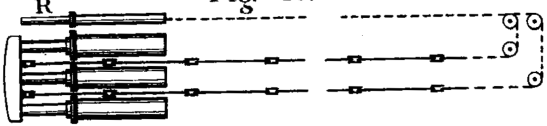


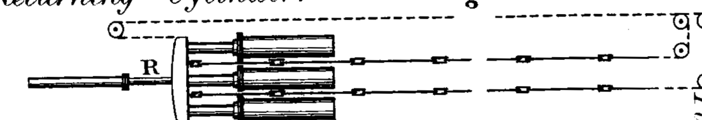
Fig. 9. *Plan.*

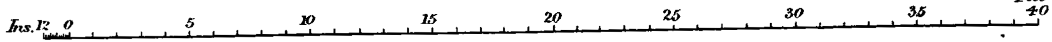


Scale 1/96th

Fig. 10. *Attachment of Returning Cylinder.* **Fig. 11.**







(Proceedings Inst. M. E. 1881.)

SLIPWAYS.

Plate 81.

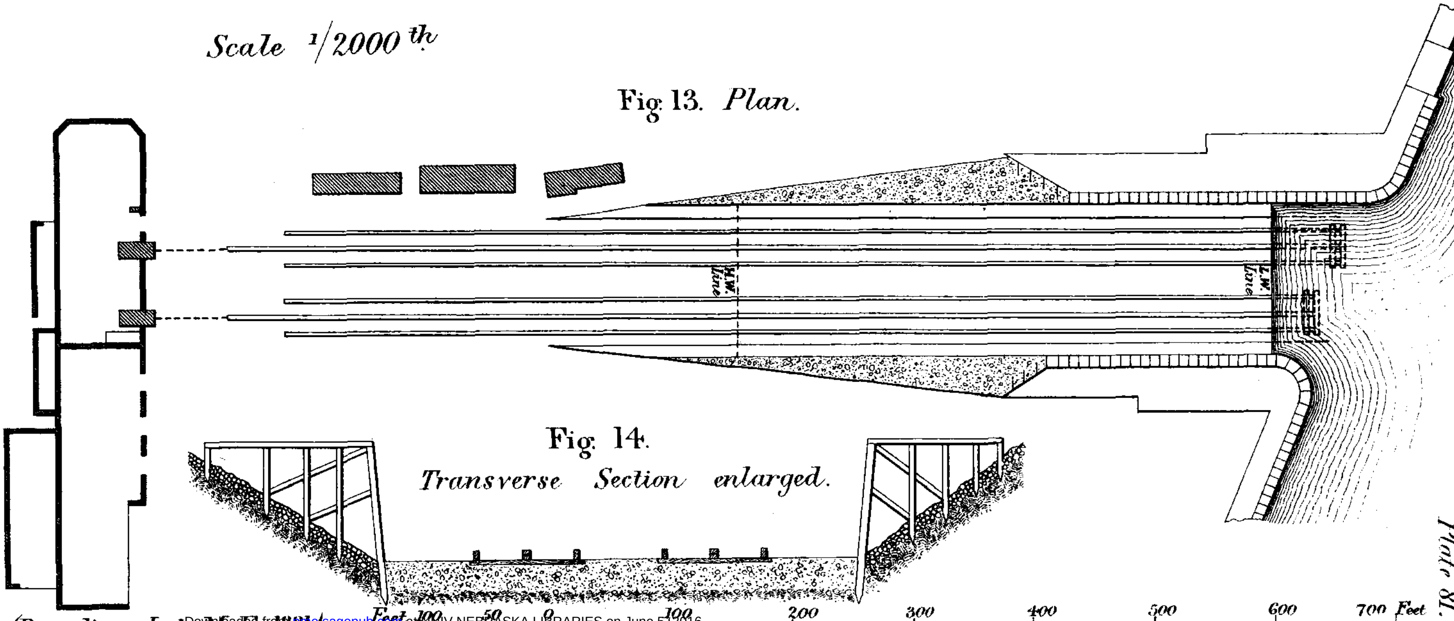
Wallsend Slipways, General arrangement.

Fig. 12. *Longitudinal Section.*

Scale 1/2000th

Fig. 13. *Plan.*

Fig. 14. *Transverse Section enlarged.*



(Proceedings Inst. M. E. 1881.)

Plate 81.

SLIPWAYS.

Plate 82.

Wallsend Slipways.

