January 10 and 17, 1865.

JOHN FOWLER, Vice-President,
in the Chair.

THE discussion upon the Paper, No. 1,115, "On the River Tees," occupied both evenings, to the exclusion of any other subject.

The following Candidates were balloted for and duly elected on January 10:—BERESFORD ANDERSON, ROBERT MATTLAND BRERETON, JOHN LAW HUNTER, and JAMES ADAIR M'CONNOCHIE, as Members; WILLIAM ALEXANDER ADAMS, ALEXANDER BROGDEN, HENRY GARLAND MATTHEWS, BENJAMIN OLIVEIRA, F.R.S., Colonel SAÏD BEY, and Captain JACKSON MUSPRATT WILLIAMS, as Associates.

January 24, 1865.

JOHN FOWLER, Vice-President,
in the Chair.

No. 1,121.—"Account of the Docks and Warehouses at Marseilles."¹ By THOMAS HAWTHORN.

IN this Paper the Author proposes to give a sketch of the docks and the adjoining warehouses, the latter being remarkable on account of their completeness and extent in one mass, as well as their external appearance. He will include the particulars of some experiments he made in conjunction with M. Barret, the Engineer-in-chief, on the Hydraulic Machinery.

The port of Marseilles comprises five docks in actual use, and one in course of construction. (Plate 8, Fig. 1.) The old dock, or old port as it is generally termed, is said to have been constructed at or about the time of Louis XV. It was formed out of an inlet of the sea, and is 1,100 yards in length, with a mean breadth of 350 yards, and has often contained as many as eight hundred vessels of all sizes. Near the entrance the depth of water is from 21 feet to 22 feet; but as the drainage of a great part of the town is allowed to run into the dock, mud constantly accumulates at the upper end, which has to be removed by dredging. The same inconvenience is being experienced in the new docks, as all the drains do not discharge directly into the sea.

Adjoining the old port there is a small basin, for careening vessels,

¹ The discussion upon this Paper extended over portions of two evenings, but an abstract of the whole is given consecutively.

and capable of containing about a dozen at one time. Near the entrance there is also a floating dock, constructed about twenty-two years ago, and belonging to the Dock Company, the works of which will be hereafter described. There are likewise two graving-docks, formed out of a canal originally used as a means of communication between the old and the new ports; but when the new graving-docks are completed, it is intended to re-open the canal for navigation.

The dock of La Joliette, the first-constructed basin of the new port, was formed by making a breakwater parallel to the shore, at a distance of about 380 mètres. It is composed mostly of artificial blocks of stone and cement, similar to those used in the construction of the docks Arenc, Lazaret, and Napoléon. The Joliette is 500 mètres long, by 380 mètres wide, and is capable of affording accommodation for about two hundred large ships, such as the steam-vessels belonging to the Messageries Impériales. This dock was constructed by the State in 1847. The Napoléon dock is 380 mètres in length by 300 mètres in width, and has just been completed by the State. The Government are also engaged in the construction of the Dock Impériale, besides repairing basins, which will be completed to the level of the quays by the Ponts et Chaussées, and be then made over to the Dock Company, on terms which will be subsequently referred to.

That part of the port of Marseilles which belongs to the Dock Company comprises the docks Lazaret and Arenc, with the adjoining quays, land, warehouses, and moles (Plate 8, Fig. 2). On the 18th June, 1854, an Imperial decree made the following concessions to the town of Marseilles:—"The establishing and carrying out, for ninety-nine years, of bonded and free docks and warehouses on that allotment of land shown by Plate 8, Fig. 2, subject to the conditions given in a 'cahier des charges.'" Article 3 of the 'cahier des charges' states, that the works to be executed by the Concessionaires are the quays, piers, moles, &c., as well as the sheds, magazines, &c., shown in Plate 8, Fig. 2; that the magazines shall be separated, one from another, by courts, or yards, partially covered, and that these courts must be sufficiently large to contain a line of railway, an ordinary road, and space for carts and merchandize; that offices, lodges, &c., should be constructed according to the demands made by the Custom-house authorities; that the Customs' dock should be isolated by a wall 4 mètres in height; that there should be lines of railway, to connect the warehouses with each other, with the quays, and with the Paris, Lyons, and Mediterranean Railway; also that an adequate stock of machines, cranes, locomotives, wagons, &c., should be provided for the efficient carrying out of the work. Article 5 prohibits the use of wood in any of the warehouses, sheds, &c.

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Article 10 states that the first basin, or Dock du Lazaret, shall serve exclusively as a Customs' dock; that ships with inland goods must load and unload along the quays of the Dock d'Arenc, the quays of the breakwater, the north quay of La Joliette, or the south quay of the Napoléon Dock. Article 13 adds, that the warehouses of the bonded dock must be capable of containing at least 150,000 tons of merchandize, but limited at first to 75,000 tons, and until such time as the increasing commerce of Marseilles may demand further accommodation. The 'cahier des charges' contains thirty-nine articles, which, with the exception of those just quoted, refer mostly to the commercial administration of the docks. Article 1 enabled the town to re-grant these concessions, subject to the same 'cahier des charges,' and with the approbation of the Ministre du Commerce et des Travaux Publiques. Thus, on the 5th November, 1856, a convention was made between the mayor of Marseilles and Monsieur Talabot, representing the Dock Company, stipulating for the re-concession to the present Dock Company, on the payment annually to the town, for the first thirty years, of 50,000 francs, and during the remainder of the concession of 100,000 francs. The present capital of the company is 40,000,000 francs.

The basins Lazaret and Arenc, like the Joliette, were formed by constructing moles in the sea (the dotted lines in Plate 8, Fig. 1, show the original shore), and by forming a pier, or breakwater, parallel to the shore, for protecting the docks from the action of the sea. The earthwork for the moles of the Joliette and Lazaret, as well as all the space upon which the magazines, warehouses, &c., are built, outside the dotted lines, was taken, for the most part from a hill immediately to the east of the docks. This hill, of nearly 100 feet in height, may be said to have been literally thrown into the sea; the number of cubic mètres of 'déblais' thus employed amounting to nearly two millions, part being used for the docks and part for filling-in to the eastward of the docks. The mole Arenc was formed with 'déblais' from the Rue Impériale, a new street cut through the old town to the level of the new town, which involved the excavation of 1,200,000 cubic mètres, (1 cubic mètre = 35.2 cubic feet.) The total amount of 'remblais' in the present grant is 1,500,000 cubic mètres, the town having furnished 513,000 cubic mètres, according to agreement. Previous to the filling-in of the Lazaret, excavations to the depth of from 8 to 10 mètres were made in some places, to remove a mass of slimy earth, formed from the residue of old soap-works, which for many years had accumulated at that part. In several places this earth was so impregnated with a green-coloured residue, that during the excavations noxious gases were given off, producing illness among the labourers engaged.

