

that the surveyors were effectually prevented taking the levels by the light of day; and it was only at length accomplished at night by means of dark lanterns. There was one clergyman, who made such alarming demonstrations of his opposition, that the extraordinary expedient was resorted to of surveying his property during the time he was engaged in the pulpit. This was managed by having a strong force of surveyors in readiness to commence their operations, who entered the clergyman's grounds on one side the moment they saw him fairly off them on the other. By a well-organised and systematic arrangement each man concluded his allotted task just as the reverend gentleman concluded his sermon; so that, before he left the church, the deed was done, and the sinners had all decamped. Similar opposition was offered at many other points, but ineffectually. The laborious application of Robert Stephenson was such, that in examining the country to ascertain the best line, he walked the whole distance between London and Birmingham upwards of twenty times.

When the Bill went before the Committee of the Commons in 1832, a formidable array of evidence was produced. All the railway experience of the day was brought to bear in support of the measure, and all that interested opposition could do was set in motion against it. The necessity for an improved mode of communication between London and Birmingham was clearly demonstrated; and the engineering evidence was regarded as quite satisfactory. Not a single fact was proved against the utility of the measure, and the Bill passed the Committee, and afterwards the third reading in the Commons, by large majorities.

It was then sent to the Lords, and went into Committee, when a similar mass of testimony was again gone through. But scarcely had the proceedings been opened, when it became clear that the fate of the Bill

had been determined before a word of the evidence had been heard. At that time the committees were open to all peers; and the promoters of the measure found, to their dismay, many of the lords who were avowed opponents of the measure as landowners, sitting as judges to decide its fate. Their principal object seemed to be, to bring the proceedings to a termination as quickly as possible. An attempt at negotiation was made in the course of the proceedings in committee, but failed, and the Bill was thrown out, on the motion of Earl Brownlow, one of Lady Bridgewater's trustees; but though carried by a large majority, the vote was far from unanimous.

As the result had been foreseen, measures were taken to neutralise the effect of this decision as regarded future operations. Not less than 32,000*l.* had been expended in preliminary and parliamentary expenses up to this stage; but the promoters determined not to look back, and forthwith made arrangements for prosecuting the Bill in a future session. A meeting of the friends of the measure was held in London, attended by members of both Houses of Parliament and by leading bankers and merchants; when a series of resolutions was passed, declaring their conviction of the necessity for the railway, and deprecating the opposition by which it had been encountered. Lord Wharncliffe, who had acted as the chairman of the Lords' Committee, attributed the failure of the Bill entirely to the landowners; and Mr. Glyn subsequently declared that they had tried to smother it by the high price which they demanded for their property. It was determined to reintroduce the Bill in the following session (1833), and measures were taken to prosecute it vigorously. Strange to say, the Bill on this occasion passed both Houses silently and almost without opposition. The mystery was afterwards solved by the appearance of a circular issued by the directors of the Company, in which it

was stated, that they had opened negotiations with the most influential of their opponents; that "these measures had been successful to a greater extent than they had ventured to anticipate; and the most active and formidable had been conciliated." An instructive commentary on the mode by which these noble lords and influential landed proprietors had been "conciliated," was found in the simple fact that the estimate for land was nearly trebled, and that the owners were paid about 750,000*l.* for what had been originally estimated at 250,000*l.* The total expenses of carrying the Bill through Parliament amounted to the enormous sum of 72,868*l.*

The landowners having thus been "conciliated," the promoters of the measure were at length permitted to proceed with the formation of their great highway. Robert Stephenson was, with his father's sanction, appointed engineer-in-chief of the line, at a salary of 1500*l.* a year. He was now a married man, having become united to Miss Frances Sanderson in 1829, since which his home had been at Newcastle, near to the works there; but on receiving his new appointment, he removed with his wife to London, to a house on Haverstock Hill, where he resided during the execution of the Birmingham Railway.

Steps were at once taken to proceed with the working survey, to prepare the working drawings, and arrange for the prosecution of the undertaking. Eighty miles of the line were shortly under construction; the works were let (within the estimates) to contractors, who were necessarily for the most part new to such work. The business of railway construction was not then well understood. There were no leviathans among contractors as now, able to undertake the formation of a line of railway hundreds of miles in length; they were for the most part men of small capital and slender experience. Their tools and machinery were imperfect;

they did not understand the economy of time and piece labour; the workmen, as well as their masters, had still to learn their trade; and every movement of an engineer was attended with outlays, which were the inevitable result of a new system of things, but which each succeeding day's experience tended to diminish.

The difficulties encountered in the construction of this railway were thus very great ; the most formidable of them originating in the character of the works themselves. Extensive tunnels had to be driven through unknown strata, and miles of underground excavation had to be carried out in order to form a level road from valley to valley under the intervening ridges. This kind of work was the newest of all to the contractors of that day. Robert Stephenson's experience in the collieries of the North rendered him well fitted to grapple with such difficulties ; yet even he, with all his practical knowledge, could scarcely have foreseen the serious obstacles which he was called upon to encounter in executing the formidable cuttings, embankments, and tunnels of the London and Birmingham Railway. It would be an uninteresting, as it would be a fruitless task, to attempt to describe these works in detail ; but a general out-



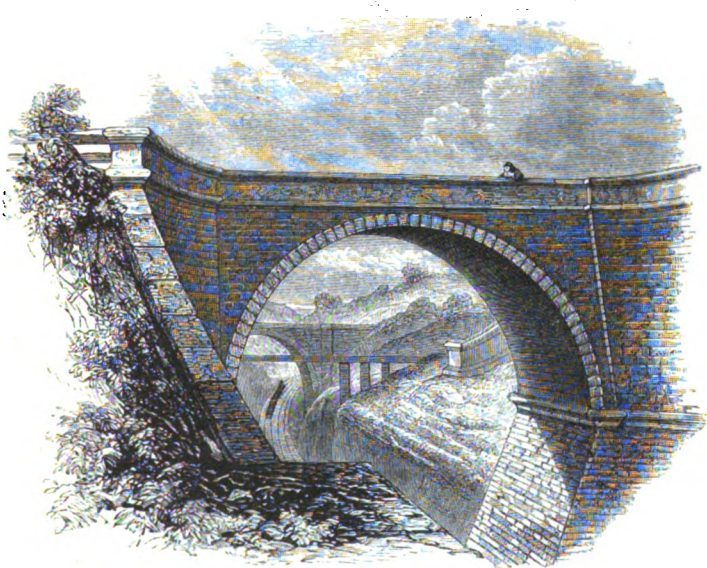
line of their extraordinary character and extent may not be out of place.

The length of railway to be constructed between London and Birmingham was $112\frac{1}{2}$ miles. The line crossed a series of low-lying districts separated from each other by considerable ridges of hills; and it was the object of the engineer to cross the valleys at as high an elevation, and the hills at as low a one as possible. The high ground was therefore cut down and the "stuff" led into embankments, in some places of great height and extent, so as to form a road upon as level a plane as was considered practicable for the working of the locomotive engine. In some places, the high grounds were passed in open cuttings, whilst in others it was necessary to bore through them in tunnels with deep cuttings at either end.

The most formidable excavations on the line are those at Tring, Denbigh Hall, and Blisworth. The Tring cutting is an immense chasm across the great chalk ridge of Ivinghoe. It is two miles and a half long, and for a quarter of a mile is fifty-seven feet deep. A million and a half cubic yards of chalk and earth were taken out of this cutting by means of horse-runs, and deposited in spoil banks; besides the immense quantity run into the embankment north of the cutting, forming a solid mound nearly six miles long and about thirty feet high. Passing over the Denbigh Hall cutting, and the Wolverton embankment of a mile and a half in length across the valley of the Ouse, we come to the excavation at Blisworth, a brief description of which will give the reader an idea of one of the most formidable kinds of railway work.

The Blisworth Cutting is a mile and a half long, in some places sixty-five feet deep, passing through earth, stiff clay, and hard rock. Not less than a million cubic yards of these materials were dug, quarried, and blasted out of it. One-third of the cutting was stone,

and beneath the stone lay a thick bed of clay, under which were found beds of loose shale so full of water that almost constant pumping was necessary at many points to enable the works to proceed. For a year and a half the contractor went on fruitlessly contending with these difficulties, and at length he was compelled to abandon the adventure. The engineer then took the works in hand for the Company, and they were vigor-



BLISWORTH CUTTING. [By Percival Skelton]

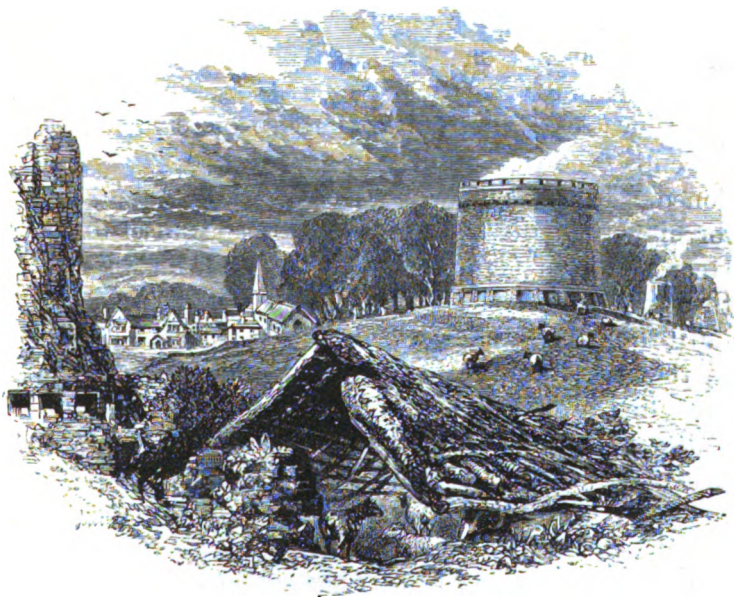
ously proceeded with. Steam-engines were set to work to pump out the water; two locomotives were put on, one at either end of the cutting, to drag away the excavated rock and clay; and eight hundred men and boys were employed along the work, in digging, wheeling, and blasting, besides a large number of horses. Some idea of the extent of the blasting operations may be formed from the fact that twenty-five barrels of gunpowder were exploded weekly; the total quantity used in forming this one excavation being about three thousand

barrels. Considerable difficulty was experienced in supporting the bed of rock cut through, which overlaid the clay and shale along either side of the cutting. It was found necessary to hold it up by strong retaining walls, to prevent the clay bed from bulging out, and these walls were further supported by a strong invert,—that is, an arch placed in an inverted position under the road,—thus binding together the walls on both sides. Behind the retaining walls, a drift or horizontal drain was run to enable the water to escape, and occasional openings were left in the walls themselves for the same purpose. The work was at length brought to a successful completion, but the extraordinary difficulties encountered in executing the undertaking had the effect of greatly increasing the cost of this portion of the railway.

The Tunnels on the line are eight in number, their total length being 7336 yards. The first high ground encountered was Primrose Hill, where the stiff London clay was passed through for a distance of about 1164 yards. The clay was close, compact, and dry, more difficult to work than stone itself. It was entirely free from water; but the absorbing properties of the clay were such that when exposed to the air it swelled out rapidly. Hence an unusual thickness of brick lining was found necessary; and the engineer afterwards informed the author that for some time he entertained an apprehension lest the pressure should force in the brickwork altogether, as afterwards happened in the case of the short Preston Brook tunnel upon the Grand Junction Railway, constructed by his father. The pressure behind the brickwork was so great, that it made the face of the bricks to fly off in minute chips which covered his clothes whilst he was inspecting the work. The materials used in the building were, however, of excellent quality; and the work was happily brought to a completion without accident.

At Watford the chalk ridge was penetrated by a tunnel about 1800 yards long; and at Northchurch, Lindslade, and Stowe Hill, there were other tunnels of minor extent. But the chief difficulty of the undertaking was the execution of that under the Kilsby ridge. Though not the largest, this is in many respects one of the most interesting works of the kind. It is about two thousand four hundred yards long, and runs at an average depth of about a hundred and sixty feet below the surface. The ridge under which it extends is of considerable extent, the famous battle of Naseby having been fought upon one of the spurs of the same high ground about seven miles to the eastward.

Previous to the letting of the contract, the character of the underground soil was fairly tested by trial shafts, which indicated that it consisted of shale of the lower oolite, and the works were let accordingly. But they had scarcely been commenced when it was discovered



LINE OF THE SHAFTS OVER KILSBY TUNNEL. [By Percival Skelton.]

that at an interval between the two trial-shafts, which had been sunk, about two hundred yards from the south end of the tunnel, there existed an extensive quicksand under a bed of clay forty feet thick, which the borings had escaped in the most singular manner. At the bottom of one of these shafts, the excavation and building of the tunnel were proceeding, when the roof at one part suddenly gave way, a deluge of water burst in, and the party of workmen with the utmost difficulty escaped with their lives. They were only saved by means of a raft, on which they were towed by one of the engineers swimming with the rope in his mouth to the lower end of the shaft, out of which they were safely lifted to the daylight.

The works were of course at that point immediately stopped. The contractor, who had undertaken the construction of the tunnel, was so overwhelmed by the calamity, that, though he was relieved by the Company from his engagement, he took to his bed and shortly after died. Pumping-engines were erected for the purpose of draining off the water, but for a long time it prevailed, and sometimes even rose in the shaft. The question arose, whether, in the face of so formidable a difficulty, the works should be proceeded with or abandoned. Robert Stephenson sent over to Alton Grange for his father, and the two took serious counsel together. George was in favour of pumping out the water from the top by powerful engines erected over each shaft, until the water was fairly mastered. Robert concurred in that view, and although other engineers who were consulted pronounced strongly against the practicability of the scheme and advised the abandonment of the enterprise, the directors authorised him to proceed; and powerful steam-engines were ordered to be constructed and delivered without loss of time.

In the mean time, Robert suggested to his father the expediency of running a drift along the heading from

the south end of the tunnel, with the view of draining off the water in that way. George said he thought it would scarcely answer, but that it was worth a trial, at all events until the pumping-engines were got ready. Robert accordingly gave orders for the drift to be proceeded with. The excavators were immediately set to work, and they had nearly reached the quicksand, when one day, while the engineer, his assistants, and the workmen were clustered about the open entrance of the drift way, they heard a sudden roar as of distant thunder. It was hoped that the water had burst in—for all the workmen were out of the drift,—and that the sand bed would now drain itself off in a natural way. Instead of which, very little water made its appearance; and on examining the inner end of the drift, it was found that the loud noise had been caused by the sudden discharge into it of an immense mass of sand, which had completely choked up the passage, and thus prevented the water from draining off.

The engineer now found that nothing remained but to sink numerous additional shafts over the line of the tunnel at the points at which it crossed the quicksand, and endeavour to master the water by sheer force of engines and pumps. The engines, which were shortly erected, possessed an aggregate power of 160 horses; and they went on pumping for eight months, emptying out an almost incredible quantity of water. It was found that the water, with which the bed of sand extending over many miles was charged, was in a great degree held back by the particles of the sand itself, and that it could only percolate through at a certain average rate. It appeared in its flow to take a slanting direction to the suction of the pumps, the angle of inclination depending upon the coarseness or fineness of the sand, and regulating the time of the flow. Hence the distribution of the pumping power at short intervals along the line of the tunnel had a much greater effect than the

concentration of that power at any one place. It soon appeared that the water had found its master. Protected by the pumps, which cleared a space for engineering operations—carried on, as it were, amidst two almost perpendicular walls of water and sand on either side—the workmen proceeded with the building of the tunnel at numerous points. Every exertion was used to wall in the dangerous parts as quickly as possible; the excavators and bricklayers labouring night and day until the work was finished. Even while under the protection of the immense pumping power above described, it often happened that the bricks were scarcely covered with cement ready for the setting, ere they were washed quite clean by the streams of water which poured from overhead. The men were accordingly under the necessity of holding over their work large whisks of straw and other appliances to protect the bricks and cement at the moment of setting.

