Mr. HARRISON said, in reply to questions from members, it was a fact that 420 tons of coals had been shipped into a screw-collier, in fifty-five minutes, on the occasion alluded to. The vessel had such very long hatchways, that several waggons could be discharged at one time; the spout had also a range of about 25 feet, and could be shifted at will. Extra men were likewise employed to trim the coals. The form of invert of the lock-chamber, or rather the raising of the heel-post, was not claimed as new, as the same system was adopted at the Monkwearmouth Docks, which were constructed by the late Mr. Brunel, and had been under Mr. Harrison's charge for many years. Having been found to answer in that case, it was adopted at the Tyne Docks, the only difference being, that the invert was continued completely through to the point of the cill, as an arch. It had been already stated in the Paper, that there was nothing which had been brought forward as an absolute novelty in the whole of the works. The reason why he had adopted the plan of making the lock-chamber so much wider than the gates was, because a great many craft and keels came in at a low state of the tide. The smaller vessels were loaded forthwith, and were sent out early on the tide. When vessels came into the outer basins on the flood tide, six full-sized colliers, or eight ordinary vessels, could be admitted at one time into the lock, which in fact formed a small half-tide basin. From inquiry he had ascertained, that the lock at the old Hartlepool Docks, which was constructed nearly a quarter of a century back, had never been used as a lock, with the exception of the first three, or four weeks after the docks were opened. Although he doubted whether this plan would be practically advantageous in all situations, there were many cases in which it might be usefully adopted.

Mr. GILES remarked, that there could be no doubt hydraulic apparatus enabled a great deal of manual labour to be dispensed with, and also expedited the operation of opening and closing dock-gates. At the same time he thought it desirable that the ordinary hand-gear should be retained. He had never adopted the hydraulic machinery, because the first cost was very great, and it seemed doubtful whether the advantages were equivalent to the expense. There must always be men to warp the vessels through the lock, and to put out fenders when necessary, and he thought they would be just as well employed in working the gearing for opening the gates, as in watching the vessel being passed through by the operation of the hydraulic machinery. On these grounds he should be glad if the Author would state, what had been the cost of that apparatus as applied to the entrance lock. He considered there was an advantage in the arched form of invert, as it prevented deposit on the apron, and with the same amount of masonry, there was greater strength than when it was flat. Reference had been made in the Paper to the intricate masonry involved in the construction of the doubly-curved—(that was curved both on plan and section)—pointing-cill. He noticed that the courses of the ashlar for the cills radiated with the curve of the gates of the lock. When Mr. Giles had used inverted cills, he had made the courses of the masonry longitudinal with the line of the lock; as he had found that plan facilitated the masons' operations, and enabled stones of less size to be used, than those shown upon the drawings of the Tyne Docks, and was on these grounds less costly. As the subject of pile-driving had been alluded to, he might mention that, in constructing some jetties, he had tried the effect of driving a series of piles, without iron shoes, through the London clay. The piles were merely pointed and hardened in the fire, and out of about two hundred, he did not think one was fractured. He regarded the fact of 420 tons of coals being shipped in fifty-five minutes, as a triumph of skill; and he thought that as the cost of shipment was only seven-sixteenths of a penny per ton, there was convincing proof, that the system adopted was both effective and economical. The coal-owners of the district could not fail to appreciate this fact, and must feel deeply indebted to the Engineer who had carried out these important works.

Mr. MURRAY thought the details given in the Paper were so comprehensive, that the Members could not fail to understand the whole system of the shipment of coals. The method of bringing the coals to the places of shipment was familiar to him, as it had been successfully employed at the Sunderland Docks. Where everything could be done by gravity, the expense was most materially reduced; but he found the state of the rails so different in wet to what they were in dry weather, that during the latter it was sometimes necessary to employ a small amount of horse power. If the rails had been laid with too great a declivity, the waggons, through neglect, might have overpowered the breaks, and endangered the drops at the places of shipment. Nothing could be better adapted for the rapid ingress and egress of shipping from docks, than an entrance without a lock. At the same time, instances might occur in which a small lock, or tidal basin, would be very useful.

With regard to hydraulic power, and its application to the opening and shutting of lock-gates, he had used it with good effect; but he had found, that the recesses for the gates should be longer than usual, and the side opposite the hollow quoin well splayed, to allow of an easy escape of the water from behind the gates. In general, also, the recesses at the heel-posts were too confined. They should be at least 12 inches, at that point, free from the gate, when fully opened; because heavy pieces of timber, and other articles, such as crowbars, &c. were apt to fall over the coping of the walls; and he had known them to come in contact with the gate and the masonry of the recesses. When the gates were opened by manual labour, of course any obstruction of this kind was at once felt, but with the application of hydraulic power it was otherwise.

Mr. ABERNETHY observed, in reference to the careful provision which appeared to have been made for draining the site of the docks, previous to the commencement of the works, by means of a large culvert, that the want of similar effective provision at the Birkenhead Docks, for carrying off the upland and spring waters, led to an extensive failure in the walls. The water was impounded in the docks in 1853, and so remained until about the end of 1857. Since then the float had been laid dry, but no provision was made for the drainage of the upland and spring waters. The consequence was that a great hydraulic pressure was brought against the walls, which caused them to give way, although they were sufficiently strong for all the ordinary purposes of wharf walls.