In the construction of the breakwater forming the Joliette, Lazaret, Arenc, and Napoléon Docks (Plate 8, Fig. 3), an embankment, or hearting, was first formed, of blocks of natural stone (*pierre froide*), levelled at a height of 2 mètres (6' 7") above low water.¹ At this level the surface has a width of 7 mètres, the slopes being at an inclination of $1\frac{1}{3}$ base to 1 in height. At the depth of 8 mètres below low water, the embankment is enlarged to 7.34 mètres, horizontally towards the sea, in order to receive the larger blocks of concrete, placed on it promiscuously, to break the action of the sea against the pier. The artificial blocks have a width of 10 mètres, measured horizontally at the level of low water, and they attain a mean height above low water of 3.80 mètres. The inside of the pier is constructed with natural blocks, so as to form a quay 30 mètres wide, with a wall in front, the latter having its foundations 6 mètres below the water-line. The embankment is also prolonged, forming a slope towards the dock of 2 base to 1 in height. As the formation of the embankment progressed, it was from time to time solidified, by placing on it artificial blocks in tiers, one above the other, by means of a floating crane, or derrick. The blocks generally settled down in about three months. The blocks of natural hard calcareous stone, mostly taken in barges from the islands opposite to the port of Marseilles, were arranged in different classes as follows:—

Rubble stones from 20 lbs. to 250 lbs. each; first class, 250 lbs. to 1 ton 2 cwt. each; second ditto, 1 ton 2 cwt. to 3 tons 15 cwt. each; third ditto, 3 tons 15 cwt. and upwards. It having been ascertained, by experiment, that blocks weighing 20 tons each, and measuring 10 cubic mètres each, could not be moved by the most violent sea in the Mediterranean, artificial blocks of concrete were made, of an average weight of 23 tons. The dimensions of these blocks were 3.40 mètres long, by 2 mètres wide, and 1.50 mètre deep, presenting a solidity of 10 cubic mètres. The manner in which these several classes were arranged is shown in Plate 8, Fig. 3.

In the formation of the artificial blocks, the concrete consists of two parts of hard limestone, and one part of cement; the cement being composed of five parts of sand to one of lime. The broken stones and the cement are mixed in the above proportions in portable iron cylinders, made to rotate by means of a belt, connected at pleasure with a steam-engine. The engine is also used to drive stones for mixing the cement. After the concrete has been well worked, the mixture in the cylinders is emptied into wooden moulds, the interior dimensions of which correspond with

¹ The level of the Mediterranean varies at Marseilles about 18 inches, according to wind and other influences.

the size of the blocks; and the moulds can be taken to pieces, in order to detach them from the blocks. The moulds are also so constructed, as to leave a groove around each end of the block, to admit of a chain being easily passed round, for facilitating the lifting and placing of them. The contents of each cylinder are beaten down in the moulds by two men, and this operation ought in all cases to occupy half a day for each block. The moulds are then allowed to remain at least three days, when the cases are taken off, but the blocks are not considered to have attained sufficient solidity and hardness before the lapse of three months for those that are to be thrown promiscuously into the sea to act as a breakwater, and of six months for those forming the foundations for the piers and quays. The plant necessary for the manufacture of a mean of 300 blocks per month is as follows:—

One 10-horse engine; two lime wagons, containing 6 cwt, each; four sand ditto, 2' 6" cube; four cement ditto; three cement mills; twelve stone wagons; four wrought-iron cylindrical concrete wagons; one hundred wooden moulds; besides iron rails and sleepers necessary for the transit of the wagons between the mills and the moulds. The blocks attain, in course of time, a hardness almost equal to that of stone. Those first put down, about sixteen years ago, are very little worn by the action of the waves. The cost of these blocks is 12*s.* 8*d.* per cubic metre, or including the setting and other incidental expenses, 15*s.* 10*d.* per cubic metre. The entire cost of the breakwater is from £290 to £310 per lineal metre.

In the construction of the quay walls of the docks Lazaret, Arenc, and Napoléon, the system of building on artificial blocks, somewhat similar to the inside of the pier, is adopted (Plate 8, Fig. 4). At 6 mètres below the low water level, an embankment is formed of second and third-class stones, having a base of from 8 mètres to 9 mètres, and an inclination at the sides of 1 to 2. Upon this embankment, and up to the water level, four rows of artificial blocks are placed longitudinally, side by side, making a total height of 6 mètres, each block being 1·50 metre high, with a base on the top of 3·40 mètres wide. Two rows of blocks are usually placed on these, to settle the embankment underneath, and are allowed to remain for about six months, when these blocks are removed, a masonry wall being built up in their place to the level of the quay. At the back of this wall there are other artificial blocks, from the upper side of which a further embankment of stones is formed, having an inclination of 1 to 2. The inner space is ballasted up to the level of the quays. The height of the level of the quays in the Arenc and Napoléon Docks is 2·40 mètres above the level of the water, whereas in the Lazaret Dock the height is 3·40 mètres. The

latter is so raised to serve as a platform, for the loading and unloading of railway wagons and carts. In several places the embankment beneath the artificial blocks has moved, generally slipping forward, and causing the artificial blocks, as well as the quay walls resting on them, to incline over into the dock. This has arisen, in most cases, from an insufficient time having been allowed for settling, and is generally to be observed in the quays on the moles, where in some places it has caused the walls to split. The only remedy appears to be, to allow the settling to go on as long as possible, and then to rebuild the wall, from the edge of the water, or the top of the blocks.

Plate 8, Fig. 4, shows the permanent quay fenders, and the manner of fixing them to the walls, as well as the mooring rings, the exposed parts of which are galvanized. The inner holdfasts are secured by a long bar of iron, running parallel to the quays, and let into the masonry. On account of the instability of the quay walls, as well as from the nature of the earthwork behind them, the hydraulic quay cranes have no foundations let into the masonry and earthwork as in England, but rest simply on platforms of heavy timbers. These platforms have sufficient base to insure stability during the sluing of the jibs; but as it has been found impossible to extend these platforms towards the dock, the hinder part of the crane-house is counter-weighted, with pigs of cast-iron, 3-tons being used for 3-ton cranes, and 1 ton for 1-ton cranes. This method answers very well, as the quay cranes may be levelled at any time with little trouble, by means of screw-jacks, should the quays beneath them move. It is important that the crane-houses should retain a perfectly perpendicular position, otherwise during the sluing of the jib the weight suspended does not move in a horizontal plane.

Towards the end of the Mole du Lazaret, the slipping of the quays has caused one or two party walls, as well as a gable end of a quay shed, to split. These walls will soon have to be taken down and rebuilt. The entire length of the quays, at present constructed, belonging to the Dock Company, is 2,840 mètres. The cost per lineal mètre of the quays above the embankment, that is, of the quay walls with the artificial blocks supporting them, is £24.