The quantity of water pumped out of the sand bed during eight months of this incessant pumping, averaged two thousand gallons per minute, raised from an average depth of 120 feet. It is difficult to form an adequate idea of the bulk of the water thus raised, but it may be stated that if allowed to flow for three hours only, it would fill a lake one acre square to the depth of one foot, and if allowed to flow for an entire day it would fill the lake to over eight feet in depth, or sufficient to float vessels of a hundred tons' burthen. The water pumped out of the tunnel while the work was in progress would be nearly equivalent to the contents of the Thames at high water, between London and Woolwich. It is a curious circumstance, that notwithstanding the quantity of water thus removed, the level of the surface in the tunnel was only lowered about two and a half to three inches per week, showing the vast area of the quicksand, which probably extended along the entire ridge of land under which the railway passed.

The cost of the line was greatly increased by the difficulties thus encountered at Kilsby. The original estimate for the tunnel was only 99,000*l.* ; but by the time it was finished it had cost about 100*l.* per lineal yard forward, or a total of nearly 300,000*l.* The expenditure on the other parts of the line also greatly exceeded the amount first set down by the engineer ; and before the railway was complete, it had been more than doubled. The land cost three times more than the estimate ; and the claims for compensation were enormous. Although the contracts were let within the estimates, very few of the contractors were able to finish them without the assistance of the Company, and many became bankrupt. Speaking of the difficulties encountered during the construction of the line, Robert Stephenson subsequently observed to us :—" After the works were let, wages rose, the prices of materials of all kinds rose, and the contractors, many of whom were men of comparatively small capital, were thrown on their beam ends. Their calculations as to expenses and profits were completely upset. Let me just go over the list. There was Jackson, who took the Primrose Hill contract—he failed. Then there was the next length—Nowells ; then Copeland and Harding ; north of them Townsend, who had the Tring cutting ; next Norris, who had Stoke Hammond ; then Soars ; then Hughes : I think all of these broke down, or at least were helped through by the directors. Then there was that terrible contract of the Kilsby Tunnel, which broke the Nowells, and killed one of them. The contractors to the north of Kilsby were more fortunate, though some of them pulled through only with the greatest difficulty. Of the eighteen contracts in which the line was originally let, only seven were completed by the original contractors. Eleven firms were ruined by their contracts, which were relet to others at advanced prices, or were carried on and

finished by the Company. The principal cause of increase in the expense, however, was the enlargement of the stations. It appeared that we had greatly underestimated the traffic, and it accordingly became necessary to spend more and more money for its accommodation, until I think I am within the mark when I say that the expenditure on this account alone exceeded by eight or ten fold the amount of the Parliamentary estimate."

The magnitude of the works, which were unprecedented in England, was one of the most remarkable features in the undertaking. The following striking comparison has been made between this railway and one of the greatest works of ancient times. The great Pyramid of Egypt was, according to Diodorus Siculus, constructed by three hundred thousand—according to Herodotus, by one hundred thousand—men. It required for its execution twenty years, and the labour expended upon it has been estimated as equivalent to lifting 15,733,000,000 of cubic feet of stone one foot high. Whereas, if the labour expended in constructing the London and Birmingham Railway be in like manner reduced to one common denomination, the result is 25,000,000,000 of cubic feet *more* than was lifted for the Great Pyramid; and yet the English work was performed by about 20,000 men in less than five years. And whilst the Egyptian work was executed by a powerful monarch concentrating upon it the labour and capital of a great nation, the English railway was constructed, in the face of every conceivable obstruction and difficulty, by a company of private individuals out of their own resources, without the aid of Government or the contribution of one farthing of public money.

The labourers who executed these formidable works were in many respects a remarkable class. The "rail-

way navvies,"¹ as they were called, were men drawn by the attraction of good wages from all parts of the kingdom; and they were ready for any sort of hard work. Many of the labourers employed on the Liverpool line were Irish; others were from the Northumberland and Durham railways, where they had been accustomed to similar work; and some of the best came from the fen districts of Lincoln and Cambridge, where they had been trained to execute works of excavation and embankment. These old practitioners formed a nucleus of skilled manipulation and aptitude, which rendered them of indispensable utility in the immense undertakings of the period. Their expertness in all sorts of earthwork, in embanking, boring, and well-sinking—their practical knowledge of the nature of soils and rocks, the tenacity of clays, and the porosity of certain stratifications—were very great; and, rough-looking as they were, many of them were as important in their own department as the contractor or the engineer.

During the railway-making period the navvy wandered about from one public work to another—apparently belonging to no country and having no home. He usually wore a white felt hat with the brim turned up, a velveteen or jean square-tailed coat, a scarlet plush waistcoat with little black spots, and a bright-coloured kerchief round his herculean neck, when, as often happened, it was not left entirely bare. His corduroy breeches were retained in position by a leathern strap round the waist, and were tied and buttoned at the knee, displaying beneath a solid calf and foot encased in strong high-laced boots. Joining together in a "butty gang," some ten or twelve of these men would take a contract to cut out and remove so much "dirt"—as they denomi-

¹ The word "navvie," or "navigator," is supposed to have originated in the fact of many of these labourers having been originally employed in

making the navigations, or canals, the construction of which immediately preceded the railway era.

nated earth-cutting—fixing their price according to the character of the “stuff,” and the distance to which it had to be wheeled and tipped. The contract taken, every man put himself to his mettle : if any was found skulking, or not putting forth his full working power, he was ejected from the gang. Their powers of endurance were extraordinary. In times of emergency they would work for twelve and even sixteen hours, with only short intervals for meals. The quantity of flesh-meat which they consumed was something enormous ; but it was to their bones and muscles what coke is to the locomotive—the means of keeping up the steam. They displayed great pluck, and seemed to disregard peril. Indeed the most dangerous sort of labour—such as working horse-barrow runs, in which accidents are of constant occurrence—has always been most in request amongst them, the danger seeming to be one of its chief recommendations.

Working together, eating, drinking, and sleeping together, and daily exposed to the same influences, these railway labourers soon presented a distinct and well-defined character, strongly marking them from the population of the districts in which they laboured. Reckless alike of their lives as of their earnings, the navvies worked hard and lived hard. For their lodging, a hut of turf would content them ; and, in their hours of leisure, the meanest public-house would serve for their parlour. Unburdened, as they usually were, by domestic ties, unsoftened by family affection, and without much moral or religious training, the navvies came to be distinguished by a sort of savage manners, which contrasted strangely with those of the surrounding population. Yet, ignorant and violent though they might be, they were usually good-hearted fellows in the main—frank and open-handed with their comrades, and ready to share their last penny with those in distress. Their

pay-nights were often a saturnalia of riot and disorder, dreaded by the inhabitants of the villages along the line of works. The irruption of such men into the quiet hamlet of Kilsby must, indeed, have produced a very startling effect on the recluse inhabitants of the place. Robert Stephenson used to tell a story of the clergyman of the parish waiting upon the foreman of one of the gangs to expostulate with him as to the shocking impropriety of his men working during Sunday. But the head navvy merely hitched up his trowsers, and said, "Why, Soondays hain't cropt out here yet!" In short, the navvies were little better than heathens, and the village of Kilsby was not restored to its wonted quiet until the tunnel-works were finished, and the engines and scaffolding removed, leaving only the immense masses of *débris* around the line of shafts which extend along the top of the tunnel.



KILSBY TUNNEL. [North End]

CHAPTER XV.

MANCHESTER AND LEEDS, AND MIDLAND RAILWAYS — STEPHENSON'S LIFE AT ALTON — VISIT TO BELGIUM — GENERAL EXTENSION OF RAILWAYS AND THEIR RESULTS.

THE rapidity with which railways were carried out, when the spirit of the country became roused, was indeed remarkable. This was doubtless in some measure owing to the increased force of the current of speculation at the time, but chiefly to the desire which the public began to entertain for the general extension of the system. It was even proposed to fill up the canals, and convert them into railways. The new roads became the topic of conversation in all circles; they were felt to give a new value to time; their vast capabilities for "business" peculiarly recommended them to the trading classes; while the friends of "progress" dilated on the great benefits they would eventually confer upon mankind at large. It began to be seen that Edward Pease had not been exaggerating when he said, "Let the country but make the railroads, and the railroads will make the country!" They also came to be regarded as inviting objects of investment to the thrifty, and a safe outlet for the accumulations of inert men of capital. Thus new avenues of iron road were soon in course of formation, branching in all directions, so that the country promised in a wonderfully short space of time to become wrapped in one vast network of iron.

In 1836 the Grand Junction Railway was under construction between Warrington and Birmingham—the northern part by Mr. Stephenson, and the southern by Mr. Rastrick. The works on that line embraced heavy

cuttings, long embankments, and numerous viaducts; but none of these are worthy of any special description. Perhaps the finest piece of masonry on the railway is the Dutton Viaduct across the valley of the Weaver. It consists of 20 arches of 60 feet span, springing 16 feet from the perpendicular shaft of each pier, and 60 feet in height from the crown of the arches to the level of the river. The foundations of the piers were built on piles driven 20 feet deep. The structure has a solid and majestic appearance, and is perhaps the finest of George Stephenson's viaducts.



THE DUTTON VIADUCT

The Manchester and Leeds line was in progress at the same time,—an important railway connecting Yorkshire and Lancashire, passing through a district full of manufacturing towns and villages, the hives of population, industry, and enterprise. An attempt was made to obtain the Act as early as the year 1831; but its promoters were defeated by the powerful opposition of the landowners aided by the canal companies, and the project was not revived for several years. The Act authorising the construction of the line was obtained in

1836; it was amended in the following year, and the first ground was broken on the 18th of August, 1837.

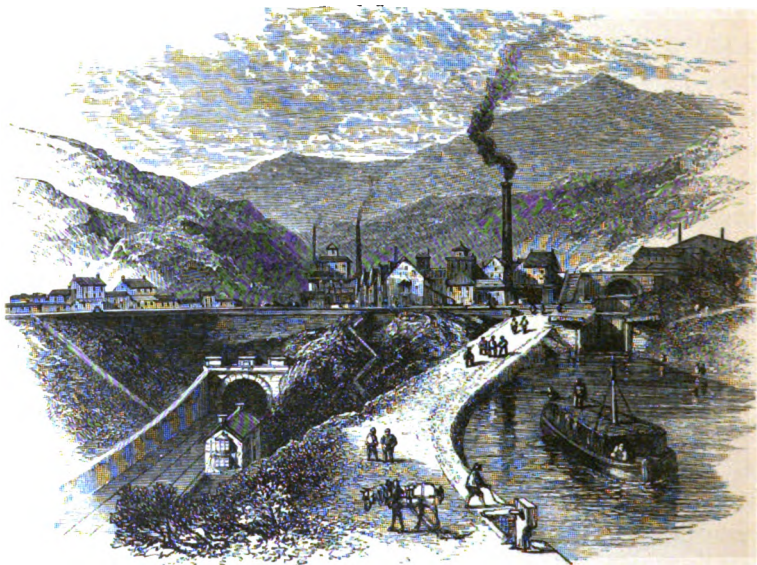
An incident occurred while the second Manchester and Leeds Bill was before the Committee of the Lords, which is worthy of passing notice in this place, as illustrative of George Stephenson's character. The line which was authorised by Parliament in 1836 had been hastily surveyed within a period of less than six weeks, but before it received the royal assent the engineer became convinced that many important improvements might be made in it, and he communicated his views to the directors. They determined, however, to obtain the Act, although conscious at the time that they would have to go for a second and improved line in the following year. The second Bill passed the Commons in 1837 without difficulty, and was expected in like manner to pass the Lords' Committee. Quite unexpectedly, however, Lord Wharnccliffe, who was interested in the Manchester and Sheffield line, which passed through his colliery property in the south of Yorkshire, conceiving that the new Manchester and Leeds line might have some damaging effect upon it, appeared as an opponent of the Bill. Himself a member of the Committee, he adopted the unusual course of rising to his feet, and making a set speech against the measure while the engineer was under examination. He alleged that the Act obtained in the preceding session was one that the promoters had no intention of carrying out, that they had only secured it for the purpose of obtaining possession of the ground and reducing the number of the opponents to their present application, and that in fact they had been practising a deception upon the House. Then, turning full round upon the witness, he said, "I ask you, sir, do you call that conduct *honest*?" Stephenson, his voice trembling with emotion, replied, "Yes, my Lord, I *do* call it honest. And I will ask your Lordship, whom I served for many years as your

enginewright at the Killingworth Collieries, did you ever know me to do anything that was not strictly honourable? You know what the collieries were when I went there, and you know what they were when I left them. Did you ever hear that I was found wanting when honest services were wanted, or when duty called me? Let your Lordship but fairly consider the circumstances of the case, and I feel persuaded you will admit that my conduct has been equally honest throughout in this matter." He then briefly but clearly stated the history of the application to Parliament for the Act, which was so satisfactory to the Committee that they passed the preamble of the Bill without further objection; and Lord Wharncliffe requested that the Committee would permit his observations to be erased from the record of the evidence, which, as an acknowledgment of his error, was allowed. Lord Kenyon and several other members of the Committee afterwards came up to Mr. Stephenson, shook him by the hand, and congratulated him on the manly way in which he had vindicated himself from the aspersions attempted to be cast upon him.

In conducting this project to an issue, the engineer had the usual opposition and prejudices to encounter. Predictions were confidently made in many quarters that the line could never succeed. It was declared that the utmost engineering skill could not construct a railway through such a country of hills and hard rocks; and it was maintained that, even if the railway were practicable, it could only be made at a cost altogether ruinous.

During the progress of the works, as the Summit Tunnel near Littleborough was approaching completion, the rumour was spread abroad in Manchester that the tunnel had fallen in and buried a number of the workmen. The last arch had been keyed in, and the work was all but finished, when a slight accident occurred which was thus exaggerated by the lying tongue of

rumour. An invert had given way through the irregular pressure of the surrounding earth and rock at a part of the tunnel where a "fault" had occurred in the strata.