With regard to adapting hydraulic power for opening and closing the gates, he agreed as to the advisability of so arranging the machinery, that manual labour could be resorted to if necessary. That he had done at Swansea, two years ago, by Sir W. G. Armstrong's aid. When hydraulic power was applied, the old hand-gearing was retained, so that if any accident occurred to the one, the other could be used. That system had been found to work extremely well. There could not be any doubt, in his opinion, as to the economy both in labour and in time, effected by the application of hydraulic apparatus. At Swansea, it used formerly to take twelve men—six on each side of the lock—fifteen minutes to open and shut the gates, which was now done, with the assistance of the hydraulic apparatus, by four men in two minutes. If the apparatus was also applied to the capstans, it would not be necessary to employ men upon the wharves. All that would then have to be done would be to place the tow-rope round the capstan barrel, and the vessel could be brought into dock at once. He thought the members would agree with him, that the arrangements for shipping coals were exceedingly effective. The shipment was carried on entirely from the high level, whereas Mr. Abernethy had worked, hitherto, entirely from the low level, raising the waggons by hydraulic power. On some future occasion, he might be in a position to give the Institution some information upon that subject.

Mr. MEADOWS RENDEL said, it had been stated, that extensive failures in the walls of the great float at Birkenhead had occurred from neglect to provide a culvert for carrying off the upland and spring waters. He was astonished that such a statement should have been made, especially by a gentleman who had been for nearly two years Engineer of the Birkenhead Dock Trust. The fact was, that a large culvert had been provided for this very purpose, and was actually the first work executed at Birkenhead, after the Dock Act was obtained. It was 10 feet 6 inches in diameter, and its outfall was about 5 feet above the level of the Morpeth Dock Cill. It extended from the river, at the Woodside Basin, to near Wallasey Bridge, where a large cut conveyed into it the waters of Bidston Marshes. The fact was that, at the period when the late Mr. Rendel ceased to be Engineer of the Docks, the walls had been built, but they were not fully backed up, and the first thing his successor ought to have done, was to have completed the backing. This was omitted to be done, and consequently the ordinary land soakage got behind the walls and forced them out.

Mr. HAWKSLEY corroborated the fact which had been referred to, as to the construction of a sewer 10 feet 6 inches diameter, by the late Mr. Rendel, at the commencement of the operations at the Birkenhead Docks. He saw that sewer himself in 1846, and it then carried off the upland water in the way which had been described.

Mr. ABERNETHY claimed permission to offer a few further remarks, in justice both to the Institution and to himself; in justice to the Institution, because he thought as practical men facts must mainly guide them, and therefore facts should be stated with the greatest truthfulness;—in justice to himself, because he believed that the observations which had been made reflected in some degree upon his professional judgment. He had commended the care which had been taken at the Tyne Docks, in providing for the drainage of the soil, by constructing a proper and suitable culvert, for taking off the upland and spring waters; and at the same time he had stated, that he attributed to the want of a similar precaution in the case of the Birkenhead Docks, the failure of a portion of the dock walls. In reply, it was said that he was wrong—first as to facts, inasmuch as a large culvert was constructed at Birkenhead for the purpose of draining the dock quays, and secondly, that the failure of the walls was not attributable to the cause he had mentioned, but to a want of professional judgment on his part, in neglecting to have the walls properly backed up. It was quite true, that there was a culvert on one side of the Birkenhead Float, and parallel with it, which served a particular purpose. Wallasey Pool was formerly a tidal reservoir, and previous to converting it into a dock, it was necessary to provide for the drainage of the large extent of low-lying land at the head of the pool. Hence the first work constructed was this culvert to take off the water from the Bidston Marshes. That culvert ran parallel with the float, but at a distance of from 500 feet to 1,200 feet from the walls, and it had no connection, by drains, with the quays.

He regretted that the course which the discussion had taken should render necessary any other comments upon the failure of the walls. When mentioning the fact of their failure, he had purposely refrained from making any personal allusions. But owing to what had been said, he thought it right to give a brief history of the past and present state of the works, to place the facts on record, and to allow the Members to draw their own conclusions. When he became the Engineer of the Birkenhead Docks, in 1851, he found the state of matters to be this: the Dock Company's warehouse wall, 520 feet in length, had given way, and the workmen were in the act of underpinning it, and adding counterforts and ties to prevent farther failure. He also found that the adjoining wall, 2,000 feet in length, had shown symptoms of giving way, and the earth had to be wheeled from the wall, and conveyed to a distance backwards. Of course that called his attention to the necessity of exercising great care in backing up the walls still remaining to be built, and which were commenced previous to his becoming the Engineer. The designs were not his, and he followed the terms of the original specifications, because he considered them judicious; but he added rubble drains at every 100 feet, to drain the soil behind the walls during their construction. These walls were completed in 1852, without any further symptoms of failure. The wall which had previously given way, came to a state of rest, was carefully backed up, and remained in that condition. The water was admitted into the float in 1852. About eighteen months ago it was suddenly laid dry, and then the walls on the Seacombe side, which had no provision for drainage behind them, at once gave way. He did not design those walls, and with the exception of a few 100 feet, they were not built under his superintendence. The remainder of the walls stood intact until within a short period, when the water gradually accumulated behind them, and having no means of exit, they at length gave way. He left it to the Members to judge, whether anything he could have done, in backing up the walls, in 1852, would have prevented their failure, under these circumstances, in 1858.