The space surrounding the Dock du Lazaret (Plate 8, Fig. 2) is reserved for the storing and movement of bonded goods, one entrance only being permitted, and that guarded by Custom-house officers. The warehouses within these limits are at present of one story only. The amount of covered space, including the floors, is 67,132 square mètres. These warehouses are constructed of rubble masonry, with dressed piers and quoins, and wrought-iron roofing, with vaulting in brickwork, similar to that which will be described

in the case of the large warehouses. Sheds, of 14 metres and of 10 metres in width, extend completely round the dock. These sheds are covered with a simple wrought-iron roofing of double T iron. Iron beams of an A section are placed transversely on the girders, for supporting the tiles. This section of iron is a French patent, and makes a light and strong roofing. This shed roofing is supported on hollow cast-iron columns, of square section. The double T girders of the roofing are allowed to slide on the top of the columns, to admit of expansion and contraction. The inner sides of the sheds are supported by stone walls, where those of the warehouses do not serve for that purpose. The front, towards the quays, is closed by sliding, or rolling doors, of corrugated zinc.

The flooring for all the warehouses and sheds consists of a layer of asphalt, half an inch in thickness, costing 2 francs per square mètre; but including the levelling of the ground, and the bed of cement below, the cost is about 6 francs per square mètre.

Parallel to the quays, and to the warehouses where necessary, tunnels, for the conveyance of the hydraulic and other pipes, are constructed at a level of 3 feet below the surface to the top of the tunnel, the latter having sufficient height for the passage of workmen in case of leakage, &c. In English docks, on the contrary, the hydraulic pipes are, for the most part, simply imbedded a short distance into the ground. These works have cost about £4 per mètre, and in all nearly £12,000.

There are also similar sheds and buildings on the quay to the south of the Dock d'Arenc, but the warehouses are not yet quite completed. These will have two vaulted floors, supported on cast-iron columns, and wrought-iron double T girders. The eastern quay, or that towards the land, is entirely occupied by goods' wagons from the railway; a line of rails passing underneath the quay cranes, where the wagons are discharged directly into the ships, and *vice versa*. This system is about to be adopted on the Mole d'Arenc, with the exception that galleries will extend from the quay cranes to the warehouses at the level of the first floor of the buildings, so that these cranes may load either directly from the warehouses, or from the railway. The dotted lines show the position of the warehouses now being commenced.

The bonded warehouses, or 'Entrepôt Commercial,' form one block, to which are adjoined the company's offices, the latter facing to the south, while the warehouses face the west, or the Dock du Lazaret, being separated from the enclosure of this dock by two lines of railway, and the public thoroughfare which runs parallel to it. Behind, to the east side, are lines of railway for sidings from the Paris, Lyons, and Mediterranean Railway, a junction with this railway having been made by means of an incline and

tunnel under the town. The boundary line, however, of the docks is the edge of the platform of the warehouse, the lines of rail to the east belonging to the Railway Company.

The total length of these warehouses is 365 mètres (1,200 feet), with a breadth of 37·50 mètres, and a height of 35·70 mètres. The offices are of the same breadth, with a length of 37·60 mètres. (Plate 8, Fig. 2.) The warehouses¹ are in four equal divisions, exactly resembling each other. Each division contains an interior court with two doorways (Plate 9, Figs. 1 to 5), one for the entrance and the other for the departure of carts. These divisions, being four in number, are termed quarters, and are distinguished as the 1st, the 2nd, the 3rd, or the 4th quarter. Two of these quarters are now used for bonded goods, while the other two are employed for merchandise of all other descriptions. The level of the first floor is 1 mètre above the paving of the courts—that is, of the general level of the dock property, which is 2·40 mètres above the level of the sea. These warehouses have six stories above the ground floor, and vaults below, the whole being constructed in stone and iron, according to a contract which stipulates that no inflammable material shall be used in any of the buildings on the Dock property. The foundations of this building rest entirely on a bed of rock, in some places as much as 6 mètres below the level of the sea. These excavations were made at an enormous cost, as at this part, above the rock, the earth was infected with a residue from the soap factories before alluded to. The whole is constructed in irregular cut stone, or a better class of rubble masonry, with the exception of the piers, arches, quoins, ornamental work, &c., which is in cut and dressed hard limestone of good quality, and the windows, which are in dressed stone, but of a much softer quality of limestone, of a yellowish colour, and a spongy appearance, though becoming hard on exposure to the atmosphere. This stone was obtained from Miramas, in the neighbourhood of Marseilles, and was easily worked, being simply scappled. The hard stone was dressed with a sort of pick, the mason's mallet being almost unknown in Marseilles. The different kinds of masonry and brickwork used in these constructions were procured, worked, and built into place at the following prices, including transit and other expenses:—

Hard limestone, £4 per cubic mètre; less hard quality (Calissane), £3. 4s. ditto; soft calcareous stone (Miramas), £2. 2s. ditto; rubble masonry, 12s. 6d. ditto; brickwork (solid or hollow bricks), £2. 8s. ditto. The thickness of the walls is

¹ This block of buildings is termed 'Entrepôt Commercial,' or commercial warehouses; while the lesser, of one and two floors, for the sake of distinction, are termed 'Magazins.'

1·25 mètre at the foundations, 1·08 mètre at the ground floor, diminishing gradually at each story, the thickness at the sixth story being 0·58 mètre. The ground floor is supported by massive stone pillars and vaulting, the other floors resting on cast-iron columns. A gangway is left at each side of the court, forming a platform for the loading and unloading of carts. Two trapdoors in this platform communicate with the cellars below, goods being taken out and in by means of hydraulic traversing cranes. The communication for goods with the different floors is made by the usual system of hydraulic hoists, as in England, each quarter having two such apparatus, lifting $1\frac{1}{2}$ ton each. There are also, in each quarter, two sets of lowering apparatus, the cradle going up empty, by means of a counterweight, while the extra charge brings it down again. It is completely under the control of the warehousemen, by means of a break, and may work from any floor to the ground, or between any two floors. At the entrance of each quarter, suitable apartments are provided for watchmen and porters; also rooms for the examination of specimens of goods, this being often necessitated by the Custom-house officers, who will not at all times open the magazines.

