TRANSACTIONS.

I. *An Account of the Harbour and Docks at Kingston-upon-Hull. By* MR. TIMPERLEY, *Resident Engineer to the Hull Dock Company. Communicated by the* PRESIDENT, JAMES WALKER, ESQ., *F.R.S., L. & E.*

THE OLD HARBOUR.

THE river Hull, according to Mr. Tickell, the historian of the town, formerly discharged itself into the Humber between Drypool and Marfleet, and that part of the present river usually called the Old Harbour, was originally no more than an open drain cut by Lord Sayer of Sallon, for the purpose of draining the country.

This harbour, from the north bridge to its junction with the Humber, was the original and, previously to the construction of the docks, the only port for the town; its direction is nearly north and south, its length from the bridge to the end of the Garrison Jetty, 2940 feet, and the average width within the staiths, at high water of spring tides, 165 feet; the area is therefore about eleven acres, and the depth is 22 feet.

As trade and commerce increased, the harbour became insufficient to contain all the vessels that frequented the port, many of which were therefore obliged to receive and deliver their cargoes whilst lying in the roads, by means of craft, and so crowded was it at times, that even up to the period of the Junction Dock being made, ships have been known to be twenty tides or more in passing from the Humber to the Old dock. But the crowded state of the harbour, and the consequent delay in getting to and from the quays, were not the only inconveniences; for, from its being an open tideway, all vessels draw-

ing more than four or five feet water grounded every tide; so that damage was frequently sustained, particularly by such as were sharply built and deeply laden. Complaints were also made by the officers of the Customs from time to time, of the great risk and difficulty in collecting the duties, whereby, it was stated, the revenue suffered very materially, and this ultimately led to the formation of the Old dock.

It should also be observed, that for some hours before low water, the current is so strong as to be unnavigable for vessels against the tide, and those passing with the stream are frequently injured; the fall or declivity from the outer end of the Old dock basin to the harbour mouth, at low water spring tides, being in general from four to five feet, and sometimes more, and the velocity of the ebb at such times from three to four miles an hour.

Before the Old dock was begun, transverse sections were taken of the harbour by Smeaton and Grundy, from which we find that the depth of water is now about the same as it was at that time, but the river is much narrower near its junction with the Humber; this diminution in the width has taken place since the Humber dock was made, from the free course of the tide, obstructed and retarded by the projection into the river of the quays and piers of the basin, causing a great accumulation of mud upon the shore for a considerable distance, both above and below the entrance to the Humber dock: and the mouth of the harbour has not only been narrowed by these works, but has been extended further into the Humber, and a new direction considerably to the westward given to it.

The harbour is scoured entirely by its back waters, of which the principal supply in summer is from the river Hull, which extends into the East Riding about twenty miles, and is navigable for vessels of fifty tons' burden; but in winter, the drainage from the extensive level of the Holderness and the low land on the west side of the river, has been, for a long time, a very powerful auxiliary in maintaining the depth.

For the convenience of vessels entering, two dolphins have been erected upon the Humber, to the east of the harbour mouth, the last in consequence of this part of the beach sanding up, as before noticed; and there is a jetty or small pier with the necessary mooring posts, and two transport buoys a little to the south of the dolphins. In former times a chain was stretched across the entrance of the harbour, and a small charge made for all vessels passing in or out, but this restriction and impost have been discontinued for many years.

On each side of the harbour, for nearly its whole length, there are staiths or platforms, fifteen feet wide, for loading and delivering vessels; they are private property, and in order not to obstruct the free course of the tide, are (in pursuance of an act of parliament) formed of large piles driven firmly into the ground, upon which are laid transverse beams, covered with close planking. Cranes are fixed on these staiths, and on the town side there is an extensive range of private warehouses for sufferance goods.

Tides. The time of high water at Hull, at the full and change of the moon, is six o'clock, but the highest tides are generally two or three days afterwards; the flow or rise of an average spring tide is about 21 feet at the harbour mouth, and 17 feet at the entrance to the Old dock; that of an average neap tide, 12 feet at the harbour mouth, and 9 feet opposite the Old dock entrance: but it may be observed, that the tides occasionally rise three to four feet higher, and sometimes, though rarely, a little more, and ebb sometimes two feet or more, lower than stated above. It may be proper to notice also, that when there are many vessels in the harbour, the ebb is not so low by nearly a foot, as when it is clear of shipping. The tide flows about five hours at the harbour mouth, and four hours and a half at the entrance of the Old dock.

THE OLD DOCK.

In consequence of the confined state of the old harbour and other inconveniences already briefly noticed, application had been made to government, a few years before obtaining the Act for making the Old dock, for a grant of part of the King's works near the Garrison, for the purpose of enlarging the harbour; but, as a legal quay formed no part of the scheme, it was opposed by the board of Customs, and nothing further was done. Some time after, however, it was intimated to the Collector and Comptroller of Customs at the port, that if a dock and legal quay were not made at Hull, the business would be removed to some other port connected with the Humber disposed to conform to these regulations; and a memorial was in consequence presented by the merchants of Gainsborough, praying that a legal quay might be established at that place.

It was now evident that something must be done to preserve the trade of the port, and it was at length resolved that the wishes of government as to a dock and legal quay should be complied with; but there appears to have

been great difficulty in obtaining an adequate subscription, and it was some time before this desirable object could be accomplished. The shareholders employed Mr. Grundy, the engineer, to furnish designs and an estimate for the work, which being approved of, and the necessary arrangements completed, application was made to parliament and an Act obtained in April, 1774, soon after which the work was begun.

At that period works of this kind were in their infancy, and we must not therefore look for the degree of perfection, either in design or execution, which has distinguished those of more recent times.

Dimensions of dock. The Old dock, which appears to have been judiciously planned and laid out, is 1703 feet long, by 254 feet wide, so that the superficial content is nearly ten acres, and therefore capable of containing a hundred square rigged vessels; it was the largest dock in the kingdom at the time.

Excavation. According to the sections the excavation averaged about 15 feet, the bottom of the dock being 15 inches above the bed of the old harbour opposite the entrance. The soil, which was altogether alluvial, was deposited upon land chiefly on the north side, and partly purchased for the purpose, which being raised thereby about five feet, and afterwards sold by the Dock Company, is now the site of several principal streets.

Dock walls. Plan, No. 2. The walls are founded upon piling of a novel description, but very inadequate to the purpose: the piles, which are 12 inches wide by 9 inches thick at the top tapering regularly to 3 inches at the bottom, are driven under the walls and counterforts, longitudinal sleepers, 12 inches wide by 6 inches deep, trenailed on the pile heads, and 3 inch transverse planking laid and spiked down on them: the whole is of fir timber, and laid perfectly level.

The walls are wholly of bricks, many of them made upon the spot, coped with Bramley-fall stone, 12 inches thick, and 3 feet wide. They were built and grouted with mortar made of Warmsworth lime and sand, part of which was fresh water sand, and the rest selected from the excavation; the brickwork, for 14 inches in depth, is at right angles to the face, the rest of the wall horizontal,—a mode of laying by no means to be recommended, as the front is thereby completely separated from the other part of the wall, and the bond, a most essential part of all building, thus entirely destroyed.

In front of the wall, at intervals of ten feet, oak fenders 9 inches wide,

and projecting $7\frac{1}{2}$ inches, are tenoned into three oak sills, 12 inches by 6 inches, built in the brickwork, and bolted and further secured to them by oak brackets spiked on each side.

From the insufficiency of the piling, and the foundation, which was only level with the bottom of the dock, not being low enough, the walls have subsided, and been forced forward in several places by the pressure of the earth behind; the greatest derangement is on the north side near the east end, noticed by Smeaton in his Reports as being at that time 2 feet $8\frac{1}{2}$ inches out of a straight line in a length of 187 yards, and found by recent measurement to be now 3 feet 10 inches out in 202 yards, or about a foot more than when examined by Smeaton shortly before the opening of the dock: the wall on the south side nearly opposite the above, for 103 yards in length, is also forced forward about 20 inches in the worst place: the rest of the dock walls are nearly as straight as when first built. This wall has given way at different times, (probably from the quays being overloaded,) and in several places eleven or twelve feet at top have been taken down and rebuilt; piles have also been driven down in front of the wall, and a cap sill with transverse planking laid thereon, upon which the new wall has been erected; this has answered the purpose, and as a further security a mass of well rammed clay has been lately deposited at the foot of the weakest parts of the wall.

Lock and basin. The original lock was 200 feet in extreme length, and 36 feet 6 inches wide, by 24 feet 6 inches deep; there were six rows of grooved sheet piling 14 feet long across the lock, which was founded on 1245 bearing piles 12 feet long, of a similar description to those for the dock walls, and on these longitudinal and transverse beams were laid, and covered with 4 inch planking, so as to form a wooden floor, which was the customary mode of building at that time.

The lock walls were built with bricks, faced with Mexborough stone, from 10 inches to 3 feet, or, on an average, 18 inches deep in the bed, with occasional *through* stones to bind the work together; the hollow quoins and coping were of Bramley-fall stone, the faces of which were set in pozzuolana mortar, as also the front masonry: the gates were made of English oak, in an arched form, and but 12 inches thick, including the planking. There was only one clough or sluice, 3 feet by 18 inches, in each gate, which did not give sufficient power to cleanse the lock and basin, without having recourse to a small lighter and drag to loosen and remove the mud whilst scouring.

There was a common wooden drawbridge on the Dutch plan, over the end of the lock.

The basin to this dock was originally 212 feet long, and 80 feet wide, with brick walls like the dock, but the wall on the north side, from some defect in the foundation, gave way before it was finished, and was in consequence never raised to its full height, a sort of timber platform being erected on it, which remained till the basin was rebuilt in 1815.

The foundations of the lock walls were also insufficiently piled, as appears from Smeaton's Report, in which it is stated that "respecting the walls of the lock they have the appearance of being well built; we, however, observe some small sets therein which we impute to the want of strength in the foundation timbers." He further says, "that the floor of the chamber had risen about three inches in the middle, and that of the platform to the gates from two to four inches."

In the course of seven or eight years after the lock was built, the walls had yielded so much as to require to be taken down about 12 feet from the top: one side was rebuilt in 1785, and the other the following year.

Quays. The quays are spacious and paved with pebbles from Spurn Point. A legal quay extends on the south side of this dock from the river Hull to Whitefriar-Gate Lock, a length of 1558 feet, and contains an area of 18,160 square yards; the superficial content of the whole quayage being about 29,000 square yards.

Moorings. The mooring posts to this dock were originally of oak, 15 to 18 inches diameter at the top, 2 or 3 feet above the quay, and 8 or 9 feet in the ground, with two oak land ties, each 20 feet long, the ends of which were secured by cross timbers, and two piles to each: the posts are 12 feet from the side of the dock, and 14 or 15 yards asunder. A very high wind arising one night, soon after the dock was made, the ships moored in the evening on one side were found next morning on the other, having dragged several of the mooring posts along with them, a plain indication that these posts had not been very securely fixed. I understand that several of the posts were renewed about twenty years ago, but there are a great many of the original ones still standing, though the parts above ground are generally in a very dilapidated state, and much worn by the mooring ropes and chains. In taking up several of these we found them, excepting the sap and about an inch of the heart on the outside, very sound and good, to within two or three feet

of the ground; but the land ties, though also of oak, being within two or three feet of the surface, were generally a good deal decayed; some few which were of elm were completely rotten. In most cases the decayed wooden moorings have been replaced by stone ones, either of Peterhead granite, or a sort of free stone from near Rotherham, about 2 feet 6 inches above ground, 18 to 20 inches diameter at top, and 15 to 17 inches at the surface: by being thus tapered downwards, they have been so weakened, as to be occasionally broken off by the shipping in very windy weather. The part of the stone in the ground is about 2 feet square, and 6 to 8 feet long, set upon oak plank, and secured by land ties similar to the wood posts.

Sheds, warehouses, and cranes.

There are two sheds upon the legal quay 13 feet from the dock, 23 feet wide, and together 635 feet long, with doors at regular intervals on the south side, and small openings or shutters for the admission of light; the north side is quite open. The long shed was erected immediately after the opening of the dock; the other, several years later.

A little to the south of the sheds, on the extremity of the Company's land, stands a range of warehouses, 345 feet long, of irregular breadths, consisting of three floors besides the cellars, and comprising a space of about 2250 square yards. The cellars are all arched with brick, and there are six cranes to these warehouses, which being the only ones belonging to the Company, are now used indiscriminately for all the docks, a rail road being laid down nearly their whole length, for the conveyance of goods between the warehouses and the shipping in the different docks.

There are six wooden cranes to this dock, four on the south side, and two on the north; the latter are *well* cranes, very lofty, fixed about six feet from the side of the quay, and calculated to lift four or five tons: the others are of a lighter description, the jibs close to the dock, and supported by frame-work in the old-fashioned way; one of these is worked by a tread-wheel.

Mud in dock.

Various schemes had been suggested for cleansing the dock of the mud brought in by the tide; one was by making reservoirs in the fortifications or old town ditches, with the requisite sluices, by means of which the mud was to be scoured out at low water; another by cutting a canal to the Humber, from the west end of the dock, where sluices had been provided, and put down for the purpose, when it was proposed to divert the ebb tide from the river Hull along the dock, and through the sluices and canal into the Humber, and so produce a current sufficient, with a little manual assistance,

to carry away the mud. Both of these schemes were however abandoned, and the plan of a horse dredging machine adopted; this work began about four years after the Old dock was completed, and continued until after the opening of the Junction dock. The machine was contained in a square and flat bottomed vessel 61 feet 6 inches long, 22 feet 6 inches wide, and drawing 4 feet water: it at first had only eleven buckets, calculated to work in 14 feet water, in which state it remained till 1814, when two buckets were added so as to work in 17 feet water, and in 1827 a further addition of four buckets was made, giving seventeen altogether, which enabled it to work in the highest spring tides. The machine was attended by three men, and worked by two horses, which did it at first with ease, but since the addition of the last four buckets, the work has been exceedingly hard.

There were generally six mud boats employed in this dock before the Humber dock was made; since which there have been only four, containing, when fully laden, about 180 tons, and usually filled in about six or seven hours; they are then taken down the old harbour and discharged in the Humber at about a hundred fathoms beyond low water mark, after which they are brought back into the dock, sometimes in three or four hours, but generally more. The mud engine has been usually employed seven or eight months in the year, commencing work in April or May.

The quantity of mud raised prior to the opening of the Junction dock, varied from 12,000 to 29,000 tons, and averaged 19,000 tons per annum; except for a few years before the rebuilding of the Old lock, when, from the bad and leaky state of the gates, a greater supply of water was required for the dock, and the average yearly quantity was about 25,000 tons. As the Junction dock, and in part also the Humber dock, are now supplied from this source, a greater quantity of water flows through the Old dock, and the mud removed has of late been about 23,000 tons a year.

It may be observed, that the greatest quantity of mud is brought into the dock during spring tides, and particularly in dry seasons, when there is not much fresh water in the Hull; in neap tides, and during freshes in the river, very little mud comes in.

Town sewers. There are two sluices in this dock, for scouring the town sewers; both on the south side, one being opposite the end of Low-Gate, the other near the Whitefriar-Gate lock: they consist of a cast iron clough 3 feet 2 inches wide by 2 feet 11 inches high worked in a groove by means

of a screw, with a conduit, also of cast iron, 3 feet wide by 2 feet 6 inches high, the bottom being about 9 feet below the dock coping.

Dock opened. By the Act of Parliament seven years were allowed for finishing this dock, but by great exertions the work was completed in four years, and the dock was opened on the 22d of September, 1778.

Rebuilding of lock and basin. The next improvement in the order of time, was the Humber dock; but as an important part of the work connected with the Old dock, namely, the entrance lock and basin, has since been completely rebuilt on an improved plan, it may be advisable to give a brief description thereof before proceeding to the Humber dock.

State of old work. This reconstruction became necessary in the early part of 1814, from the ruinous state in which the lock then was. The water being drawn out of the dock to within four or five feet of the bottom, a coffer dam formed at the outer end of the basin adjoining the harbour, and a temporary dam of clay three or four feet above the surface of the water, on the side next the dock, the lock and basin walls were taken down, and it was found that the stone facing was much decayed, the mortar almost entirely washed out of the joints, particularly above high water of neap tides, and the walls greatly defaced by the coal hooks and stowers used in passing vessels through the lock: below the level of neap tides the stone was in a better state of preservation, but from its softness was a little worn away by the shipping; the hollow quoins which had been forced forward were in a bad state, and caused a great quantity of water to be wasted. The piles, sleepers, and planking, in the bottom of the lock and foundations, were all perfectly sound; the nails and small spikes were much wasted, but a great many of the large spikes and bolts were so little corroded, that they were used again in the construction of the new lock; the foundations had however sunk, by which the upper part of the wall was brought forward, and the timbers of the floor were several inches higher in the middle than at the sides.

The gates, which, when new, were much too slight, had become actually dangerous, although there had been new head posts to them all: and when they were taken up, the mortices, tenons, and iron fastenings were so bad, that they literally dropped to pieces.

The basin walls and foundations were in much the same state as the lock; but the front piles were pressed down by the superincumbent weight, in some

places 18 inches lower than the back ones, and the top of the wall bulged out in consequence. The ground in this part appears to have been particularly soft.

New lock. The ground having been cleared, the rebuilding of the lock was begun in May, 1814, from the design and under the direction of the late Mr. Rennie, Mr. George Miller being the company's resident engineer. This lock is 120 feet 9 inches long within the gates, 24 feet 6 inches high above the pointing sills, and 38 feet wide at the top, being 18 inches wider than the original lock: the foundations and walls are nearly the same as in the Humber dock lock, which will be more particularly described hereafter; but it should be observed that all the old piles remained to strengthen the foundation. The inverted arch is built with bricks set in pozzuolana mortar, as also the side walls, which are faced with Bramley-fall stone, the first or lowest course being all headers 4 feet in the bed by 18 inches thick; the hollow quoins came from near Rotherham, and are set in the same mortar; the backing or body of the wall is brick work, with one entire *through* course and occasional *through* stones besides, set and grouted in common mortar; and the coping is of Bramley-fall stone, 4 feet wide by 15 inches thick, joined together with stone dowels. This lock appears substantial and well built.

Gates. The gates, except the planking which is $2\frac{1}{2}$ inch fir, are all of English oak, and are each 23 feet wide, 24 feet 3 inches high above the pointing sill, 16 inches thick at the heel, and $14\frac{1}{2}$ inches at the head, including the close planking: there are ten bars or ribs of a curved form, the versed sine of which is 12 inches in the inside, tenoned into the head and heel posts, and further secured by wrought iron straps and screw bolts in the usual way: the two gate sluices of cast iron are 2 feet 6 inches square in the clear, and are worked by a wrought iron screw and brass nut, with bevel gear at top. The gates are moved by machinery on the sides of the lock, turning a cast iron roller, round which the chain revolves; these chains are all of $\frac{7}{8}$ inch iron, and are fixed from 2 to 4 feet above the bottom sill for shutting, and 7 feet for opening the gates, the latter operation being assisted by a counterbalance weight to prevent the chains from running off the roller. There are one horizontal and two vertical rollers fixed in the front of the lock walls about ten feet above the sill, with another large horizontal one at the foot of each wall, round which the chains turn in working the gates. A cast iron socket in the bottom of the heel post $3\frac{1}{2}$ inches diameter by $1\frac{3}{4}$ inch deep, turns upon a cast iron pivot fixed on the platform; and

a friction roller of brass (by which the gate moves on a cast iron segment in the bottom) 10 inches diameter by 4 inches wide, is fixed in a cast iron box or frame near the meeting post, with a wrought iron regulating rod reaching up to near the top of the gate, for adjusting the roller to the proper height. The gate is secured at top by means of a cast iron anchor with wrought iron collar in the common way.

From the frequent working of the gates, the pivot and socket on which they turn at the bottom wear away, in which case the gates are occasionally lifted up a little by screws, and a piece of hard brass about an inch thick is nicely fitted into the socket, to restore the original height.