Mr. E. A. Cowper considered the arrangements for shipping coal at the Tyne Docks were most admirable. The waggons were not brought forward in a sluggish manner, but ran in quickly: the coals were shot out, the waggons immediately entered the return line, and others advanced to the staiths in rapid succession. With reference to the statement in the Paper, that coal would slide on smooth iron plates without rolling at an angle of 50°, he remarked that in ordinary cases, when the coal came out of the shoot, it fell to the bottom of the ship, or tumbled over and over upon that first shot in, producing in both cases a considerable amount of breakage. That would be the case whether the coal was loaded by the hatchway, or from a shoot. With small colliers the damage was less than with large ones, the fall in the former case not being so great. Some years ago he was led to consider whether a plan could not be devised, for lowering coal into a ship, so as to prevent breakage. Mr. Cowper then explained two plans for that purpose, designed by Mr. W. Laird and himself, drawings of which were exhibited. In the one case, the coals were delivered from a shoot into a hopper, having attached to it a wrought-iron tube, similar in shape to the funnel of a steamboat, through which the coals descended into the hold of the ship; the tube being always kept full, the descent was regulated by the coal escaping at the lower end. As the tube was moveable at its lower end, it could be inclined in any direction, so that the coals could be trimmed, or deposited in any required position. The other plan was merely that of a dredging-machine inverted, by which the coals were delivered to any part of the ship required. Mr. Cowper also explained the adoption of the apparatus to the shipment and trimming of general descriptions of goods, by the addition of a simple hanging railway, consisting of a single bar of iron attached to the under sides of the deck-beams, on which a small pulley, or roller ran, from which the goods were suspended. A lever, having a long and a short arm, being hung from the rollers, any goods, such as a cask, a bale of Manchester goods, &c., might be attached to the short arm, and a man depressing the end of the long arm, the goods were lifted with the greatest ease, and then run along the ship to the spot where they were to be stowed. This plan was applicable to every description of ships carrying general cargo, and had been adopted in H.M. Navy, for moving the coals to the stoke-hole.

Mr. Michael Scott thought the great merit of the arrangements for the shipment of coal at the Tyne Docks had not been sufficiently dwelt upon. So little had been said about them in the Paper, that the subject had passed by without the notice that it deserved. He believed the facilities thus obtained would save the Railway Company many thousands of pounds a-year, and nothing could exceed the beauty of the system.

In speaking of the river wall, which was constructed of creosoted timber, by one of Nasmyth's steam pile-engines, the Author had said, "where there is a large amount of straightforward piling to be done, or in cases of difficult driving, it is believed the Nasmyth pile-driver is unequalled." Now Mr. Scott dissented entirely from that opinion. More than two years ago, he minutely investigated the subject of pile-driving, in conjunction with Mr. A. J. Robertson (Assoc. Inst. C.E.), both theoretically and experimentally; and the result was, the construction of a machine with which a good deal of work had been done at Blyth. It was different from Nasmyth's engine; and with the permission of the Meeting he would give some of the results, as compared with the performances of that machine. In Nasmyth's engine the ram was $1\frac{1}{2}$ ton in weight, with a fall of 3 feet. The principle of the Blyth machine was that of a small portable engine, applied to operate a double-acting steam crab, so arranged that both rams were worked at the same time, in ordinary leaders, lifting the ram and letting it fall. In the Blyth machine the rams also were each $1\frac{1}{2}$ ton in weight, but the fall could be varied from 3 feet to 15 feet. That great amount of fall was adopted for this reason;—that the material of a pile not being perfectly hard, and the ground being more, or less elastic, the efficiency of the engine must depend upon the surplus power of the blow, above the current resistance. As that surplus power was greater with a heavy blow than with a light blow, it followed that a few heavy blows were more efficient than a great number of light ones. On referring to the results in the two cases, he found that with the Blyth engine, the ram falling on the whole 706 feet, drove a pile 13 feet 4 inches through hard gravel and sand; or at the rate of 1,060 feet, if the distance driven had been 20 feet. The person in charge of the machine at the Tyne Docks stated, that it required the ram to fall through a space of 3,600 feet, to drive a pile 20 feet into the Jarrow Slake,—a very different material to that at Blyth. In other respects the Blyth machine compared favourably with Nasmyth's engine. In the first place, he believed the cost was not more than one-fourth; that of Nasmyth's machine being about £1,800, whilst that of the Blyth machine was only about £450. He was informed, that the extent of work done by the Nasmyth engine at the Tyne Docks was ten piles driven per day, or equal to a distance of 200 feet driven. He did not know what was the HP. of the engine; but there was a donkey-engine for shifting the machine, and a large driving-engine, which was worked at a high velocity, having long-jointed steam-pipes which produced great condensation. He felt satisfied, however, that an engine of 6 HP. would do this amount of work with the Blyth machine. He did not say that it would do as much work per minute as the Nasmyth machine; but the question was, how much it would do per day. The machine had to be shifted; therefore, it was not so much what quantity of work was done per minute, as how much was accomplished in a day. Moreover, it was to be observed that Nasmyth's engine was limited in its application. For instance, at Blyth the piles were driven in sand 10 feet to 13 feet under high water. In such a case it would be impossible to work the Nasmyth engine without an expensive framing,—a difficulty which was not experienced with the Blyth machine. The latter had also this material advantage—that it was not simply a pile-engine, but it could be taken to pieces when not wanted for piling, and the steam-engine could be applied to other purposes. It was light, as it weighed not more than 12 tons, or less than one-half of Nasmyth's, it could be easily moved, and, as had been previously mentioned, it was applicable to many purposes for which the Nasmyth engine could not be used; whilst he knew of no case to which the Nasmyth engine was applicable, where the Blyth machine could not also be employed. The Author had remarked, that very few pile rings were broken at the Tyne Docks. Mr. Scott could state, that piles had been driven in sand by the Blyth machine, and on looking at the heads of many of the piles, there was nothing to show, whether they had been driven, or not; in fact, the heads were not in the least abraded.

Whilst upon the subject of piling, he would refer to another point. At the Victoria (London) Docks, it appeared that the face piles depended, mainly, for support upon the land-tie piles. He had found by experience, in the construction of pile quays, that when the connecting rod was screwed up tight, the whole strain was upon the land-tie pile, and it would give way before the power of resistance of the face pile was developed: on the other hand, if it was not screwed up, the face pile would yield before the power of resistance of the land tie was developed. At the Victoria Docks, the application of the land tie was quite legitimate; but the tie pile was not, in his opinion, so well placed at the Tyne Docks.