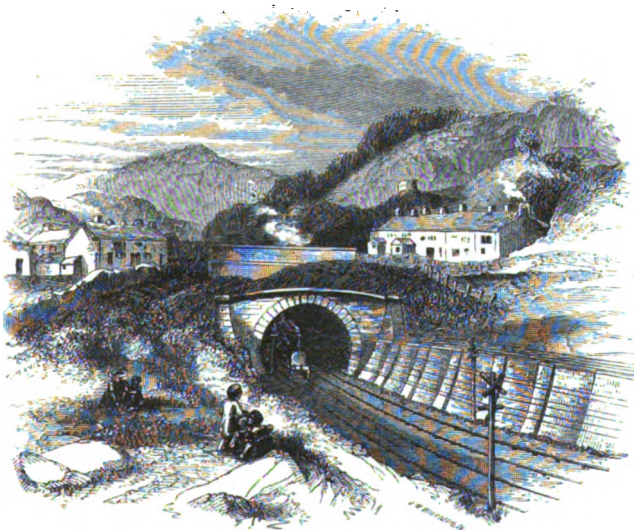


ENTRANCE TO THE SUMMIT TUNNEL, LITTLEBOROUGH

[By Percival Skelton]

A party of the directors accompanied the engineer to inspect the scene of the accident. They entered the tunnel mouth preceded by upwards of fifty navvies, each bearing a torch. After walking a distance of about half a mile, the inspecting party arrived at the scene of the "frightful accident," about which so much alarm had been spread abroad. All that was visible was a certain unevenness of the ground, which had been forced up by the invert under it giving way; thus the ballast had been loosened, the drain running along the centre of the road had been displaced, and small pools of water stood about. But the whole of the walls and the roof were still as perfect as at any other part of the tunnel. The engineer explained the cause of the

accident; the blue shale, he said, through which the excavation passed at that point, was considered so hard and firm, as to render it unnecessary to build the invert very strong there. But shale is always a deceptive material. Subjected to the influence of the atmosphere, it gives but a treacherous support. In this case, falling away like quicklime, it had left the lip of the invert alone to support the pressure of the arch above, and hence its springing inwards and upwards. Stephenson then directed the attention of the visitors to the completeness of the arch overhead, where not the slightest fracture or yielding could be detected. Speaking of the work, in the course of the same day, he said, "I will stake my character, my head, if that tunnel ever give way, so as to cause danger to any of the public passing through it. Taking it as a whole, I don't think there is such another piece of work in the world. It is the greatest work that has yet been done of this kind, and there has been less repairing than is usual,—though an engineer might well be beaten in his calcu-



THE LITTLEBOROUGH TUNNEL [The Walsden End]



lations, for he cannot beforehand see into those little fractured parts of the earth he may meet with." As Stephenson had promised, the invert was put in; and the tunnel was made perfectly safe.

The construction of this subterranean road employed the labour of above a thousand men for nearly four years. Besides excavating the arch out of the solid rock, they used 23,000,000 of bricks, and 8000 tons of Roman cement in the building of the tunnel. Thirteen stationary engines, and about 100 horses, were also employed in drawing the earth and stone out of the shafts. Its entire length is 2869 yards, or nearly a mile and three-quarters,—exceeding the famous Kilsby Tunnel by 471 yards.

The Midland Railway was a favourite line of Mr. Stephenson's for several reasons. It passed through a rich mining district, in which it opened up many valuable coal-fields, and it formed part of the great main line of communication between London and Edinburgh. The line was originally projected by gentlemen interested in the London and Birmingham Railway. Their intention was to

extend that line from Rugby to Leeds; but, finding themselves anticipated in part by the projection of the Midland Counties Railway from Rugby to Derby, they confined themselves to the district between Derby and Leeds; and in 1835, a Company was formed to construct the North Midland line, with George Stephenson for its engineer. The Act was obtained in 1836, and the first ground was broken in February, 1837.

Although the Midland Railway was only one of the many great works of the same kind executed at that time, it was almost enough of itself to be the achievement of a life. Compare it, for example, with Napoleon's military road over the Simplon, and it will at once be seen how greatly it excels that work, not only in the constructive skill displayed in it, but also in its cost and magnitude, and the amount of labour employed in its formation. The road of the Simplon is 45 miles in length; the North Midland Railway $72\frac{1}{2}$ miles. The former has 50 bridges and 5 tunnels, measuring together 1338 feet in length; the latter has 200 bridges and 7 tunnels, measuring together 11,400 feet, or about $2\frac{1}{4}$ miles. The former cost about 720,000*l.* sterling, the latter above 3,000,000*l.* Napoleon's grand military road was constructed in six years, at the public cost of the two great kingdoms of France and Italy; while Stephenson's railway was formed in about three years, by a company of private merchants and capitalists out of their own funds, and under their own superintendence.

It is scarcely necessary that we should give any account in detail of the North Midland works. The making of one tunnel so much resembles the making of another,—the building of bridges and viaducts, no matter how extensive, so much resembles the building of others,—the cutting out of “dirt,” the blasting of rocks, and the wheeling of excavation into embankments, is so much matter of mere time and hard work,—that it is quite unnecessary to detain the reader by

any attempt at their description. Of course there were the usual difficulties to encounter and overcome,—but the railway engineer regarded these as mere matters of course, and would probably have been disappointed if they had not presented themselves.

On the Midland, as on other lines, water was the great enemy to be fought against,—water in the Clay-cross and other tunnels,—water in the boggy or sandy foundations of bridges,—and water in cuttings and embankments. As an illustration of the difficulties of



LAND-SLIP ON NORTH MIDLAND LINE.
NEAR AMBERGATE.

bridge building, we may mention the case of the five-arch bridge over the Derwent, where it took two years' work, night and day, to get in the foundations of the piers alone. Another curious illustration of the mischief done by water in cuttings may be briefly mentioned. At a part of the North Midland line, near Ambergate, it was necessary to pass along a hillside in a cutting a few

yards deep. As the cutting proceeded, a seam of shale was cut across, lying at an inclination of 6 to 1; and shortly after, the water getting behind it, the whole mass of earth along the hill above began to move down across the line of excavation. The accident completely upset the estimates of the contractor, who, instead of

fifty thousand cubic yards, found that he had about five hundred thousand to remove ; the execution of this part of the railway occupying fifteen months instead of two.

The Oakenshaw cutting near Wakefield was also of a very formidable character. About six hundred thousand yards of rock shale and bind were quarried out of it, and led to form the adjoining Oakenshaw embankment. The Normanton cutting was almost as heavy, requiring the removal of four hundred thousand yards of the same kind of excavation into embankment and spoil. But the progress of the works on the line was so rapid during 1839, that no less than 450,000 cubic yards of excavation were accomplished per month.



BULL-BRIDGE, NEAR AMBERGATE.

As a curiosity in construction, we may also mention a very delicate piece of work executed on the same railway at Bullbridge in Derbyshire, where the line at the same point passes *over* a bridge which here spans the river Amber, and *under* the bed of the Cromford Canal.

Water, bridge, railway, and canal, were thus piled one above the other, four stories high. In order to prevent the possibility of the waters of the canal breaking in upon the railway works, Stephenson had an iron trough made, 150 feet long, of the width of the canal, and exactly fitting the bottom. It was brought to the spot in three pieces, which were firmly welded together, and the trough was then floated into its place and sunk; the whole operation being completed without in the least interfering with the navigation of the canal. The railway works underneath were then proceeded with and finished.

Another line of the same series, constructed by George Stephenson, was the York and North Midland, extending from Normanton—a point on the Midland Railway—to York; but it was a line of easy formation, traversing a comparatively level country. The inhabitants of Whitby, as well as York, were projecting a railway to connect these towns as early as 1832; and in the year following, Whitby succeeded in obtaining a horse line of twenty-four miles, connecting it with the small market-town of Pickering. The York citizens were more ambitious, and agitated the question of a locomotive line to connect them with the town of Leeds. Stephenson recommended them to connect their line with the Midland at Normanton, and they adopted his advice. The Company was formed, the shares were at once subscribed for, the Act was obtained in the following year, and the works were constructed without difficulty.

As the best proof of his conviction that the York and North Midland would prove a good investment, Stephenson invested in it a considerable portion of his savings, being a subscriber for 420 shares. The interest taken in this line by the engineer was on more than one occasion specially mentioned by Mr. Hudson, then Lord Mayor of York, as an inducement to other persons

of capital to join the undertaking; and had it not been afterwards encumbered and overlaid by comparatively useless and profitless branches, in the projection of which Stephenson had no part, the sanguine expectations which he early formed of the paying qualities of that railway would have been more than realised.

There was one branch, however, of the York and North Midland Line in which he took an anxious interest, and of which he may be said to have been the projector—the branch to Scarborough; which proved one of the most profitable parts of the railway. He was so satisfied of its value, that, at a meeting of the York and North Midland proprietors, he volunteered his gratuitous services as engineer until the Company was formed, in addition to subscribing largely to the undertaking. At that meeting he took an opportunity of referring to the charges brought against engineers of so greatly exceeding the estimates:—"He had had a good deal to do with making out the estimate of the North Midland Railway, and he believed there never was a more honest one. He had always endeavoured to state the truth as far as was in his power. He had known a contractor, who, when he (Mr. Stephenson) had sent in an estimate, came forward and said, 'I can do it for half the money.' The contractor's estimate went into Parliament, but it came out his. He could go through the whole list of the undertakings in which he had been engaged, and show that he had never had anything to do with stock-jobbing concerns. He would say that he would not be concerned in any scheme, unless he was satisfied that it would pay the proprietors: and in bringing forward the proposed line to Scarborough, he was satisfied that it would pay, or he would have had nothing to do with it."

During the time that our engineer was engaged in superintending the execution of these undertakings,

he was occupied upon other projected railways in various parts of the country. He surveyed several lines in the neighbourhood of Glasgow, and afterwards alternative routes along the east coast from Newcastle to Edinburgh, with the view of completing the main line of communication with London. When out on foot in the fields, on these occasions, he was ever foremost in the march; and he delighted to test the prowess of his companions by a good jump at any hedge or ditch that lay in their way. His companions used to remark his singular quickness of observation. Nothing escaped his attention—the trees, the crops, the birds, or the farmer's stock; and he was usually full of lively conversation, everything in nature affording him an opportunity for making some striking remark, or propounding some ingenious theory. When taking a flying survey of a new line, his keen observation proved very useful, for he rapidly noted the general configuration of the country and inferred its geological structure. He afterwards remarked to a friend, "I have planned many a railway travelling along in a postchaise, and following the natural line of the country." And it was remarkable that his first impressions of the direction to be taken almost invariably proved correct; and there are few of the lines surveyed and recommended by him which have not been executed, either during his lifetime or since. As an illustration of his quick and shrewd observation on such occasions, we may mention that when employed to lay out a line to connect Manchester, through Macclesfield, with the Potteries, the gentleman who accompanied him on the journey of inspection cautioned him to provide large accommodation for carrying off the water, observing—"You must not judge by the appearance of the brooks; for after heavy rains these hills pour down volumes of water, of which you can have no conception." "Pooh! pooh! *don't I see your bridges?*" replied the

engineer. He had noted the details of each as he passed along.

Among the other projects which occupied his attention about the same time, were the projected lines between Chester and Holyhead, between Leeds and Bradford, and between Lancaster and Maryport by the west coast. This latter was intended to form part of a western line to Scotland; Stephenson favouring it partly because of the flatness of the gradients, and because it could be formed at comparatively small cost, while it would open out a valuable iron-mining district, from which a large traffic in ironstone was expected. One of its collateral advantages, in the engineer's opinion, was, that by forming the railway directly across Morecambe Bay, on the north-west coast of Lancashire, a large tract of valuable land might be reclaimed from the sea, the sale of which would considerably reduce the cost of the works. He estimated that by means of a solid embankment across the bay, not less than 40,000 acres of rich alluvial land would be gained. He proposed to carry the road across the ten miles of sands which lie between Poulton, near Lancaster, and Humphrey Head on the opposite coast, forming the line in a segment of a circle of five miles' radius. His plan was to drive in piles across the entire length, forming a solid fence of stone blocks on the land side for the purpose of retaining the sand and silt brought down by the rivers from the interior. The embankment would then be raised from time to time as the deposit accumulated, until the land was filled up to high-water mark; provision being made, by means of sufficient arches, for the flow of the river waters into the bay. The execution of the railway after this plan would, however, have occupied more years than the promoters of the West Coast line were disposed to wait; and eventually Mr. Locke's more direct but less level line by Shap Fell was adopted. A railway

has, however, since been carried across the head of the bay, in a modified form, by the Ulverstone and Lancaster Railway Company; and it is not improbable that Stephenson's larger scheme of reclaiming the vast tract of land now left bare at every receding tide, may yet be carried out.

While occupied in carrying out the great railway undertakings which we have above so briefly described, George Stephenson's home continued, for the greater part of the time, to be at Alton Grange, near Leicester. But he was so much occupied in travelling about from one committee of directors to another—one week in England, another in Scotland, and probably the next in Ireland,—that he often did not see his home for weeks together. He had also to make frequent inspections of the various important and difficult works in progress, especially on the Midland and Manchester and Leeds lines; besides occasionally going to Newcastle to see how the locomotive works were going on there. During the three years ending 1837—perhaps the busiest years of his life¹—he travelled by postchaise alone upwards of 20,000 miles, and yet not less than six months out of the three years were spent in London. Hence there is comparatively little to record of Mr. Stephenson's private life at this period; during which he had scarcely a moment that he could call his own.

To give an idea of the number of projects which at this time occupied our engineer's attention, and of the extent and rapidity of his journeys, we subjoin from his private secretary's journal the following epitome of one

¹ During this period he was engaged on the North Midland, extending from Derby to Leeds; the York and North Midland, from Normanton to York; the Manchester and Leeds; the Birmingham and Derby, and the Sheffield and Rotherham Railways; the whole of these, of which

he was principal engineer, having been authorised in 1836. In that session alone, powers were obtained for the construction of 214 miles of new railways under his direction, at an expenditure of upwards of five millions sterling.

of them, on which he entered immediately after the conclusion of the heavy parliamentary session of 1836.

“August 9th.—From Alton Grange to Derby and Matlock ; and forward by mail to Manchester, to meet the committee of the South Union Railway. August 10th.—Manchester to Stock port, to meet Committee of the Manchester and Leeds Railway ; thence to meet directors of the Chester and Birkenhead, and Chester and Crewe Railways. August 11th.—Liverpool to Woodside, to meet committee of the Chester and Birkenhead line ; journey with them along the proposed railway to Chester ; then back to Liverpool. August 12th.—Liverpool to Manchester, to meet directors of the Manchester and Leeds Railway, and travelling with them over the works in progress. August 13th.—Continued journey over the works, and arrival at Wakefield ; thence to York. August 14th.—Meeting with Mr. Hudson at York, and journey from York to Newcastle. August 15th.—At Newcastle, working up arrears of correspondence. August 16th.—Meeting with Mr. Brandling, as to the station for the Brandling Junction at Gateshead, and stations at other parts of the line. August 17th.—Carlisle to Wigton and Maryport, examining the railway. August 19th.—Maryport to Carlisle, continuing the inspection. August 20th.—At Carlisle, examining the ground for a station ; and working up correspondence. August 21st.—Carlisle to Dumfries by mail ; forward to Ayr by chaise, proceeding up the valley of the Nith, through Thornhill, Sanquhar, and Cumnock. August 22nd.—Meeting with promoters of the Glasgow, Kilmarnock, and Ayr Railway, and journey along the proposed line ; meeting with the magistrates of Kilmarnock at Beith, and journey with them over Mr. Gale’s proposed line to Kilmarnock. August 23rd.—From Kilmarnock along Mr. Miller’s proposed line to Beith, Paisley, and Glasgow. August 24th.—Examination of site of proposed station at Glasgow ; meeting with the directors ; then from Glasgow, by Falkirk and Linlithgow, to Edinburgh, meeting there with Mr. Grainger, engineer, and several of the committee of the proposed Edinburgh and Dunbar Railway. August 25th.—Examining the site of the proposed station at Edinburgh ; then to Dunbar, by Portobello and Haddington, examining the proposed line of railway. August 26th.—Dunbar to Tommy Grant’s, to examine the summit of the country towards Berwick, with a view to a through line to Newcastle ; then return to Edinburgh. August

27th.—At Edinburgh, meeting the provisional committee of the proposed Edinburgh and Dunbar Railway. August 28th.—Journey from Edinburgh, through Melrose and Jedburgh, to Horsley, along the route of Mr. Richardson's proposed railway across Carter Fell. August 29th.—From Horsley to Mr. Brandling's, then on to Newcastle; engaged on the Brandling Junction Railway. August 30th.—Engaged with Mr. Brandling; after which, meeting a deputation from Maryport. August 31st.—Meeting with Mr. Brandling and others as to the direction of the Brandling Junction in connexion with the Great North of England line, and the course of the railway through Newcastle; then on to York. September 1st.—At York; meeting with York and North Midland directors; then journeying over Lord Howden's property, to arrange for a deviation; examining the proposed site of the station at York. September 2nd.—At York, giving instructions as to the survey; then to Manchester by Leeds. September 3rd.—At Manchester; journey to Stockport, with Mr. Bidder and Mr. Bourne, examining the line to Stockport, and fixing the crossing of the river there; attending to the surveys; then journey back to Manchester, to meet the directors of the Manchester and Leeds Railway. September 4th.—Sunday at Manchester. September 5th.—Journey along part of the Manchester and Leeds Railway. September 6th.—At Manchester, examining and laying down the section of the South Union line to Stockport; afterwards engaged on the Manchester and Leeds working plans, in endeavouring to give a greater radius to the curves; seeing Mr. Seddon about the Liverpool, Manchester, and Leeds Junction Railway. September 7th.—Journey along the Manchester and Leeds line, then on to Derby. September 8th.—At Derby; seeing Mr. Carter and Mr. Beale about the Tamworth deviation; then home to Alton Grange. September 10th.—At Alton Grange, preparing report to the committee of the Edinburgh and Dunbar Railway."