Balance bridge. The bridge over the lock is of cast iron, on the lifting principle, and 15 feet wide, the carriage way being 7 feet 6 inches, and the foot ways 3 feet 6 inches each; the whole length is 81 feet. The bridge consists of six ribs, $1\frac{1}{2}$ inch thick in the plain part, and 3 inches at the edge or flanch, 9 inches deep at the meeting or middle, increasing, though not regularly, towards the sides, and it turns on a cast iron shaft or main axis 8 inches square, with four round bearings working in plummer blocks, fixed in cast iron carriages, bolted to the masonry of the lock. When the bridge is to be opened, a cast iron flap, turning on an axis $4\frac{1}{2}$ inches square, is lifted by a lever, in order to give room for it to rise: this flap forms at the same time a guard or barrier against passengers, and after the bridge is lowered into its place it is let down and forms part of the roadway. The bridge is covered with 3 inch oak plank laid across and bolted to the ribs; in the carriage way the planks are, for preservation, overlaid with $1\frac{1}{2}$ inch fir or elm boards, which are renewed from time to time, and the foot paths are covered with similar boards on oak joists, elevated about 5 inches above the carriage way, with a cast iron curb on each side, and wrought iron stanchions and chains as a fence on the outside. In lowering the bridge, when first erected, one of the outside ribs was broken by striking against the under side of the fixed planking at the outer end; this was repaired by bolting a cast iron plate to one side, and for greater security all the ribs were afterwards strengthened in the same manner. It will be understood, from the principle of this bridge, that as it is raised, the outer end descends into a quadrantal pit or cavity, which, to ensure proper working, it is essential should be kept clear of water. The machinery is similar to that of the Junction dock bridges, which will be more particularly described afterwards; one man

can raise or lower each leaf in half a minute, but two men with the greatest ease.

From a small yielding of the walls, the bridge was forced from its bearings on both sides, by which the weight of the carriages passing over it was thrown upon the main shaft; this has lately been remedied by cramping wrought iron plates, $\frac{3}{4}$ inch thick, to the bearings of each rib. This bridge, the first of the kind erected in Hull, was cast and put up by Messrs. Ayden and Etwell, of the Shelf Iron Works near Bradford, and weighs, exclusive of the wood work, about eighty tons.

Basin. The entrance basin is 213 feet long by 80 feet 6 inches wide at the top, 71 feet at the bottom, and the same depth as the dock. The walls are of brick with a Bramley-fall stone coping, a *through* course 14 feet from the bottom, and oak fenders on the same plan as the Humber dock; the walls are supported at foot by means of brick inverted arches across the bottom 6 feet wide by 18 inches deep, with spaces ten feet wide between, and the whole is covered with earth to nearly the level of the lock sills.

Re-opened. This lock and basin were finished and re-opened on the 13th of November, 1815.

Lockage. With a rising tide, it is usual to begin locking when there is a depth of 6 to 7 feet on the sill, and when required, five pens can be made before the water is level inside and out; the gates are then all opened, and large ships passed at the top of the tide, after which they are again closed; but the penning is frequently resumed, until the water has fallen to about 7 feet on the sill, by which time five pens more have been made. Seven or eight hours a tide are thus occupied in locking; and when business presses, this is done during both tides. If there are many large vessels to pass, it is sometimes found necessary to draw off the water one or two feet, so that the surface on the two sides may become level sooner, and the gates continue longer open, of which advantage is also taken to pass craft without the labour and delay of lockage; but this practice is never resorted to, except in cases of necessity, as the deposit of mud in the dock is much increased by it, the water abstracted, which is comparatively pure from time having been allowed for subsidence, being replaced by the very muddy water of the tide. In busy times, the gates have also sometimes to be kept open for a short time after high

water, and in neap tides doing so is unobjectionable; but in springs it ought to be avoided, as from there being then a considerable current through the lock, when the tide has begun to ebb, there is some difficulty and risk in shutting them.

State of dock walls. Before concluding this brief account of the Old dock, it may not be deemed irrelevant to point out the state of the walls and foundations, as found in executing the Junction Dock, when they were taken down, at the western extremity, as far as the north gates of the Whitefriar-Gate Lock.

The timber and planking of the foundations were perfectly sound, and the spikes also generally in a good state; but the oak fenders were decayed and a good deal bruised and worn away at the upper part by the vessels; new tops had been scarved to many, but the part of the fenders below an average tide, say eight or nine feet under the coping, as well as the sills and brackets for securing them, were generally sound, the sap and a little of the outside excepted.

The front of the wall for about the same depth had but an indifferent appearance, the bricks being in places much decayed and rubbed away by the vessels, and the mortar washed out of the joints, but below this the bricks were generally in a much better state, and the pointing nearly entire. It has been before observed that the mortar for this wall was made partly from sand dug out of the dock, which was far from being of the best quality; the interior of the wall was grouted, and not very sparingly, as in some places the mortar was found nearly as thick as the bricks. The mortar in the inside of the wall varied very much in quality according to circumstances; where the wall was solid and undisturbed, it was very hard, requiring picks, and in many places sledges and wedges, to take it down; but where the wall had given way or been otherwise disturbed, and cracks and cavities thus caused in the inside, the mortar was in general very soft. This was observed in a variety of places, and it was not uncommon to see the mortar in one part of the wall exceedingly hard and good, and within a few inches from it, where the wall was open and the water had found its way, quite soft and bad, or but little harder than when first built. From this we see how essential it is, that building in water should have a substantial and immovable foundation, and that the walls should be completely solid and impervious, particularly where a good water lime cannot easily be obtained.

From the front of the wall not being properly bonded to the back, the parts are not only unconnected, but in many places entirely separate, so that a rod may be thrust down many feet between them. It was observed also, that where the wall had given way, it was completely separated from the counterforts, to the extent, I understand, of one to two feet or more in the worst places, whereby the strength of the wall has been greatly reduced.

THE HUMBER DOCK.

Before the Act was obtained for making the Humber dock, the Old dock and harbour were found insufficient for the shipping and increased business of the port. This want of accommodation had been felt and complained of for some time, and various plans and schemes were proposed for the improvement of the port, all having in view increased dock and quay room. One proposal was to make another dock on the east side of the old harbour, and connected therewith by a suitable lock: another was to convert the harbour itself into a floating dock, by an entrance lock near the Humber, and another lock near the north bridge; and to excavate a new channel for the river Hull from above the proposed dock, to the Humber, eastward of the Garrison: but fortunately for the port, neither of these plans was adopted.

The Dock Company, in order to obtain the best advice on a matter of so much importance, called in the able assistance of the late Mr. Rennie, who was afterwards joined with Mr. William Chapman of Newcastle-upon-Tyne, on behalf of the Corporation of Hull. These gentlemen furnished the plans for this dock, and the work was carried on and completed under their joint direction: Mr. John Harrop, an old servant of the company, (who had done the carpenter's work of the Old dock,) was the resident engineer, and was assisted by Mr. George Miller, afterwards his successor.

The Act of parliament was passed in 1802, and the work was begun early in the following year.

Area of dock. The area of this dock is seven acres and a half, and will contain seventy square rigged vessels, with ample room for moving them; but there have been a hundred sea-going vessels, besides thirty or forty smaller craft, in it at one time.

Coffer dam. The coffer dam at the south end of the lock, for keeping out the tidal water during the execution of the works, was 280 feet span, and the versed sine 140 feet; it consisted of two concentric rows of close Danzig piling, 13 to 14 inches square, and 7 feet 6 inches apart, well bolted and braced together, with a trunk and shuttle in the middle at the bottom, the internal space being filled up with bricks laid in sand to above the level of high water. This dam was firmly and judiciously constructed, but having sometimes a perpendicular head of water of nearly thirty feet against it, shewed signs of great weakness during an extraordinary high tide a little before the work was completed; being however promptly secured by shores and braces, no further damage ensued.

A steam-engine of six horse power was fixed upon the east side of the lock, and worked two 11 inch pumps, for keeping the works clear of water, and also at the same time, two 7 cwt. rams for driving the piles of the coffer dam.

Excavation. The excavation of the dock was 24 feet deep on an average, all in alluvial soil; the upper part for about five feet in depth was good clay, of which a great many bricks were made for the use of the works; and the rest of the soil was used to raise the ground and form the quay and road on the west side of the dock, and also the beach or shore of the Humber from the mouth of the old harbour to some distance above the dock; on part of this ground, several good streets have since been built. Notwithstanding the immediate contiguity of the dock to the Humber, a fine fresh water spring was found in the excavation of the lock pit, which was so powerful, that the stopping of it was attended with considerable difficulty and expense. The bottom of this dock, for reasons not very obvious, is not so low by ten inches as the lock sills.

The site of the basin, being outside the coffer dam, and overflowed by the Humber every tide, was excavated by tide work. Part of the soil was removed by horse runs, to raise the ground near the lock, and the remainder conveyed away in ballast lighters, and discharged in the Humber.

Dock-walls, Plan No. 3. The foundations are all piled, with a row of 6 inch grooved sheeting piles in front; the bearing piles are 9 inches, the counterfort piles 8 inches diameter. They were all driven with a ringing engine and a ram of nearly 4 cwt., worked by fifteen or sixteen men; these piles proved to be too short for so lofty a wall, where the ground in general is so soft and compressible. Longitudinal sleepers of half timber were bolted down

upon the heads of the bearing piles, the sheeting piles spiked to an inner waling of the same scantling, and the whole covered with 4 inch transverse close planking, on which the wall was raised. The timber used was Memel or Danzig, excepting the piles, which are chiefly of Norway fir.

The dock walls are all of brick, with the exception of a stone *through* course at the bottom of the fenders, three courses of stone on the level of an average tide, and the coping. The mortar was made of Warmsworth blue lime, and sharp fresh water sand only; the lime, having been ground in its dry state in a mill worked by a steam-engine, was mixed with two parts of sand, for the front work, and water having been added, the whole was ground again, and the mortar used immediately afterwards, whilst hot and fresh. The backing mortar was composed of one part of unslaked lime to three parts of sand, mixed and tempered in the usual way. The brickwork of the front and back was laid in mortar, the rest grouted every course; part of these walls being built a little before winter, the front mortar was affected by the frost, but the joints were afterwards raked out and pointed with pozzuolana mortar. The *through* course at the foot of the fenders is of Barnsley stone, 15 inches thick, those in which the fenders are fixed projecting a little from the face, and having a dove-tailed groove to receive each fender; the three courses above are also of Barnsley stone, the lowest being a *through* course: these stones are all properly squared and dressed and the front *bosted.* The coping is of Bramley-fall stone, 4 feet wide and 15 inches thick, squared and dressed, the front and top well bosted, the arris rounded off, and the joints secured by stone dowels.

Before the walls were raised to their full height, it was found that they had been forced forward on the east and west sides, near the middle, two feet from a straight line, carrying the foundation piling along with them. As a security, a quantity of earth, about ten feet high in the centre, diminishing gradually to six feet at each end, was immediately laid in front, where it still remains; a length of the upper part of each wall was also taken down and rebuilt in a straight line. Some time after the dock was finished, the water having been drawn down to within thirteen feet of the bottom, for the purpose of making a level bed for the counter balance weight of the gate chains, the east wall again gave way a little, but the movement ceased on the rising of the tide. The circumstance operated as a warning not to draw the water so low in future.

All round the dock, to protect the walls, there are oak fenders 12 inches square, let 4 inches into the brickwork, and projecting 8 inches before the face, dovetailed into stone corbels at foot, as before mentioned, and secured by oak ties with wrought iron fastenings near the top, which is covered with a cast iron cap. There are also two rows of horizontal fir fenders, 7 inches square, let into the upright ones by short tenons, with angle pieces to prevent vessels catching underneath or riding upon them, as the tide rises and falls.

Lock. The entrance lock is 158 feet long within the gates, 42 feet wide at the top, and 31 feet high above the pointing sills, on which the average depth is 26 feet at high water of spring, and 20 feet at that of neap tides.

The foundation consists of four rows of bearing piles, 16 to 19 feet long, for each wall of the chamber, and two rows for the counterforts; on the heads of these, longitudinal sleepers of half timber are bolted, transverse sleepers of the same scantling placed on edge securely fixed to them, and the whole is covered with 4 inch close planking, the interstices being filled in solid with brickwork, on which the inverted arch and side walls are built. There are five rows of 6 inch grooved sheeting piles, 16 to 20 feet long, driven across each platform, the bearing piles for which are 3 to 4 feet apart each way, and carry longitudinal sleepers, 12 inches square, with two courses of close transverse sleepers bolted thereon for 13 feet in length from the main sills, on which the pointing sills are fixed. The remainder of the platform is covered with 6 inch elm close planking, on which cast iron segments are laid for the gates to traverse upon. There is an apron or platform at the tail of this lock, about 50 feet in length, covered with 4 inch planking spiked to transverse sills, which are bolted down upon the heads of the bearing piles, with a row of 6 inch grooved sheeting piles at the outer end. The piles are of Norway timber, the sleepers and planking, except for the platforms, principally of Danzig fir, and the pointing and main sills of English oak.

The side walls are 6 feet 9 inches wide at top, and there are six counterforts on a side, each 6 feet square; besides the foundations for the bridge, which stand 9 feet higher than the rest. These walls and the invert are of brickwork, faced with Bramley-fall stone. The front was set in mortar composed of three parts of ground Warmsworth blue lime, two parts of ground pozzuolana, and five parts of sharp fresh water sand, properly mixed and screened, and well tempered; this work was done by men with beaters, till the erection of the mill, in which the mortar was afterwards ground wholly, and used immediately; the rest of

the work was set and grouted in common mortar, composed of one part of unslaked Warmsworth lime to three parts of sharp fresh water sand, mixed and screened, and tempered in the usual way. The hollow quoins are of Dundee stone, well squared and dressed, set in pozzuolana mortar, with close beds and joints, the parts in which the gates turn being well rubbed to a smooth surface, so as to be water-tight; this very hard durable stone, being of a fine grit, does but little injury to the heel posts, and is therefore very proper for hollow quoins. The south wing walls are also faced with Dundee stone for a short length. The coping is of Bramley-fall stone, 4 feet wide, by 15 inches thick, joggled together in the same manner as that of the dock walls.

Caisson. In the masonry at each end of the lock, there is a chase or groove 12 inches deep, 21 inches wide in the front, and 15 inches at the back, for receiving a caisson or floating gate, which was originally built as a preventer dam at the south end during the execution of the work, and was afterwards used to keep the tidal water out of the lock in repairing one of the gate chains; but having gone to decay, it has since been broken up. The keel was made to fit the stone groove so as to be water-tight, and about ten feet above the bottom, there was a cast iron cross cylinder, 2 feet diameter, communicating with the water on either side, by means of four apertures, 9 inches diameter, fitted with brass plugs worked by screws and rods, reaching to the deck, by which the water was admitted to sink the caisson in its place, and let out at low water when no longer wanted, so that, the plugs being inserted, the vessel rose by its own buoyancy the succeeding tide. This gate or vessel being very deep, and only 22 feet 6 inches in beam, was kept in a vertical position by about thirty tons of ballast.

Gates. The lock gates are all of English oak, except the planking, which is of fir; they are 31 feet 4 inches high above the pointing sills, and 25 feet 6 inches broad, measured in the curve line, the camber being $14\frac{3}{4}$ inches; the thickness is $16\frac{1}{2}$ inches at the heel, and $14\frac{1}{2}$ inches at the head, the 3 inch close planking included. Each gate originally consisted of twelve bars framed into the head and heel, and further secured by wrought iron straps and bolts; but a few years after they were put up, several of the lower bars being broken by the great pressure of the water and the heavy stroke of the sea in stormy weather, they were replaced by new ones, and several additional bars inserted, so that the gates are now a solid mass of timber (excepting the cloughs) for ten feet from the bottom. There are two cast iron sluices to every

gate, each 3 feet square in the clear, worked by a wrought iron screw, with a sluice rod reaching to the top. The machinery for opening and shutting consists of a 6 inch pinion, working into a cog-wheel 4 feet diameter, on the axis of which is a cast iron roller 2 feet 9 inches long by 10½ inches diameter, for the gate chain to wind on. The other parts of the gates and their appendages are so much like those of the Old dock lock, that it is deemed unnecessary to repeat the description.

Before the piers of the entrance basin were erected, the waves from the Humber sometimes forced open the outer gates a little, notwithstanding the great pressure of water behind; and the violent concussion in shutting fractured the lower bars, as already mentioned, and would in all probability soon have destroyed the gates had they remained much longer exposed. Since the erection of the piers the swell is much diminished; but even now, with strong gales from the south, it is dangerous to attempt to open or shut the gates by the machinery, and at such times recourse is had to blocks and tackle provided for the purpose. When the gates are left open after high water also, the current out of this lock, in particular, is so strong as to require great caution in shutting them; this used to be done at such times by what is termed *back handling*, that is, the gate-men standing at the machinery for opening, keep a tight hand upon it, to prevent the gates from closing too forcibly; but recently a safer and more simple plan has been adopted, namely, by a rope hooked to each gate head, and taking a turn round the mooring posts on each side of the lock, by which the gates can be eased to with the greatest safety.

Bridge. Over the centre of this lock there is a swivel bridge, 12 feet 3 inches wide; it is 81 feet 9 inches long, and composed of two parts, which, meeting in the middle, form a segment of a circle. The bridge consists of six cast iron ribs, about 2 inches thick in the plain part, and 2½ inches at the lower edge, connected together by cast iron braces, and planked with 2½ inch oak, which is protected by a covering of 1½ inch fir. The foot-paths, each 2 feet 8 inches wide, are slightly raised above the carriage way on oak joists, covered with fir boards, and have cast iron curbs next the road way; a wrought iron railing, 3 feet 7 inches high, runs along each side. On each side of the lock, in the stone coping of a large brick pier, there is firmly imbedded a cast iron circular plate, 11 feet 9 inches diameter by 6 inches wide, with a cross and pivot in the centre, also securely let into the masonry, and working in a socket underneath the

bridge, with twenty conical rollers, 6 inches wide, by $10\frac{3}{4}$ inches diameter at one end and $9\frac{3}{4}$ inches at the other, fitted in a frame, and revolving between the circular plate above mentioned and a similar plate in the under side of the bridge. The ends or meeting parts of the bridge are not described from the centre pivot or axis of motion, but from a point a little on one side thereof, whereby these parts, in shutting into a tongue and grooved joint, do not come into actual contact till the bridge is shut; it is then completely fast, being closely wedged to the abutments on each side and kept in place by two keys at the meeting, thus making the whole firm and secure. The machinery for opening and shutting the bridge, consists of two 8 inch bevel pinions, to one of which the handle is applied, and at the bottom of the vertical shaft of the other is fixed a 9 inch pinion, working into a spur wheel, 4 feet diameter, on the axis of which is another pinion, 12 inches diameter, which turns the bridge by means of a toothed segment at the outer end. One man can open or shut either part of the bridge with ease in half a minute. Messrs. Ayden and Etwell, already named in the account of the Old dock, constructed this bridge also.

Basin walls. The walls of the entrance basin are so much like those of the dock, that a very brief description may suffice. They are 10 feet wide at the bottom, by 6 feet at the top, fronted entirely with Bramley-fall stone, and having two *through* courses, and a stone coping, similar to the dock; the rest of the wall and counterforts is of brickwork; the front masonry, and also the back of the walls, are set in pozzuolana mortar, the remainder in common mortar, of the same proportions and mixed as for the lock. There are three rows of stout piling, 16 to 18 feet long, under the walls, and a row of 6 inch grooved sheeting piles, 16 feet long, in front, with transverse sleepers, and close planking over all; the counterforts are piled and planked in the same way. There was also a quantity of Hessle-cliff stone rammed between the foundation timbers, and about two feet in width behind the walls. This wall, on the outside of the cofferdam, was wholly executed in tide-work.

Quays. The quays are paved with spurn pebbles; the east side, and the south up to the lock, form a legal quay, upwards of 1000 feet long: the drainage is into the sewers by gratings every 25 yards.