All these warehouses were constructed without the aid of scaffolding. The stonework, cement, and other materials were raised by means of three travelling cranes,—two on one side of the building, and one on the other,—running on rails parallel to the building on each side. These cranes consisted simply of a long jib, suspended a little below its centre. As soon as the load was raised sufficiently high, the top end of the jib was allowed to incline over towards the building, by means of a rope connecting the lower end of the jib with a roller worked by an engine; sufficient angularity being given to the jib, the load was lowered by means of a break on to the building. The jib then resumed a nearly perpendicular position; the empty bucket, or cradle, descending again to the ground to be recharged. The total length of the jib was 28 mètres; and the extreme load lifted was $2\frac{1}{2}$ tons. This mode of construction was found to be simple and economical, each crane lifting 50 tons of material per day. All the iron work, such as the columns, girders, and roofing, was raised in the spaces in the floors left for the hoists, by means of small portable engines; the winch, boiler, and engine being all on a small frame carried upon four wheels.

The cost of the masonry of these warehouses was 3,000,000 francs (£120,000), exclusive of the foundations, the latter having cost 203,000 francs. The number of cubic mètres of masonry, independent of the foundations, was 14,136. All the doors and the window frames are of wrought iron, there being two hundred and fifty-one of the former in these warehouses, and twelve

hundred and eighty of the latter. The wrought iron for the doors weighed in all 1,600 tons, for which £30 per ton was paid, making a total for the doors of £4,800. The floors for each story are of wrought-iron double T girders of 0·500 mètre deep, resting on hollow cast-iron columns, varying in section at each story according to the load. The columns are at a distance of 4·750 mètres apart from each other throughout the whole building. Plate 9, Figs. 6, 7, and 8, gives the details of these columns and girders and their tie-rods, as well as the manner of securing the tie-rods in the walls. The junction of the two columns with the wrought-iron girders is so made as to allow for the expansion of the girders. One column simply rests on the top of the other, the two ends being turned in a lathe; while the girders rest on the lower flange of the upper column, being tied together by bolts passing through the column. The girders supporting the vaulting are tied together transversely, by wrought-iron tie-rods, at intervals of 1 mètre from each other. These tie-rods can be adjusted by a screw at one end, the other end working in a socket. The columns were all cast vertically. They are 4 mètres in height, and were tested to support a vertical load equal to 8 kilos per square millimètre of section. The wrought-iron girders were subjected to a tensional force equal to 12 kilos per square millimètre of section. An alteration of elasticity after this test was considered sufficient for the refusal of the piece.

The cost of these girders, of wrought iron, 0·500 mètre deep, weighing 145 kilos per mètre, and delivered at the docks, was £22 per ton. This apparently high price was occasioned by the extra size of iron of the I section, so large a girder not having been previously rolled. The length of each girder is 4·530 mètres. The following Table gives the weight and the cost of the wrought and cast iron used in the floors and columns.

	Number of Columns.	Weight in Tons.	Total Weight of Cast Iron.	Tons of Wrought Iron.	Cost in Francs.
Ground floor . . .	..	..	914	489	530,660
1st floor . . .	304	494			
2nd floor . . .	304	308	382	496	374,848
3rd floor . . .	304	268	349	498	365,842
4th floor . . .	304	234	550	498	366,719
5th floor . . .	304	312	428	506	394,137
6th floor . . .	..	..	112	499	294,386
					2,326,592

The contract price for the columns and pedestals, delivered at the docks, was 300 francs per ton; for wrought-iron girders,

0.50 mètre deep, 550 francs per ton; for other pieces of wrought iron, such as tie-rods, &c., 500 francs per ton; and for ordinary castings, 270 francs per ton. The vaulting between the girders is built of hollow bricks, 6 inches deep, costing 10 francs per square mètre complete. The space between the asphalte of the flooring and the vaulting is filled with cement. This is made perfectly level on the surface previous to the application of the layer of asphalte, which, as before stated, is half an inch in thickness, and costs 2 francs per square mètre.

The floors are constructed to carry 2 tons per square mètre throughout the whole building; but from the care taken in the selection of the materials and in the construction, they would probably carry much more with safety. The whole of this iron is the produce of French manufactories, and the work is excellent, the castings being sound, and the heavy girders carefully rolled.

The wrought-iron roofing of the warehouses, shown in detail in Plate 9, Fig. 9, is of the style generally adopted by the Dock Company for all its constructions, with the exception of the quay sheds, which are formed entirely of double T irons. Previous to the erection of these buildings, it was determined, by experiment, that a welded piece, or rod of wrought iron, in no case resisted more than 85 per cent. of the tensional strain that would be borne by a non-welded piece of the same section. It was therefore determined to have as few welds as possible throughout the dock buildings, and in the roofing, where lightness was necessary, to have none at all. Hence, all the tie-rods, &c., have simply been bent round the bolts, instead of eyes being formed. The girder (Plate 9, Fig. 9) is composed of two angle-irons at the top, and two at the bottom of the section, separated by strips of flat iron, forming a sort of lattice web, the struts being of wrought iron. The end of each girder rests on a cast-iron shoe bedded on the wall, and is simply held transversely, allowing free play in the direction of its length for expansion. The girders are 4 mètres apart from centre to centre, and are separated at the crown by girders of similar construction. The tiles are supported by galvanized irons, termed 'Fer Zorés,' running from girder to girder, at intervals of 323 millimètres. This section of iron permits of great lightness in proportion to its strength. It was some time before efficiency was arrived at in the rolling, but, by the apex being left a little thick, the manufacture was much facilitated.

The depth of the **A** section, in the case of this roof, is 8 centimètres; but these irons are now often made much larger, and are used in some cases as floor rafters. The following is a list of some of them, with the weight per mètre, and the prices in each case, galvanized and delivered at the docks. :—

		Weight per Mètre. Kilogrammes.	Cost per Cwt.		
			£.	s.	d.
A	20 centimètres high . . .	38	2	16	8
	15 " " . . .	20	2	13	4
	10 " " . . .	10	2	10	0
	8 " " . . .	6	2	8	4

They may be in lengths of from 7 mètres to 8 mètres if required. The extreme load this roofing ought to bear is 4 cwt. per square mètre. The shoe on the wall, upon which each girder rests, is secured by a single bolt for each piece. The bolt is held by another bolt or rod running transversely to it. This roofing is exceedingly pretty and light. The Author thinks there is no similar construction equal to it in England, where expense at the outset is more considered than by public companies in France. The vaulting between the girders renders this roofing perfectly water-tight, so that even goods liable to be damaged by damp may be stored in the sixth story. At present this floor is much used for grain. The vaulting is formed of hollow bricks, similar to those used for the floors, but much lighter. The corners are filled with hollow cylindrical tiles and cement, a concave space being left between the girders on the top for letting off any water that may pass between the tiles. The cost of this vaulting, including all expenses, is 6s. 8d. per square mètre. In the roofing of these warehouses there are 340 tons of cast and wrought iron, at a mean cost of £24 per ton, making a total of £8,160.