It had been mentioned, that it was considered desirable to retain the old hand gearing, when hydraulic apparatus was applied for opening and closing the dock gates. In 1846, he had occasion to report upon the application of hydraulic apparatus for hoisting goods in the warehouses at Liverpool. He then recommended that small hydraulic engines—not unlike in external appearance small steam-engines, should be employed, in preference to large cylinders, upon the ground that those small engines producing rotary motion, and acting through gearing, would give the same results as the large cylinder acting more directly upon the weight. And as it was well known, that small engines at a high velocity would produce perhaps a better effect, at less cost for machinery, than large engines going slowly, he estimated that there would be considerable advantage from the employment of those small engines. He believed, in the majority of cases, such an arrangement of hydraulic apparatus would be found not only a better, but also a cheaper system.

Mr. J. W. Johns gave, through the Secretary, the following particulars in reference to the Nasmyth pile-drivers as usually made:—The weight of the entire apparatus was about 24 tons.

It was capable of being separated into easily transportable pieces, the heaviest piece being the boiler, which weighed about 76 cwt. The hammer weighed about 30 cwt., and could make sixty to seventy blows per minute on the head of the pile. It was one of the many advantages of the rapid blows, aided by the dropping of the hammer-case, cylinder, &c., on the shoulder of the pile, that the timber was forced into the hardest soil without injuring the head, so that the usual iron hoop could generally be dispensed with, the octagonal mouthpiece of the hammer-case, which fitted, extinguisher-like, upon the shoulder of the pile, answering usually for the iron hoop, or collar; or a light hoop might be used and transferred from the driven pile to the next in succession. In ordinary ground, such as a pile could be driven into, the Nasmyth machine would drive a pile, 14 inches square, at the rate of 5 feet to 10 feet of actual penetration per minute while driving—a speed greatly in excess of all other pile-driving machinery. The apparatus was believed to be, in every respect, perfect and complete, for the rapid and effective driving of piles, at the least expense, taking precedence over every other system, the cheapest hand labour not excepted, for economy of working as well as speed. By means of a small steam-engine fixed on the framing, the piles were hoisted, the steam hammer (part of the apparatus) was raised to the shoulder of the pile, and the entire apparatus was moved on the rails, as required, without manual labour, so that three active men were sufficient for the management of the machine and for the superintendence of the process of driving piles. The boiler, which was of the locomotive construction, with wrought-iron tubes, fire-box and smoke-box, was equal to about 25 HP. The fire-box being adapted to burn chips, and other wood fuel, a small supply of coals would suffice. As the whole of the apparatus was fixed on a substantial, independent timber framework, the Nasmyth pile-driver worked as well when placed on a suitable boat, as on the solid ground.

Mr. Robert Rawlinson said, at the Liverpool Docks Mr. Hartley adopted the plan of forming a culvert behind the gates, with outlets over the whole area, which had the effect of flushing the apron, and thus insuring the gates working freely.

In pile-driving it had been found, that timber which had been long in water, and had become coated with slime and vegetation, drove more easily than dry timber. Where it was required to drive large numbers of piles, it might be found advisable to wet the timber, and to give it an artificial covering of slime.

Mr. W. A. Brooks could add his testimony to that already given, in regard to the efficiency of the Nasmyth pile-engine. A great deal of work had been done in the Tyne with that machine, and by no other means with which he was acquainted would it have been possible to do it so cheaply, or expeditiously. The piling at the Tyne Docks was of a very difficult character. Many of the piles were inclined, and had to be driven through sand, which was known to be a most troublesome material to penetrate. In driving into sand, sharp, quick blows were more effective than blows given from a great fall, and the piles went down more rapidly.

Mr. A. J. Robertson remarked that, it was precisely because the piles were difficult to drive at the Tyne Docks that the Blyth machine was superior to Nasmyth's pile-engine. In driving the piles for the foundations of the piers of the High Level Bridge, at Newcastle, it was necessary to cut off the heads of the piles frequently, because they were completely smashed by the Nasmyth machine. The reason was that, as the resistance was very great, and the power of the blow insufficient to overcome it, the whole power of the pile-driver was expended upon the pile itself; whereas, had the blow been more powerful, it would have driven the pile into the ground.

Mr. Brooks observed that, when the docks were projected at Jarrow Slake, there was considerable opposition in Parliament, and much diversity of opinion was expressed, as to whether the works would have a beneficial, or an injurious effect upon the tidal flow of the river Tyne.

One great cause of injury from the existence of Jarrow Slake was the inset of the tide into it, instead of directly up the river. The dock wall had had the effect of guiding the tide up the main channel of the river, and there was an instantaneous improvement in the bed. The sudden elevation of the bed, at the west end of the Harbour of Shields showed the effect of the tide setting up the Slake, instead of up the main channel of the river; but since the construction of the river and dock works, the bed had been lowered considerably. Originally there was not more than 18 inches of water at low water abreast of Jarrow Slake; whereas, now there was a depth of 5 feet, and at some points 6 feet, or 7 feet, and he had no doubt of there being eventually from 10 feet to 12 feet of water at low water of spring tides. Alluding to the situation of Jarrow Slake, he wished to point out the excellent arrangement of the dock. It would be seen by the plan (Plate 7), that the outer basin, or entrance, was subject to a very strong tide. Had the Engineer followed the plan which was very properly acted upon at the Victoria (London) Docks, on a convex shore, there would have been such a rush of tide past the entrance, that no vessel could have safely entered the Jarrow Docks; but by the construction of the tidal basin there, the vessels went in without difficulty. Both the Victoria and the Tyne Docks might be said to have been admirably arranged, with reference to their several conditions and localities.