Moorings. The mooring posts are about 10 yards apart, and 4 yards from the side of the dock; they are of wood, iron, and stone. The wooden ones are simply round oak trees, 18 inches in diameter at the top, driven

firmly into the ground by pile-engines, and having two shores, a little below the surface of the ground, abutting on the back of the wall, by which the strain of the shipping upon the posts is transferred to the wall; a plan that cannot be recommended. The iron posts (twelve pounder cannon) are 9 or 10 feet long, the breech or lower end being let into a stone block, and secured thereto by wrought iron straps and bolts, and also built round with brickwork up to near the surface of the ground. I understand that some of these posts are secured by land ties, but in general there is only a large stone laid to the back of the coping, thus throwing the strain upon the wall, as noticed above, in the case of the wooden moorings. The stone posts are of Peterhead granite and Dundee sand stone, of similar dimensions, and secured in like manner to those at the Old dock: but from their being too much tapered near the ground, several have been broken by the heavy strain in windy weather.

Dolphins. There are four dolphins in this dock, each consisting of five piles, the centre one perpendicular and standing above the others, which are battering, and the whole secured together by two tiers of cross braces, and planked over on top and sides, for 11 feet down. These dolphins were erected at the time the Junction dock was made, for the purpose of warping vessels in their passage to and from that dock, as well as for the more convenient mooring of ships on the west side of the Old dock.

Sheds and Cranes. A range of sheds, 750 feet long, 25 feet wide, and 15 feet from the side, extends along the legal quay on the east side of the dock: they are principally of fir timber, covered with weather boarding and enclosed with large doors on the east, but open on the west, except the bale shed at the south end, which is all enclosed, with large doors on each side. The roof is covered with blue slate, and the floor formed with 6 inch flags for a width of 15 feet, the rest being paved with spurn pebbles.

There are seven cast iron cranes to this dock, four on the east and three on the west side; the large one near the north west corner is a *well* crane, calculated to lift 10 tons; the vertical shaft is 5 feet 3 inches from the side of the dock, and its foot 15 feet below the coping; the jib is 19 feet 3 inches high to the under side of the pulley, and projects 22 feet. The other six cranes are all of the *pillar* kind, and calculated to lift 3 tons. The pillar is 6 feet high, and fixed at a distance of 5 feet from the dock, in a socket in the centre of a cast iron cross, securely bolted to the coping. The jib is 16

feet 6 inches high, projects 15 feet, and is movable on the pillar by a pivot and socket at the top, and a cast iron collar faced with brass at the bottom.

There are four wooden cranes to the basin, three of them well cranes calculated to lift 3 or 4 tons, and the other, which has been recently put up, a pillar crane for 2 tons; the jibs of all project about 20 feet, or 13 feet beyond the basin wall. These cranes are principally used for steam-packets.

Cleansing dock. This dock was not cleansed for three years and a half after it was opened, the dredging machine and mud boats not being completed until then; and such is the impurity of the water in the Humber, that during this time the mud had accumulated to the height of twelve feet at the south end of the dock, and three feet at the north, so that deeply laden vessels were prevented, at neap tides, from entering or going out.

Dredging machine. The dredging machine is worked by a steam-engine fixed on board a square flat bottomed vessel, 80 feet long, 20 feet wide, and drawing 5 feet water. The engine is 6 horse power, and works a 2 feet stroke forty strokes per minute, giving motion, by means of a bell crank, to four cog wheels, on the axis of the upper of which is a square tumbler, with one corresponding at the lower end of the bucket frame. Round these the wrought iron buckets, twenty-nine in number, revolve by an endless chain, and the mud is discharged over the upper tumbler into a spout leading into lighters lying alongside; the ladder turns on an axis at the upper end, and the lower end is raised or lowered through an opening in the middle of the boat, by a crab and tackling fixed directly over it, by which the buckets are adapted to the proper level for taking up the mud. The vessel is drawn to its work by means of a cable revolving round a roller attached to the engine, and from it by two men at a crab in the stern; there is also a contrivance for moving it sidewise when required. It is usual in inland navigations and canals, where the dredging machine has to pass through locks and bridges, to have the buckets in the middle of the vessel, as in the present instance; but in docks, harbours, &c., where there is no want of room, they are much better on the outside, as there is less waste in discharging the mud into the lighters, and there may be a double set of buckets, one on each side, if necessary.

Four men, including the engine-keeper, are required to work this machine, and two more to attend the lighters. The work has for a short time been upwards of 2 tons per minute, (or twelve buckets of 4 cwt. each,) and where the mud is in plenty and there is no impediment, 60 tons per hour may easily

be raised; but the ordinary work is about 45 tons an hour, or twelve boats containing from 500 to 550 tons per day of twelve to fifteen hours.

Mud boats. Plan, No. 4.

The mud boats are flat bottomed and sharp at each end, and draw, when fully laden, about 4 feet water. Six of them, which were formerly used exclusively for the Old dock, are 48 feet long at top, 17 feet 6 inches wide in midships, by 5 feet 6 inches deep, and carry 40 tons on an average; the six Humber dock boats are rather larger, carring 48 tons each. They are ceiled inside in a sloping direction like a hopper, with two trap doors in the bottom, through which the mud is discharged, the water rising in the boat to the same level as on the outside, but the cavity between the ceiling and the bottom preserving the buoyancy.

When laden, these boats are linked together in pairs, six usually forming a set, which require ten or twelve men to work them; they generally go out of dock when the gates are all opened, a little before high water, and are warped 100 or 150 fathoms from the pier-head, where the mud is discharged; the empty boats then return to the dock, the time occupied being usually from two to three hours, according to the rapidity of the tide, and as the passage is more or less clear of shipping.

Quantity of mud.

The quantity of mud taken out of this dock, was about 36,000 tons a year before the Junction dock was made; since then it has been about 30,000 tons, the diminution arising from the water being now in part supplied from the river Hull, which is much purer than the Humber *, and having also to flow through the Old and Junction docks, where a great part of the mud is deposited.

Scouring of basin.

The tide-basin being connected with a river highly charged with mud, it was necessary to make provision for cleansing it. The head, or north end of the basin, is partly scoured by water from the lock, conveyed 130 feet in two cast iron pipes laid close behind the wall, and 4 feet diameter next the lock, diminishing to 2 feet 6 inches at the outer end; these pipes are in 9 feet lengths, each 30 to 35 cwt., with flanches at the ends bolted together, and resting on a cap-sill, supported by two piles at each joint. To these mains, at equal distances, are connected ten 18 inch pipes on each side of the lock, which discharge themselves through the basin wall, about 5 feet

* The respective quantities of deposit of the two rivers are found, by experience, to be nearly as one to three.

above the level of the sills, on a wooden apron 40 feet wide, laid in front to prevent the foundations from being undermined. Two other mains, also 4 feet diameter, are connected with the dock, one at the south east, the other at the south-west corner, terminating at the south-east and south-west corners of the basin respectively; their bottom being about two feet above the level of the lock sills, and aprons placed at the ends, similar to those at the head of the basin. These pipes were intended to scour away the mud along the inner sides of the piers, and also to assist in preserving a deep channel between the heads. There is a vertical cylinder, 4 feet 6 inches diameter, to each of the latter pipes, near the corner of the dock, with a cast iron sluice at bottom for opening and shutting; the sluices for the scouring pipes at the head of the basin are in the face of the lock wall, in the gate recesses; they are all worked by wrought iron screws with handles at the upper end of the sluice-rod. Several of the pipes from the dock to the basin, from being too slight, failed before the dock was opened, and were replaced, at great labour and expense, by new ones; others, which were less fractured, were repaired and strengthened by ribs in the inside.

To shew the effect of these sluices, I would state that the four from the lock, and the small ones at the head of the basin only, when all open, lower the water in the Humber dock a foot in four minutes: the latter, with the two from the dock, are generally worked at low water, twice every spring-tide, and notwithstanding their great power, only scour out a narrow channel at each place, sufficient for the steam-packets and small craft to lie in; but being assisted by the sluices of the gates, the main channel from the lock into the Humber is effectually scoured, and maintained to nearly the depth of the sills. Over the rest of the basin the sluicing has no power whatever, and the mud deposited there has been removed by manual labour, at great expense; two mud lighters having been, till within the last two years, almost constantly employed upon it since the dock was opened.

It having occurred to the writer of this, that the water wasted in locking might be beneficially used in cleansing the basin, he recommended a new scouring pipe to be laid at the north east corner, on a much higher level than the other pipes for the purpose. A new 4 feet pipe was accordingly put down in the spring of 1831; from its junction with the old pipe to the outlet in front of the basin wall is 18 feet, and the bottom at the outer end is 10 feet 6 inches above the lock sill. There is a sluice, worked by a rack and pinion, at the

top of a brick shaft or well, to stop the old pipe and divert the water through the new one, when in use; at other times, this sluice being drawn up, the water is discharged as before. At the outer end of the new pipe is a wooden spout, 18 feet long, turning on hinges in the wall, so as to be reared up against it when not in use, and to the end of this another spout, 85 feet long, is connected, which can be turned so as to scour in almost any direction. It should be observed, that the largest quantity of mud is deposited on this side of the basin, and that, before the making of this sluice, it had accumulated to a great height, and become so exceedingly hard and tenacious, that it was found necessary to remove it into the stream by workmen with spaddles. In this manner about 12,000 tons of mud were removed in eight weeks after the sluice was set to work. Since that time there has been only one man to attend the sluice about three or four days every spring tide, except when clearing away the mud alongside the east wall and near the east pier, which cannot be done by the scouring power alone. The new sluice, when in full operation, lowers the water in the three docks about 6 inches an hour, and usually runs about three or four hours each tide.

Sewers. The sewers are all of brick, and are 3 feet wide by 4 feet high; that on the east side commences at the end of Myton-gate, at a depth of 8 feet 6 inches below the dock coping, and terminates at the north end of the basin 4 feet lower, the extremity being closed by a flap, opening outwards, to discharge the drainage water and shut out the tide. This sewer was formerly cleansed by manual labour, but is now scoured by a sluice constructed for the purpose on the east side of the Junction dock. The sewer on the west side discharges itself into one in Kingston street, which leads to the general outfall into the Humber, at Limekiln Creek.

There is an iron sluice at the north-east corner of the dock, 7 feet 6 inches below the coping, protected by a wooden door, worked by a screw, and having an iron conduit, 2 feet 6 inches wide by 2 feet high, leading from it to scour the town sewers.

Dock opened. The water was let in on the 3d of December, 1808, and the dock publicly opened for business, with due honours, on the 30th of June, 1809. The expense was defrayed by the Dock Company, and the Corporation and Trinity House jointly, the two latter contributing one moiety of the expense, and the Company the other, for which purpose sixty new shares were created, under the authority of an Act of Parliament.

Pier heads. Plans, Nos. 5, 6, and 7.

The piers of the entrance basin were begun soon after the dock was opened: their construction will be better understood from the drawings than by description. They are wholly of fir, of the scantlings stated on the plan No. 7, and the filling up or hearting is of Hessle-cliff stone; the sheet piling on both sides was grooved. The passage between the heads is 105 feet at the top.

Slip-way.

In the summer of 1829, a slip, for repairing the mud boats and the lock gates, was built on the west side of the entrance basin, abutting upon the Humber. The length is 66 feet, the width 28 feet 6 inches, and the depth 11 feet at the lower end, diminishing upwards in the proportion of six horizontal to one vertical; the side walls are of brickwork, with stone coping; the bottom floor is covered with 3 inch fir plank, spiked to transverse sleepers, supported upon piles. The coping and front brickwork were set with Parker's cement and sharp fresh water sand, in equal proportions, and although exposed to the waves and swell of the Humber, have stood hitherto with scarcely a failing joint.

Lockage.

What has been said on this head respecting the Old dock, applies also in a great measure here. Locking is begun when there is about the same depth of water, but the sill being 6 feet lower than in that dock, the work can be carried on longer, and fourteen or fifteen pens made at one time. As many as 25 sea-going vessels have passed this lock in a tide, thirteen of the largest when the gates were open for about an hour at high water, and the rest by penning.

There are usually three men to open or shut each gate, which they do in two minutes to two minutes and a half; but frequently two men do the work. With 6 or 7 feet of water on the sill, in average tides, the lock can be emptied or filled in about eight minutes, with all the sluices; but this is seldom done, no more than two sluices being generally opened, for fear of damage to the shipping or the works from the great agitation of the water: with two sluices, the time is about 14 minutes. It may be observed, that two men can easily raise or lower one of these sluices, with a full head of water, in five minutes.

State of walls.

In concluding this account of the Humber dock, I would, as before, briefly advert to the state of the walls and foundations, as found when taken down in executing the Junction dock.

The timber in the foundations, which was all fir, was, with the exception of the sap, invariably as sound and good as when first put down; the oak fenders, constantly under water, were also in a good state, but the upper part of many of them beginning to decay, and a few actually rotten; as were the horizontal fir fenders, and the oak ties near the top of the wall. The wrought iron varied considerably: in some places the spikes in the foundations were quite fresh and good, in others a little corroded, and in others almost rusted away.

The mortar was generally very soft, but at the wide parts, and especially the foundations of the old communication at Myton gate, so much so, that it might have been beat up without a drop of water, and used again. In the parts near the top of the wall not so much exposed to damps, the mortar was tolerably hard; but I saw none, except in the inverted arch of Myton-gate old communication, that would bear any comparison with that of the Old dock; the mortar in that invert, which was made from ground lime, mixed with a proper proportion of sand, and then ground again in the mill, was, however, so hard, and adhered so firmly to the bricks, that it required a sledge and wedges to separate them. The mortar in the front of the wall had much the same appearance as that of the Old dock, being soft and very much out of the joints for nine or ten feet from the top; below this the joints were not wasted, but had thrown out a sort of stalactite or calcareous incrustation that entirely covered the face of the wall. Notwithstanding the soft state of the mortar in these walls, I am of opinion, from their being in general so well flushed or grouted as to be impervious to water, that it will ultimately acquire considerable hardness, although perhaps not for many years. This I infer from the state of the mortar in the Old dock and several other walls that I have had an opportunity of observing, built with nearly the same kind of lime.

The pozzuolana mortar, where always wet, or where wet and dry alternately, and also where constantly dry, was found in general exceedingly hard, being both in hardness and colour very much like a well burnt red brick. This mortar usually adheres very well to the bricks, but sometimes not so well to the stone, partly perhaps from the stone being set too dry, which is commonly the case in summer, and partly from a property peculiar to mortar made from magnesian stone, of expelling or throwing the lime to the outside, either in a dry state, like *flour*, or where the walls are wet or damp, like

paste; but whether arising from these causes or not, this want of adhesion detracts very much from its other excellent qualities as a valuable mortar for aquatic buildings.

The stone was found in a very good state, particularly the Dundee and Bramley-fall; the Barnsley stone, a little above and below high water, was in places somewhat wasted and decayed, but in all other parts sound and good.

Repair of lock gates. The gates and hollow quoins of the entrance lock, having lately undergone some alterations and repairs, it may be proper in this place to notice their state and mode of reparation.

From a defect not uncommon in artificial foundations, the lock walls had subsided a little, and come over about three inches on each side at the top, thereby contracting the lock six inches, which caused the gates to open and shut badly; one of the gates in particular required four men to work it.

Mr. Walker, who was then engaged in the construction of the Junction dock, was called to advise on the subject, and recommended that these gates should be taken up, the hollow quoins brought to a vertical line, and afterwards secured by land ties. The gates were accordingly lifted in the spring of 1830, by means of two powerful crabs, and two sets of stout treble blocks and pulleys, with a 5 inch fall, one pair being applied at the head, the other at the heel of the gate, and the whole suspended from the butt ends of two large oak trees, raised five feet above the coping, with the inner end resting on the ground, and kept down by two large stones, near four tons each; the chains to which the lower blocks were lashed, were fastened round the sixth bar from the top, blocking being placed between each bar upwards, the better to sustain the weight of the gate. Being thus prepared, the gate, weighing thirty tons, was lifted about eight feet, by a set of men at each crab, when, to take the strain off the blocks and tackling, a chain being passed several times round the gate-bar and the tree on the wall, the blocks were eased till the chains bore the principal part of the weight.

The hollow quoins were then dressed to a true perpendicular, and afterwards firmly secured by land ties, nearly similar to those of the Junction dock, which will be hereafter more particularly described. The quoins of the north gates could not be dressed down, on account of the water in the dock, but were securely land-tied in the same manner as the others.

The timber in the gates was all sound; but the bottom bar, from the great pressure against the sill, was worn away upwards of an inch in depth, and the heads and heels were also rubbed a little; the hoops at the foot of the meeting-posts were cut away an inch or more by dragging upon the traverse rails. The wrought iron straps and bolts were much corroded, and came off by a tap with a hammer in thick flakes; the cast iron sluices and frames were particularly soft for about an eighth of an inch on the outside, and might be cut with a knife, like lead; the cast iron plates of the pointing sills were very rough, or in holes and furrows, as if eaten away.

After the repairs were all completed, the gates were lowered into their places. The time occupied in performing the whole was about eight weeks, during which there was very little interruption to the shipping.

THE JUNCTION DOCK.

It appears that a short time after the Humber dock was made, so desirable was a junction of the two docks considered, that a temporary canal was proposed to effect it; this would no doubt have been of great service, as at that time dock room was not so much wanted as a safe and expeditious passage between the docks, which such a canal would have given. This scheme, as well as the more effectual one of a new junction dock, was, however, from one cause or other, deferred till further delay would have been highly injurious to the commerce and trade of the town as well as to the interests of the Dock Company.

By a clause in the Humber Dock Act, the Company were required to make a third dock whenever the shipping frequenting the port attained a certain amount of tonnage therein specified, provided a moiety of the expense was furnished them for the purpose. Some difficulties having, however, taken place in raising the stipulated supplies, the Company, impressed with the urgent necessity of making another dock, resolved, much to their honour, to execute it solely at their own expense, and the necessary arrangements having been completed, the work was begun in October, 1826, according to the designs and under the direction of Mr. James Walker, Civil Engineer, assisted by Mr. Thomas Thornton, the then resident engineer of the Company, as superin-

tendent of the works, in which office he was succeeded, in the month of July following, by the writer of this account.

It is proper in this place to state, that in the early part of the year 1826, Mr. Telford was employed by the Exchequer Bill Loan Commissioners to survey and report upon the proposed works; and the Dock Company being desirous of having the best advice, availed themselves of the opportunity of taking the opinion of that distinguished engineer. His report in general confirmed the plans of Mr. Walker; the principal alteration recommended was the substituting of a lock at each end of the dock, for an entrance with tidal gates only, and it was adopted.

Area. This dock is six acres in area, and is capable of containing sixty square-rigged vessels, with room for passing to and from the other docks.

Temporary works. The first preparatory works were the two coffer-dams, which were constructed principally of Memel timber; the south dam, or that next the Humber dock, was the largest, being 220 feet span, with a versed sine of 61 feet. The space between the two concentric rows of close piling, which were 6 feet apart in the clear, was filled to the level of the dock coping with clay puddle, the mud in the bottom having been previously well cleansed out; these piles were about 40 feet long, and 13 to 14 inches square. The gauge piles in front, forty-two in number on each side, were about the same dimensions, and had two rows of wale pieces, 13 by 8 inches, between them and the close piling on each side of the dam, all properly framed and bolted together. The close piling was connected together by an inner wale and cross braces near the top, and wrought iron tie rods lower down, and was further strengthened by a mass of loamy earth and loose bricks thrown in at foot.

On the concave side of this dam, and connected with it, was the temporary bridge. The road way, 24 feet wide, was supported by three rows of whole timber piles, braced together, and connected with the coffer-dam; and on their heads were transverse cap sills, carrying the bearing joists, which were covered with 3 inch planking and paved; a close boarded fence, six or seven feet high, was fixed on each side. From the great height of the dam, and there being at times a pressure of 28 feet of water against it, some of the piles were a little bent, and in very high tides the water found its way through rather freely near the top, particularly along the upper cross braces, but attention

being given in time, no detriment to the works ensued. It was found in the repairs, that the puddle had settled from 6 inches to a foot below the cross braces, and that this was the principal cause of the leakage, as the earth for the puddle was good, and the work appeared well done.

In order to guard against accidents, a preventer dam was afterwards made across the centre of Myton-gate lock, in the form of a segment of a circle, the convex side being next the Humber dock. This dam was chiefly composed of tenacious earth well rammed, with a dry brick wall on each side, 6 feet thick at bottom, diminishing to 2 feet 6 inches at top, and including the walls, was 30 feet wide at the bottom, and 8 feet at the top; it was carried to the height of the coping of the lock.