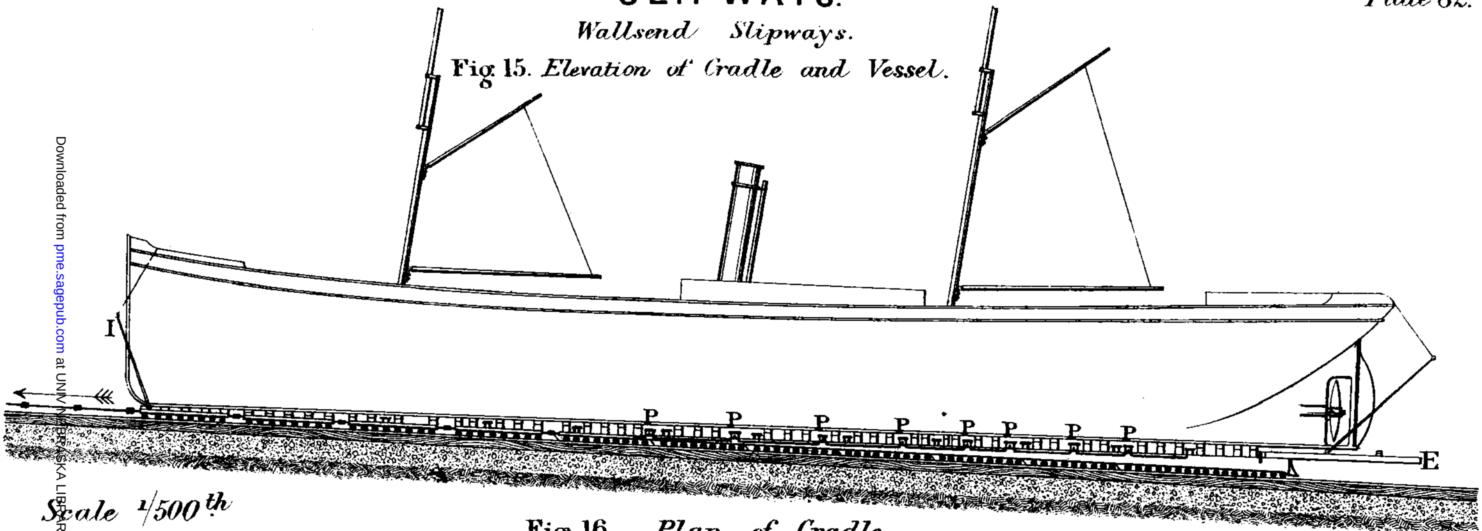


Fig. 15. *Elevation of Cradle and Vessel.*

Scale 1/500th.

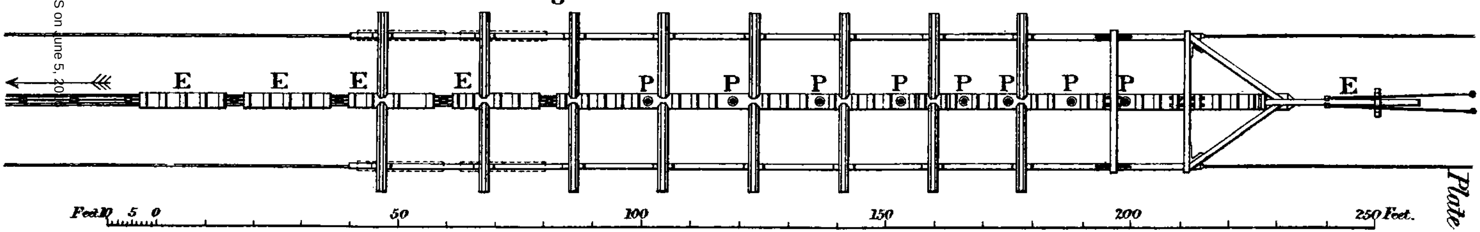


Fig. 16. *Plan of Cradle.*

(Proceedings Inst. M.E. 1881.)

Plate 82.

Wallsend Slipways.

Fig. 17. Hauling Apparatus. Elevation.