Such is a specimen of the enormous amount of physical and mental labour undergone by the engineer during the busy years above referred to. He was no sooner home than he was called away again by some other railway or business engagement. Thus, in four days after his arrival at Alton Grange from the above journey into Scotland, we find him going over

the whole of the North Midland line as far as Leeds ; then by Halifax to Manchester, where he stayed for several days on the business of the South Union line ; then to Birmingham and London ; back to Alton Grange, and next day to Congleton and Leek ; thence to Leeds and Goole, and home again by the Sheffield and Rotherham and the Midland works. And early in the following month (October) he was engaged in the north of Ireland, examining the line, and reporting upon the plans, of the projected Ulster Railway. He was also called upon to inspect and report upon colliery works, salt works, brass and copper works, and such like, in addition to his own colliery and railway business. He usually also staked out himself the lines laid out by him, which involved a good deal of labour since undertaken by assistants. And occasionally he would run up to London, attending in person to the preparation and depositing of the plans and sections of the projected undertakings for which he was engaged as engineer.

His correspondence increased so much, that he found it necessary to engage a private secretary, who accompanied him on his journeys. He was himself exceedingly averse to writing letters. The comparatively advanced age at which he learnt the art of writing, and the nature of his duties while engaged at the Killingworth Colliery, precluded that facility in correspondence which only constant practice can give. He gradually, however, acquired great facility in dictation, and had also the power of labouring continuously at this work ; the gentleman who acted as his secretary in the year 1835, having informed us that during his busy season he one day dictated no fewer than thirty-seven letters, several of them embodying the results of much close thinking and calculation. On another occasion, he dictated reports and letters for twelve continuous hours, until his secretary was ready to drop off his chair from sheer exhaustion, and at length pleaded for a suspen-

sion of the labour. This great mass of correspondence, though closely bearing on the subjects under discussion, was not, however, of a kind to supply the biographer with matter for quotation, or to give that insight into the life and character of the writer which the letters of literary men so often furnish. They were, for the most part, letters of mere business, relating to works in progress, parliamentary contests, new surveys, estimates of cost, and railway policy,—curt, and to the point; in short, the letters of a man every moment of whose time was precious.

Fortunately George Stephenson possessed a facility of sleeping, which enabled him to pass through this enormous amount of fatigue and labour without injury to his health. He had been trained in a hard school, and could bear with ease conditions which, to men more softly nurtured, would have been the extreme of physical discomfort. Many, many nights he snatched his sleep while travelling in his chaise; and at break of day he would be at work, surveying until dark, and this for weeks in succession. His whole powers seemed to be under the control of his will, for he could wake at any hour, and go to work at once. It was difficult for secretaries and assistants to keep up with such a man.

It is pleasant to record that in the midst of these engrossing occupations, his heart remained as soft and loving as ever. In spring-time he would not be debarred of his boyish amusement of bird-nesting; but would go rambling along the hedges spying for nests. In the autumn he went nutting, and when he could snatch a few minutes he indulged in his old love of gardening. His uniform kindness and good temper, and his communicative, intelligent disposition, made him a great favourite with the neighbouring farmers, to whom he would volunteer much valuable advice on agricultural operations, drainage, ploughing, and labour-

saving processes. Sometimes he took a long rural ride on his favourite "Bobby," now growing old, but as fond of his master as ever. Towards the end of his life "Bobby" lived in clover, his master's pet, doing no work; and he died at Tapton in 1845, more than twenty years old.

During one of George's brief sojourns at the Grange, he found time to write to his son a touching account of a pair of robins that had built their nest within one of the empty upper chambers of the house. One day he observed a robin fluttering outside the windows, and beating its wings against the panes, as if eager to gain admission. He went up stairs, and there found, in a retired part of one of the rooms, a robin's nest, with one of the parent birds sitting over three or four young—all dead. The excluded bird outside still beat against the panes; and on the window being let down, it flew into the room, but was so exhausted that it dropped upon the floor. Stephenson took up the bird, carried it down stairs, and had it warmed and fed. The poor robin revived, and for a time was one of his pets. But it shortly died too, as if unable to recover from the privations it had endured during its three days' fluttering and beating at the windows. It appeared that the room had been unoccupied, and the sash having been let down, the robins had taken the opportunity of building their nest within it; but the servant having closed the window again, the calamity befell the birds which so strongly excited the engineer's sympathies. An incident such as this, trifling though it may seem, gives a true key to the heart of a man.

The amount of his Parliamentary business having greatly increased with the projection of new lines of railway, the Stephensons found it necessary to set up an office in London in 1836. George's first office was at No. 9, Duke-street, Westminster, from whence he removed in the following year to 30½, Great George-

street. That office was the busy scene of railway politics for several years. There consultations were held, schemes were matured, deputations were received, and many projectors called upon our engineer for the purpose of submitting to him their plans of railways and railway working. His private secretary at the time has informed us that at the end of the first Parliamentary session in which he had been engaged as engineer for more Companies than one, it became necessary for him to give instructions as to the preparation of the accounts to be rendered to the several Companies. In the simplicity of his heart, he directed Mr. Binns to take his full time at the rate of ten guineas a day, and charge the Railway Companies in the proportion in which he had actually been employed in their respective business during each day. When Robert heard of this instruction, he went directly to his father and expostulated with him against this unprofessional course; and, other influences being brought to bear upon him, George at length reluctantly consented to charge as other engineers did, an entire day's fee to each of the Companies for which he was concerned while their business was going forward; but he cut down the number of days charged for, and reduced the daily amount from ten to seven guineas.

Besides his journeys at home, George Stephenson was on more than one occasion called abroad on railway business. Thus, at the desire of King Leopold, he made several visits to Belgium to assist the Belgian engineers in laying out the national lines of the kingdom. That enlightened monarch at an early period discerned the powerful instrumentality of railways in developing a country's resources, and he determined at the earliest possible period to adopt them as the great high-roads of the nation. The country, being rich in coals and minerals, had great manufacturing capabilities. It had good ports, fine navigable rivers, abundant canals, and

a teeming, industrious population. Leopold perceived that railways were eminently calculated to bring the industry of the country into full play, and to render the riches of the provinces available to the rest of the kingdom. He therefore openly declared himself the promoter of public railways throughout Belgium. A system of lines was projected, at his instance, connecting Brussels with the chief towns and cities of the state; extending from Ostend eastward to the Prussian frontier, and from Antwerp southward to the French frontier.

Mr. Stephenson and his son, as the leading railway engineers of England, were consulted by the King, in 1835, as to the best mode of carrying out his intentions. In the course of that year they visited Belgium, and had several interesting conferences with Leopold and his ministers on the subject of the proposed railways. The King then appointed George Stephenson by royal ordinance a Knight of the Order of Leopold. At the invitation of the monarch, Mr. Stephenson made a second visit to Belgium in 1837, on the occasion of the public opening of the line from Brussels to Ghent. At Brussels there was a public procession, and another at Ghent on the arrival of the train. Stephenson and his party accompanied it to the Public Hall, there to dine with the chief Ministers of State, the municipal authorities, and about five hundred of the principal inhabitants of the city; the English Ambassador being also present. After the King's health and a few others had been drunk, that of Mr. Stephenson was proposed; on which the whole assembly rose up, amidst great excitement and loud applause, and made their way to where he sat, in order to "jingle glasses" with him, greatly to his own amazement. On the day following, our engineer dined with the King and Queen at their own table at Laaken, by special invitation; afterwards accompanying his Majesty and suite to a public ball,

given by the municipality of Brussels, in honour of the opening of the line to Ghent, as well as of their distinguished English guests. On entering the room, the general and excited inquiry was, "Which is Stephenson?" The English engineer had not before imagined that he was esteemed to be so great a man.

The London and Birmingham Railway having been completed in September, 1838, after being about five years in progress, the great main system of railway communication between London, Liverpool, and Manchester was then opened to the public. For some months previously, the line had been partially open, coaches performing the journey between Denbigh Hall (near Wolverton) and Rugby,—the works of the Kilsby tunnel being still incomplete. It was already amusing to hear the complaints of the travellers about the slowness of the coaches as compared with the railway, though the coaches travelled at a speed of eleven miles an hour. The comparison of comfort was also greatly to the disparagement of the coaches. Then the railway train could accommodate any quantity, whereas the road conveyances were limited; and when a press of travellers occurred—as on the occasion of the Queen's coronation—the greatest inconvenience was experienced; as much as 10*l.* having been paid for a seat on a donkey-chaise between Rugby and Denbigh. On the opening of the railway throughout, of course all this inconvenience and delay was brought to an end.

Numerous other openings of railways constructed by George Stephenson took place about the same time. The Birmingham and Derby line was opened for traffic in August, 1839; the Sheffield and Rotherham in November, 1839; and in the course of the following year, the Midland, the York and North Midland, the Chester and Crewe, the Chester and Birkenhead, the Manchester and Birmingham, the Manchester and Leeds, and the Maryport and Carlisle railways, were all pub-

licly opened in whole or in part. Thus 321 miles of railway (exclusive of the London and Birmingham) constructed under Mr. Stephenson's superintendence, at a cost of upwards of eleven millions sterling, were, in the course of about two years, added to the traffic accommodation of the country.

The ceremonies which accompanied the public opening of these lines were often of an interesting character. The adjoining population held general holiday; bands played, banners waved, and assembled thousands cheered the passing trains amidst the occasional booming of cannon. The proceedings were usually wound up by a public dinner; and in the course of his speech which followed, Mr. Stephenson would revert to his favourite topic—the difficulties which he had early encountered in the promotion of the railway system, and in establishing the superiority of the locomotive. On such occasions he always took great pleasure in alluding to the services rendered to himself and the public by the young men brought up under his eye—his pupils at first, and afterwards his assistants. No great master ever possessed a more devoted band of assistants and fellow-workers than he did. And it was one of the most marked evidences of his admirable tact and judgment that he selected, with such undeviating correctness, the men best fitted to carry out his plans. Indeed, the ability to accomplish great things, to carry grand ideas into practical effect, depends in no small measure on that intuitive knowledge of character which our engineer possessed in so remarkable a degree.

At the dinner at York, which followed the partial opening of the York and North Midland Railway, Mr. Stephenson said, "he was sure they would appreciate his feelings when he told them, that when he first began railway business his hair was black, although it was now grey; and that he began his life's labour as but a poor ploughboy. About thirty years since, he

had applied himself to the study of how to generate high velocities by mechanical means. He thought he had solved that problem ; and they had for themselves seen, that day, what perseverance had brought him to. He was, on that occasion, only too happy to have an opportunity of acknowledging that he had, in the latter portion of his career, received much most valuable assistance, particularly from young men brought up in his manufactory. Whenever talent showed itself in a young man, he had always given that talent encouragement where he could, and he would continue to do so."

That this was no exaggerated statement is amply proved by many facts which redound to Stephenson's credit. He was no niggard of encouragement and praise when he saw honest industry struggling for a footing. Many were the young men whom, in the course of his career, he took by the hand and led steadily up to honour and emolument, simply because he had noted their zeal, diligence, and integrity. One youth excited his interest while working as a common carpenter on the Liverpool and Manchester line ; and before many years had passed he was recognised as an engineer of distinction. Another young man he found industriously working away at his bye-hours, and, admiring his diligence, he engaged him as his private secretary, the gentleman shortly after rising to a position of eminent influence and usefulness. Indeed, nothing gave the engineer greater pleasure than in this way to help on any deserving youth who came under his observation, and, in his own expressive phrase, to "make a man of him."

The openings of the great main lines of railroad communication shortly proved the fallaciousness of the numerous rash prophecies which had been promulgated by the opponents of railways. The proprietors of the canals were astounded by the fact that, notwithstanding

the immense traffic conveyed by rail, their own traffic and receipts continued to increase ; and that, in common with other interests, they fully shared in the expansion of trade and commerce which had been so effectually promoted by the extension of the railway system. The cattle-owners were equally amazed to find the price of horse-flesh increasing with the extension of railways, and that the number of coaches running to and from the new railway-stations gave employment to a greater number of horses than under the old stage-coach system. Those who had prophesied the decay of the metropolis, and the ruin of the suburban cabbage-growers, in consequence of the approach of railways to London, were disappointed ; for, while the new roads let citizens out of London, they also let country-people in. Their action, in this respect, was centripetal as well as centrifugal. Tens of thousands who had never seen the metropolis could now visit it expeditiously and cheaply ; and Londoners who had never visited the country, or but rarely, were enabled, at little cost of time or money, to see green fields and clear blue skies, far from the smoke and bustle of town. If the dear suburban-grown cabbages became depreciated in value, there were truck-loads of fresh-grown country cabbages to make amends for the loss : in this case, the "partial evil" was a far more general good. The food of the metropolis became rapidly improved, especially in the supply of wholesome meat and vegetables. And then the price of coals—an article which, in this country, is as indispensable as daily food to all classes—was greatly reduced. What a blessing to the metropolitan poor is described in this single fact !

The prophecies of ruin and disaster to landlords and farmers were equally confounded by the openings of the railways. The agricultural communications, so far from being "destroyed," as had been predicted, were immensely improved. The farmers were enabled to

buy their coals, lime, and manure for less money, while they obtained a readier access to the best markets for their stock and farm-produce. Notwithstanding the predictions to the contrary, their cows gave milk as before, the sheep fed and fattened, and even skittish horses ceased to shy at the passing trains. The smoke of the engines did not obscure the sky, nor were farmyards burnt up by the fire thrown from the locomotives. The farming classes were not reduced to beggary: on the contrary, they soon felt that, so far from having anything to dread, they had very much good to expect from the extension of railways.

Landlords also found that they could get higher rents for farms situated near a railway than at a distance from one. Hence they became clamorous for "sidings." They felt it to be a grievance to be placed at a distance from a station. After a railway had been once opened, not a landlord would consent to have the line taken from him. Owners who had fought the promoters before Parliament, and compelled them to pass their domains at a distance, at a vastly-increased expense in tunnels and deviations, now petitioned for branches and nearer station-accommodation. Those who held property near towns, and had extorted large sums as compensation for the anticipated deterioration in the value of their building land, found a new demand for it springing up at greatly advanced prices. Land was now advertised for sale, with the attraction of being "near a railway station."