The gates also to both locks, after being hung in their places and finished, were well shored and braced, which turned out afterwards to be of the most essential service.

The north coffer-dam, at the west end of the Old dock, was 115 feet span, and the versed sine 14 feet. The plan of this dam and temporary bridge, and the scantlings of the timber, were similar to those of the other dam, except the piles, which were five feet shorter, the depth not being so great as in the Humber dock. This dam stood remarkably well, though there was sometimes a small leakage during very high tides near the walls and upper part.

There were two cast iron pipes laid along this dam for supplying the town with water while the works were in progress.

Two steam engines, six horse power each, were used for clearing the works of water; that at the south end of the dock was erected about the same time as the coffer-dams, and was also occasionally employed for grinding the pozzuolana; the other was put up in the end of 1827, at the east end of St. John's church, and was principally employed in pumping the water out of the White-friar-gate lock and the north end of the dock; it was also sometimes used for pugging mortar. This engine was taken down some time before the works were completed; the other remained until they were finished, a nine-inch pipe for conveying away the water having previously been laid through the west wall of the dock, and securely plugged after the engine had done working.

Water in the works. The water that arose in the excavation was not considerable; it was nearly pure, its slightly saline taste being caused, it is imagined, by its passing through the alluvial soil, which no doubt had been formerly deposited by the tide.

Excavation. The excavation of the dock and lock pits commenced soon after the coffer dams; the principal part of the material, over and above what was necessary for backing the walls and forming the quays and roads to the bridges, was used to raise the adjoining low ground and as ballast for shipping. The sides of the dock were cut to a slope of about one horizontal to one vertical, and the lock pits about one and a half horizontal to one vertical, and formed in steps, 3 feet wide, to receive the backing. The top, for 4 or 5 feet below the surface, was a stiffish clay, of which a great many bricks were made for the use of the works; below this, to the bottom of the dock, was silt, or a mixture of mud and sand, evidently left by the tide, from the small shells and other extraneous matter interspersed in it; this soil becomes exceedingly firm and solid very soon after removal. Several slips occurred both in the dock and lock pits; one on the east side of the dock, near the south end, (probably caused by the old fortifications or town ditches,) was about 90 yards long, and extended back to the buildings, several of which gave way, and had to be rebuilt; some of the foundation piles near the south-east corner of the dock were also forced forward. The ground was a good deal cracked in other places on this side, but further damage was prevented by shoring with timber; and the smaller slips that took place, particularly in the lock pits, were attended with no further inconvenience than the expense of their removal. The average depth of the excavation of the dock was 19 feet, that of the lock pits 6 to 7 feet more; the quantity of excavation was about 300,000 cubic yards.

Piling of foundations. The bearing piles were chiefly of American red pine, 10 inches square; the sheeting piles of Memel fir, 6 inches thick, with tongue and groove 2 inches square; all were driven without shoes, but the heads were in general hooped, to prevent splitting. The piling commenced in the dock wall on the east side, the first pile being driven near the south-east corner.

Pile driving. In all buildings resting on piling, it is important that the piles should be well driven, so as to carry the weight of the superstructure, and also to resist the lateral pressure, which in dock walls like the present is very considerable, and in alluvial soils of a loose and yielding nature, more than ordinary strength is necessary in this direction. Such being the case, and having before him the example of the other two docks, the walls of which had both given way, Mr. Walker was particularly desirous that the piling of the Junction dock should be effectually done; and for this end, requested to have an account of the driving from time to time, and where the ground proved softer than

ordinary, longer piles were used: indeed, the length and size of the piles were adapted as much as possible to the nature of the soil, varying in length from 10 to 18 feet in the dock walls, and in the locks some of them were 24 feet long.

Much irregularity prevails in pile-driving; sometimes a pile will go down at the last stroke more than it did at the third or fourth, though the fall of the ram and the density of the ground may be nearly the same, and the friction of course greater. Hence we perceive how uncertain all theories must be which profess to ascertain the actual weight a pile will bear, by having given the weight of the ram, the fall, and the depth driven at a stroke. There can be no doubt that a great deal depends upon the state of the head and point, for when these are sound and perfect, the pile will penetrate much deeper by a given stroke, than when soft and bruised; this is well known to pile-drivers, for frequently, when the pile moves but little or none, by sawing or even paring off a little of the head, it will go down again freely: also, if the weight falls exactly in the direction of the pile, and strikes the head fairly, so that the two bodies come into actual contact in every part, the pile will go further at a blow than when the stroke is oblique and the head only partially struck by the ram.

The sheeting piles under the front of the dock walls, driven by a crab engine, with a $10\frac{1}{2}$ cwt. iron ram, the fall varying from 8 to 18 feet, or 12 feet on an average, went down, at the end, about an inch at a stroke; the bearing piles, with a 20 feet average fall, about $1\frac{2}{3}$ inch, except in particularly hard ground, where they did not go down more than half the above at a stroke. The piles of the dock walls all battered about $2\frac{1}{2}$ inches to a foot.

The bearing piles in the foundations of the locks were driven with a ram of $13\frac{1}{2}$ cwt., and the average depth per stroke, when fully driven, was about 2 inches, with a 24 feet fall. The sheet piles, driven with a ram weighing $11\frac{1}{2}$ cwt., went down $1\frac{1}{2}$ inch with a 17 feet average stroke.

There is greater regularity in the driving of piles by the *ringing* than the *crab* engine, which is attributed principally to the head and point being much less injured, in consequence of the shorter fall of the ram, and its being of wood; but as the crab has the advantage in point of economy of working, the ringing engine was but little used, and that only for the dock piling. The bearing piles driven by it went down, on an average, $1\frac{1}{2}$ inch in thirty strokes, with a six feet fall, when fully driven; and the sheeting piles, 1 to $1\frac{1}{2}$ inch

with the same fall and number of strokes. The points of all the bearing piles were very obtuse, tapering not more than 12 inches, the better to support the weight of the walls.

It is well known that in piling, the ground, particularly if soft, becomes much consolidated, the first piles driving more easily than those after; on this account it was found advisable to drive the sheeting piles first, as they then went easier and were truer than when driven after the bearing piles; and this was more particularly the case in the lock pits, in some parts of which, especially under the platforms, where a great number of piles are inserted in a small space, the ground with the piles, after they were driven, rose together several inches.

Under the dock walls there are 2,411 bearing piles, containing 18,500 cubic feet of timber, and 2,140 lineal feet of sheet piling, 12 feet long, containing 12,840 cubic feet. In the Myton-gate lock there are 923 bearing piles, containing 10,126 cubic feet, and 540 lineal feet of sheeting piles, 16 feet long, (except the row next the Humber dock, which is 20 feet long,) containing together 4,440 cubic feet. In the Whitefriar-gate lock there are 956 bearing piles, containing 9,862 cubic feet, and 600 lineal feet of sheeting piles, 14 feet 6 inches long, amounting to 4,350 cubic feet.

It may be useful to know the actual weight sustained by some of these piles. The bridges are each supported by about twenty-eight 16 feet piles, and the superincumbent mass of masonry and iron being about 600 tons, there is a load of upwards of 20 tons on each pile; this is borne without settlement.

In variable ground it is not to be expected that all the piles can be equally well driven; but it may be stated, that the only yielding observed in the whole of this work, was at the projecting corners of the locks adjoining the dock wall, where a small crack, about the thickness of a knife blade, or little more, appeared for a few courses below the coping, caused, as it is believed, not by the sinking of the piles, but by the lateral pressure of the earth behind, on a part which from its construction is necessarily weak.

Dock walls. Plan, No. 8.

We proceed now to the dock walls, in the foundations of which an arrangement of the piling somewhat different from that in previous use was adopted. A row of bearing piles having been driven outside, a wale, 12 by 6 inches, was bolted to it, and the sheet piling driven behind and spiked to this wale. The back piles having also been driven, transverse sleepers of half timber are fixed on the pile heads, and over them were laid three

longitudinal planks, 12 by 4 inches. Except the main piles, the whole is of Memel timber, and well spiked together.

The space for 18 inches below the sleepers is filled up with brick rubbish, or Hessle-cliff stone, puddled in with hot lime and sand, and a similar concrete is laid at the foot of the wall, and covered with earth as an additional protection to the foundation.

The wall is of brickwork, faced in part with stone, and built in mortar consisting, for the backing, of one part of unslaked blue Warmsworth or Weldon lime to three parts and a half of sharp, clean, fresh water sand, and, for the front, two parts and a half of sand; but a great part of the outside, or facing, was set in the mortar hereafter described for the stonework.

The stone facing, which extends for a height of 11 feet 9 inches from the top of the wall, is of Bramley-fall stone, in 12 inch courses, except the lowest two courses, which are of Barnsley and Whitby stone, 15 inches thick; the coping is also 15 inches thick. The work is laid with one header to two stretchers, the headers being 1 foot 9 inches to 2 feet 3 inches on face, by 2 feet 9 inches to 3 feet 3 inches in bed, and the stretchers 2 feet 6 inches to 3 feet 6 inches long by 18 inches in bed, except at the corners of the dock, where they are 2 feet deep. The joints are champhered in front, the four lower courses are hammer dressed on face, and the rest neatly *bosted*. The coping, which is 4 feet wide, is secured by a 4 inch square dowel at each joint.

All the masonry, except the hollow quoins, is set in mortar, composed of two parts of unslaked blue Warmsworth or Weldon lime, one part of finely ground pozzuolana, and four parts of clean, sharp, fresh water sand, tempered in a pug-mill; the mortar for the hollow quoins was composed of one part of lime from Haling, near Rochester, one part of ground pozzuolana, and two parts of sand. The whole of the mortar and grout was used in the hot or caustic state.

The walls, except near the church, are curved horizontally, (7 feet on the east and west sides,) a mode of construction which, giving great additional strength, is advantageous in all situations, but more particularly in soils like those of the Hull docks.

Locks. Plans, Nos. 9 and 10.

The locks are 120 feet long within the gates, 36 feet 6 inches wide at top, and 25 feet high above the pointing sills; the construction of the two being, with some trivial exceptions, alike, a description of one will suffice: we take the first begun, viz. that at Myton-gate.

The construction of the timber work of the foundations, is believed to be

in some degree new, and appears to connect the different portions together more effectually than the ordinary mode. The piling is in rows driven at the intervals shewn by the sections, with additional piles under the hollow quoins and traverse rails, the better to support the weight of the gates. Longitudinal sleepers of whole timber are laid upon the pile heads, and over them transverse sills, 12 by 6 inches, and a foot apart in the chamber, and 12 inches die square, close together, with water-tight joints, in the platform; in laying the sills of the platform, the last, which was about the middle, was made tapering, and driven down by a pile engine, whereby the joints were wedged up. These sills and sleepers are all of Memel timber, but could elm of the requisite lengths and scantlings have been procured in sufficient quantities, it would have been preferable, as spikes hold much better in it, and drive without splitting the timber. The platforms are covered with 6 inch elm planking, laid upon a bed of tarred felt, firmly spiked with close water-tight joints. The platforms of the reversed gates were done nearly in the same manner, but without felt, and the transverse sills are laid about nine inches apart, the interstices being filled up with brickwork. For economy, the foundations of the bridges were not laid so low as the rest of the lock, but particular care was bestowed on the driving of the piles, which are 22 feet long, by 11 inches square. The sills generally are spiked down, but in the platforms they are secured by two *dogs* to each pile.

The pointing sills were not fixed till the lock was nearly completed. The principal ones are of African oak, 18 inches die square; they were sunk $1\frac{1}{2}$ inch into the planking of the platform, strengthened by oak cleats abutting on the back sill, and the whole secured by jagged bolts, straps, &c. A cast iron plate, about 12 feet long by 5 inches wide, was secured to the top of each sill near the middle of the lock, to prevent injury from deeply laden vessels, and as a further security, there is a strong sill at each end of the lock, laid level with the pointing sills. The reversed pointing sills are 14 inches square, and are secured nearly in the same manner as the principal ones.

The ground was taken out to a foot below the heads of the piles, and the space filled with Hessle-cliff stone, flushed with soft mortar up to the top of the longitudinal sleepers; the intervals between the transverse sills are made up with bricks as a flooring for the inverted arch, which in the chamber of the lock is entirely of brickwork, except the stone quoins at the ends. The invert

consists of three separate rings of headers set in pozzuolana mortar, the work behind being laid in level courses with common mortar and well grouted: the short inverted arches between the direct and reversed hollow quoins, are chiefly of Mexborough stone, bosted on face and radiated in the joints; the facing over them is likewise of stone, as also that of the wings beyond. The work of the side walls of the lock is generally of the same character as of those of the dock, except that the stones of the facing are of somewhat larger dimensions and greater depth of bed.

The hollow quoins are of Dundee stone, 5 feet 6 inches long by 3 feet 6 inches wide, and in 12 inch courses to correspond with the ashlar facing, laid header and stretcher alternately, with two cast iron hollow dowels let into the beds of each joint to unite all firmly together, and the part in which the heel-post of the gate turns well rubbed to a smooth water-tight surface. The reversed hollow quoins, so called from being intended to receive the gates in a reversed position, are of Bramley-fall stone, dressed and set in like manner, but without dowels.

The foundations of the bridge are brought solid to the proper level, and then divided by partition walls of stonework into four pits, each about 4 feet wide, to receive the ends or *tails* of the bridge when up.

Lock gates. Plan, No. 11.

The lock gates are partly of English, partly of African oak, from the difficulty of procuring the former timber of the requisite curve and size. They are framed and secured together in the usual way, with 3 inch fir planking closely jointed and caulked on one side, and $2\frac{1}{2}$ inch fender planks on the other. The gates were completely fitted on shore, and having been taken apart, were reframed in the bottom.

Each gate is hung at top with a wrought iron collar in a cast iron anchor let into the stonework; and fitted to the lower extremity of the heel-post is an iron socket, which turns on a brass pivot fixed in the platform, the outer end of the gate being supported by a brass roller, 12 inches diameter by 4 inches wide, fitted with an adjusting screw, revolving on a brass segment let into a cast iron one screwed down to the platform; the socket and shoe at the foot of the heel-post being of cast iron, a brass circular plate, $1\frac{1}{4}$ inch thick, is let into the bottom quoin, to protect the stone from injury and prevent leakage. The gangway or footpath is supported on cast iron brackets, and has a chain and stanchion fence on each side.

The machinery for working the gates, which is fixed in a cast iron box on

the side of the lock, consists of a 7 inch pinion working into a spur wheel 4 feet diameter, on the axis of which is a cast iron roller, 3 feet long, and varying from 12 to 9 inches in diameter; round this a $\frac{3}{4}$ inch chain winds, and passing under a roller at the bottom of the well, and over another similar roller in the face of the wall, is secured to the gate. There is also a counterbalance weight and chain, as in the other locks.

There are two sets of sluices to each gate, with three doors in each set, working on brass facings, in iron grooves, and so constructed that one set is raised whilst the other is lowered; which is done by the sluice-rod connected with the screw at top having a rack upon it that turns a spur wheel working into another rack attached to the other sluice-rod. By the disposition and mode of adapting the sluices to the spaces between the bars, a capacious opening is obtained without weakening the gates, and one man can perform the work of two in the ordinary way, in less than half the time,—an important consideration where economy and despatch are required. The machinery ought to be completely enclosed, to prevent chips or other floating matter getting inside, for want of which, one of these racks was broken soon after the dock was opened; and there should also be a stop to keep the sluices from falling into the bottom of the lock in case of accident.

Each gate complete, it is calculated, weighs upwards of 20 tons, or each pair 40 tons; the whole weight resting on the platform, which has not, however, settled in the least, but is now as level and perfect as when first completed. This, it need hardly be observed, is a most essential point in the working of large gates that move on friction rollers at the bottom, as is also the perpendicularity of the hollow quoins. To effectually ensure the latter point, Mr. Walker judged it expedient to have all the hollow quoins securely land-tied; this was done by putting a 6 inch landing, or flag, about 12 feet long by 8 or 10 feet deep, vertically behind the walls at the hollow quoins, with three 2 inch tie rods, let through and secured to the flag by means of nuts and screws and a wrought iron plate extending its whole length, the other ends of the rods taking hold of the anchor and being cramped into the stonework. Three similar tie rods are secured in like manner to the landing on the reverse side, having a connecting ring at the outer end by which they are united to a single tie extending to a row of piling about fifty feet from the side of the lock, like that for securing the mooring rings in the dock walls, but with shorter piles.

Reversing gates. The reverse hollow quoins and pointing sills, alluded to above, are for facilitating the repairing of the lock when necessary; in which case the gates will be removed into these quoins, so that the water may be pumped out of the lock for the repairs, without interrupting the business of the docks. This plan was first adopted by Mr. Walker at the Commercial Docks in London, where the gates were lifted by barges, and removed in a vertical position into the reverse quoins, and were ready for emptying the lock in one tide. The arrangement is simple, and attended with but little extra expense,—points that cannot fail to recommend its adoption.

Bridges. The bridges over the locks are on the balance or lifting principle, and consist of eight cast iron ribs, 9 inches deep at the centre or meeting by $1\frac{1}{2}$ inch thick in the plain part, and 2 to 3 inches at the edges, connected together by two sets of cast iron crosses to each half or leaf, the lowest being close to the abutment, by hollow pipes and bolts nearer the middle, and by the meeting plates, which fit together with a tongue and groove. When the bridge is down, the under side or soffit of the ribs forms an arch of 36 feet 6 inches span, and 3 feet 6 inches rise, resting on cast iron abutment plates fixed in the masonry at the sides. From near the axis, the ribs curve down below the fixed part of the bridge, and terminate in boxes filled with kentlidge, by way of counterbalance, each box being attached to two ribs. The axis on which the bridge turns is 9 inches square, with five turned bearings working in plummer blocks bedded on the stonework, the centre being 5 feet 3 inches from the side of the lock. The fixed part of the bridge is supported by iron joists resting on the division walls of the pits above described. The roadway is formed very much as in the bridge over the Old dock lock.

The bridge is lifted by means of four crabs, two on each side; the handle is applied to a 6 inch pinion, which works into a spur wheel, 4 feet diameter, having on its axis a 12 inch pinion, which works into a toothed segment, 5 feet 9 inches radius, fixed to the outer rib of the bridge.

When the bridge was nearly finished, it was found that a variable counterbalance weight was necessary in addition to the kentlidge, to render it nearly on an equipoise in all positions; this is effected by hooking to the tail two chains, which passing over pulleys fixed in the stone work at the back, and from thence over two other pulleys on the dock wall, are attached to a chain, composed of heavy flexible links, hanging into the bridge pit; when the bridge is up, the chain is just clear of the bottom, and assists by its gravity to draw

it down, and as the bridge descends and less balance is required, the weight of the chain, by falling on the bottom is reduced accordingly, till the kentlidge alone acts. In raising the bridge, exactly the reverse of this takes place. The weight of each bridge is about 100 tons; one half or leaf is usually opened or shut by three men in half a minute, but in an emergency two can do the work.

In comparing the balance with the swivel bridge, it may be observed that the former will work longer without adjustment, and is also stronger, from bearing more firmly upon its abutments; but it is more affected by the wind, the original cost is greater, and double the number of men are required to work it.

The bridges and lock gates were constructed by Messrs. Hunter and English, Millwrights, of Bow, London, who deserve credit for the complete and workmanlike manner in which they executed their contract; the ironwork was cast at Alfreton, Derbyshire.

Quays. The part of the backing for a width of a yard next the dock and lock walls is composed of the best clay or loamy earth, well rammed, so as to be water-tight, and the top of the quay afterwards levelled and trimmed, with a declination of $\frac{3}{4}$ inch in a yard from the side of the dock, covered for a foot in thickness with Hessle-cliff stone and shingle gravel, and having a paved channel towards the outside, with proper grates for the rain water. The quay is nearly level with the streets, on the east side of the dock, but six or seven feet above them on the west side, where it is supported for a considerable distance by a retaining wall.

There is a post and chain fence round the dock, about 15 feet from the side, and a railway is laid outside the east quay, within 5 feet of the footpath, to connect the railways of the Old and Humber dock, as already noticed.