The hydraulic pressure and outlet pipes are conveyed along the outside of the building, under the railway platform, in a tunnel permitting of access in case of repairs being necessary. In the building itself, the pipes are contained in cast-iron troughs, bedded in the floors, and covered with cast-iron plates. Water pipes also from the town, with a pressure equal to 4 atmospheres, to be used in case of fire, are carried to every floor in each quarter of the building. Moreover, a tank is provided on the roof of each quarter, containing 40 tons, in the event of the town supply being cut off.

The whole of the door locks are Fichet's, and are similar to Stubb's. They are double, two keys being necessary to open them. In the bonded warehouses, one key is held by the Dock Company, while the other is in the hands of the Custom-house officers.

It is believed that these warehouses cannot be surpassed in point of construction. The general arrangements have been carefully studied, from examples in England, and then adapted to the commerce of Marseilles.

It is intended to cover over the courts of these warehouses with wrought iron and glass, as a protection from the rain. This

building has cost in all, comprising machinery, hydraulic pipes, &c., 12,500,000 francs (£500,000).

GRAVING DOCKS.

Previous to the Crimean war, the only facilities at Marseilles, for examining and repairing the hulls of ships, consisted of a floating wooden pontoon dock, and a small stone basin adjoining the old port, for careening on the usual system. About the year 1854, the 'Messageries Impériales' having bought several large steamers in England, the necessity for immediate dock accommodation was felt. It was then decided to convert the existing canal, which formed a communication between the old and the new ports, into two dry basins, by constructing a partition wall at the centre, and by placing a caisson gate at each extremity, the water being pumped out by steam power. This work was executed by M. Pascal of the Ponts et Chaussées, in 1856, and on its completion was conceded to the Dock Company. The south basin is 115 mètres in length, by 16 mètres wide, and 8 mètres deep. The north basin is 98 mètres long, by 16 mètres wide, and 8 mètres deep. Both are of rectangular section, the depth of water in each being 6·40 mètres, or capable of admitting a ship drawing 20 feet of water. The former basin contains 10,986 cubic mètres (1 cubic mètre of water = 1,000 kilos. = 1 ton.) The division wall between the ends of the basins is 4 mètres wide. The cost of the construction of these two docks, with their appurtenances, was—

	£.
Excavations, masonry, and cement work for the South Dock .	4,560
Ditto ditto ditto North Dock .	4,160
Partition wall	520
Engine-house	1,040
Sheds, office, &c.	120
Necessary keel-blocks, struts, and fenders	3,200
Two caissons for the lock-gates, with framing in oak	11,600
Two steam pumping-engines complete	6,000
	<hr/>
	£31,200

One of the pumping-engines is of 90 H.P., and works three of Gwynne's centrifugal pumps, for emptying the basins, and the other is of 16 H.P., for keeping the docks dry, against leakage from the gates.

The 90-horse engine is vertical, with one cylinder 0·70 mètre diameter, and a stroke of 0·60 mètre, acting directly on to a shaft carrying three large sheaves of 4·20 mètres diameter each. The mean number of revolutions per minute made by this engine is 90, while that of the pumps is 500. This engine is supplied with steam by three plain cylindrical boilers, at a pressure of 50 lbs. per

square inch. The south dock is emptied on an average in $4\frac{1}{4}$ hours, and the north dock in $3\frac{1}{4}$ hours; that is, 61 cubic mètres, or tons, are lifted a mean height of 4.50 mètres per minute. These pumps work remarkably well, but unfortunately the consumption of fuel per horse power of the water lifted is considerable—about 25 lbs. per hour, arising partly from the friction caused by the immense speed at which it is necessary to drive the pumps. The discs have a diameter of 580 millimètres, with a discharge and suction pipe of 380 millimètres diameter. The original pumps, from England, had brass discs; but it was found, owing to the galvanic action produced by the salt water, when brass and iron were combined, that they soon became loose; hence cast iron is now adopted.

The iron caissons, or gates (Pl. 9, Figs. 10 to 13), are constructed according to the old system usual in England, or nearly so. They are floated in and out of their places, by the filling and emptying of a tank on the top of each gate. The material used in the construction of each gate, with the framework let into the masonry, is 95 tons of wrought iron and 4.5 tons of oak. 18 tons of ballast are placed in each caisson. The average number of ships docked annually in these two docks, the south basin generally taking two at a time, is one hundred and sixty.

The floating dry dock, built eighteen years ago, is constructed entirely of wood. This dock is simply a box, 64 mètres in length, by 19 mètres in breadth, and 7 mètres in depth. The principal parts, such as the angles, ribs, longitudinal beams, sluices, and doors are of oak, the remainder being of Riga fir. The sections of the sides are triangular, 100 tons of stone ballast being placed within these spaces, for the purpose of sinking the dock when required. The draught of the dock, when empty, is 0.800 mètré, or equal to 966 tons. The dock is emptied by an engine of 10 H.P., having a single tubular boiler supplying steam at a pressure of 40 lbs. per square inch; the engine works four single-acting pumps, known in France as Le Testu's system, consisting simply of a conical piston with leather valve on the whole surface. These pumps empty the dock in $4\frac{1}{2}$ hours. This dock cost for construction, with engines, &c., complete, 355,000 francs; at present its value is estimated at 125,000 francs, the wood having been eighteen years in the water; yet no appearance of rot can be detected, nor has the worm affected it; in fact, the latter cannot exist here on account of the residue from the soap factories. The trenails of acacia are not now to be depended upon, and the iron bolts, which have been unfortunately used instead of brass, are in some places eaten away to half their original section. The bolts number about 20,000.

One angle of the dock has, in course of time, sunk about 18 inches below its original level. This arose from faulty construc-

tion, additional strength not having been given to the dock where the engine is placed. Thus, notwithstanding that extra timbers were previously added, the water at times comes up as far as the foundation plate of the engine, especially if the ship in the dock be at all large. Ships with uneven keels are carefully excluded, on account of the danger of causing too great a strain on this old structure, should the keel blocks not have been accurately adjusted to the keel. It is, however, absolutely necessary to keep this dock in working order, until such time as further graving-docks are completed, the present accommodation not being sufficient. As soon as other docks are completed, the use of this wooden graving-dock will probably be abandoned, and the canal between the old and the new ports will also be reopened, as this communication is much demanded by the commerce of Marseilles.

The new graving-docks (Plate 8, Fig. 1) now being commenced at the northern extremity of the docks, leading out of the Dock Impériale, will comprise two dry basins, one of 130 mètres in length, and the other of 110 mètres in length, to be emptied by steam power. In addition to these two basins, there will be an hydraulic lift on Mr. Edwin Clark's system, capable of lifting a ship of 4,000 tons. A suitable shallow basin will also be made to contain the pontoons, upon which the ships will remain during repairs, painting, &c. These works will be constructed to the level of the quays by the Ponts et Chaussées, and will then be leased to the Dock Company for a period of ninety-nine years. The company will complete all the machinery, workshops, &c., belonging to this system of graving-docks, at a cost of about four million francs, and will carry out the working of the whole. The estimate for the works up to the level of the quays is nine million francs, of which three millions are to be paid by the Company.