Mr. HARRISON would, in the first place, reply to the question which had been asked, as to the relative cost of hand-labour and of hydraulic power, for opening and shutting the dock-gates. In a matter of this kind, there was no more important consideration than that of cost—both first cost and working expenses. A great deal depended upon the circumstances under which hydraulic power was to be applied. At the Tyne Docks he did not put an engine solely to work the gates and sluices, but the engine was used for other purposes. It was applied, in the first instance, to four ballast cranes, which delivered from the ships 150,000 tons of ballast per annum; and also to the cranes which were in course of construction for the delivery of goods to and from the vessels. As the time occupied in pumping the water necessary for working the gates was only a few minutes in the course of each day, it was difficult to estimate the cost of the power, but it could not amount to much. Then, again, the pipes which conveyed the water to the gates were also used for all the cranes along the quay. There were two engines of 25 HP. each for working the hydraulic cranes, placed in the south-east corner of the Docks. In order to apply either hand-labour, or hydraulic power, the machinery was constructed as if intended for hand-labour only. There were three small hydraulic engines fixed on the sides of the locks, the water to work them being supplied from the main engines, and these three engines worked on the shafting which ran along the whole length of the lock-walls, and was connected by means of spur-wheels (which could be put in, or out of gear) with the crabs. When required for manual labour, the hydraulic machinery was put out of gear, and the capstan head was worked with the ordinary handspikes. He found that the whole additional cost of the hydraulic power, as applied to the working of four sets of gates, besides the opening and closing of sixteen sluices, each 5 feet by 4 feet, was under £5,000. With manual labour, the least number of men that would be required was twelve, but with hydraulic power six were now employed, and he believed that in a short time four would be sufficient. The result would be a saving of the wages of eight men,—say £400 a year; or even supposing it were only six men, there would be a saving of £300 a year, which was more than equal to the usual rate of interest upon the additional first cost of the hydraulic power. Besides, there was the advantage of expedition in performing the work when using the lock, which would not be the case if the sluices for filling and emptying were worked by hand. The question therefore was not dependent on the first cost, or on the annual working expenses alone, but on the advantages derived in a variety of ways from the hydraulic machinery. At the same time, if a steam-engine was erected for the sole purpose of working the gates, there might be a doubt, on the score of economy, as to the desirability of applying hydraulic power.

With regard to the use of the pile-driving machine, he had listened attentively to what had been said, but he could not admit that his views were changed. He had used the Nasmyth engine very extensively, and under circumstances of the greatest difficulty. Nasmyth's machine had been used at the High Level Bridge, Newcastle, where the whole of the piles, which were 50 feet long, were driven through sand—and there was no kind of driving more difficult than through that material; and it was also used in driving the piles for the Royal Border Bridge over the Tweed.[1] In order to test the power of the Nasmyth engine, after a pile had been driven as far as was considered possible, a dead weight of 100 tons of pig iron was placed on the top of it, and allowed to remain there for three months. Not the slightest change was produced in the condition of the pile, nor did it sink at all under that great weight, but remained in a state of rest. When the load of iron was removed, the Nasmyth engine was applied to the pile, which was then driven down many feet further. The rapid motion of eighty blows per minute, obtained with the Nasmyth machine, was so great an advantage, that he felt satisfied if the power necessary to move that pile with a heavy ram and a great fall had been applied, the sole result would have been to split the pile. At the Tyne Docks he had also used a hammer worked by a crab and engine; and in some cases he should be inclined to use the machine described by Mr. Scott. But where there was a large quantity of straightforward pile-driving, he repeated, from his own experience, that there was nothing to be compared with Nasmyth's engine.

It had been suggested, that where a particularly tender coal had to be dealt with, it would be necessary to employ other apparatus for the shipment, in order to lessen, or to prevent the possibility of breakage. But he felt satisfied, the plans which had been explained were not applicable to the requirements of the Tyne Docks, where from 6,000 to 7,000 tons were shipped per day. Indeed it would be impossible to conduct the work with such appliances; nor was the coal shipped there of so tender a quality as that of Wales, or Birkenhead. No doubt the plans alluded to were adapted for tender coal, and where expedition was not so much an object.

With regard to the lock-gates, he might mention, that there was one point involving some novelty, which was deserving of consideration. That was in the roller being adjusted upon a long

[1] A description of this Bridge, by Mr. G. B. Bruce, M. Inst. C.E., was given in the Session 1850-51. *Vide* Minutes of Proceedings, Vol. x. p. 219.—EDITOR.

axle. In the ordinary mode, the axle was very short, and in consequence nothing was more easy than for the roller to get out of truth with reference to the roller path. Mr. Robert Stephenson, however, suggested the idea of a long axle, and in this case it was made about 6 feet long. It was more easily adjusted than a short axle, and was fitted in the same manner as the ordinary axle-box of a locomotive engine. The weight of the gate was, as shown in Plate 7, borne on the outer end of the axle, and the axle itself was supported at the inner end by the axle-box directly under the gate. The axle could be removed by two men without difficulty. This arrangement was a novelty in dock-gates, and he thought there was a decided advantage in it.

It had been stated in the previous discussion,[1] that one reason why cast-iron gates had been adopted at the Sunderland Docks, was in order to obtain a great weight, so as to resist the action of the waves of the sea. He would submit, that it was desirable to avoid having very heavy gates; and he thought a wrought-iron gate was as capable of being made to act with the object which had been suggested as any other description of structure. By the insertion of a valve, the gates could be very rapidly filled with water to any height that was desired; so that if a gale of wind sprung up, it was only the work of a few minutes to render them sufficiently heavy to resist the action of the waves. In this way all the advantages could be gained which were ascribed to heavy cast-iron gates under such conditions, avoiding at the same time the constant wear and tear upon the rollers which had been so very extensive in the dock-gates at Sunderland. It had been urged, as an objection to wrought-iron gates, that the rivets were liable to be started, by the concussion of vessels against the gates. He considered if the iron was good, and the work was well done, that was an unimportant objection. There was more, in his opinion, in the argument as to the result of the action of salt water upon the iron. But these gates were so easily floated out, that it would be a matter of no difficulty, and of but trifling expense, if they were taken out every five years, examined, painted, and put in again; and thus the question of the corroding of the iron might be readily met. As far as his own views were concerned, those objections would not weigh with him.