Moorings. Plan, No. 8. On the east side of the dock, at intervals of about twenty yards, there are wrought iron mooring rings, fixed in front of the wall underneath the coping, and coupled to a wrought iron tie rod, the outer end of which is secured to a waling, behind a row of piling driven at some distance back. The ring is prevented from being lifted, by a wrought iron vertical plate sunk in and secured to the stonework by means of three dovetailed screw bolts, let into the wall. This plate being convex, and projecting a little from the wall, at the same time answers in some measure the purpose of a fender. The rings make very durable and excellent moorings, and have

besides the advantage of keeping the quays clear of ropes and chains, which are always an annoyance to business.

The moorings for the other parts of this dock, in consequence of the Company having had timber on hand, are oak posts, about 18 feet long, and 15 to 18 inches diameter near the top, fixed about 12 feet from the side of the dock, and secured by two Memel land ties, 9 by 6 inches, about 30 feet long, and diverging outwards, like the letter V, so as to be about 10 yards apart at the outer end, where they are bolted to a sill behind piling, nearly in the same manner as the ring moorings. The timber underground is all *charred*, for preservation. The moorings to the locks are either of small cannon or of Bramley-fall stone, 2 feet diameter, and are 3 feet 6 inches high.

Buoys. There are six buoys for warping and mooring vessels in the dock; they are 6 feet 6 inches square, by 4 feet 6 inches deep, made solid of Memel logs, with a casing of 3 inch fir planking spiked on tarred woollen felt, and the joints caulked. The ring is secured to a wrought iron bolt driven through the centre of the buoy; underneath hang a shackle and chain 9 yards long, the lower end of which is fastened to a strong timber framing bolted to four piles, 20 feet long, driven below the bottom of the dock.

Sewers. There are two main sewers for draining the quays and some parts of the town adjacent; that on the east side of the dock is 9 feet below the coping, and extends from Whitefriar-gate to Myton-gate, where it joins the Humber dock sewer. The other commences at the west side of Whitefriar-gate bridge, and joins the town sewers near the Dock Company's workshops on the west side of this dock; its bottom is 12 to 13 feet below the dock coping.

The sewers for draining the bridge pits are 2 feet wide by 3 feet high in the middle; the pits on the east side being 2 or 3 feet below the bottom of the sewer, the water has to be pumped out occasionally; but on the west side, the drainage by the new sewer is effectual.

A scouring sluice near Postern gate cleanses the sewer on the east side of the dock, and another near St. John's church, that on the west. These sluices are both alike, and of cast iron, 3 feet 3 inches wide by 3 feet high inside, sliding in a cast iron groove in the face of the dock wall, and worked by a screw: their bottoms are 9 feet below the coping, and there is an oak frame with folding doors on the outside to protect the sluices, which communicate with the main sewers by a culvert, 3 feet square. The sewer at Postern gate

is provided with two of these sluices, by opening one and shutting the other of which, the scour is to the north or south as may be required.

The sluice at the east end of St. John's Church was built at the expense of the commissioners under the Myton Improvement Act; the water, after passing along part of the Company's sewer, cleanses several others in Myton, and proceeding still further westward, discharges itself into the Humber at the general outfall in Lime-kiln Creek.

Water pipes. The pipes for supplying the town with water, which formerly were across the site of Whitefriar-gate lock, were removed while the works were in progress, and laid across the coffer-dam, as noticed before. In building the lock, a cavity, 2 feet 9 inches wide by 15 inches deep, was formed in the face of the stonework, across the bottom and up the sides to the level of high water of neap tides, and in this cavity two 8 inch cast iron pipes were laid, and secured to the stonework by a flanch cramped down at each joint; the space round was then filled in solid with brickwork, and covered with cast iron plates, bolted to the masonry. There are two bonnet pipes at the middle of the invert, made a little deeper than the rest, to contain any sediment that may remain, and so formed that the top can be taken off and the pipe cleansed by means of the diving bell; but to prevent any great accumulation, there is a small chain inside the pipes, by drawing which backwards and forwards it is supposed the sediment will be disturbed, and carried away by the force of the water. From the level of high water of neap tides, the pipes are built inside the wall, and carried up in a slanting direction to the height of the under side of the coping, near which they are joined by the regular mains leading from the water works into the town. Before these pipes were used, they were proved by means of the force-pump of a fire-engine, to a pressure of upwards of 200 feet of water.

Gas pipes. About the end of 1828, the Hull Oil Gas Company requested permission to lay a gas pipe under each of the Junction dock locks; this was granted them on certain conditions, and the Dock Company also resolved to lay two pipes in each place at their own expense, in order to prevent the possibility of a monopoly, and so at all times secure to the town and its environs a supply of gas at a reasonable rate: as the locks were at this time nearly completed, the work was attended with some difficulty, and much greater expense han if it had been done at an earlier period.

The provision made at the two locks was nearly the same; we shall describe that at Whitefriar-gate. In the first place, there was sunk, on each side at the north end of the lock, a shaft or well 30 feet deep, *steined* with brickwork, at the bottom of which an aperture was made under the foundation of the walls to receive the pipes; a trench was then cut across the bottom, and two rows of piles, 9 feet asunder, driven down 4 feet below the dock sills; transverse cap sills were next bolted on the pile heads, and blocking sills firmly spiked to them, on which 10 inch pipes in 9 feet lengths, with spigot and faucit joints, were, after being proved, laid with a declivity of 12 inches from side to side, to allow the sediment from the gas to run to tar cisterns provided at the bottom of the wells; the cisterns that belong to the Dock Company being on one side, and the Gas Company's on the other. In order to guard the pipes from injury, two longitudinal sills, 9 inches wide by 17 inches deep, and extending from wall to wall, were fixed, one on each side, on the transverse sills, and brickwork laid in the foundations as high as the under side of the pipes, which were then surrounded with a 4½ inch brick ring set in Parker's cement, and the rest built up with brickwork to the under side of the longitudinal sleepers, which were connected together at top by cross ties. The whole was afterwards covered with earth to the level of the dock bottom, the openings under the walls closely bricked up, and the wells coped and covered with oak planking. The tar cisterns were laid on large 6 inch flags, and had short pipes at the side and top to unite with the horizontal and vertical gas pipes; these pipes not having yet been wanted, are still unconnected with the street pipes, but this can soon be done when required.

Breach in coffer-dam.

It has been before observed, that a preventer dam was made across the Myton-gate lock-pit; for further security, as soon as the south gates were hung, they were ordered to be securely braced, to prevent any irruption of water from the Humber into the new dock. The coffer-dam at the Whitefriar-gate lock being less extensive, was considered safer, and it was at first thought the bracing of the gates might be dispensed with, but the contractor having prematurely begun to remove the temporary bridge, with a view no doubt to expedite the completion of the work, the coffer-dam being connected therewith was placed in jeopardy, and it became necessary that these gates should also be securely braced. This precaution was soon found to be of the utmost advantage both to the work and for the safety of the shipping.

The following spring tides, in the morning of 21st March, 1829, there

appeared a small leakage under the east end of the coffer-dam, which it was attempted to stop by treading in a quantity of tempered clay, but without success, as the leak still continued, and in three hours there were several feet of water between the dam and the lock gates; the leakage then increased very rapidly, and filled the above space so fast, that for the safety of the gates, it was thought advisable to draw the sluices and let the water flow into the dock: about the same time the sluices of the Old dock gates were also opened, to lower the water in that dock, then about 19 feet deep on the lock sills, in order to reduce the pressure upon the Junction dock gates; but the breach under the dam soon after became so extensive as to undermine the Old dock wall, and in the course of the forenoon a length of about 60 feet of it fell down. This in some measure stopped the leak, and the water rose more slowly afterwards; but the succeeding tide it was nearly on the same level in the Old and Junction docks.

Happening as it did, near the conclusion of a great work that had been so far successfully carried on, this accident is to be regretted, and the more, as it might certainly have been avoided by deferring the removal of the temporary bridge a week or two longer, when the works would have been in such a state as to have allowed the dock to be filled with water in the regular way; yet the damage might have been infinitely greater, had not the Junction dock gates been closed and secured previously to the accident; it was this, indeed, that prevented the dam from being blown up altogether, in which case, from the tremendous rush of water through the lock, the consequences to this part of the work would in all probability have been most disastrous, while the shipping in the Old dock near the dam must inevitably have been swept with violence into the lock, and most serious damage been the result.

On being apprised of this accident, Mr. Walker repaired to Hull without loss of time, and finding the works so far advanced that they might be completed with the diving bell, advised the immediate removal of both coffer-dams and temporary bridges, and that the materials left in the bottom of the dock and locks should be taken out by the bell at the same time. He also recommended that the Old dock wall should be rebuilt upon piles, about 11 feet below the top of the wall, having a row of close piling with a substantial wale in the front, well land-tied, with cross sleepers and planks over all; this was accordingly done, and a stone string course laid on the front piling, upon which the brick wall was erected in the course of three or four weeks.

Removal of temporary works.

In removing the temporary bridges and coffer-dams, the piles were principally drawn by the engine crabs, with double blocks and chains, and so firmly did they hold, that some of them required sixteen men with four crabs to move them, but in general half this power was sufficient; after the piles were started, one crab with four men (assisted by the buoyancy of the water) accomplished the business. The power applied to some of these piles was not less than from fifteen to twenty tons. There being occasion in the course of the work to draw several of the sheeting piles in the Whitefriar-gate lock pit, a 4 inch screw was used, and one of the piles, 14 feet long by 12 inches wide, required, on the most moderate calculation, a power of 18 tons to draw it, the soil being nearly a pure sand; another pile could not be drawn by even a greater force, until a hole was dug round it, but the others, being in softer ground, moved more easily. In examining the sheeting piles when drawn, we found the points (none of which were shod) generally in a good state; a few, which were driven into a sheer black sand, bruised a little, and some of the grooves, originally 2 inches wide, increased to 3 inches, from having been forced outwards by the tongue in the hard soil.

After the dam and bridge piles were all drawn, and the part of the puddle above water removed, the remainder of the puddle and the earth at the foot of the dams were taken up by the dredging machines.

Dock opened.

The dock was publicly opened on the 1st June, 1829, being little more than two years and a half from the commencement of the work.

Mortar and lime.

The Warmsworth having been represented as a good water lime, the work was begun with mortar made from it and sand only; but from the bad state of similar mortar in the Humber dock walls, when taken down, and from some experiments, the lime appeared not to answer the description given of it, and Mr. Walker recommended the front of the dock and lock walls, to be set in pozzuolana mortar, which was accordingly done. At this time the greater part of the east wall of the dock, and a part on the south side of St. John's Church, were as high as the under side of the stonework, and it was observed that, notwithstanding the thickness and solidity of the walls, the water in very wet weather found its way through, so that they were exceedingly damp even in front, and in several places the water literally ran down the face of them; this was ascribed to the mortar and grout not hardening sufficiently, as in all cases where the front was set in pozzuolana mortar,

although the walls were a little damp in places, the water never penetrated through.

It may be proper in this place to state very briefly the result of some experiments on various kinds of mortar, which were made by the writer at Mr. Walker's request. The specimens were in small flat cakes, dried for a few days before being put into water. With respect to the quality of the lime, but little difference was found between the Warmsworth, the Weldon, and Fairburne; none of them mixed only with sand ever hardening in water, but on the contrary, dissolving quite in the course of a few weeks. Experiments were also made with these limes mixed with sand and pounded bricks or brick dust; with sand and *minion*, or pounded iron scales; and with sand, pounded scales, and bricks, in various proportions; but none of these different compositions shewed any tendency to become hard in water, and were indeed little better than lime and sand only. Several specimens made with the same kinds of lime mixed with sand and pozzuolana in various proportions, were then tried, and it was found that one of lime, one of pozzuolana, and two of sand, made an excellent mortar, either in or out of water; but, for economy, a mortar composed of two of lime, one of pozzuolana, and four of sand, was afterwards adopted, which, although it did not indurate quite so soon, retained its hardness in the water, and was but very little inferior to the former. Some experiments were also made with mortar of Haling lime and sand only, which, though superior to that made with the Warmsworth or Weldon lime, was by no means to be compared with the pozzuolana mortar, and as the expense was nearly the same, there was no hesitation in giving the latter the preference.

Stone. A few words descriptive of the stone used may not be improper. The Bramley-fall, got from an extensive quarry on the side of the Leeds and Liverpool canal, about four miles west of Leeds, is a coarse sand-stone, or mill-stone grit, of an excellent quality, and in durability as a building stone in all situations, perhaps inferior to none in this country except granite. Kirkstall Abbey, which is near seven centuries old, is built of it, and although the building is now a ruin, the stone generally is very perfect and entire. The Old bridge of Leeds is built of a similar stone; this structure has been twice widened, but the original part is very ancient, and still in a good state of preservation; as are also some of the locks on the Aire and Calder Navigation,

which have been erected more than fifty years. The Barnsley and Whitby are both fine sand-stones; the former, a sharp grit, much in use for grind-stones: they are generally used in their immediate neighbourhoods for building in water and otherwise, and some beds of each are very durable; but they are both much inferior in this respect to Bramley-fall. The Dundee stone used in the hollow quoins is a fine grained close stone, very hard and durable, though on account of its laminated structure, improper for coping, and if quarried a little before or during winter time, liable to be rent by the frost. There were several other kinds of stone brought on the ground, particularly the Mexborough, but being of inferior quality, they were only used in the inverted arches of the locks, and other parts constantly under water. Whilst upon this subject, it may be proper to observe, that by fronting the walls with stone above high water of neap tides, they have been rendered exceedingly durable as compared with a brick facing, without materially adding to the expense.

Lockage. The passage of a ship through the lock, including the opening and shutting of the bridge, usually occupies about five minutes, but frequently little more than half that time; six to eight heavy laden ships, besides small craft, have passed through Whitefriar-gate lock in an hour, proper time being also allowed for the passengers and traffic over the bridge, which is here very great.

In stating the waste of water, or leakage, it should be noticed that there are seven scouring sluices besides the eight sluices of the entrance lock gates. From a series of observations made on Sundays, when there is no waste by locking, the leakage of the three docks is about three quarters of an inch per hour in spring tides, and half an inch in neaps.

Mud. The accumulation of mud in the Junction Dock has hitherto been very little, certainly not more than at the rate of an inch a year; so that the total quantity of mud in the three docks now, is not so great as in the two docks heretofore; and as the steam dredger has now a ready communication with the different docks, it performs the whole work, the horse machine having been altogether dispensed with since 1829.

State of walls. Having before described the state of the mortar in the Old and Humber dock walls, I shall here give a very brief description of that in the

Junction dock. The common front mortar, especially that used late in autumn, all suffered more or less injury from frost; and no part of it, so far as there has been opportunity of examining, has hitherto, where damp, acquired any considerable degree of hardness; nevertheless, as the walls are all substantially founded and solidly built, it is confidently expected that the mortar will continue to indurate till the whole becomes one compact body. The pozzuolana mortar in the front of the walls, even before the water was let in, was in general hard and good, the only defective part being in the west end of the dock, where the wall was damp in consequence of being backed with wet soft earth; some part of this mortar, being used late in the year, was a little perished by the frost, and required fresh pointing, but the front of the walls has been frequently examined since the dock was opened, and the joints found every where as perfect and entire as at first. In some parts of the work, accidentally injured by the shipping, and taken down and rebuilt, the pozzuolana mortar was found in a good state, although not so hard in the interior as in the front; the mortar in the beds of the stonework, also, was more indurated than in the vertical joints, and for the most part adhered much firmer.

Town-walls or fortifications.

In the course of the works of the Junction Dock, a part of the old fortifications on the east side was cut through and taken down; from their antiquity they may be deemed not unworthy of notice. The walls are said to have been originally built of stone in the time of Edward the Second, but repaired and strengthened with bricks in Richard the Second's reign, when the art of brick-making was revived in this country. The bricks were about 11 inches long by $5\frac{3}{4}$ inches wide, and $2\frac{1}{2}$ inches thick. The mortar was of two kinds, one composed of lime and sand only, the other of lime and powdered bricks or tiles, with very little sand; both were, with a very few exceptions, extremely hard, the latter being the more so. The mortar appeared to have been used in a very soft state, or as grout, but by no means well tempered, small lumps of pure lime, resembling hard tallow, being interspersed in great abundance. In three or four of the bottom courses, and nine to eighteen inches in width at the back of the wall, where it was in a damp state, it had not set in the least, and at the bottom in particular, appeared like pure sand, while the neighbouring parts, being dry, were particularly hard, and united together like a rock. It is a generally received opinion, that the extreme hardness of the mortar in old buildings is owing entirely to its having been

much better tempered in ancient than in modern times; although there is no doubt that this is a most essential point in all kinds of mortar, it is conceived that the superiority is caused chiefly if not wholly by *time*, and that mortar continues to harden in certain situations probably for centuries. The foundations were eight or ten feet under high water, and in some parts were on small piles, the rest being on the natural ground. The piles were 5 or 6 feet long, and 6 or 7 inches diameter, some of oak, some of fir, and the hearts of both kinds quite sound and of a blackish colour, but the sap much decayed.

Tides and currents in docks.

It was expected when the Junction dock was opened, that it would, on account of its situation, be in a great measure supplied with water from the Humber, but the contrary has been the case, the principal supply being certainly from the river Hull, as is proved by the altered quantities of mud deposited in the Old and Humber docks already noticed; there being an annual increase of mud in the Old dock of about 4,000 tons, and a decrease in the Humber dock of about 6,000 tons, since the Junction dock was opened, as compared with former years. This also shews, that even the Humber dock is in part supplied from the purer source of the Hull.

As a further elucidation of the nature and course of the tides since the Junction dock was opened, the following observations are submitted. During the night tides and on Sundays, when no business is done in the docks, the Humber dock gates are secured fast together, in order to shut out the muddy waters of the Humber. On one of these occasions, very soon after this contrivance was adopted, I noticed that, the water being level on the two sides when the gates were thus shut, the flow was faster on the side next the Humber for the first quarter of an hour, at the end of which the difference was at its maximum of about three inches; the water on the opposite sides then began to approximate again, and at the end of fifteen minutes more it was again exactly level throughout. This observation has been since repeated with nearly the same result, though varying a little, according to the state of the tides, and as there may be freshes in the river Hull; in one instance the difference of level was as much as four inches. It appears, then, that the principal supply from the Humber is in the first half hour after the tidal water arrives at the level of the water in the docks, and this agrees with the current or course of the tide through the different locks. I have frequently set off from the Old dock lock at the time the tidal water opened the gates and began to flow into the dock, and have walked slowly on to the Whitefriar-gate lock, where the water had

just commenced running very gently into the Junction dock; proceeding forward to the Myton-gate lock, I have generally found the water stagnant, but in the course of a few minutes there appeared a very slow motion towards the Humber dock, and by the time I have arrived at the Humber lock, or about half an hour after leaving the Old dock lock, the water was running gently towards the Humber. It should be observed, that in neap tides the above currents through the locks are always slow, but in spring tides, and when there are freshes in the Hull, the velocity is often as much as three quarters of a mile per hour, and sometimes even more. The current into the Old dock through the entrance lock is also considerably increased since the Junction dock was made; from observations soon after the opening of the latter, as to the exact level of the tide at the entrances to the Old and Humber docks, it was found that, on an average of several tides, the gates of the former were opened by the rising tide about three minutes before those of the Humber dock.

Before leaving the subject of the tides, I may notice a curious fact, founded upon repeated observation; viz., that about three hours before and after high water, there is sixteen feet water on the Humber, and only ten feet on the Old dock sill.

Conclusion. Having thus endeavoured to give a concise account of the Harbour and Docks at Kingston-upon-Hull, with reference to that department more immediately connected with the object of the Institution for which this paper has been drawn up, I cannot conclude without again briefly adverting to the great and important advantage the town and port have derived from the improvements described.