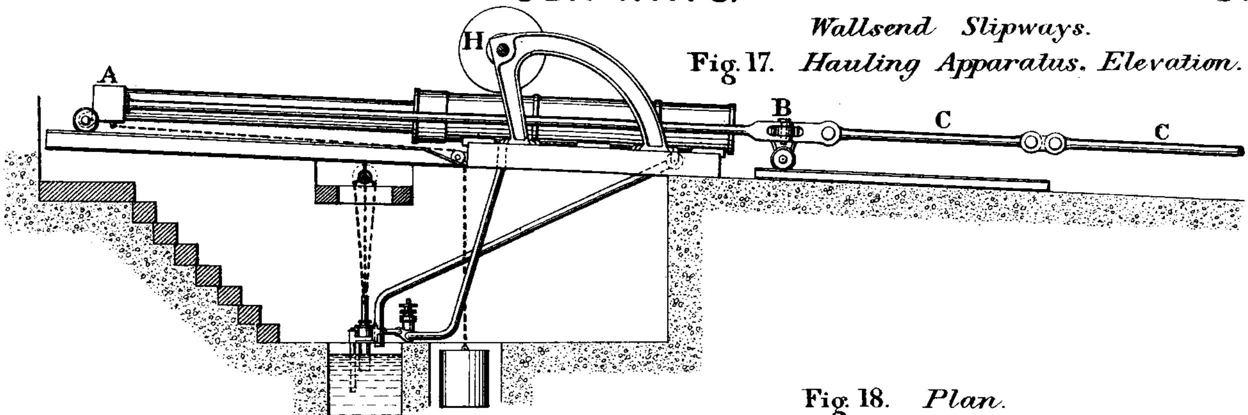
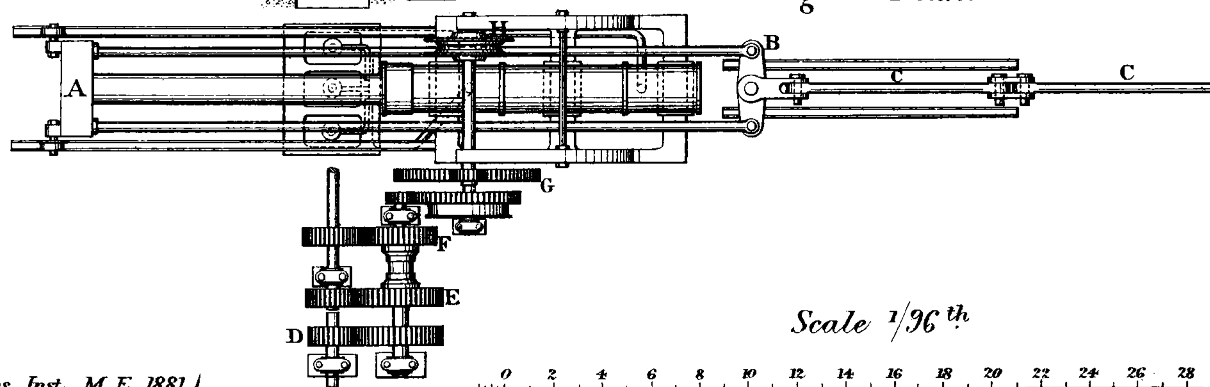


Fig. 18. Plan.



Scale 1/96th.

0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 Feet.

Wallsend Slipways.

Fig. 19. *Transverse Section of Cradle and Rails.*

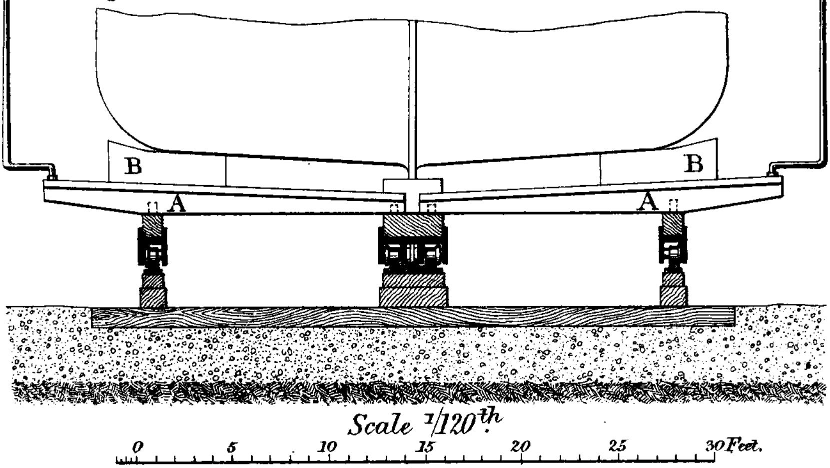


Fig. 20. *Enlargement of Rack and Rails.*

Fig. 21. *Double Rods. Elevation.*

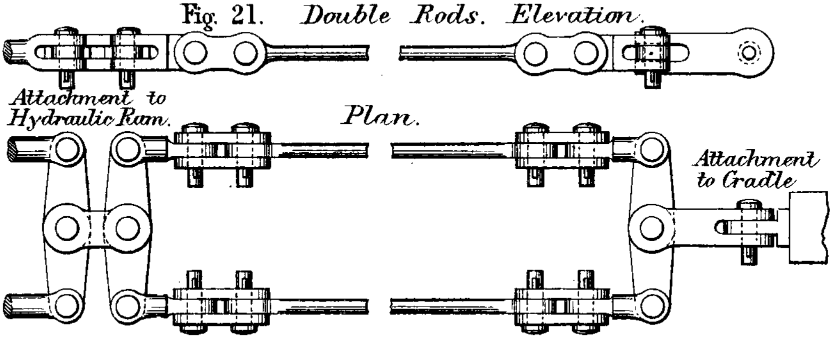


Fig. 22. *Single Rods. Elevation.*