The hydraulic machinery is precisely similar in character to that which Sir William Armstrong has so largely applied for docks in England. Only those particulars, therefore, will be given which are peculiar to these docks, viz., the extent of the machinery, the prices paid to the Société des Forges et Chantiers for its construction, and, lastly, the results of a series of experiments made with a view of ascertaining the useful mechanical effect of these machines, as compared with direct steam power, together with some particulars noticed during the working of this machinery.

The present stock of hydraulic machines in actual use comprises one 120 H.P. steam engine, with two accumulators; eight $1\frac{1}{2}$ -ton hoists for the large warehouses; two $1\frac{1}{4}$ -ton hoists for magazines; eight cellar cranes for the large warehouses; eleven quay cranes, having a maximum lift of 3 tons; twelve ditto of 1 ton; three warehouse cranes with a lift of $1\frac{1}{4}$ ton; three rotary three-cylinder

hydraulic engines, of 8, 10, and 16 H.P. respectively, working mills for crushing sugar.

The machines now in construction, or about to be ordered, are, one 120 H.P. steam engine, with three boilers; two accumulators; seven 1-ton quay cranes; eleven 3-ton ditto; eight lowering machines; forty-five hoists of different descriptions.

The following are the prices paid to the Société des Forges et Chantiers for the machinery now completed and in actual use. The contract was sealed in November, 1860, and it stipulates for the strict adherence to the designs furnished by Sir W. Armstrong, for the guarantee of these machines for six months after completion, and for the payment of all patent rights. For metal of all sorts, finished and fitted in place—for all engines, and hydraulic machines, such as hoists, quay cranes, cellar cranes, &c., £56 per ton; for the accumulators complete, £40 per ton; for the boilers, and all pertaining to them, £32 per ton; for all chains and iron work, independent of the actual working machinery, such as foot-plates, &c., £28 per ton; for all pieces of cast iron, independent of machinery, when the number of these pieces does not exceed five, and for the hydraulic pipes fitted in place, &c., £18 per ton, but, when the number of pieces exceeds five, £14 per ton; and for rough pipes to keep in stock, £12 per ton. For oak the price is £11, for pine £9, and for fir £7 per cubic mètre in each case.

The specifications are, of course, much more detailed, but the above will suffice to give a general idea of the cost. The Engineers of the Dock Company have the right of inspecting the machinery in course of construction, and of rejecting any piece from defect in material, or nonconformity with the drawings, from the commencement of the works until the end of the guarantee.

The general arrangements of the hydraulic engines, with their boilers and accumulators, are shown in Plate 9, Figs. 14 and 15. The second engine is now in course of construction by the Société des Forges et Chantiers, the whole being contracted for at a cost of 143,000 francs, subject to the same conditions as the former. This price is somewhat lower than the first engine, as the drawings, models, &c., of the former will serve for the second machine.

EXPERIMENTS ON THE HYDRAULIC MACHINERY OF THE DOCKS.

The object of these experiments was, first, to find the volume of water actually given out by the hydraulic pumps, as compared with the interior volume of these pumps, or their working capacity, at different speeds of engine; and, secondly, the useful mechanical effect of the hydraulic apparatus, as compared with the engine and accumulator.

The effective quantity of water given out by the force pumps

was determined by comparing it with the working capacity of the pumps, or that liable to be filled at each stroke. Twenty revolutions of the engine, or eighty simple strokes of the pumps, served as a basis for the calculations. All communication, excepting with the accumulator, being cut off, the rise of the accumulator during these twenty revolutions of the engine revealed the exact quantity of water given by the pumps. A plank of wood being fixed to the accumulator guides, the rise was exactly determined by a man, riding on the crosshead of the ram, pressing a pencil on the plank as soon as the twenty revolutions were commenced, and withdrawing it upon their termination, leaving a line exactly corresponding to the ascent, which distance, multiplied by the section of the ram, indicated exactly the volume of water given by the pumps. Twelve consecutive observations were made, increasing gradually the speed of the engine at each observation, and noting the exact time occupied by the twenty revolutions. The pressure on the accumulator was taken by a Bourdon's pressure-gauge, as well as calculated by the weight on the ram. The pressure indicated depended upon whether the ram was ascending or descending; thus, in rising, it indicated $52\frac{1}{2}$ atmospheres, and in descending, $51\frac{1}{2}$ atmospheres. The difference, 1 atmosphere, is equal to double the friction, hence the friction = 757 kilogrammes. The total weight on the ram at 52 atmospheres = 78,750 kilogrammes, which divided by 757 = friction, or .97 per cent.

The principal dimensions of the engine, force pumps, and accumulators, are—Engine: number of steam cylinders, 2; diameter of steam cylinders, 540 millimètres; stroke of pistons, 960 millimètres. Accumulators: diameter of ram, 432 millimètres; total pressure on ram, 78,750 kilogrammes. Force pumps: number of pumps, 2; diameter of pistons, 140 millimètres; diameter of rams, 98.5 millimètres; stroke, 960 millimètres; surface of pistons, 15,393 square millimètres; section of rams, 7,542 square millimètres; annular surface, being the difference of the two latter, 7,851 square millimètres; mean working capacity given by simple stroke of pump,¹ 7.389 cubic decimètres; working capacity evolved by 1 revolution of engine, 29.55 cubic decimètres; working capacity evolved by twenty revolutions of engine, or eighty simple strokes of pump, 591.13 litres (1 litre = 1 cubic decimètre).

The pumps are differential and double acting; that is, the volume of water given by the forward stroke corresponds to that given by the surface of the piston, minus the section of the ram, while that of the return stroke corresponds to the section of the ram only.

¹ By working capacity is meant, the exact vacuum space left by the piston on each side of it.—T. H.

The following Table contains the results of twelve experiments:—

TABLE No. I.
WORK DONE BY FORCE PUMPS.
Comparison of Work given out by Engine, Pumps, and Accumulators.