In the Paper he had referred to a new description of chock, a model of which was exhibited, as possessing some novelty. He did not claim the merit of that invention. He gave the general idea of what was wanted to an ingenious working man, named Simpkin, who had been in his employ for twenty years, when a sketch was produced which was afterwards carried out in the

[1] *Vide* ante, p. 479.

model. The same might be said with regard to the mode of crossing the rails,—a model of which was likewise shown,—which was the design of the same person. He did not know whether he was peculiarly fortunate in having about him men of greater natural ability than other engineers had; but he had only to suggest an idea of what was required, and there was always found some one amongst his men who sketched out the very thing he needed.

Some remarks had been made, as to the influence of the construction of these works upon the state of the tide in the River Tyne. As had been already stated, when the project was before the Committee of the. House of Commons, there was a strong contest upon this point. On that occasion Mr. Brooks prepared a diagram (Plate 9), which, no doubt, had a beneficial influence in settling the case before the Committee. That diagram set forth a problem, which it was desirable for the Members to discuss; and if Mr. Brooks would, on a future occasion, bring forward a Paper upon the subject, that discussion might be elicited. But as some features had not been explained, he would briefly call attention to a few facts. From the Bar of the River Tyne to the commencement of Jarrow Slake, a distance of a mile and a half, the river passed through the Harbour of Shields (Plate 9). There was then Jarrow Slake, a large lagoon of 350 acres, which was covered at about half-flood, having from 4 feet to 8 feet of water over it at high-water spring-tide; and Newcastle Bridge was eight miles further up the river. To a town like Newcastle, having a population of one hundred and eighty thousand souls, with a large amount of shipping trading to its quays, the state of the navigation of the river leading up to it was a matter of vital importance. It would be observed, on reference to the section (Plate 9), that from the bar to the commencement of Jarrow Slake, there was a depth of water regulated by the bar and the two shoals within it. At Jarrow Slake there was a sudden elevation in the bed of the river, and then the depth of water was nearly uniform up to Newcastle Bridge, which acted as a dam. Here there was another elevation in the bed of the river, which continued as far as the navigation was open. Thus, there were three distinct series of depths in the navigable part of the river; much the same as in a canal. The question raised by the Admiralty authorities was, whether the great depth of water below Jarrow was due to the large lagoon, or Slake. If the question was only one of the navigation for the length of the Harbour of Shields, and not for fourteen miles further up, then Jarrow Slake might have been of more importance. But what was really involved, was the navigation up to Newcastle; and he did not think any one in designing the features of a river, depending mainly for its depth on the tidal waters, and having for its object to reach Newcastle, would propose a series of Jarrow Slakes. In such a case the tide would not reach the same height at Newcastle that it did now; and if a series of Jarrow Slakes was bad, one could not be good. He maintained, therefore, that Jarrow Slake was an actual injury to the tidal flow up the river. The flood-tide passed immediately on to the Slake, and before the river-wall was constructed, the flood and the ebb passed over different portions of the bed of the river. The current of the tide above Jarrow Slake slackened when it began to flow over the Slake; and there was an inclined plane in the level of the water between the bar and the high and low end of Jarrow Slake. The diagram showed further, that when it was high-water at the bar of the River Tyne, it wanted 2 feet 6 inches of high-water at Newcastle, and it was dead low-water at Stella, above Newcastle. Ultimately the crest of the wave reached a level corresponding with high-water on the bar, but not until the tide had fallen many feet at the bar. Again at low-water, with the flood-tide making at the bar, the diagram showed the level of the ebbing tide in the river above the bar, and the ultimate level to which it ebbed, and the quantity of ebbing water which had to meet the flowing tide. The centre wedge, coloured blue, represented in section the beneficial quantity of water brought in by the flood-tide. The remaining space was filled by the advance of the tidal wave. He believed that if Jarrow Slake were enclosed, the bed of the river above would be lowered, and the navigation would be gradually improved up to Newcastle. The effect of the enclosure of the Slake would be to cause a scour which would carry down a portion of the sand from the bed of the river above; and for a period of time that would be deposited in the harbour below; but when the river was brought into a perfect state, the deposit would be carried away. The area of Jarrow Slake was calculated to hold, at high-water of a spring-tide, three millions of cubic yards of water. Assuming that the enclosure of Jarrow Slake so increased the flow of the tide above it, that the tide rose 9 inches higher throughout, at the moment of high-water on the bar, and that on the ebb-tide it ebbed out 9 inches lower, at the time of low-water on the bar, such an increased flow and ebb, extending over fourteen miles, would be equivalent to the entire quantity of water abstracted by the enclosure of Jarrow Slake. With a little assistance from dredging, it would not be long before the water flowing into the river would be equal to that abstracted by the construction of the Docks; and, at the same time, there would be a greater depth of water all the way up the river. That was the problem which he should be glad to have fairly discussed before the Institution; and if Mr. Brooks, who, he was aware, possessed a fund of valuable information upon the subject, would write a Paper upon the state of the river Tyne, it would not only be of immense value, but would induce a discussion of great interest.

If Mr. Brooks would also investigate the question of the piers that were now being constructed at the entrance of the river, he would also do good service to the profession. Having known the River Tyne for many years, Mr. Harrison had much doubt as to the ultimate effect of those piers upon the river, particularly when the importance of preserving the navigation to a distance above Newcastle was considered. It would be seen by referring to the general plan (Plate 7), that the piers, shown in dotted lines, were projected, one from Tynemouth Castle and the other from the South Shields shore, the heads of the piers approaching within about 1,100 feet of each other, which would be the width of the entrance. At present the flood-tide from the north struck upon the Trow Rocks, and returned in over the Herd Sand with considerable force; no doubt the shape of the entrance promoting the flow of the tide. In the case of the River Wear, after the original construction of the piers there, the tide did not flow as high at Lambton Castle by nearly one foot, as it did before the piers were constructed; and it was a question, whether the same effect would not be produced in the Tyne, as had taken place in the Wear, and whether the quantity of water would not be diminished.