It is but little more than half a century since the first dock was completed; before that time, the river Hull below the bridge was the only safe harbour in the port, and in this narrow confined space the shipping and small craft were so crowded together, that it was often with great difficulty they could have access to the quays to take in or deliver their cargoes, and damage was sustained by the larger vessels from grounding every tide. It also sometimes happened that the harbour was incapable of containing all the shipping that frequented the port, in which case they were laden and delivered in the Humber by means of craft, at the expense of much delay and considerable additional charges. These inconveniences, and the want of a legal quay, with the complaints they gave rise to on the part of the revenue officers, at length led to the

formation of a dock, which in time was followed by another. But, extensive and commodious as were the Old and Humber docks, for want of a ready passage between them they were still incomplete,—the Junction dock has perfected the communication; and instead of being surrounded, as of old, by fortified walls and deep ditches, which (their occupation being gone) had latterly become stagnant pools, the common receptacles for filth and nuisance, the town is now encircled by the rivers Humber and Hull, and three spacious and commodious docks; improving the public health by the assistance afforded to drainage through the liberality of the Dock Company, and rivalling, in convenience for mercantile men and facilities for the despatch of business, those of any port in the kingdom. These, and the means of inland communication, enjoyed or in prospect, with a district peculiarly rich in minerals and manufactures, added to its situation on so noble an estuary, and its contiguity to the continent, cannot fail to maintain the eminent rank Hull has hitherto held among British ports.

DOCKS.

	Length.	Breadth.	Area.			Number of Ships.
	Feet.	Feet.	Acres.	Roods.	Poles.	
Old Dock . . .	1703	254	9	3	29	100
Humber Dock . .	914	342	7	0	24	70
Junction Dock . .	645	407	6	0	5	60
			23	0	18	230

BASINS.

	Length.	Breadth.	Area.		
	Feet.	Feet.	Acres.	Roods.	Poles.
Old Dock . . .	213	$80\frac{1}{2}$	0	1	23
Humber Dock . .	267	435	2	2	27
			3	0	10

ENTRANCE LOCKS.

	Length.		Breadth.		Depth of Water on Sills at Neap Tides.		Spring Tides.	
	Feet.	In.	Feet.	In.	Feet.	In.	Feet.	In.
Old Dock . . .	120	9	38	0	14	0	20	0
Humber Dock . .	158	0	42	0	20	0	26	0
Junction Dock . .	120	0	36	6	14	0	20	0

BRIDGES.

	Each Footway.		Carriage-ways.		Width inside Railing.		Total width outside.	
	Feet.	In.	Feet.	In.	Feet.	In.	Feet.	In.
Old Dock . . .	3	6	7	6	14	6	15	0
Humber Dock . .	2	8	6	11	12	3	12	6
Junction Dock . .	4	0	15	3	23	3	24	0

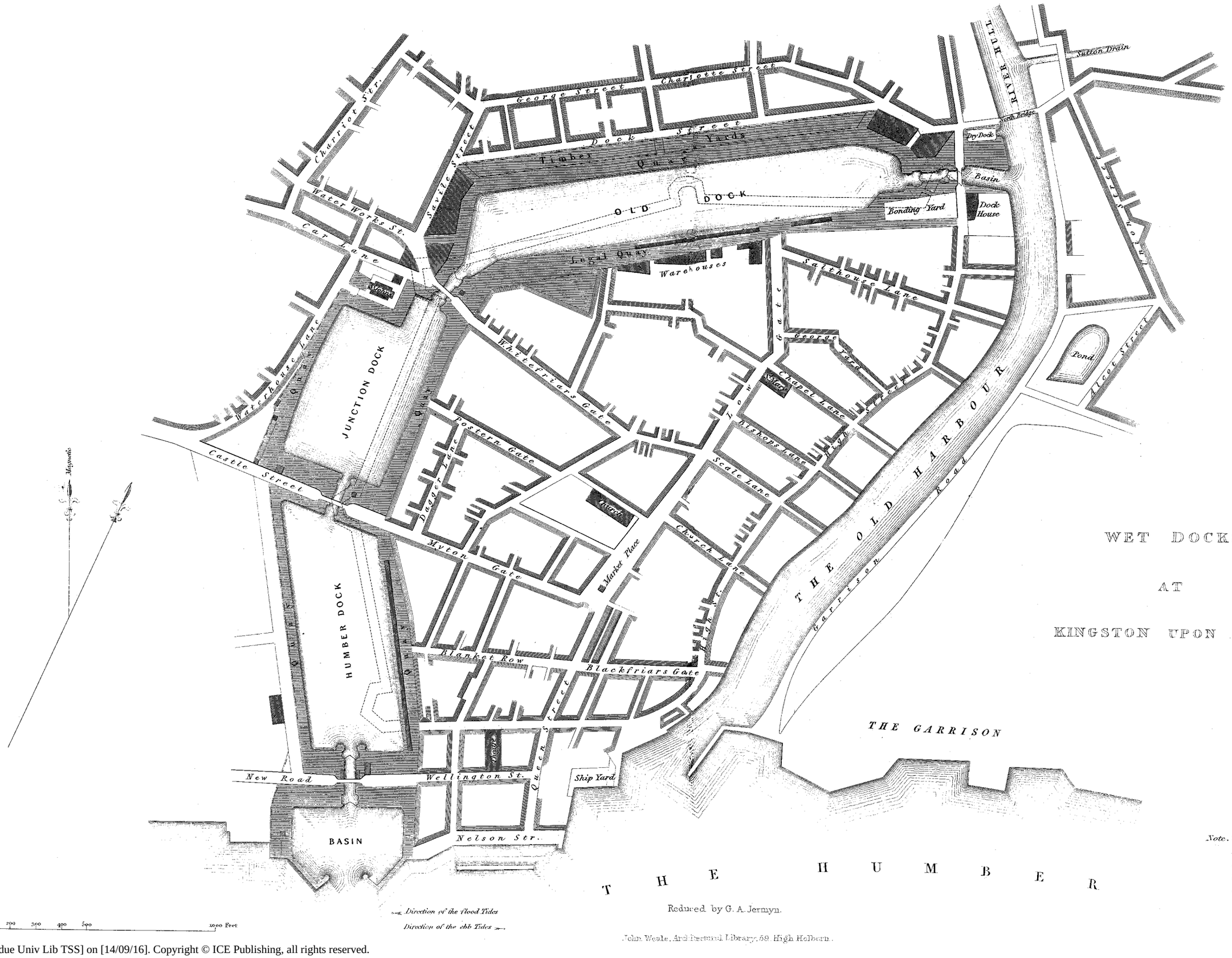
WAREHOUSES AND SHEDS.

	Length.	Breadth.	Area.
	Feet.	Feet.	Superficial Yards.
Warehouses, Old Dock . . .	345	. . .	2,251
Sheds, Ditto	143	23	1,623
	492	23	
Sheds, Humber Dock . .	754	25	2,095

QUAYS.

	Legal Quays.	Totals.
	Square Yards.	Square Yards.
Old Dock . . .	18,160	29,000
Humber Dock . .	8,830	17,639
Junction Dock . .	. . .	15,643
Humber Dock Basin .	. . .	8,419
	26,990	70,701

WET DOCKS AT KINGSTON UPON HULL.

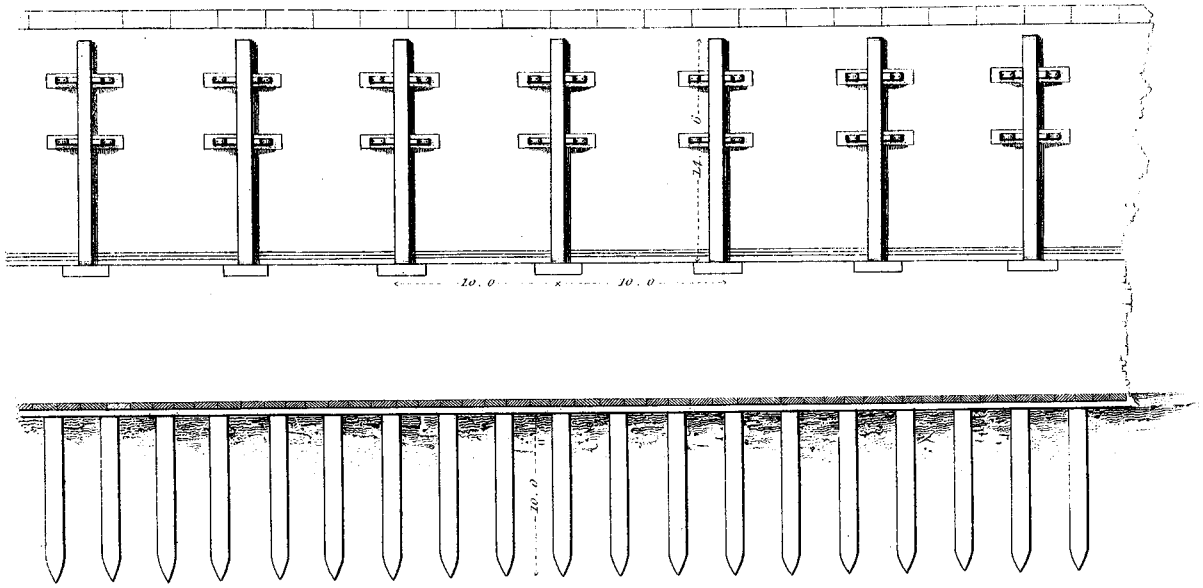


Note. The dotted line thus ..... shews the direction of the ancient fortifications: and line thus ——— the boundary of the Company's property.

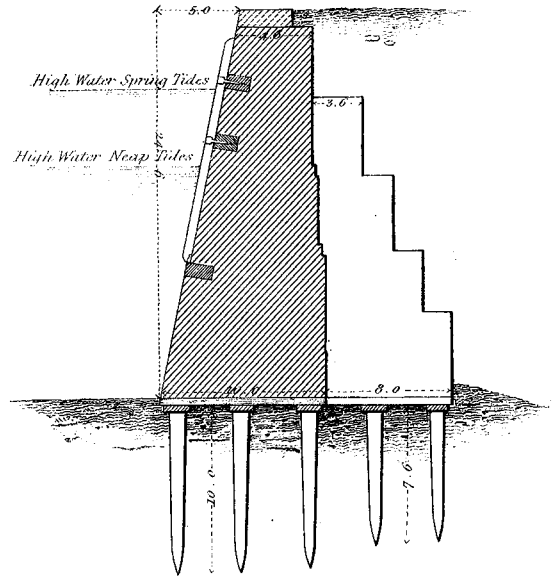
Reduced by G. A. Jermyn.

John Weale, Architectural Library, 59 High Holborn.

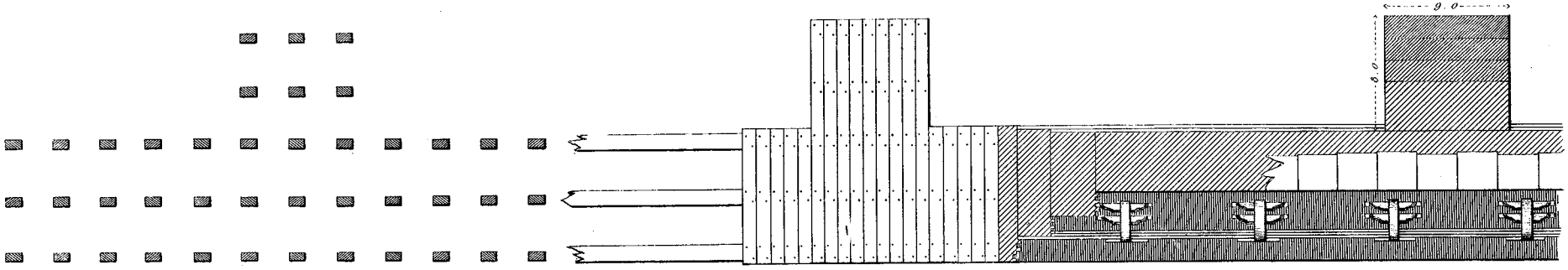
HULL DOCKS, OLD DOCK WALL.



ELEVATION



CROSS SECTION.



PLAN

10 5 0 10 20 30 feet.

Reduced by G.A. Jermyn.

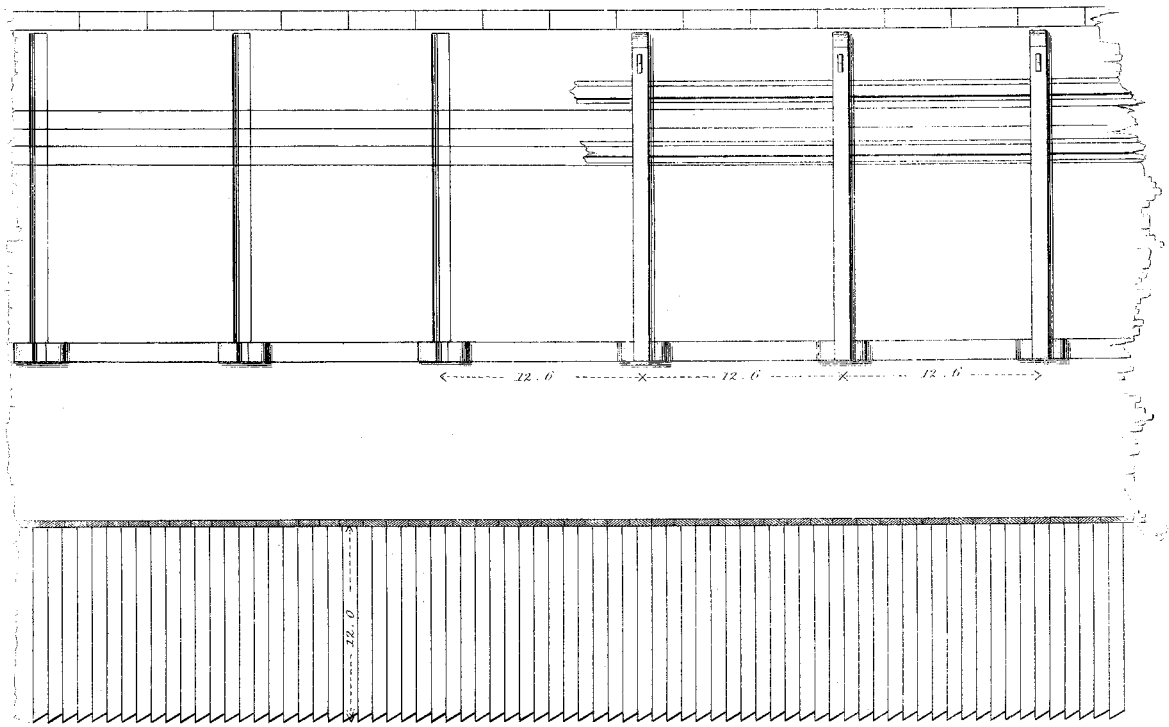
J. & D. Timperley del.

S. Bellin sc.

John Weale, Architectural Library, 59, High Holborn.

HULL DOCKS. HUMBER DOCK WALL.

ELEVATION



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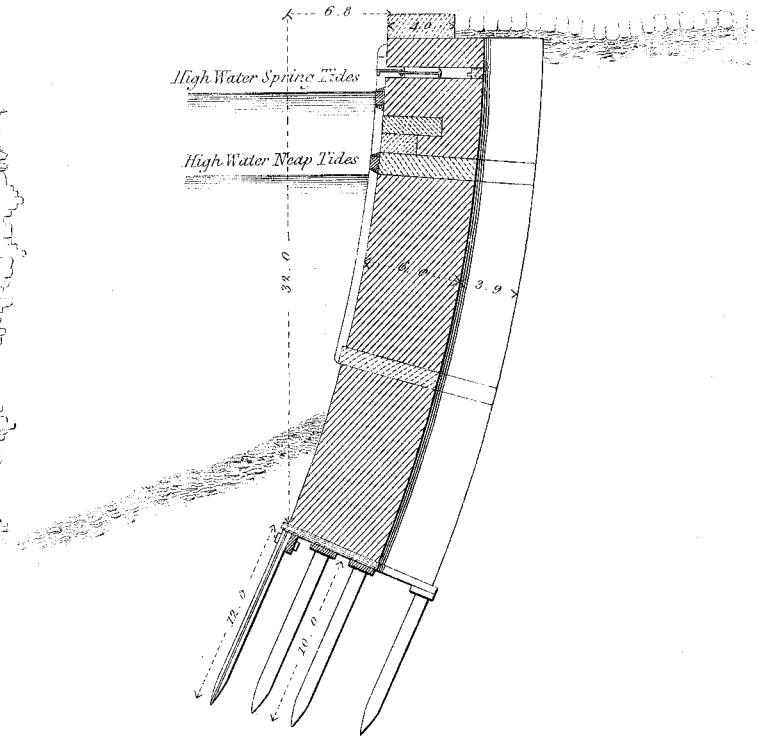
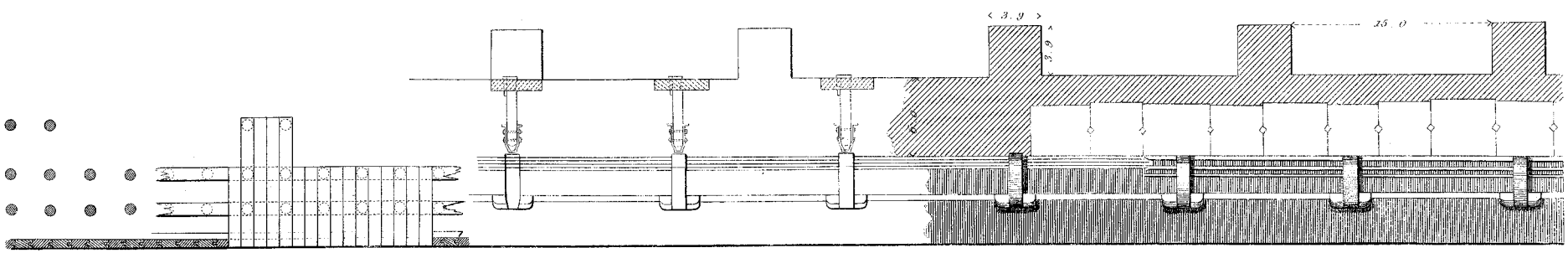


PLAN



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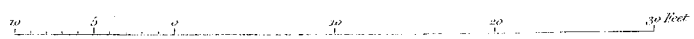
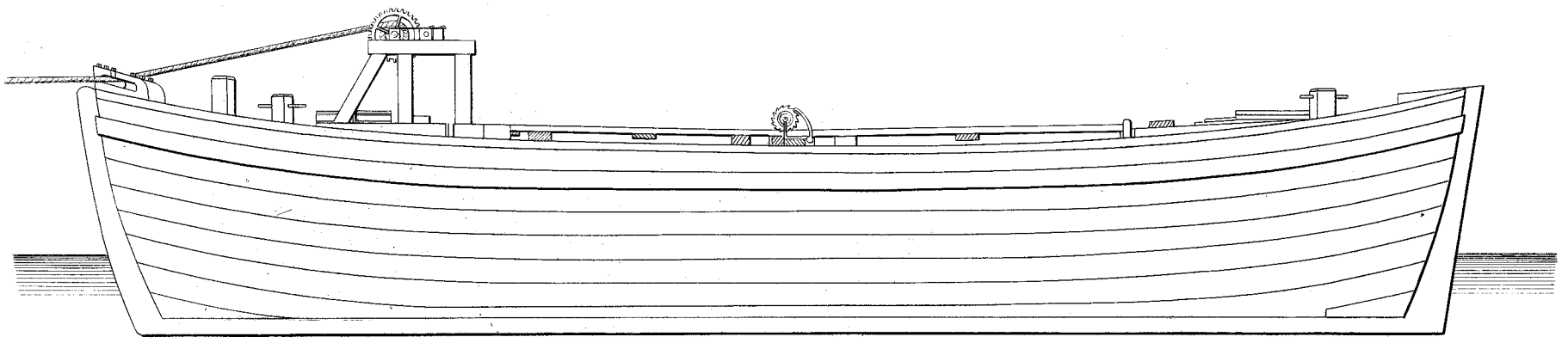


J. & D. Tuperley del.

S. Bellin sc.

HULL DOCKS. HUMBER DOCK MUD BOATS.