ACCUMULATORS.					FORCE PUMPS.				ENGINE (STEAM).				
Lift or Stroke of Accumulator during 20 Revolutions of Engine, in Metres.	Duration of 20 Revolutions, in Seconds.	Volume of Water in cubic Decimetres or Litres forced into Accumulator during 20 Revolutions of Engine.	Volume of Water in Litres forced into Accumulator per Second.	Corresponding Force in Kilogrammetres.	Number of Horse Power, counting 75 Kilogrammetres per Horse Power.	Working Capacity in Pumps in 20 Revolutions of Engine.	Difference between Working Capacity evolved by Pumps and corresponding Volume of Water forced into Accumulator, in Litres.	Loss of Pumps per Cent, as compared with Working Capacity of Pumps.	Number of Revolutions per Minute.	Speed of Pistons per Second, in Metres.	Mean Pressure in Kilos, per square Centimetre on Pistons.	Indicated Horse Power in Steam Cylinders.	Comparison of Water accumulated, with Indicated Horse Power per Cent.
3-778	190	553-85	2-915	1,581	21	591-13	37-28	6-31	6-3	0-202	2-131	261	80
3-815	109	559-28	5-131	2,782	37	..	31-85	5-38	11	0-352	2-172	461	79
3-810	90	558-55	6-206	3,366	44-8	..	32-58	5-51	13-3	0-426	2-250	581	76-5
3-780	90	554-15	6-157	3,339	44-5	..	36-98	6-25	13-3	0-426	2-250	581	76
3-280	85	560-01	6-558	3,573	47-6	..	31-12	5-26	14-1	0-451	2-280	63	75-5
3-815	85	559-28	6-579	5,568	47-5	..	31-85	5-38	14-1	0-451	2-280	63	75-4
3-800	70	557-08	7-958	4,316	57-5	..	34-05	5-76	17-2	0-550	2-302	771	74-2
3-847	66	563-97	8-545	4,634	61-7	..	27-16	4-59	18-2	0-582	2-325	881	73-9
3-870	60	567-34	9-455	5,127	68-3	..	23-79	4-02	20	0-640	2-357	92	74-2
3-875	48	568-07	11-834	6,418	85-5	..	23-06	3-90	25	0-800	2-380	1161	73-4
3-820	42	560-01	13-333	7,230	96-4	..	31-12	5-26	28-5	0-912	2-393	133	72-4
3-885	37	569-54	15-393	8,340	111-3	..	21-59	3-65	32-5	1-040	2-446	156	71-3

NOTE.—1 kilogramme = 1 kilogramme raised 1 metre in 1 second. 75 kilogrammetres = 33,000 foot-pounds = 1 horse power.

HYDRAULIC HOISTS.

The effective, or useful, power of these machines was found by comparing the mechanical effect of the load lifted to the volume of water used, the value of which is known by the pressure indicated at the accumulator. Two experiments were made; the first with five hoists working simultaneously, each laden with 1,500 kilogrammes ($1\frac{1}{2}$ ton) during $1\frac{1}{2}$ hour; the second with one hoist, varying the load on the cradle at each lift. In the first experiment, the number and height of the lifts made by the five hoists in $1\frac{1}{2}$ hour, with $1\frac{1}{2}$ ton on each cradle, were noted. This work was compared with the volume of water used, this volume being 90·03 per cent. of the working capacity of the pumps, calculated from the number of strokes of the engine during the $1\frac{1}{2}$ hour.¹ To calculate the indicated horse-power of the engine, diagrams of each cylinder were taken every $\frac{1}{4}$ hour. The speed of the engine was so regulated as to maintain, as nearly as possible, the accumulator at $\frac{1}{2}$ stroke, so that the volume of water used was equal to that given by the pumps. The quantity of coal consumed cannot be considered as a result, the fires being pushed, to keep the steam pressure up to $4\frac{1}{2}$ atmospheres, including the external atmosphere.

PRINCIPAL DIMENSIONS of the HOISTS.

Diameter of ram	254 millimètres.
Section of ram	506·7 square centimètres.
Extreme length of stroke	3·094 mètres.
Purchase (reversed)	8 to 1.
Extreme lift of cradle	24·750 mètres.
Load	1,500 kilos. = $1\frac{1}{2}$ ton.

EXPERIMENT No. 1.

Three boilers under steam, the pressure being maintained at 4·5 atmospheres (French measurement).

Engines cutting off steam at $\frac{1}{2}$ stroke.

French coal (Rocher bleu) consumed in $1\frac{1}{2}$ hour = 760 kilos.

Number of Lifts made during Experiment by each Hoist.	Height of each Lift in Mètres.	Total Height of Lift in Mètres.	Remarks.
91	21·850	1988·3	{ Obligated to work slowly as sheaves heated.
92	21·780	2003·8	
87	21·780	1849·9	
67	21·775	1458·9	
92	21·775	2001·5	

¹ This is less per centage than was given in the first experiments with the force-pumps, and arises probably from a little variation in the height of the accumulator.—T. H.

CONTINUATION OF EXPERIMENT.

Engine. Steam Cylinders.

Number of revolutions in $1\frac{1}{2}$ hour	2,225
Number of revolutions per minute	24.772
Speed of pistons per second	0.7911 mètre.
Mean pressure on pistons per square centimètre	2.42 kilos.
Power indicated in two cylinders in kilogrammètres	8,767
Indicated horse power	116
Total consumption of coal per hour	507 kilos.
Total consumption of coal per indicated horse-power per hour	4.37 kilos.

Pumps.

Working capacity of pumps per revolution of engine	29.56 litres.
" " in 2,225 revolutions	65,771 litres.
" " per second	12.178 litres.
Working capacity given by five rams of hoists per second	10.96 litres.
Loss of pumps	10 per cent.

Hoists.

Total number of lifts made by five hoists	429
Total height of lifts in $1\frac{1}{2}$ hour	9347.4 mètres.
Corresponding speed of cradle per second	1.731 mètre.
Load on cradle	1,500 kilos.
Mechanical effect resulting from load lifted in kilogrammètres ($1,500 \times 1.731$ m.) =	2596.5
Horse-power of 75 kilogrammètres	34.62
Coal burnt per horse-power per hour	14.64
Speed of rams per second (the mean of five hoists taken as single result)	0.216 mètre.
Volume of water used per second in each hoist	10.96 litres.
Mechanical force in kilogrammètres of water used (pressure 52 atmospheres)	5885.5
Horse-power in water used	78.47
Coal consumed per horse-power of water used	6.46 kilos.

RECAPITULATION.—COMPARISONS OF INDICATED HORSE POWER OF ENGINE, WITH WATER USED, AND LOAD LIFTED BY HOISTS.

	Horse Power.	Power of Engines being 100.	Force contained in Water being 100.	Consumption of Fuel per Horse Power.
Engine	116	..	..	Kilos. 4.37
Water used	78.47	67.64	100	6.40
Load lifted by hoists.	34.62	20.8	44.05	14.64

EXPERIMENT No. 2.

This consisted in varying the load on the cradle of one hoist from 0 until the load was in equilibrium with the power of the machine. Bags of sand were carefully weighed, containing each 50 kilos. (1 cwt.), and the load was increased at each lift by 100 kilos. (2 cwt.). In Table No. 2 the results at every 500 kilos. only are given, this being sufficient to compare the work at different loads.

TABLE No. 2.