The prediction that, even if railways were made, the public would not use them, was also completely falsified by the results. The ordinary mode of fast travelling for the middle classes had heretofore been by mail-coach and stage-coach. Those who could not afford to pay the high prices charged by such conveyances went by waggon, and the poorer classes trudged on foot. George Stephenson was wont to say that he hoped

to see the day when it would be cheaper for a poor man to travel by railway than to walk, and not many years passed before his expectation was fulfilled. In no country in the world is time worth more money than in England; and by saving time—the criterion of distance—the railway proved a great benefactor to men of industry in all classes.

Many deplored the inevitable downfall of the old stage-coach system. There was to be an end of that delightful variety of incident usually attendant on a journey by road. The rapid scamper across a fine country on the outside of the four-horse "Express" or "Highflyer;" the seat on the box beside Jehu, or the equally coveted place near the facetious guard behind; the journey amid open green fields, through smiling villages and fine old towns, where the stage stopped to change horses and the passengers to dine—was all very delightful in its way; and many regretted that this old-fashioned and pleasant style of travelling was about to pass away. But it had its dark side also. Any one who remembers the journey by stage from London to Manchester or York, will associate it with recollections and sensations of not unmixed delight. To be perched for twenty hours, exposed to all weathers, on the outside of a coach, trying in vain to find a soft seat—sitting now with the face to the wind, rain, or sun, and now with the back—without any shelter such as the commonest penny-a-mile parliamentary train now daily provides—was a miserable undertaking, looked forward to with horror by many whose business required them to travel frequently between the provinces and the metropolis. Nor were the inside passengers more agreeably accommodated. To be closely packed in a little, inconvenient, straight-backed vehicle, where the cramped limbs could not be in the least extended, nor the wearied frame indulge in any change of posture, was felt by many to be a terrible thing. Then there were the con-

stantly-recurring demands, not always couched in the politest terms, for an allowance to the driver every two or three stages, and to the guard every six or eight; and if the gratuity did not equal their expectations, growling and open abuse were not unusual. These *désagréments*, together with the exactions practised on travellers by innkeepers, seriously detracted from the romance of stage-coach travelling, and there was a general disposition on the part of the public to change the system for a better.

The avidity with which the public at once availed themselves of the railways proved that this better system had been discovered. Notwithstanding the reduction of the coach-fares on many of the roads to one-third of their previous rate, the public preferred travelling by the railway. They saved in time; and they saved in money, taking the whole expenses into account. In point of comfort there could be no doubt as to the infinite superiority of the locomotive train. But there remained the question of safety, which had been a great bugbear with the early opponents of railways, and was made the most of by the coach-proprietors to deter the public from using them. It was predicted that trains of passengers would be blown to pieces, and that none but fools would entrust their persons to the conduct of an explosive machine such as the locomotive. It appeared, however, that during the first eight years not fewer than five millions of passengers had been conveyed along the Liverpool and Manchester Railway, and of this vast number only two persons had lost their lives by accident. During the same period, the loss of life by the upsetting of stage-coaches had been immensely greater in proportion. The public were not slow, therefore, to detect the fact that travelling by railways was greatly safer than travelling by common roads; and in all districts penetrated by railways the coaches were very shortly taken off for want of support.

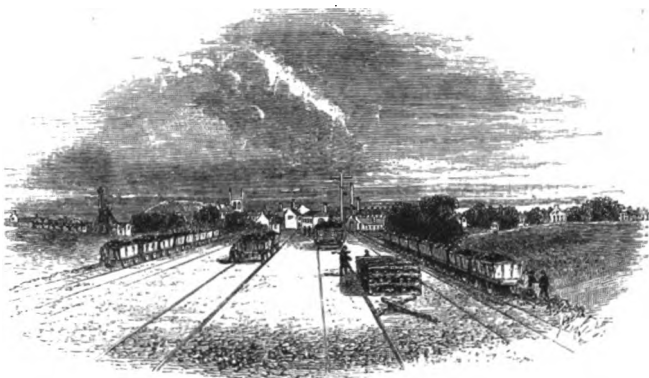
George Stephenson himself had a narrow escape in one of the stage-coach accidents so common thirty years since, but which are already almost forgotten. While the Birmingham line was under construction, he had occasion to travel from Ashby-de-la-Zouch to London by coach. He was an inside passenger with several others, and the outsides were pretty numerous. When within ten miles of Dunstable, he felt, from the rolling of the coach, that one of the linchpins securing the wheels had given way, and that the vehicle must upset. He endeavoured to fix himself in his seat, holding on firmly by the arm-straps, so that he might save himself on whichever side the coach fell. The coach soon toppled over, and fell crash upon the road, amidst the shrieks of his fellow-passengers and the smashing of glass. He immediately pulled himself up by the arm-strap above him, let down the coach window, and climbed out. The coachman and passengers lay scattered about on the road, stunned, and some of them bleeding, while the horses were plunging in their harness. Taking out his pocket-knife, he at once cut the traces, and set the horses free. He then went to the help of the passengers, who were all more or less hurt. The guard had his arm broken, and the driver was seriously cut and contused. A scream from one of his fellow-passenger "insides" here attracted his attention: it proceeded from an elderly lady, whom he had before observed to be decorated with one of the enormous bonnets in fashion at the time. Opening the coach-door, he lifted the lady out, and her principal lamentation was that her large bonnet had been crushed beyond remedy! Stephenson then proceeded to the nearest village for help, and saw the passengers provided with proper assistance before he himself went forward on his journey.

It was some time before the more opulent classes, who could afford to post to town in aristocratic style,

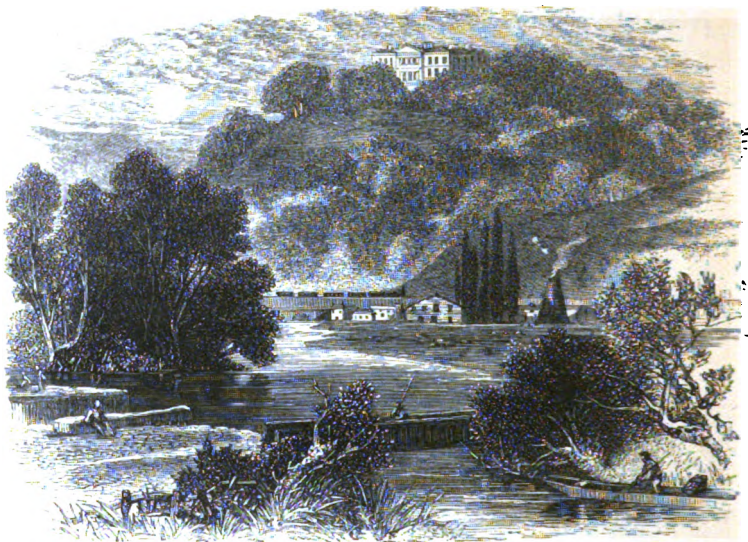
became reconciled to the railway train. It put an end to that gradation of rank in travelling which was one of the few things left by which the nobleman could be distinguished from the Manchester manufacturer and bagman. But to younger sons of noble families the convenience and cheapness of the railway did not fail to commend itself. One of these, whose eldest brother had just succeeded to an earldom, said to a railway manager: "I like railways—they just suit young fellows like me with 'nothing per annum paid quarterly.' You know, we can't afford to post, and it used to be deuced annoying to me, as I was jogging along on the box-seat of the stage-coach, to see the little Earl go by drawn by his four posters, and just look up at me and give me a nod. But now, with railways, it's different. It's true, he may take a first-class ticket, while I can only afford a second-class one, but *we both go the same pace.*"

For a time, however, many of the old families sent forward their servants and luggage by railroad, and condemned themselves to jog along the old highway in the accustomed family chariot, dragged by country post-horses. But the superior comfort of the railway shortly recommended itself to even the oldest families; posting went out of date; post-horses were with difficulty to be had along even the great high-roads; and nobles and servants, manufacturers and peasants, alike shared in the comfort, the convenience, and the despatch of railway travelling. The late Dr. Arnold, of Rugby, regarded the opening of the London and Birmingham line as another great step accomplished in the march of civilisation. "I rejoice to see it," he said, as he stood on one of the bridges over the railway, and watched the train flashing along under him, and away through the distant hedgerows—"I rejoice to see it, and to think that feudality is gone for ever: it is so great a blessing to think that any one evil is really extinct."

It was long before the late Duke of Wellington would trust himself behind a locomotive. The fatal accident to Mr. Huskisson, which had happened before his eyes, contributed to prejudice him strongly against railways, and it was not until the year 1843 that he performed his first trip on the South-Western Railway, in attendance upon her Majesty. Prince Albert had for some time been accustomed to travel by railway alone, but in 1842 the Queen began to make use of the same mode of conveyance between Windsor and London. Even Colonel Sibthorpe was eventually compelled to acknowledge its utility. For a time he continued to post to and from the country as before. Then he compromised the matter by taking a railway ticket for the long journey, and posting only a stage or two nearest town; until, at length, he undisguisedly committed himself, like other people, to the express train, and performed the journey throughout upon what he had formerly denounced as "the infernal railroad."



COALVILLE AND SNIBSTON COLLIERY.



TAPTON HOUSE [By Percival Skelton]

CHAPTER XVI.

GEORGE STEPHENSON'S COAL MINES — APPEARS AT MECHANICS' INSTITUTES — HIS OPINION ON RAILWAY SPEEDS — ATMOSPHERIC SYSTEM — RAILWAY MANIA — VISITS TO BELGIUM AND SPAIN.

WHILE George Stephenson was engaged in carrying on the works of the Midland Railway in the neighbourhood of Chesterfield, several seams of coal were cut through in the Claycross Tunnel, when it occurred to him that if mines were opened out there, the railway would provide the means of a ready sale for the article in the midland counties, and even as far south as the metropolis itself.

At a time when everybody else was sceptical as to the possibility of coals being carried from the midland counties to London, and sold there at a price to compete with those which were seaborne, he declared his firm

conviction that the time was fast approaching when the London market would be regularly supplied with north-country coals led by railway. One of the great advantages of railways, in his opinion, was that they would bring iron and coal, the staple products of the country, to the doors of all England. "The strength of Britain," he would say, "lies in her iron and coal beds; and the locomotive is destined, above all other agencies, to bring it forth. The Lord Chancellor now sits upon a bag of wool; but wool has long ceased to be emblematical of the staple commodity of England. He ought rather to sit upon a bag of coals, though it might not prove quite so comfortable a seat. Then think of the Lord Chancellor being addressed as the noble and learned lord *on the coal-sack*! I am afraid it wouldn't answer, after all."

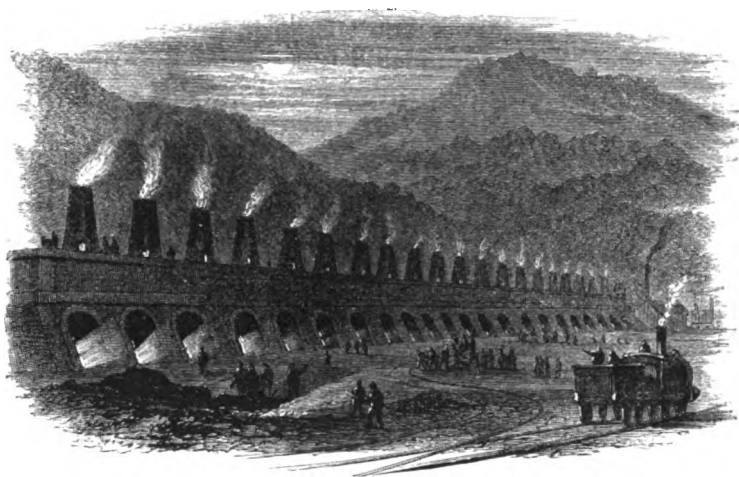
To one gentleman he said: "We want from the coal-mining, the iron-producing and manufacturing districts, a great railway for the carriage of these valuable products. We want, if I may so say, a stream of steam running directly through the country, from the North to London, and from other similar districts to London. Speed is not so much an object as utility and cheapness. It will not do to mix up the heavy merchandize and coal trains with the passenger trains. Coal and most kinds of goods can wait; but passengers will not. A less perfect road and less expensive works will do well enough for coal trains, if run at a low speed; and if the line be flat, it is not of much consequence whether it be direct or not. Whenever you put passenger-trains on a line, all the other trains must be run at high speeds to keep out of their way. But coal trains run at high speeds pull the road to pieces, besides causing large expenditure in locomotive power; and I doubt very much whether they will pay after all; but a succession of long coal trains, if run at from ten to fourteen miles an hour, would pay very well. Thus the Stockton and

Darlington Company made a larger profit when running coal at low speeds at a halfpenny a ton per mile, than they have been able to do since they put on their fast passenger-trains, when everything must needs be run faster, and a much larger proportion of the gross receipts is consequently absorbed by working expenses."

In advocating these views, George Stephenson was considerably ahead of his time; and although he did not live to see his anticipations fully realised as to the supply of the London coal-market, he was nevertheless the first to point out, and to some extent to prove, the practicability of establishing a profitable coal trade by railway between the northern counties and the metropolis. So long, however, as the traffic was conducted on main passenger-lines at comparatively high speeds, it was found that the expenditure on tear and wear of road and locomotive power,—not to mention the increased risk of carrying on the first-class passenger traffic with which it was mixed up,—necessarily left a very small margin of profit; and hence our engineer was in the habit of urging the propriety of constructing a railway which should be exclusively devoted to goods and mineral traffic run at low speeds as the only condition on which a large railway traffic of that sort could be profitably conducted.

Having induced some of his Liverpool friends to join him in a coal-mining adventure at Chesterfield, a lease was taken of the Claycross estate, then for sale, and operations were shortly after begun. At a subsequent period Stephenson extended his coal-mining operations in the same neighbourhood; and in 1841 he himself entered into a contract with owners of land in the townships of Tapton, Brimington, and Newbold, for the working of the coal thereunder; and pits were opened on the Tapton estate on an extensive scale. About the same time he erected great lime-works, close to the Ambergate station of the Midland Railway, from which,

when in full operation, he was able to turn out upwards of two hundred tons a day. The limestone was brought on a tramway from the village of Crich, about two or three miles distant from the kilns, the coal being supplied from his adjoining Claycross Colliery. The works were on a scale such as had not before been attempted by any private individual engaged in a similar trade; and we believe they proved very successful.



LIME WORKS AT AMBERGATE. [By Percival Skelton.]

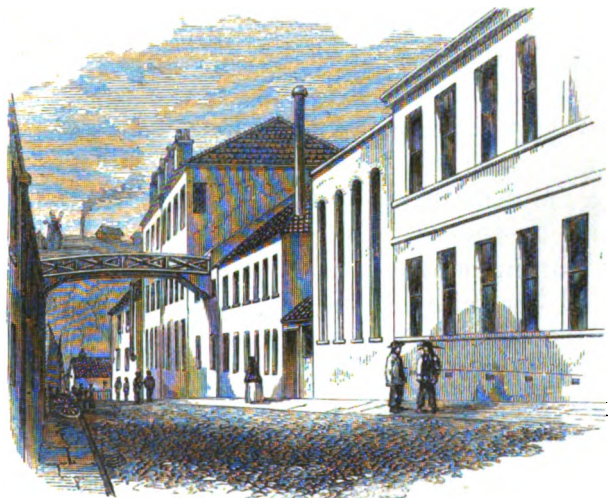
Tapton House was included in the lease of one of the collieries, and as it was conveniently situated—being, as it were, a central point on the Midland Railway, from which the engineer could readily proceed north or south, on his journeys of inspection of the various lines then under construction in the midland and northern counties,—he took up his residence there, and it continued his home until the close of his life.