There was only one other point to which he would allude. That was in reference to the shipment of coals, a subject which he brought before the Institution in 1837, in a 'Description of the Drops used by the Stanhope and Tyne Railroad Company for the Shipment of Coals at South Shields.'[1] The plan, shown in Plate 8, Thompson's Coal Cranes, Figs. No. 1 and No. 2, was the first important deviation from the old system of shipping coals by keels. The first coals were shipped mechanically, from the Pelaw Main Colliery, in August 1812, and he had a perfect recollection of seeing the waggons descend by that drop. His father being connected with the colliery, he was taken there as a boy, and the circumstance made an impression upon his mind which had never been forgotten. He might add that he was acquainted with all the changes in the system of shipping coals that had taken place in the interval, or during the last forty-seven years. The main principle in shipping coals by spout was, that the hoppers should always be kept full; so that when the waggon was emptied, the coals fell upon a bed of coal, and the whole mass was kept as close up to the waggon as was possible. There was a trap by which the descent of the coal could be regulated with the greatest

[1] *Vide* Transactions Inst. C.E., vol. ii. 4to, p. 69.

nicety. The men also used large flat iron plates, about 4 yards long by 1 yard wide, by means of which the coals were directed into the hold of the ship. He was satisfied that when care was taken to keep the hoppers full, and to allow the coals to slide down gradually, the shipment could be effected without any great amount of breakage: indeed one of the men had used the expression that, he could ship a load of eggs without breaking one. Before fitting up this apparatus, he took the opinion of Mr. Nicholas Wood (M. Inst. C. E.), who he considered to be the highest authority in the coal trade. That gentleman agreed with him, that the only difficulty was in overcoming the tendency of the men to neglect their duty: but assuming that the points he had mentioned were attended to, no doubt the coals could be shipped with the least possible amount of breakage.

Sir John Rennie believed, that iron was first used for lock-gates by Telford, on the Caledonian Canal. In that case the ribs were of cast iron, and the other parts were of wood. In 1819, the late Mr. Rennie constructed gates wholly of iron, at Sheerness. There were three pairs of lock-gates, 60 feet wide and 32 feet high, the mitre and heel-posts, and ribs of which were of cast-iron, and the remainder of wrought iron. Although exposed to the action of salt water for nearly forty years, these gates had remained perfectly sound to the present time. He had listened with great interest to the remarks which had been made, as to the probable effect of the Tyne Docks upon the tide of that river. It was a very large question, and one well worthy of being discussed before the Institution, quite apart from that of the piers at the mouth of the Tyne, which was a totally distinct subject, requiring much research, and general, as well as local knowledge. If the Paper which had been alluded to was brought forward, he should probably have a few words to say upon the subject, as he had paid considerable attention to the River Tyne for many years. He would, therefore, only say at present, that anything which tended to diminish the amount of tidal water entering the estuary, must injure the river; and that if the width, or surface area, was reduced, the depth ought to be increased, to allow the same quantity of water to pass in and out as before.

Mr. Bidder, *V.P.*, said, having had an opportunity of examining the Tyne Docks, he could not refrain from expressing his admiration at the ability which had been shown in adapting the works to the locality in which they were situated. It was not in expensive works that the skill of an Engineer was displayed, but in taking advantage, to the greatest extent, of local peculiarities, so as to meet, in the most economical and perfect manner, the requirements of a particular traffic. That was eminently the case with the Tyne Docks. He alluded, more especially, to the means adopted for loading the coal into the vessels; but altogether these docks, taken with reference to their foundation and their adaptation to the particular situation, were master-pieces of engineering.

There were circumstances of peculiar interest connected with those works, which every true lover of the profession would do well to study. These were, their situation on the Tyne, and their possible effect upon the régime of that river. Referring to the longitudinal section (Plate 9), it would be seen that there was a sudden rise in the bed opposite to Jarrow Slake, which was a bay of the river extending over, it was said, 350 acres. If the river between this point and Newcastle Bridge were supposed to be of the uniform width of 200 yards, then the area of that division would be between 600 and 700 acres. Therefore, the area of Jarrow Slake formed a sensible proportion of the whole area of the river, between the two points mentioned. No doubt, Jarrow Slake was originally a deep inlet, which had been gradually silted up, inasmuch as the river was so much widened at that point, that the current occasioned a deposit, which ultimately produced that considerable shoal. When the Bill for these Docks was before Parliament, the authorities at the Admiralty took objection to it, as they had done previously in the case of the Birkenhead Docks, alleging that it would interfere with the régime of the river, and especially with the scour over the Tyne bar. On the part of the promoters it was suggested, that where the widening of an estuary took place immediately within the outlet, it was likely to be detrimental, because it impeded the tidal wave flowing to the upper regions of the river, and materially affected the scour at low water, when it was likely to be most effectual. Now, since it was low-water at Stella, $15\frac{1}{2}$ miles above the mouth of the river, when it was high-water at the bar, it would, he thought, be obvious that if the form of the river was rendered more uniform, a far greater body of water would be driven up the river, than could possibly have entered the estuary before the enclosure of the Slake, and would come in under circumstances more available for the scour of the Tyne bar.