RESULTS of EXPERIMENTS made with one HYDRAULIC Hoist, commencing with the Cradle Empty, and then increasing the Load gradually until in Equilibrium.

Lift of cradle during experiments 24.56 mètres. Quantity of water used at each lift 155.56 litres.
 Stroke of ram " 3.07 " Pressure of water used in accumulator 52 atmospheres.

Load lifted on Cradle in Kilos.	Mechanical Effect of Load lifted 24.56 m. in Kilogram-mètres.	Pressure on Ram arising from Load on Cradle, the Machine being at rest, in Kilos. per square Centimètre.	Mean Pressure of Water in Cylinder, measured from Diagrams taken at each Lift, in Kilos. per square Centimètre.	Mean Total Pressure on Ram in Kilogram-mètres.	Mechanical Work given out by Water in Cylinder during each Lift, in Kilogram-mètres. ¹	Mechanical Force contained in Water used to lift Load = 155.56 litres at 52 Atmospheres, in Kilogram-mètres.	Friction caused by Ram, Sheaves, Chains, Guides, Counterweights, &c., in Kilogram-mètres.	COMPARISONS.		
								Mechanical Work of Power contained in Water used at 52 Atmospheres being 1.	Mechanical Work done by Water in Cylinder, The Power contained in Water at 52 Atmospheres being 1.	Mechanical Work of Load lifted. The Work contained in Water used in Cylinder being 1.
0	..	3.50	8.00	4053.68	12444.79	83,546	12444.79	..	0.148	..
500	12,280	12.50	19.60	9931.32	30489.15	..	18209.15	0.146	0.365	0.402
1,000	24,560	20.50	29.90	15150.33	46310.52	..	21350.52	0.293	0.556	0.528
1,500	36,840	28.00	40.40	20470.68	62844.74	..	26004.74	0.440	0.752	0.586
2,000	49,120	36.00	51.00	25541.70	79334.01	..	30214.01	0.558	0.949	0.619
2,050	50,348	37.00	52.63	26667.60	81869.53	..	31521.53	0.602	0.980	0.614

N.B. Weight of cradle = 750 kilos, not noticed, being considered as part of apparatus.

¹ Total mean pressure on ram multiplied by stroke.

In order to ascertain the mean pressure on the ram during its stroke, an indicator, similar to that used for the steam cylinders, and constructed expressly for that purpose, being graduated up to 60 atmospheres, was placed on the hydraulic cylinder. The diagrams from this indicator were very clear, and showed exactly the work going on in the cylinder. Three of these diagrams, corresponding to Table No. 2, are given.

Cradle empty.

Mean pressure on ram = 8 kilos. per square centimètre.

Ascent, 25 sec. Descent, 23 sec.

Fig. 1.

Load on Cradle, 1 ton.

Mean pressure on ram = 29·90 kilos. per square centimètre.

Ascent, 24 sec. Descent, 26 sec.

Fig. 2.

Load on Cradle, 2 tons.

Mean pressure on ram = 51 kilos. per square centimètre.

Ascent, 34 sec. Descent, 42 sec.

Fig. 3.

The lift of the cradle was always exactly 24·56 mètres, and

hence the stroke of the ram was $\frac{1}{10}$ th of this, or 3·07 mètres. The quantity of water at 52 atmospheres entering the cylinder at each lift may be exactly found. By the indicator is known the exact mean pressure on the ram, diminished by the ram receding, as the water enters the cylinder; except in the case where the cradle is in equilibrium, and then the pressure on the ram is exactly equal to the pressure of the water. The exact effective work done is found by multiplying the load by the height it is raised. These taken together give the effective work done by the hoist, as compared with the water used to do that work, and by deduction, as in the preceding tables, the exact amount of friction is also found.

From these experiments it would appear, that the weight lifted by the hydraulic apparatus, on the principle described, is only about 45 per cent. of the power contained in the water, and 30 per cent. of the indicated horse-power on the steam piston. This would seem to be a small result; yet when many machines are used, there is no doubt of the great advantage of this system, only one steam engine being used, and this collecting its force by means of accumulators, for a moment when many machines may be working simultaneously. But it may be added, that these machines were perfectly new, and that the return water was always expelled back to the engine-house, a considerable distance in many cases. The length of 5-inch piping laid from the engine to the various cranes, &c., is 3,500 metres, and the same for the return-pipes (6 inches in diameter). The cistern at the engine-house is at a higher level than the machine cylinders, in order that the latter may be always full of water. The results from experiments made with a three-cylinder direct-acting rotary engine of 8 H.P., were much greater in proportion to the water used.¹ In these experiments the power was found, by attaching a sheave and break directly to the shaft, the lever of the break being 800 millimètres, the extreme weight lifted at this leverage being 182 kilos., making exactly 40 revolutions per minute. This was equal to 8·13 H. P., while that of the water used = 12·6 H.P., thus the useful mechanical effect was 65 per cent. of the water used; or 20 per cent. more than in the case of the hoists.

It will be evident that no expense whatever has been spared in any of these works. Thirty million francs have been already expended by the Dock Company under the concession of 1856, without including any part of the breakwater. To complete the works remaining to be executed under this concession, not including the

¹ This increase arises from the fact of the engine being direct acting, and hence the absence of chains and multiplying gear.—T. H.

graving docks about to be constructed, the administration has voted a further sum of forty million francs. This will include the purchase of extra land bought by the company.

Up to the present time the docks have not been a success, in a commercial point of view. The 'Portefaix,' a class of labourers peculiar to Marseilles, their forefathers having been engaged as they are, solely in the loading and unloading of ships, are divided into gangs, each gang having a leader termed 'Maitre Portefaix.' These latter have societies among themselves, and are for the present, as it were, leagued against working by machinery, considering that it will rob them of their bread. These men all work by the piece, and many, being rich, have some influence with the Marseilles merchants. Hence the quay cranes, and other machines, often remain idle, from the persistence of these men to maintain hand labour. But in a short time, these docks cannot fail to reap great profits, from the accommodation afforded by them, as well as from the fast-increasing commerce of Marseilles, the imports and exports to which may now be estimated at three millions of tons per annum.

The Paper is illustrated by a series of drawings, from which Plates 8 and 9, and woodcuts Figs. 1, 2, and 3 have been compiled.

---Encloses Customs, Docks and Warehouses
Within dotted line are Bonded Warehouses, two stories high
Shedding with Wrought Iron Roofing
Height of Level of Quays above Level of Sea
in Dock du Lazaret 3^m 40'
" Dock d'Arenc 2^m 40'
Minimum depth of Water 7 metres.

GENERAL PLAN OF DOCKS AND WAREHOUSES.
FINISHED AND IN EXECUTION FEB. 1864.

DOCKS AND WAREHOUSES AT MARSEILLES.