Tapton House is a large roomy brick mansion, beautifully situated amidst woods, upon a commanding eminence, about a mile to the north-east of the town of Chesterfield. Green fields dotted with fine trees slope away from the house in all directions. The surrounding

country is undulating and highly picturesque. North and south the eye ranges over a vast extent of lovely scenery; and on the west, looking over the town of Chesterfield, with its church and crooked spire, the extensive range of the Derbyshire hills bounds the distance. The Midland Railway skirts the western edge of the park in a deep rock cutting, and the locomotive's shrill whistle sounds near at hand as the trains speed past. The gardens and pleasure-grounds adjoining the house were in a very neglected state when Mr. Stephenson first went to Tapton; and he promised himself, when he had secured rest and leisure from business, that he would put a new face upon both. The first improvement he made was in cutting a woodland footpath up the hill-side, by which he at the same time added a beautiful feature to the park and secured a shorter road to the Chesterfield station. But it was some years before he found time to carry into effect his contemplated improvements in the adjoining gardens and pleasure-grounds. He had so long been accustomed to laborious pursuits, and felt himself still so full of work, that he could not at once settle down into the habit of quietly enjoying the fruits of his industry.

He had no difficulty in usefully employing his time. Besides directing the mining operations at Claycross, the establishment of the lime-kilns at Ambergate, and the construction of the extensive railways still in progress, he occasionally paid visits to Newcastle, where his locomotive manufactory was now in full work, and the proprietors were reaping the advantages of his early foresight in an abundant measure of prosperity. One of his most interesting visits to the place was in 1838, on the occasion of the meeting of the British Association there, when he acted as one of the Vice-Presidents in the section of Mechanical Science. Extraordinary changes had taken place in his own fortunes, as well as in the face of the country, since he had first

appeared before a scientific body in Newcastle—the members of the Literary and Philosophical Institute—to submit his safety-lamp for their examination. Twenty-three years had passed over his head, full of honest work, of manful struggle; and the humble “colliery enginewright of the name of Stephenson” had achieved an almost world-wide reputation as a public benefactor. His fellow-townsmen, therefore, could not hesitate to recognise his merits and do honour to



FORTH STREET WORKS, NEWCASTLE.

his presence. During the sittings of the Association, the engineer took the opportunity of paying a visit to Killingworth, accompanied by some of the distinguished savans whom he numbered amongst his friends. He there pointed out to them, with a degree of honest pride, the cottage in which he had lived for so many years, showed what parts of it had been his own handiwork, and told them the story of the sun-dial over the door, describing the study and the labour it had cost him and his son to calculate its dimensions, and fix it in its place. The dial had been serenely numbering

the hours through the busy years that had elapsed since that humble dwelling had been his home ; during which the Killingworth locomotive had become a great working power, and its contriver had established the railway system, which was now rapidly becoming extended in all parts of the civilised world.

About the same time, his services were very much in request at the meetings of Mechanics' Institutes held throughout the northern counties. From a very early period in his history, he had taken an active interest in these valuable institutions. While residing at Newcastle in 1824, shortly after his locomotive foundry had been started in Forth-street, he presided at a public meeting held in that town for the purpose of establishing a Mechanics' Institute. The meeting was held ; but as George Stephenson was a man comparatively unknown even in Newcastle at that time, his name failed to secure "an influential attendance." Among those who addressed the meeting on the occasion, was Joseph Locke, then his pupil, and afterwards his rival as an engineer. The local papers scarcely noticed the proceedings ; yet the Mechanics' Institute was founded and struggled into existence. Years passed, and it was now felt to be an honour to secure Mr. Stephenson's presence at any public meetings held for the promotion of popular education. Among the Mechanics' Institutes in his immediate neighbourhood at Tapton, were those of Belper and Chesterfield ; and at their soirées he was a frequent and a welcome visitor. On these occasions he loved to tell his auditors of the difficulties which had early beset him through want of knowledge, and of the means by which he had overcome them. His grand text was—**PERSEVERE** ; and there was manhood in the word.

On more than one occasion, the author had the pleasure of listening to George Stephenson's homely but forcible addresses at the annual soirées of the Leeds

Mechanics' Institute. He was always an immense favourite with his audiences there. His personal appearance was greatly in his favour. A handsome, ruddy, expressive face, lit up by bright dark-blue eyes, prepared one for his earnest words when he stood up to speak, and the cheers had subsided which invariably hailed his rising. He was not glib, but he was very impressive. And who, so well as he, could serve as a guide to the working man in his endeavours after higher knowledge? His early life had been all struggle—encounter with difficulty—groping in the dark after greater light, but always earnestly and perseveringly. His words were therefore all the more weighty, since he spoke from the fulness of his own experience.

Nor did he remain a mere inactive spectator of the improvements in railway working which increasing experience from day to day suggested. He continued to contrive improvements in the locomotive, and to mature his invention of the carriage-brake. When examined before the Select Committee on Railways in 1841, his mind seems to have been impressed with the necessity which existed for adopting a system of self-acting brakes; stating that, in his opinion, this was the most important arrangement that could be provided for increasing the safety of railway travelling. "I believe," he said, "that if self-acting brakes were put upon every carriage, scarcely any accident could take place." His plan consisted in employing the momentum of the running train to throw his proposed brakes into action, immediately on the moving power of the engine being checked. He would also have these brakes under the control of the guard, by means of a connecting line running along the whole length of the train, by which they should at once be thrown out of gear when necessary. At the same time he suggested, as an additional means of safety, that the signals of the line should be self-acting, and worked by the locomotives

as they passed along the railway. He considered the adoption of this plan of so much importance, that, with a view to the public safety, he would even have it enforced upon railway companies by the legislature. He was also of opinion that it was the interest of the companies themselves to adopt the plan, as it would save great tear and wear of engines, carriages, tenders, and brake-vans, besides greatly diminishing the risk of accidents upon railways.

While before the same Committee, he took the opportunity of stating his views with reference to railway speeds, about which wild ideas were then afloat—one gentleman of celebrity having publicly expressed the opinion that a speed of a hundred miles an hour was practicable in railway travelling! Not many years had passed since Mr. Stephenson had been pronounced *insane* for stating his conviction that twelve miles an hour could be performed by the locomotive; but now that he had established the fact, and greatly exceeded that speed, he was thought behind the age because he recommended it to be limited to forty miles an hour. He said: "I do not like either forty or fifty miles an hour upon any line—I think it is an unnecessary speed; and if there is danger upon a railway, it is high velocity that creates it. I should say no railway ought to exceed forty miles an hour on the most favourable gradient; but upon a curved line the speed ought not to exceed twenty-four or twenty-five miles an hour." He had, indeed, constructed for the Great Western Railway an engine capable of running fifty miles an hour with a load, and eighty miles without one. But he never was in favour of a hurricane speed of this sort, believing it could only be accomplished at an unnecessary increase both of danger and expense.

"It is true," he observed on other occasions,¹ "I

¹ It may be mentioned that these views were communicated to the author by Robert Stephenson, and noted down in his presence.

have said the locomotive engine *might* be made to travel a hundred miles an hour; but I always put a qualification on this, namely, as to what speed would best suit the public. The public may, however, be unreasonable; and fifty or sixty miles an hour is an unreasonable speed. Long before railway travelling became general, I said to my friends that there was no limit to the speed of the locomotive, *provided the works could be made to stand*. But there are limits to the strength of iron, whether it be manufactured into rails or locomotives; and there is a point at which both rails and tyres must break. Every increase of speed, by increasing the strain upon the road and the rolling stock, brings us nearer to that point. At thirty miles a slighter road will do, and less perfect rolling stock may be run upon it with safety. But if you increase the speed by say ten miles, then everything must be greatly strengthened. You must have heavier engines, heavier and better-fastened rails, and all your working expenses will be immensely increased. I think I know enough of mechanics to know where to stop. I know that a pound will weigh a pound, and that more should not be put upon an iron rail than it will bear. If you could ensure perfect iron, perfect rails, and perfect locomotives, I grant fifty miles an hour or more might be run with safety on a level railway. But then you must not forget that iron, even the best, will 'tire,' and with constant use will become more and more liable to break at the weakest point—perhaps where there is a secret flaw that the eye cannot detect. Then look at the rubbishy rails now manufactured on the contract system—some of them little better than cast metal: indeed, I have seen rails break merely on being thrown from the truck on to the ground. How is it possible for such rails to stand a twenty or thirty ton engine dashing over them at the speed of fifty miles an hour? No, no," he would conclude, "I am in favour

of low speeds because they are safe, and because they are economical ; and you may rely upon it that, beyond a certain point, with every increase of speed there is a certain increase in the element of danger."

When railways became the subject of popular discussion, many new and unsound theories were started with reference to them, which Stephenson opposed as calculated, in his opinion, to bring discredit on the locomotive system. One of these was with reference to what were called "undulating lines." Dr. Lardner, who at an earlier period was sceptical as to the powers of the locomotive, now promulgated the idea that a railway constructed with rising and falling gradients would be practically as easy to work as a line perfectly level. Mr. Badnell went even beyond him, for he held that an undulating railway was much better than a level one for purposes of working.¹ For a time, this theory found favour, and the "undulating system" was extensively adopted ; but George Stephenson never ceased to inveigh against it ; and experience has proved that his judgment was correct. His practice, from the beginning of his career until the end of it, was to secure a road as nearly as possible on a level, following the course of the valleys and the natural line of the country ; preferring to go round a hill rather than to tunnel under it or carry his railway over it, and often making a considerable circuit to secure good workable gradients. He studied to lay out his lines so that long trains of minerals and merchandise, as well as passengers, might be hauled along them at the least possible expenditure of locomotive power. He had long before ascertained, by careful experiments at Killingworth, that the engine expends half its power in overcoming a rising gradient of 1 in 260, which is about 20 feet in the mile ; and that when the gradient

¹ 'Treatise on Railway Improvements.' By Mr. Richard Badnell, C.E.

is so steep as 1 in 100, not less than three-fourths of its power is sacrificed in ascending the acclivity. He never forgot the valuable practical lessons taught him by these early trials, which he had made and registered long before the advantages of railways had become recognized. He saw clearly that the longer flat line must eventually prove superior to the shorter line of steep gradients as respected its paying qualities. He urged that, after all, the power of the locomotive was but limited; and, although he and his son had done more than any other men to increase its working capacity, it provoked him to find that every improvement made in it was neutralised by the steep gradients which the new school of engineers were setting it to overcome. On one occasion, when Robert Stephenson stated before a Parliamentary Committee that every successive improvement in the locomotive was being rendered virtually nugatory by the difficult and almost impracticable gradients proposed on many of the new lines, his father, on his leaving the witness-box, went up to him, and said, "Robert, you never spoke truer words than those in all your life."

To this it must be added, that in urging these views George Stephenson was strongly influenced by commercial considerations. He had no desire to build up his reputation at the expense of railway shareholders, nor to obtain engineering *éclat* by making "ducks and drakes" of their money. He was persuaded that, in order to secure the practical success of railways, they must be so laid out as not only to prove of decided public utility, but also to be worked economically and to the advantage of their proprietors. They were not government roads, but private ventures—in fact, commercial speculations. He therefore endeavoured to render them financially profitable; and he repeatedly declared that if he did not believe they could be "made to pay," he

would have nothing to do with them.¹ Nor was he influenced by the sordid consideration merely of what he could *make* out of any Company that employed him ; but in many cases he voluntarily gave up his claim to remuneration where the promoters of schemes which he thought praiseworthy had suffered serious loss. Thus, when the first application was made to Parliament for the Chester and Birkenhead Railway Bill, the promoters were defeated. They repeated their application, on the understanding that in event of their succeeding, the engineer and surveyor were to be paid their costs in respect of the defeated measure. The Bill was successful, and to several parties their costs were paid. Stephenson's amounted to 800*l.*, and he very nobly said, "You have had an expensive career in Parliament ; you have had a great struggle ; you are a young Company ; you cannot afford to pay me this amount of money ; I will reduce it to 200*l.*, and I will not ask you for the 200*l.* until your shares are at 20*l.* premium ; for whatever may be the reverses you have to go through, I am satisfied I shall live to see the day when your shares will be at 20*l.* premium, and when I can legally and honourably claim that 200*l.*"² We may add that the shares did eventually rise to the premium specified, and the engineer was no loser by his generous conduct in the transaction.

Another novelty of the time, with which George

¹ He often refused to act as engineer for lines which he thought would not prove remunerative, or when he considered the estimates too low. Thus, when giving evidence on the Great Western Bill, Stephenson said, "I made out an estimate for the Hartlepool Railway, which they returned on account of its being too high, but I declined going to Parliament with a lower estimate. Another engineer was employed. Then,

again, "I was consulted about a line from Edinburgh to Glasgow. The directors chalked out a line and sent it to me, and I told them I could not support it in that case." Hence the employment of another engineer to carry out the line which Stephenson could not conscientiously advocate.

² Speech of Wm. Jackson, Esq., M.P., at the meeting of the Chester and Birkenhead Railway Company, held at Liverpool, October, 1845.

Stephenson had to contend, was the proposed substitution of atmospheric pressure for locomotive steam-power in the working of railways. The idea of obtaining motion by means of atmospheric pressure originated with Denis Papin more than a century and a half ago; but it slept until revived in 1810 by Mr. Medhurst, who published a pamphlet to prove the practicability of carrying letters and goods by air. In 1824, Mr. Vallance of Brighton took out a patent for projecting passengers through a tube large enough to contain a train of carriages; the tube ahead of the carriages being previously exhausted of its atmospheric air. The same idea was afterwards taken up, in 1835, by Mr. Pinkus, an ingenious American. Several scientific gentlemen, Dr. Lardner and Mr. Clegg amongst others, advocated the plan; and an association was formed to carry it into effect. Shares were created, and 18,000*l.* raised; and a model apparatus was exhibited in London. Mr. Vignolles took his friend Mr. Stephenson to see the model; and after carefully examining it, he observed emphatically, "*It won't do*: it is only the fixed engines and ropes over again, in another form; and, to tell you the truth, I don't think this rope of wind will answer so well as the rope of wire did." He did not think the principle would stand the test of practice, and he objected to the mode of applying the principle. The stationary-engine system was open to serious objections in whatever form applied; and every day's experience showed that the fixed engines could not compete with locomotives in point of efficiency and economy. Stephenson stood by the locomotive engine; and subsequent experience proved that he was right.

Messrs. Clegg and Samuda afterwards, in 1840, patented their plan of an atmospheric railway; and they publicly tested its working on a portion of the West London Railway. The results of the experi-

ment were considered so satisfactory, that the directors of the Dublin and Kingstown line adopted it between Kingstown and Dalkey. The London and Croydon Company also adopted the atmospheric principle; and their line was opened in 1845. The ordinary mode of applying the power was to lay between the line of rails a pipe, in which a large piston was inserted, and attached by a shaft to the framework of a carriage. The propelling power was the ordinary pressure of the atmosphere acting against the piston in the tube on one side, a vacuum being created in the tube on the other side of the piston by the working of a stationary engine. Great was the popularity of the atmospheric system; and still George Stephenson said, "It won't do: it's but a gimcrack." Engineers of distinction said he was prejudiced, and that he looked upon the locomotive as a pet child of his own. "Wait a little," he replied, "and you will see that I am right." It was generally supposed that the locomotive system was about to be snuffed out. "Not so fast," said Stephenson. "Let us wait to see if it will pay." He never believed it would. It was ingenious, clever, scientific, and all that; but railways were commercial enterprises, not toys; and if the atmospheric railway could not work to a profit, it would not do. Considered in this light, he even went so far as to call it "a great humbug."