Works were now in progress, under the sanction of the Lords of the Admiralty, at the entrance of the Tyne, which would, in his opinion, lead to much greater imperfection in the régime of the river. He felt strongly upon this subject, because, under the pressure of the Admiralty, supported by some Civil Engineers, he had formerly been compelled to lay out money uselessly. He alluded to a portion of the railway between Yarmouth and Norwich, where there was an estuary above Yarmouth, called Breydon Water. As the circumstances were peculiar, he would briefly describe them. The tide rose and fell at Yarmouth Pier about 5 feet, at Yarmouth Bridge only 2 feet, and at the head of Breydon Water 1 foot; therefore, there was only about 12 or 18 inches flow of tide over that area. That was, however, considered so important, that when about two acres of that space were enclosed, the Admiralty authorities compelled the Railway Company to throw in two other acres of valuable pasture land, to maintain the scour of the Yare; whilst by regulating the river between Yarmouth Pier and Yarmouth Bridge, the depth of the river would have been increased, and thousands of tons more water would have been available for the purpose they were so anxious to secure. He made these remarks because he believed the present works at the mouth of the Tyne would be injurious. He considered that the whole of Jarrow Slake ought to be fully enclosed, and that the only way to have an effectual scour was by the regulation of the banks of the river from the mouth upwards.

Mr. HAWKSHAW, *V.P.*, regretted that two such important Papers as Mr. Kingsbury's 'Description of the Victoria (London) Docks,' and Mr. Harrison's 'Account of the Tyne Docks,' should have been brought forward at so late a period of the session, as both were worthy of careful examination and ample discussion. With regard to the description of the mode of shipping the coals at the Tyne Docks, he was surprised that it had elicited so few remarks. The only doubt he had heard expressed was, that the plan had a tendency to break the coal. He had, however, been assured that such was not the case, if the hoppers were kept full; as then the coal would only be subjected to a sliding motion, and would suffer the smallest amount of breakage. In South Wales the shipment of the coal was performed on a different system. As the anthracite and steam coal were generally in larger masses, a hopper could not be used, unless it was made of very large dimensions, and the steam coal being very friable, it was necessary to resort to some other plan. Accordingly, the waggons, which could be tilted at one end, were lowered on a balanced platform, to as near as practicable the hatchway of the ship, when the coal was allowed to slide out.

Mr. R. STEPHENSON, M.P., said, he had watched the progress of the works now in course of execution at the mouth of the Tyne, and they were so much at variance with his opinions respecting the action of tidal water in rivers, that he could not justify himself in remaining entirely silent on an occasion like the present. He took an active part, in the House of Commons, in opposing Sir James Graham, upon a clause which the Admiralty proposed to insert into the Bill for the Tyne Docks, founded upon a report which had been made to the Admiralty by two of its officers. The Jarrow Slake was a natural indentation in the channel of the river; and it was proposed that if the whole, or any portion of it, was enclosed, an obligation should be imposed upon the Dock Company to make a corresponding excavation, which would have amounted to about half a million cubic yards, in some other portion of the river, either opposite to the Slake, or higher up. He succeeded in carrying the House with him, and Sir James Graham withdrew the clause, which would have entailed upon the Dock Company an additional expenditure of £30,000. or £40,000. The docks were made, but after the works were commenced, the River Tyne Commissioners began to construct narrow solid piers, on each side of the entrance of the river, with a view to move the bar further into the sea; but he thought they would have the effect of contracting the trumpet-shaped mouth, and of reducing the quantity of tidal water entering the river. Instead of the momentum of the tidal wave being reduced by the enclosure of Jarrow Slake, he believed it would be increased, and that the tide would rise several inches higher, above Newcastle, than formerly; and in that view, the Tyne Docks would improve the régime of the river.

Mr. ABERNETHY said, it was highly important that the real facts of the case should be stated. It had been argued that, the Admiralty opposed the Jarrow Docks Bill merely upon the grounds that a certain quantity of water would be abstracted from the river by the formation of the docks. Now the Admiralty, as the public conservators of tidal rivers, held that the condition of the channel of the Tyne, and particularly of the bar at its entrance, was dependent mainly upon the quantity of water ebbing and flowing into, or out of the channel; and therefore, as a general principle, it was most essential to preserve the volume of tidal water, and not to diminish it. What the Admiralty said was, "If you abstract a certain quantity of water by the construction of these docks, compensate for that to the cubical amount you abstract by dredging, and we will not oppose your Bill." It was manifest that, if as public conservators they allowed an abstraction of water in one instance, they could not object to it in others; therefore they must make a stand and avoid a precedent. If the channel and the bar were dependent upon the volume of water passing up and down the river, care must be taken that the volume was increased rather than diminished.

Mr. R. STEPHENSON, M.P., replied, that no one would attempt to dispute the principle just laid down, that there should be no abstraction of water from tidal rivers. But he entirely dissented from the conclusions which appeared to be drawn from that principle, and he contended that by enclosing that large lake, which was formerly only 5 feet, or 6 feet deep at high-water, the water would not be prevented from entering, and further, that the momentum of the tidal wave being taken up near the mouth of the river, the height of the water in the upper part of the river would be increased.

Mr. BIDDER, *V.P.*, said, the abstract principle, that the quantity of tidal water in a river should be maintained, was so obvious, that it did not require further remark. But the question was, the best way of doing it. For the Admiralty to say, that because a hole existed in one part of a river, therefore when that area was enclosed, an excavation must be made in some other locality, to make up the amount of water, was an absurdity. It was well known that, the removal of Old London Bridge had had the effect of bringing more water up the river than 200 or 300 acres of inlet would have done. He contended that a large inlet, or slake, at the mouth of a harbour was a wrong thing. He had been frequently compelled by the Admiralty to spend money in a manner which could result in no benefit, either to the public, or to the parties whose money was spent. He had been obliged to build several bridges in that way, and on one occasion he had to spend £14,000 for a shifting bridge, which had never been opened from the time it was completed, and through which a vessel would probably never pass.

May 10 and 17, 1859.

JOHN HAWKSHAW, Vice-President,
in the Chair.

The Discussion upon Mr. Kingsbury's "Description of the Victoria (London) Docks," and upon Mr. Harrison's "Account of the Tyne Docks, &c.," was continued throughout both evenings.