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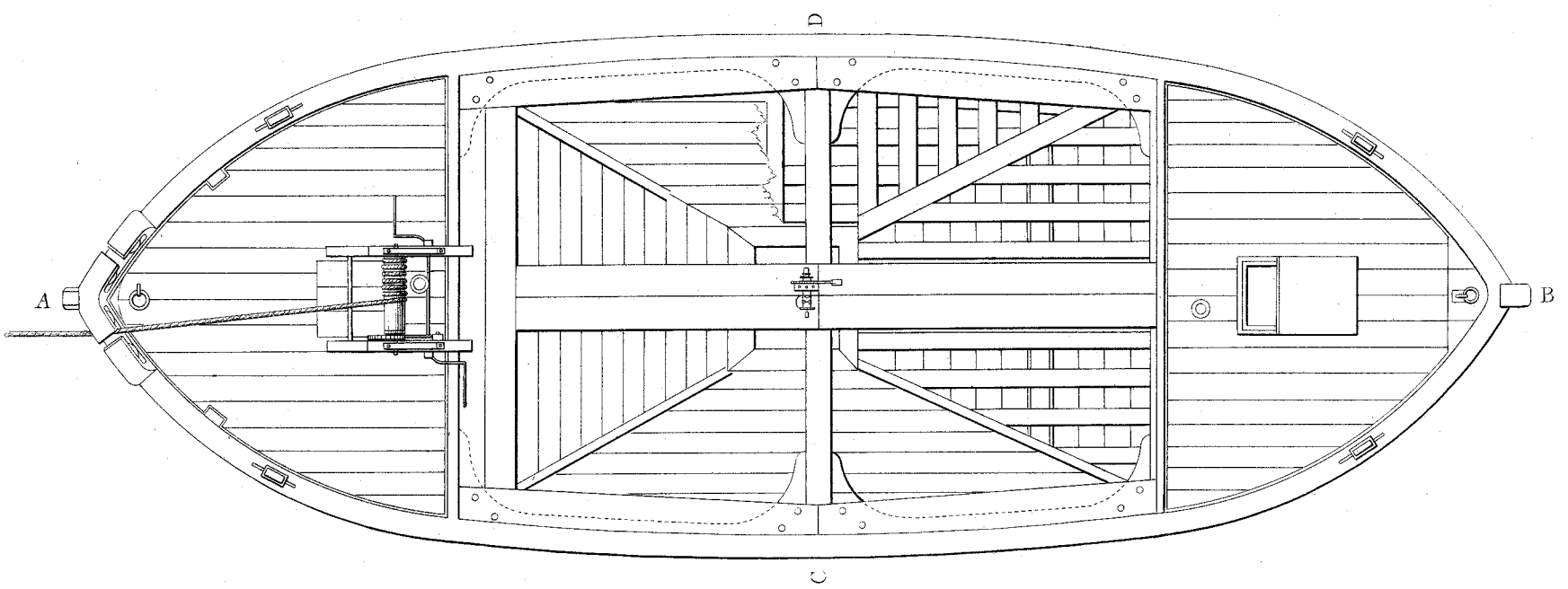

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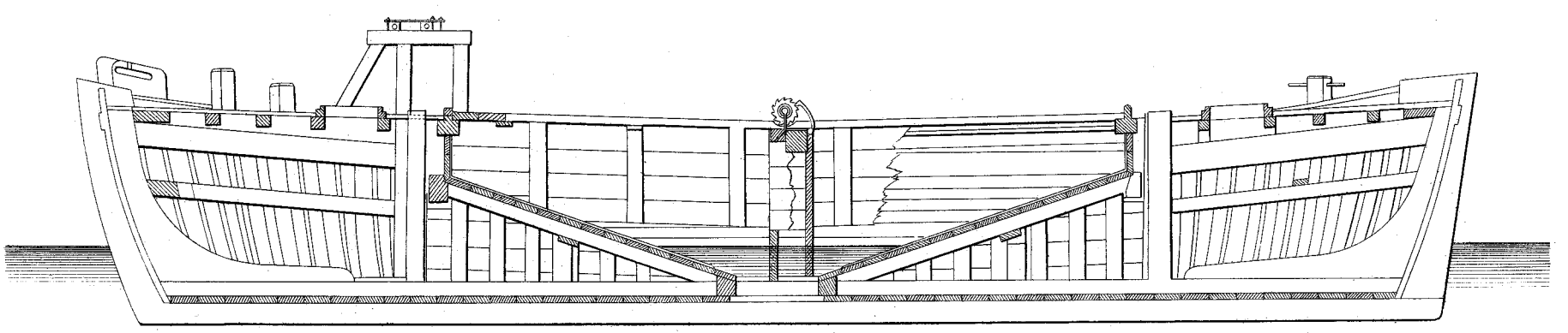
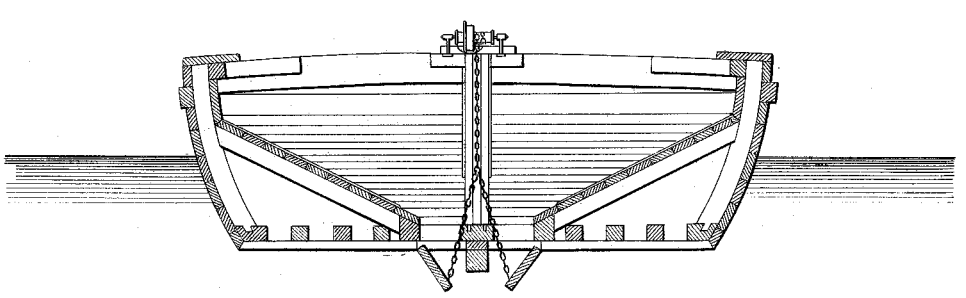


SECTION A. B.



SECTION C. D.

Reduced by G. A. Jermyn.

J. & D. Timperley del. S. Bellin sc.

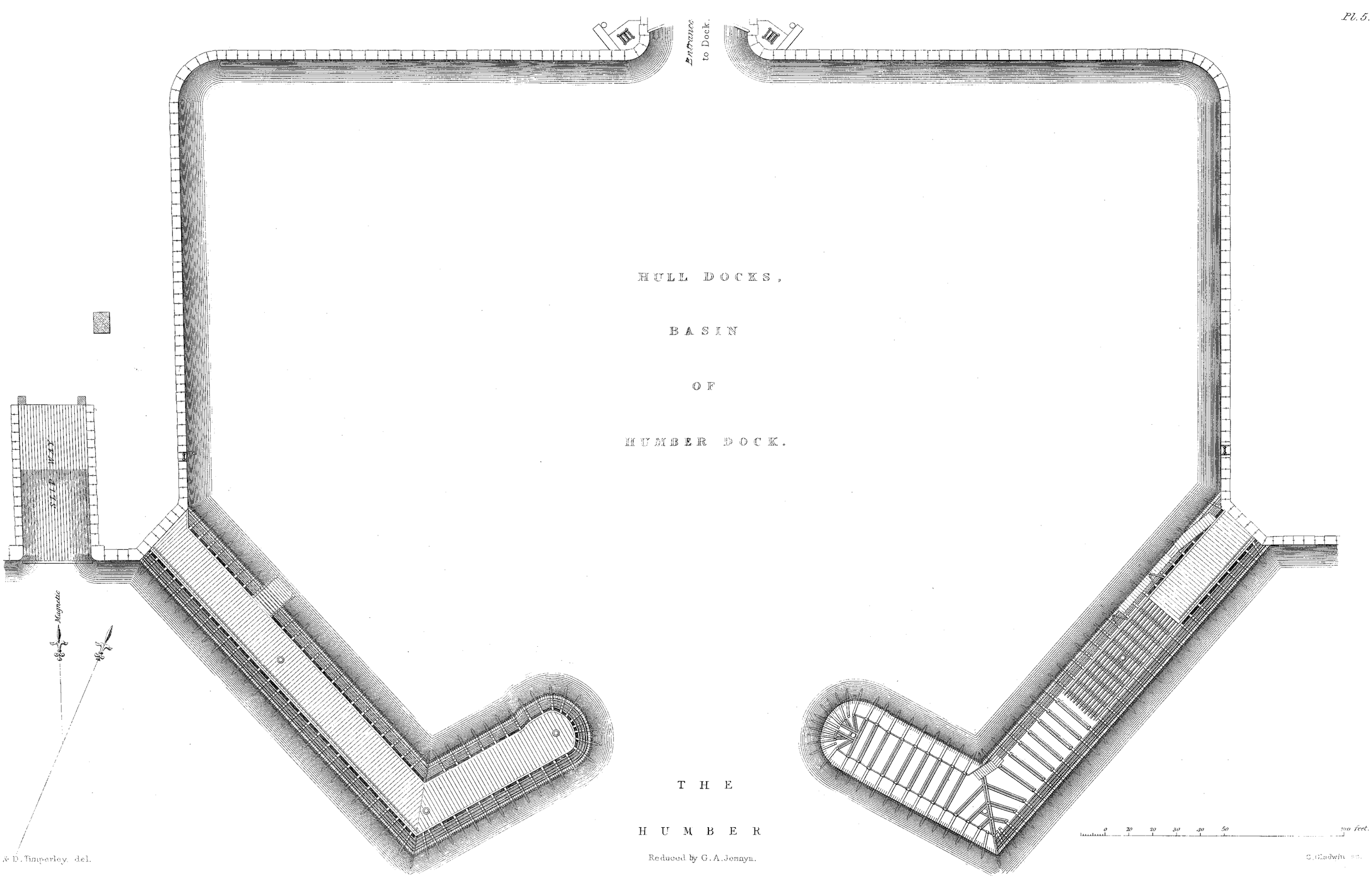
John Weale, Architectural Library, 59, High Holborn.

HULL DOCKS,

BASIN

OF

HUMBER DOCK.



THE

HUMBER

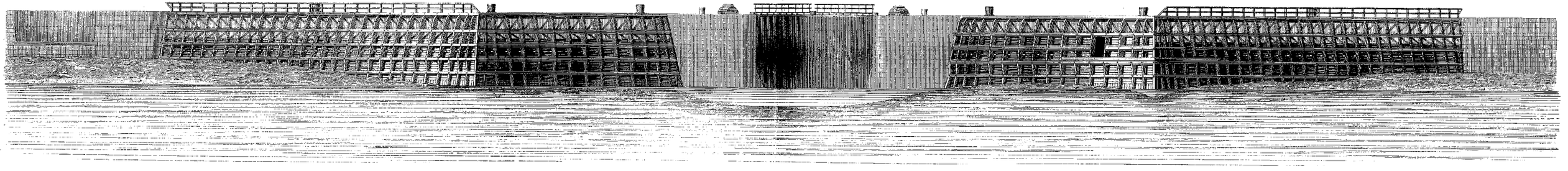
Reduced by G. A. Jennyn.

J. & D. Timperley del.

C. Gladwin sc.

John Weale, Architectural Library, 59, High Holborn.

HULL DOCKS, PIER HEADS OF BASIN AND ENTRANCE OF HUMBER DOCK.



10 3 0 10 20 30 40 50 200 Feet.

Reduced by G. A. Jermyn.

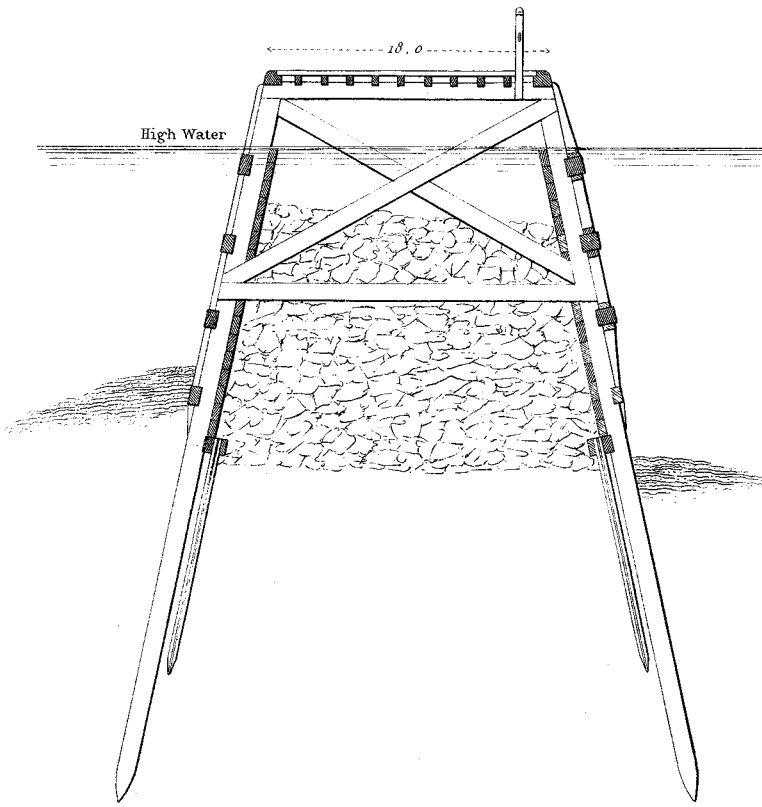
J & D. Timperley, del.

G. Gladwin sc.

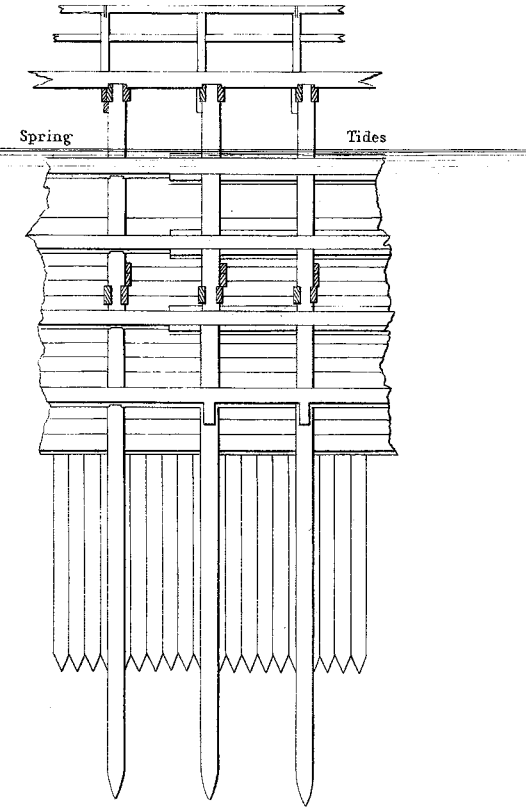
John Weale, Architectural Library, 59, High Holborn.

HULL DOCKS, PIERS OF HUMBER BASIN.

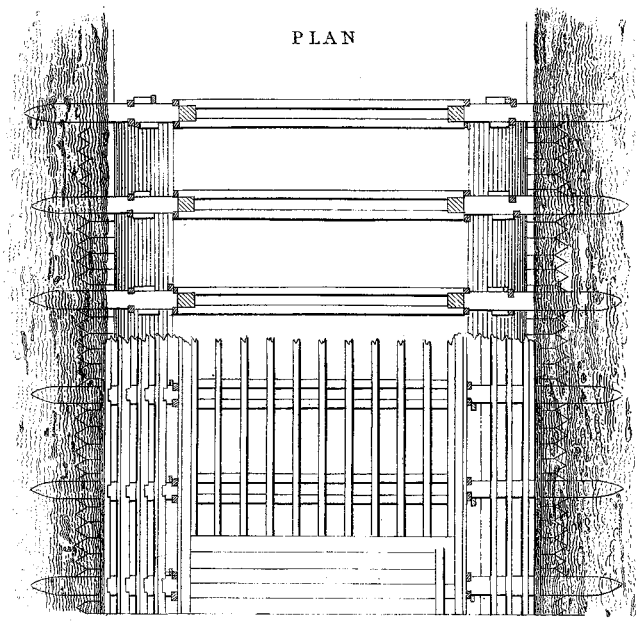
TRANSVERSE SECTION



ELEVATION



PLAN



Scantlings.

Main Piles	*14 + 14*
Outer Wale	*14 + 14*
Inner Wale	*12 + 6*
Cap Sill	*12 + 10*
Joists	*7 + 4*
Ties	*12 + 6*
Sheet Piling	*6 in. thick*
Planking	*3 in. thick*

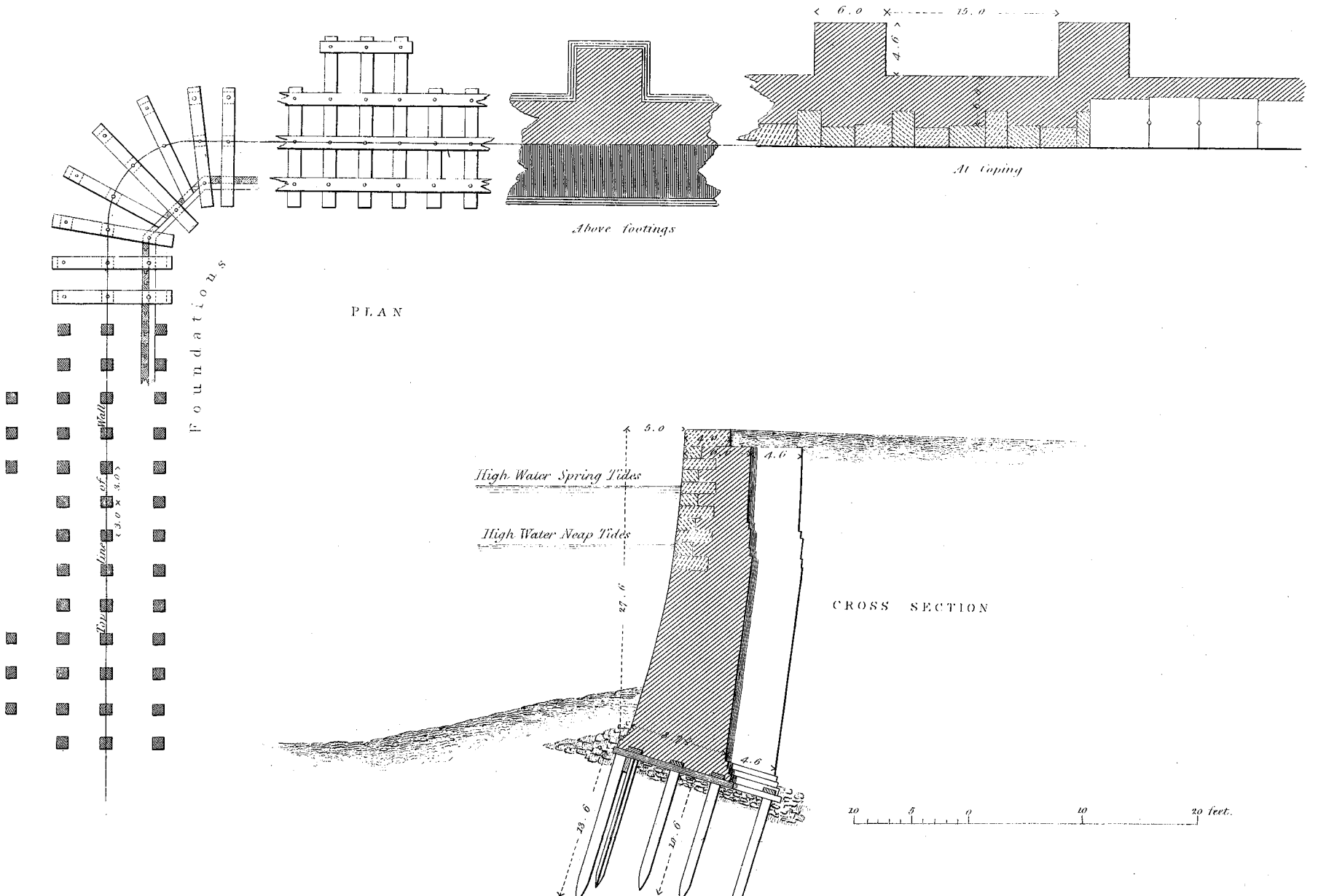
Reduced by C.A.Jermyn.

J & D. Tinperley del.

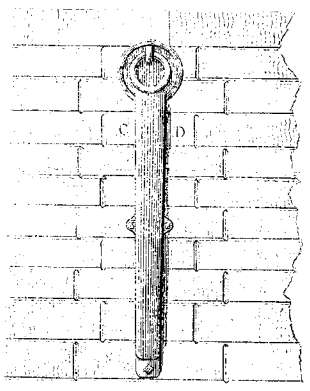
John Weale, Architectural Library, 59 High Holborn.