No one can say that the atmospheric railway had not a fair trial. The Government engineer, General Pasley, did for it what had never been done for the locomotive—he reported in its favour, whereas a former Government engineer had inferentially reported against the use of locomotive power on railways. The House of Commons had also reported in favour of the use of the steam-engine on common roads; yet the railway locomotive had vitality enough in it to live through all. "Nothing will beat it," said George Stephenson, "for

efficiency in all weathers, for economy in drawing loads of average weight, and for power and speed as occasion may require."

The atmospheric system was fairly and fully tried, and it was found wanting. It was admitted to be an exceedingly elegant mode of applying power; its devices were very skilful, and its mechanism was most ingenious. But it was costly, irregular in action, and, in particular kinds of weather, not to be depended upon. At best, it was but a modification of the stationary-engine system, and experience proved it to be so expensive that it was shortly after entirely abandoned in favour of locomotive power.¹

One of the remarkable results of the system of railway locomotion which George Stephenson had by his persevering labours mainly contributed to establish, was the outbreak of the railway mania towards the close of his professional career. The success of the first main lines of railway naturally led to their extension into many new districts; but a strongly speculative tendency soon began to display itself, which contained in it the elements of great danger.

The extension of railways had, up to the year 1844, been mainly effected by men of the commercial classes, and the shareholders in them principally belonged to the manufacturing districts,—the capitalists of the metropolis as yet holding aloof, and prophesying disaster to all concerned in railway projects. The Stock Exchange looked askance upon them, and it was with difficulty that respectable brokers could be found to do business in the shares. But when the lugubrious anti-

¹ The question of the specific merits of the atmospheric as compared with the fixed engine and locomotive systems, will be found fully discussed in Robert Stephenson's able 'Report on the Atmospheric Railway System,' 1844, in which he gave the result of numerous observations and experi-

ments made by him on the Kingstown Atmospheric Railway, with the object of ascertaining whether the new power would be applicable for the working of the Chester and Holyhead Railway then under construction. His opinion was decidedly against the atmospheric system.

cipations of the City men were found to be so entirely falsified by the results—when, after the lapse of years, it was ascertained that railway traffic rapidly increased and dividends steadily improved—a change came over the spirit of the London capitalists. They then invested largely in railways, the shares in which became a leading branch of business on the Stock Exchange, and the prices of some rose to nearly double their original value.

A stimulus was thus given to the projection of further lines, the shares in most of which came out at a premium, and became the subject of immediate traffic. A reckless spirit of gambling set in, which completely changed the character and objects of railway enterprise. The public outside the Stock Exchange became also infected, and many persons utterly ignorant of railways, but hungering and thirsting after premiums, rushed eagerly into the vortex. They applied for allotments, and subscribed for shares in lines, of the engineering character or probable traffic of which they knew nothing. Provided they could but obtain allotments which they could sell at a premium, and put the profit—in many cases the only capital they possessed¹—into their pockets, it was enough for them. The mania was not confined to the precincts of the Stock Exchange, but infected all ranks. It embraced merchants and manufacturers, gentry and shopkeepers, clerks in public offices, and loungers at the clubs. Noble lords were pointed at as “stags;” there were even clergymen who were characterised as “bulls,” and amiable ladies who had the reputation of “bears,” in the share-markets. The few quiet men who remained uninfluenced by the speculation of the time were, in not a

¹ The Marquis of Clanricarde brought under the notice of the House of Lords, in 1845, that one Charles Guernsey, the son of a charwoman and a clerk

in a broker's office at 12s. a week, had his name down as a subscriber for shares in the London and York line for 52,000*l*.

few cases, even reproached for doing injustice to their families, in declining to help themselves from the stores of wealth that were poured out on all sides.

Folly and knavery were for a time in the ascendant. The sharpers of society were let loose, and jobbers and schemers became more and more plentiful. They threw out railway schemes as lures to catch the unwary. They fed the mania with a constant succession of new projects. The railway papers became loaded with their advertisements. The post-office was scarcely able to distribute the multitude of prospectuses and circulars which they issued. For a time their popularity was immense. They rose like froth into the upper heights of society, and the flunkey FitzPlushe, by virtue of his supposed wealth, sat amongst peers and was idolised. Then was the harvest-time for scheming lawyers, parliamentary agents, engineers, surveyors, and traffic-takers, who were ready to take up any railway scheme however desperate, and to prove any amount of traffic even where none existed. The traffic in the credulity of their dupes was, however, the great fact that mainly concerned them, and of the profitable character of which there could be no doubt.

Parliament, whose previous conduct in connection with railway legislation was so open to reprehension, interposed no check—attempted no remedy. On the contrary, it helped to intensify the evils arising from this unseemly state of things. Many of its members were themselves involved in the mania, and as much interested in its continuance as the vulgar herd of money-grubbers. The railway prospectuses now issued—unlike the original Liverpool and Manchester, and London and Birmingham schemes—were headed by peers, baronets, landed proprietors, and strings of M.P.'s. Thus, it was found in 1845 that no fewer than 157 members of Parliament were on the lists of new Com-

panies as subscribers for sums ranging from 291,000*l.* downwards! The projectors of new lines even came to boast of their parliamentary strength, and of the number of votes which they could command in "the House." At all events, it is matter of fact, that many utterly ruinous branches and extensions projected during the mania, calculated only to benefit the inhabitants of a few miserable boroughs accidentally omitted from Schedule A, were authorised in the memorable sessions of 1844 and 1845.

George Stephenson was anxiously entreated to lend his name to prospectuses during the railway mania; but he invariably refused. He held aloof from the headlong folly of the hour; and endeavoured to check it, but in vain. Had he been less scrupulous, and given his countenance to the numerous projects about which he was consulted, he might, without any trouble, have thus secured enormous gains; but he had no desire to accumulate a fortune without labour and without honour. He himself never speculated in shares. When he was satisfied as to the merits of an undertaking, he would sometimes subscribe for a certain amount of capital in it, when he held on, neither buying nor selling. At a dinner of the Leeds and Bradford directors at Ben Rydding in October, 1844, before the mania had reached its height, he warned those present against the prevalent disposition towards railway speculation. It was, he said, like walking upon a piece of ice with shallows and deeps; the shallows were frozen over, and they would carry, but it required great caution to get over the deeps. He was satisfied that in the course of the next year many would step on to places not strong enough to carry them, and would get into the deeps; they would be taking shares, and afterwards be unable to pay the calls upon them. Yorkshiremen were reckoned clever men, and his advice to them was, to stick together and promote communication in their own neighbour-

hood,—not to go abroad with their speculations. If any had done so, he advised them to get their money back as fast as they could, for if they did not they would not get it at all. He informed the company, at the same time, of his earliest holding of railway shares; it was in the Stockton and Darlington Railway, and the number he held was *three*—"a very large capital for him to possess at the time." But a Stockton friend was anxious to possess a share, and he sold him *one* at a premium of 33s.; he supposed he had been about the first man in England to sell a railway share at a premium.

During 1845, his son's office in Great George-street, Westminster, was crowded with persons of various conditions seeking interviews, presenting very much the appearance of the levee of a minister of state. The burly figure of Mr. Hudson, the "Railway King," surrounded by an admiring group of followers, was often to be seen there; and a still more interesting person, in the estimation of many, was George Stephenson, dressed in black, his coat of somewhat old-fashioned cut, with square pockets in the tails. He wore a white neckcloth, and a large bunch of seals was suspended from his watch-ribbon. Altogether, he presented an appearance of health, intelligence, and good humour, that it gladdened one to look upon in that sordid, selfish, and eventually ruinous saturnalia of railway speculation.

Being still the consulting engineer of several of the older Companies, he necessarily appeared before Parliament in support of their branches and extensions. In 1845 his name was associated with that of his son as the engineer of the Southport and Preston Junction. In the same session he gave evidence in favour of the Syston and Peterborough branch of the Midland Railway; but his principal attention was confined to the promotion of the line from Newcastle to Ber-

wick, in which he had never ceased to take the deepest interest.

Powers were granted by Parliament, in 1845, to construct not less than 2883 miles of new railways in Britain, at an expenditure of about forty-four millions sterling! Yet the mania was not appeased; for in the following session of 1846, applications were made to Parliament for powers to raise 389,000,000*l.* sterling for the construction of further lines; and they were actually conceded to the extent of 4790 miles (including 60 miles of tunnels), at a cost of about 120,000,000*l.* sterling.¹ During this session, Mr. Stephenson appeared as engineer for only one new line,—the Buxton, Macclesfield, Congleton, and Crewe Railway—a line in which, as a coal-owner, he was personally interested;—and of three branch-lines in connexion with existing companies for which he had long acted as engineer. At the same period, all the leading professional men were fully occupied, some of them appearing as consulting engineers for upwards of thirty lines each!

One of the features of this mania was the rage for “direct lines” which everywhere displayed itself. There were “Direct Manchester,” “Direct Exeter,” “Direct York,” and, indeed, new direct lines between most of the large towns. The Marquis of Bristol, speaking in favour of the “Direct Norwich and London” project, at a public meeting at Haverill, said, “If necessary, they might *make a tunnel beneath his very drawing-room*, rather than be defeated in their undertaking!” And the Rev. F. Litchfield, at a meeting in Banbury, on the subject of a line to that town, said “He had laid down for himself a limit to his approbation of railways,—at least of such as approached the neighbourhood with

¹ On the 17th November, 1845, Mr. Spackman published a list of the lines projected (many of which were not afterwards prosecuted), from which it

appeared that there were then 620 new railway projects before the public, requiring a capital of 563,203,000*l.*

which he was connected,—and that limit was, that he did not wish them to approach any nearer to him than *to run through his bedroom, with the bedposts for a station!*” How different was the spirit which influenced these noble lords and gentlemen but a few years before!

The course adopted by Parliament in dealing with the multitude of railway Bills applied for during the prevalence of the mania, was as irrational as it proved unfortunate. The want of foresight displayed by both Houses in obstructing the railway system so long as it was based upon sound commercial principles, was only equalled by the fatal facility with which they now granted railway projects based upon the wildest speculation. Parliament interposed no check, laid down no principle, furnished no guidance, for the conduct of railway projectors; but left every Company to select its own locality, determine its own line, and fix its own gauge. No regard was paid to the claims of existing Companies, which had already expended so large an amount in the formation of useful railways; and speculators were left at liberty to project and carry out lines almost parallel with theirs.

The House of Commons became thoroughly influenced by the prevailing excitement. Even the Board of Trade began to favour the views of the new and reckless school of engineers. In their “Report on the Lines projected in the Manchester and Leeds District,” they promulgated some remarkable views respecting gradients, declaring themselves in favour of the “undulating system.” They there stated that lines of an undulating character “which have gradients of 1 in 70 or 1 in 80 distributed over them in short lengths, may be positively *better* lines, *i. e.*, *more susceptible of cheap and expeditious working*, than others which have nothing steeper than 1 in 100 or 1 in 120!” They concluded by reporting in favour of the line which exhibited the worst gradients and the sharpest curves,

chiefly on the ground that it could be constructed for less money.

Sir Robert Peel took occasion, when speaking in favour of the continuance of the Railways Department of the Board of Trade, to advert to this Report in the House of Commons on the 4th of March following, as containing "a novel and highly important view on the subject of gradients, which, he was certain, never could have been taken by any Committee of the House of Commons, however intelligent;" and he might have added, that the more intelligent, the less likely they would be to arrive at any such conclusion. When George Stephenson saw this report of the Premier's speech in the newspapers of the following morning, he went forth-with to his son, and asked him to write a letter to Sir Robert Peel on the subject. He saw clearly that if such views were adopted, the utility and economy of railways would be seriously curtailed. "These members of Parliament," said he, "are now as much disposed to exaggerate the powers of the locomotive, as they were to under-estimate them but a few years ago." Robert accordingly wrote a letter for his father's signature, embodying the views which he so strongly entertained as to the importance of flat gradients, and referring to the experiments conducted by him many years before, in proof of the great loss of working power which was incurred on a line of steep as compared with easy gradients. It was clear, from the tone of Sir Robert Peel's speech in a subsequent debate, that he had carefully read and considered Mr. Stephenson's practical observations on the subject; though it did not appear that he had come to any definite conclusion thereon, further than that he strongly approved of the Trent Valley Railway, by which Tamworth would be placed upon a direct main line of communication.

The result of the labours of Parliament was a tissue

of legislative bungling, involving enormous loss to the nation. Railway Bills were granted in heaps. Two hundred and seventy-two additional Acts were passed in 1846. Some authorised the construction of lines running almost parallel with existing railways, in order to afford the public "the benefits of unrestricted competition." Locomotive and atmospheric lines, broad-gauge and narrow-gauge lines, were granted without hesitation. Committees decided without judgment and without discrimination; and in the scramble for Bills, the most unscrupulous were usually the most successful. As an illustration of the legislative folly of the period, Robert Stephenson, speaking at Toronto, in Upper Canada, some years later, adduced the following instances :—

"There was one district through which it was proposed to run two lines, and there was no other difficulty between them than the simple rivalry that, if one got a charter, the other might also. But here, where the Committee might have given both, they gave neither. In another instance, two lines were projected through a barren country, and the Committee gave the one which afforded the least accommodation to the public. In another, where two lines were projected to run, merely to shorten the time by a few minutes, leading through a mountainous country, the Committee gave both. So that, where the Committee might have given both, they gave neither, and where they should have given neither, they gave both."

Among the many ill effects of the mania, one of the worst was that it introduced a low tone of morality into railway transactions. The bad spirit which had been evoked by it unhappily extended to the commercial classes, and many of the most flagrant swindles of recent times had their origin in the year 1845. Those who had suddenly gained large sums without labour, and also without honour, were too ready to enter upon courses of the wildest extravagance; and a false style of living arose, the poisonous influence of which ex-

tended through all classes. Men began to look upon railways as instruments to job with. Persons sometimes possessing information respecting railways, but more frequently possessing none, got upon boards for the purpose of promoting their individual objects, often in a very unscrupulous manner; landowners, to promote branch lines through their property; speculators in shares, to trade upon the exclusive information which they obtained; while some directors were appointed through the influence mainly of solicitors, contractors, or engineers, who used them as tools to serve their own ends. In this way the unfortunate proprietors were in many cases betrayed, and their property was shamefully squandered, much to the discredit of the railway system.

One of the most prominent celebrities of the mania was George Hudson, of York. He was a man of some local repute in that city when the line between Leeds and York was projected. His views as to railways were then extremely moderate, and his main object in joining the undertaking was to secure for York the advantages of the best railway communication. The Company was not very prosperous at first, and during the years 1840 and 1841 the shares had greatly sunk in value. Mr. Alderman Meek, the first chairman, having retired, Mr. Hudson was elected in his stead, and he very shortly contrived to pay improved dividends to the proprietors, who asked no questions. Desiring to extend the field of his operations, he proceeded to lease the Leeds and Selby Railway at five per cent. That line had hitherto been a losing concern; so its owners readily struck a bargain with Mr. Hudson, and sounded his praises in all directions. He increased the dividends on the York and North Midland shares to ten per cent, and began to be cited as the model of a railway chairman.