S. Bellin sc.

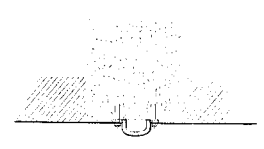
HULL DOCKS. JUNCTION DOCK WALL.



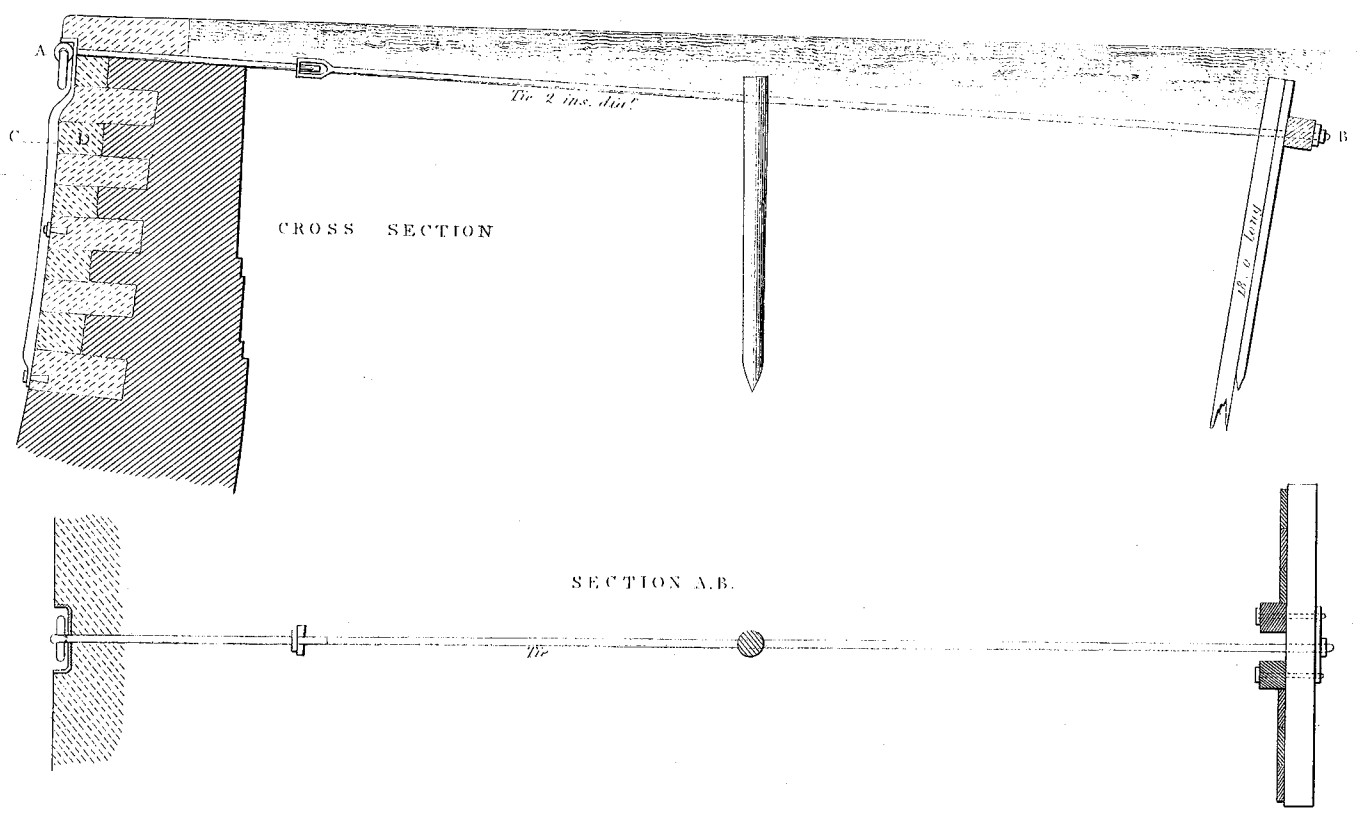
RING MOORINGS ON THE EAST SIDE OF DOCK.



ELEVATION



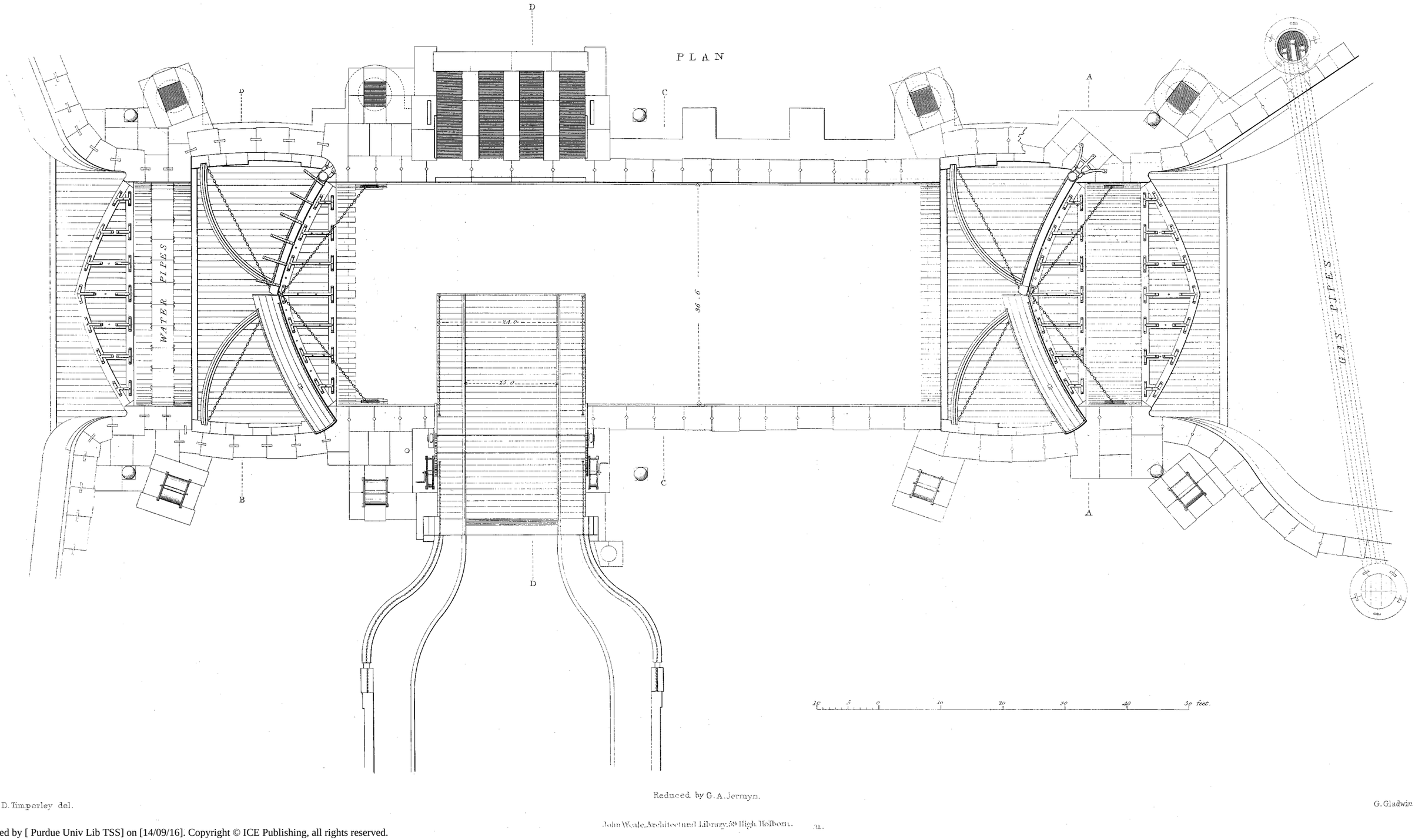
SECTION C.D.



J & D. Timperley del. Reduced by G. A. Jeremyn. S. Bellin sc.

John Weale, Architectural Library, 59 High Holborn.

HULL DOCKS. LOCKS OF JUNCTION DOCK.

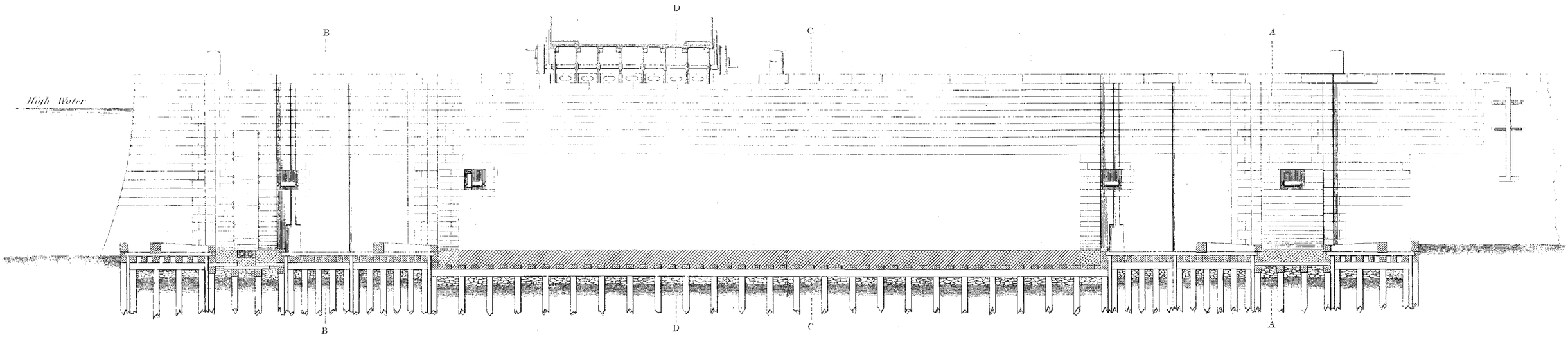


J. & D. Timperley del.

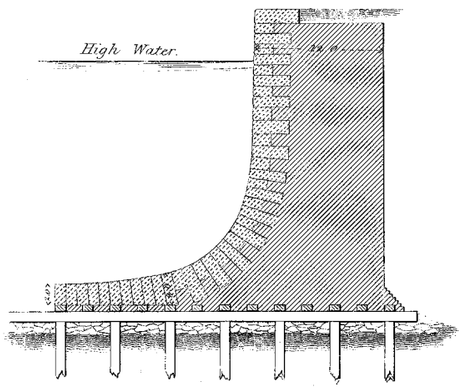
Reduced by G. A. Jermyn.

G. Gladwin sc.

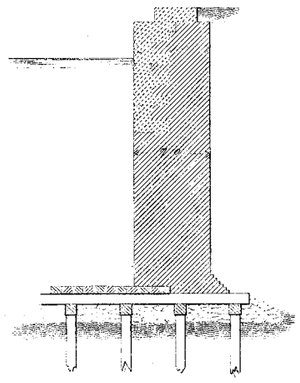
HULL DOCKS. LOCKS OF JUNCTION DOCK.



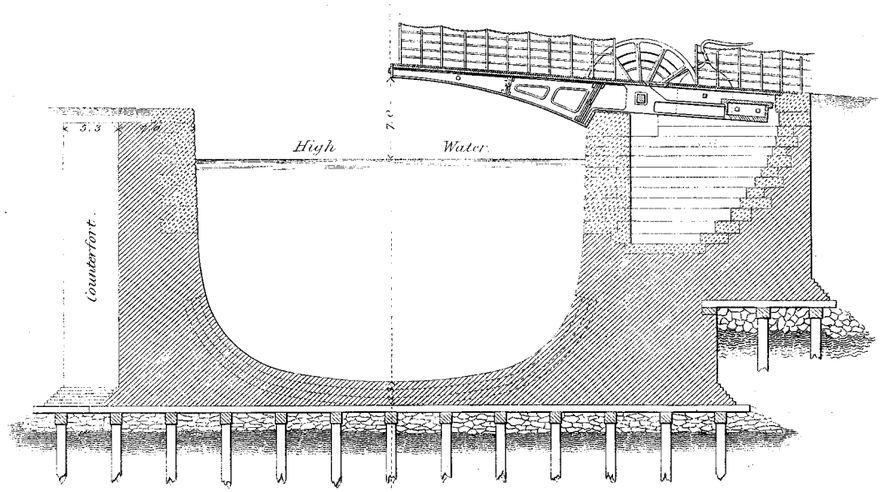
LONGITUDINAL SECTION



TRANSVERSE SECTION THROUGH A.A.



SECTION THROUGH B.B.



TRANSVERSE SECTIONS THROUGH C.C. AND D.D.

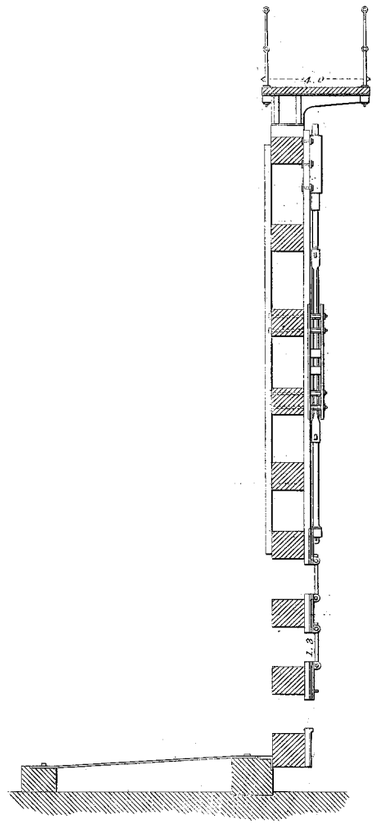
0 10 20 30 40 50 feet.

Reduced by G.A.Jermyn.

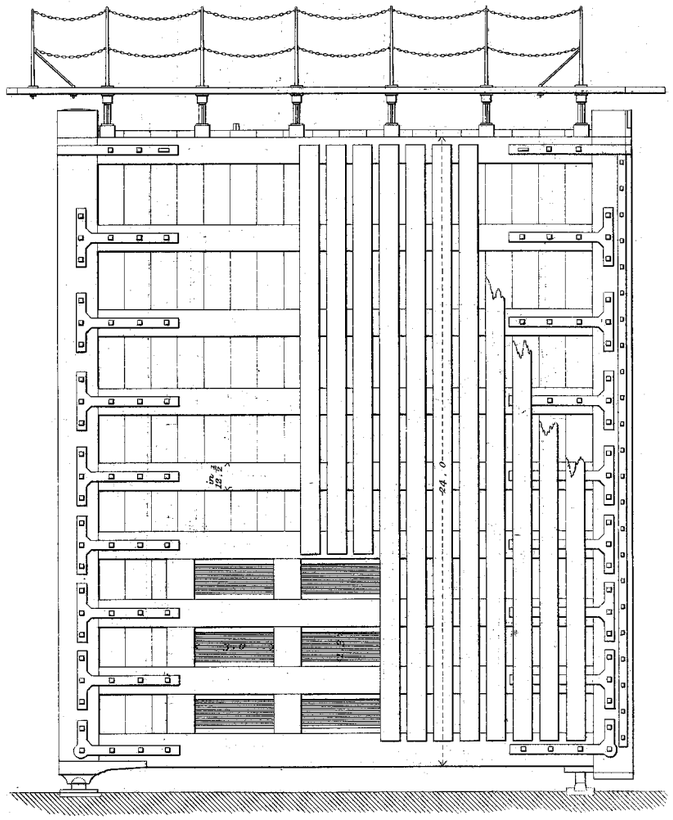
J. & H. Emperley del.

G. Gladwin sc.

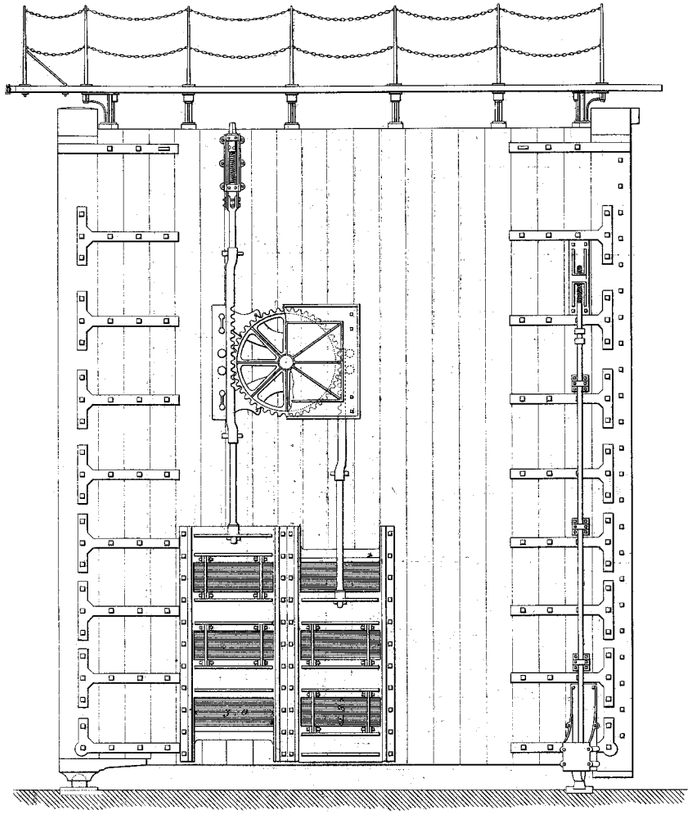
HULL DOCKS, GATES OF JUNCTION DOCK LOCKS.



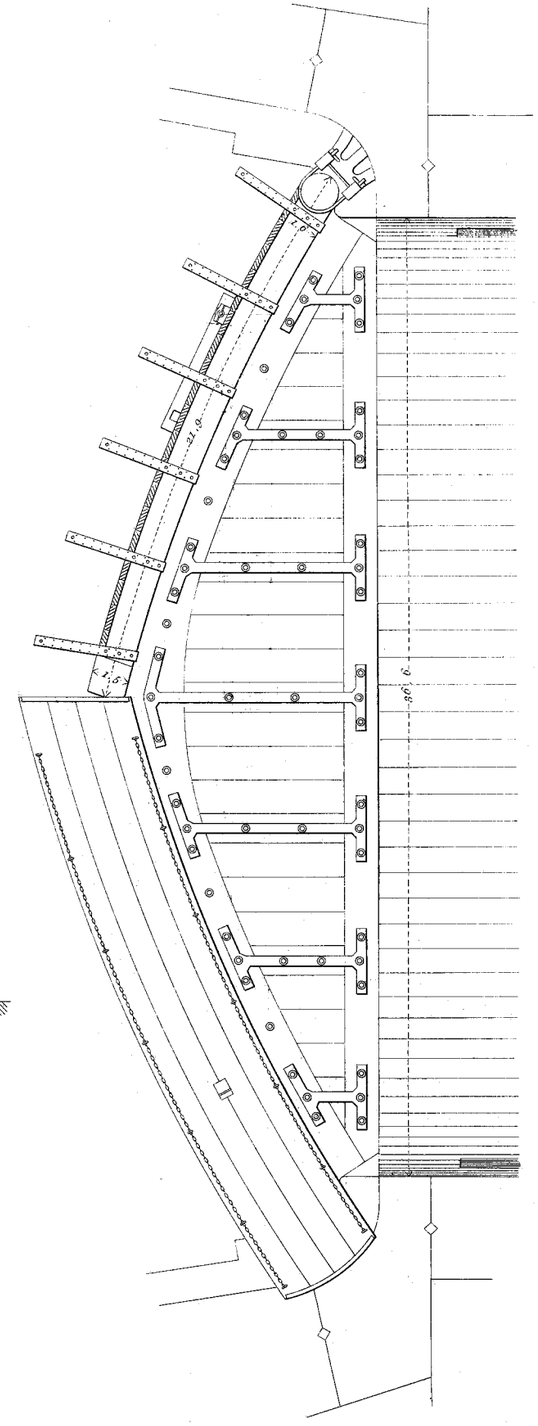
SECTION



ÉLEVATION OF BACK.



ELEVATION OF FRONT.



PLAN

in. 12 0 1 2 3 4 5 6 7 8 9 10 20 feet.

Reduced by G. A. Jermyn.

J & D. Timperley del.

G. Gladwin sc.

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