He next interested himself in the North Midland

Railway, where he appeared in the character of a reformer of abuses. The North Midland shares also had gone to a heavy discount, and the shareholders were accordingly desirous of securing his services. They elected him a director. His bustling, pushing, persevering character gave him an influential position at the board, and he soon pushed the old members from their stools. He laboured hard, at much personal inconvenience, to help the concern out of its difficulties, and he succeeded. The new directors, recognising his power, elected him their chairman.

Railways revived in 1842, and public confidence in them as profitable investments was gradually increasing. Mr. Hudson had the benefit of this growing prosperity. The dividends in his lines improved, and the shares rose in value. The Lord Mayor of York began to be quoted as one of the most capable of railway directors. Stimulated by his success and encouraged by his followers, he struck out or supported many new projects—a line to Scarborough, a line to Bradford, lines in the Midland districts, and lines to connect York with Newcastle and Edinburgh. He was elected chairman of the Newcastle and Darlington Railway; and when—in order to complete the continuity of the main line of communication—it was found necessary to secure the Durham junction, which was an important link in the chain, he and George Stephenson boldly purchased that railway between them, at the price of 88,500*l*. It was an exceedingly fortunate purchase for the Company, to whom it was worth double the money. The act, though not strictly legal, proved successful in the issue, and was much lauded. Thus encouraged, Mr. Hudson proceeded to buy the Brandling Junction line for 500,000*l*., in his own name—an operation at the time regarded as equally favourable, though he was afterwards charged with appropriating 1600 of the shares created for the purchase, when worth 21*l*. premium each. The Great

North of England line being completed, Mr. Hudson had thus secured the entire line of communication from York to Newcastle, and the route was opened to the public in June, 1844. On that occasion Newcastle eulogised Mr. Hudson in its choicest local eloquence, and he was pronounced to be the greatest benefactor the district had ever known.

The adulation which followed Mr. Hudson would have intoxicated a stronger and more self-denying man. He was pronounced the man of the age, and hailed as "the Railway King." The highest test by which the shareholders judged him was the dividends that he paid, though subsequent events proved that these dividends were in many cases delusive, intended only "to make things pleasant." The policy, however, had its effect. The shares in all the lines of which he was chairman went to a premium, and then arose the temptation to create new shares in branch and extension lines, often worthless, which were issued at a premium also. Thus he shortly found himself chairman of nearly 600 miles of railway, extending from Rugby to Newcastle, and at the head of numerous new projects, by means of which paper-wealth could be created as it were at pleasure. He held in his own hands almost the entire administrative power of the Companies over which he presided: he was chairman, board, manager, and all. His admirers for the time, inspired sometimes by gratitude for past favours, but oftener by the expectation of favours to come, supported him in all his measures. At the meetings of the Companies, if any suspicious shareholder ventured to put a question about the accounts, he was snubbed by the chair and hissed by the proprietors. The Railway King was voted praises, testimonials, and surplus shares alike liberally; and scarcely a word against him could find a hearing. He was equally popular outside the circle of railway proprietors. His entertainments

at Albert Gate were crowded by sycophants, many of them titled; and he went his rounds of visits among the peerage like a prince.

Of course Mr. Hudson was a great authority on railway questions in Parliament, to which the burgesses of Sunderland had sent him. His experience of railways, still little understood though the subject of so much legislation, gave value and weight to his opinions, and in many respects he was a useful member. During the first years of his membership he was chiefly occupied in passing the railway Bills in which he was more particularly interested; and in the session of 1845, when he was at the height of his power, it was triumphantly said of him, that "he walked quietly through Parliament with some sixteen railway Bills under his arm."

One of these Bills, however, was the subject of a severe contest—we mean that empowering the construction of the railway from Newcastle to Berwick. It was almost the only Bill in which George Stephenson was concerned that year. Mr. Hudson displayed great energy in supporting the measure, and he worked hard to ensure its success both in and out of Parliament; but he himself attributed the chief merit to Stephenson. He accordingly suggested to the shareholders that they should present the engineer with some fitting testimonial in recognition of his services. Indeed, a Stephenson Testimonial had long been spoken of, and a committee was formed for raising subscriptions for the purpose as early as the year 1839. Mr. Hudson now revived the subject, and appealed to the Newcastle and Darlington, the Midland, and the York and North Midland Companies, who unanimously adopted the resolutions which he proposed to them amidst "loud applause," but there the matter ended.

The Hudson Testimonial was a much more taking thing; for Hudson had it in his power to allot shares (selling at a premium) to his adulators. But Stephen-

son pretended to fill no man's pocket with premiums; he was no creator of shares, and could not therefore work upon shareholders' gratitude for "favours to come." The proposed testimonial to him accordingly ended with resolutions and speeches. The York, Newcastle, and Berwick Board—in other words, Mr. Hudson—did indeed mark their sense of the "great obligations" which they were under to George Stephenson for helping to carry their Bill through Parliament, by making him an allotment of thirty of the new shares authorised by the Act. But, as afterwards appeared, the chairman had at the same time appropriated to himself not fewer than 10,894 of the same shares, the premiums on which were then worth, in the market, about 145,000*l*. This shabby manner of acknowledging the gratitude of the Company to their engineer was strongly resented by Stephenson at the time, and a coolness took place between him and Hudson which was never wholly removed—though they afterwards shook hands, and Stephenson declared that all was forgotten.

Mr. Hudson's brief reign drew to a close. The saturnalia of 1845 was followed by the usual reaction. Shares went down faster than they had gone up; the holders of them hastened to sell in order to avoid payment of the calls, and many found themselves ruined. Then came repentance, and a sudden return to virtue. The betting man who, temporarily abandoning the turf for the share-market, had played his heaviest stake and lost; the merchant who had left his business, and the doctor who had neglected his patients, to gamble in railway stock, and been ruined; the penniless knaves and schemers who had speculated so recklessly and gained so little; the titled and fashionable people, who had bowed themselves so low before the idol of the day, and found themselves deceived and "done;" the credulous small capitalists, who, dazzled by premiums, had

invested their all in railway shares, and now saw themselves stripped of everything—were grievously enraged, and looked about them for a victim. In this temper were shareholders, when, at a railway meeting in York, some pertinent questions were put to the Railway King. His replies were not satisfactory, and the questions were pushed home. Mr. Hudson became confused. Angry voices rose in the meeting. A committee of investigation was appointed. The golden calf was found to be of brass, and hurled down; Hudson's own toadies and sycophants eagerly joining the chorus of popular indignation. Similar proceedings shortly after followed at the meetings of other Companies, and the bubbles having by that time burst, the Railway Mania thus came to an ignominious end.

While the mania was at its height in England, railways were also being extended abroad, and George Stephenson continued to be invited to give the directors of foreign undertakings the benefit of his advice. One of the most agreeable of his excursions with that object was his third visit to Belgium in 1845. His special purpose was to examine the proposed line of the Sambre and Meuse Railway, for which a concession had been granted by the Belgian legislature. Arrived on the ground, he went carefully over the entire length of the proposed line, by Couvins, through the Forest of Ardennes, to Rocroi, across the French frontier; examining the bearings of the coal-field, the slate and marble quarries, and the numerous iron mines in existence between the Sambre and the Meuse, as well as carefully exploring the ravines which extended through the district, in order to satisfy himself that the best possible route had been selected. Stephenson was delighted with the novelty of the journey, the beauty of the scenery, and the industry of the population. His companions were entertained by his ample and varied stores of practical information on all subjects,

and his conversation was full of reminiscences of his youth, on which he always delighted to dwell when in the society of his more intimate friends. The journey was varied by a visit to the coal-mines near Jemappe, where Stephenson examined with interest the mode adopted by the Belgian miners of draining the pits, inspecting their engines and brakeing machines, so familiar to him in early life.

The engineers of Belgium took the opportunity of the engineer's visit to invite him to a magnificent banquet at Brussels. The Public Hall, in which they entertained him, was gaily decorated with flags, prominent amongst which was the Union Jack, in honour of their distinguished guest. A handsome marble pedestal, ornamented with his bust crowned with laurels, stood at one end of the room. The chair was occupied by M. Massui, the Chief Director of the National Railways of Belgium; and the most eminent scientific men of the kingdom were present. Their reception of "the Father of railways" was of the most enthusiastic description. Stephenson was greatly pleased with the entertainment. Not the least interesting incident of the evening was his observing, when the dinner was about half over, the model of a locomotive engine placed upon the centre table, under a triumphal arch. Turning suddenly to his friend Sopwith, he exclaimed, "Do you see the 'Rocket'?" It was indeed the model of that celebrated locomotive; and the engincer prized the delicate compliment thus paid him, perhaps more than all the encomiums of the evening.

The next day (April 5th) King Leopold invited him to a private interview at the palace. Accompanied by Mr. Sopwith, he proceeded to Laaken, and was cordially received by his Majesty. The king immediately entered into familiar conversation with him, discussing first the railway project which had been the object of his visit to Belgium, and then the structure of the

Belgian coal-fields,—his Majesty expressing his sense of the great importance of economy in a fuel which had become indispensable to the comfort and well-being of society, which was the basis of all manufactures, and the vital power of railway locomotion. The subject was always a favourite one with George Stephenson, and, encouraged by the king, he proceeded to explain to him the geological structure of Belgium, the original formation of coal, its subsequent elevation by volcanic forces, and the vast amount of denudation. In describing the coal-beds he used his hat as a sort of model to illustrate his meaning; and the eyes of the king were fixed upon it as he proceeded with his description. The conversation then passed to the rise and progress of trade and manufactures,—Stephenson pointing out how closely they everywhere followed the coal, being mainly dependent upon it, as it were, for their very existence.

The king seemed greatly pleased with the interview, and at its close expressed himself as obliged by the interesting information which the engineer had communicated. Shaking hands cordially with both the gentlemen, and wishing them success in their important undertakings, he bade them adieu. As they were leaving the palace, Stephenson, bethinking him of the model by which he had just been illustrating the Belgian coal-fields, said to his friend, "By the by, Sopwith, I was afraid the king would see the inside of my hat; it's a shocking bad one!"

George Stephenson paid a further visit to Belgium in the course of the same year, on the business of the West Flanders Railway; and he had scarcely returned from it ere he was requested to proceed to Spain, for the purpose of examining and reporting upon a scheme then on foot for constructing "the Royal North of Spain Railway." A concession had been made by the Spanish Government of a line of railway from Madrid

to the Bay of Biscay, and a numerous staff of engineers was engaged in surveying the proposed line. The directors of the Company had declined making the necessary deposits until more favourable terms had been secured; and Sir Joshua Walmsley, on their part, was about to visit Spain and press the Government on the subject. George Stephenson, whom he consulted, was alive to the difficulties of the office which Sir Joshua was induced to undertake, and offered to be his companion and adviser on the occasion,—declining to receive any recompense beyond the simple expenses of the journey. He could only arrange to be absent for six weeks, and he set out from England about the middle of September, 1845.

The party was joined at Paris by Mr. Mackenzie, the contractor for the Orleans and Tours Railway, then in course of construction, who took them over the works and accompanied them as far as Tours. They soon reached the great chain of the Pyrenees, and crossed over into Spain. It was on a Sunday evening, after a long day's toilsome journey through the mountains, that the party suddenly found themselves in one of those beautiful secluded valleys lying amidst the Western Pyrenees. A small hamlet lay before them, consisting of some thirty or forty houses and a fine old church. The sun was low on the horizon, and under the wide porch, beneath the shadow of the church, were seated nearly all the inhabitants of the place. They were dressed in their holiday attire. The bright bits of red and amber colour in the dresses of the women, and the gay sashes of the men, formed a striking picture, on which the travellers gazed in silent admiration. It was something entirely novel and unexpected. Beside the villagers sat two venerable old men, whose canonical hats indicated their quality as village pastors. Two groups of young women and children were dancing outside the porch to the accom-

paniment of a simple pipe ; and within a hundred yards of them, some of the youths of the village were disporting themselves in athletic exercises ; the whole being carried on beneath the fostering care of the old church, and with the sanction of its ministers. It was a beautiful scene, and deeply moved the travellers as they approached the principal group. The villagers greeted them courteously, supplied their present wants, and pressed upon them some fine melons, brought from their adjoining gardens. George Stephenson used afterwards to look back upon that simple scene, and speak of it as one of the most charming pastorals he had ever witnessed.

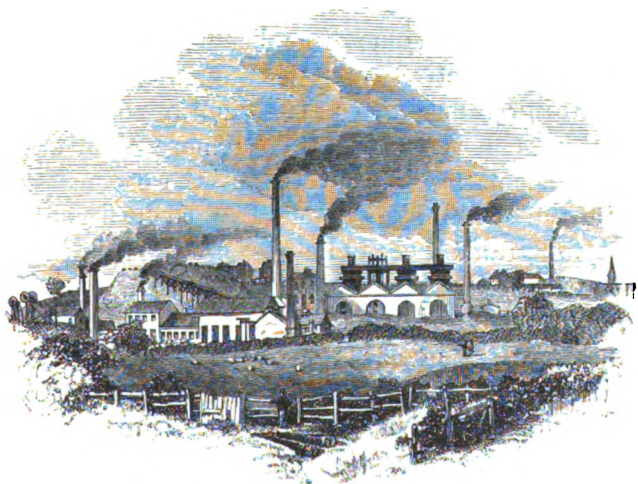
They shortly reached the site of the proposed railway, passing through Irun, St. Sebastian, St. Andero, and Bilbao, at which places they met deputations of the principal inhabitants who were interested in the object of their journey. At Raynosa Stephenson carefully examined the mountain passes and ravines through which a railway could be made. He rose at break of day, and surveyed until the darkness set in ; and frequently his resting-place at night was the floor of some miserable hovel. He was thus laboriously occupied for ten days, after which he proceeded across the province of Old Castile towards Madrid, surveying as he went. The proposed plan included the purchase of the Castile Canal ; and that property was also examined. He next proceeded to El Escorial, situated at the foot of the Guadarama mountains, through which he found that it would be necessary to construct two formidable tunnels ; added to which he ascertained that the country between El Escorial and Madrid was of a very difficult and expensive character to work through. Taking these circumstances into account, and looking at the expected traffic on the proposed line, Sir Joshua Walmsley, acting under the advice of Mr Stephenson, offered to con-

struct the line from Madrid to the Bay of Biscay, on condition that the requisite land was given to the Company for the purpose; that they should be allowed every facility for cutting such timber belonging to the Crown as might be required for the purposes of the railway; and also that the materials required from abroad for the construction of the line should be admitted free of duty. In return for these concessions, the Company offered to clothe and feed several thousand convicts while engaged in the execution of the earthworks. General Narvaez, afterwards Duke of Valencia, received Sir Joshua Walmsley and Mr. Stephenson on the subject of their proposition, and expressed his willingness to close with them; but it was necessary that other influential parties should give their concurrence before the scheme could be carried into effect. The deputation waited ten days to receive the answer of the Spanish Government; but no answer of any kind was vouchsafed. The authorities, indeed, invited them to be present at a Spanish bull-fight, but that was not quite the business Stephenson had gone all the way to Spain to transact; and the offer was politely declined. The result was that Stephenson dissuaded his friend from making the necessary deposit at Madrid. Besides, he had by this time formed an unfavourable opinion of the entire project, and considered that the traffic would not amount to one-eighth of the estimate.

Mr. Stephenson was now anxious to be in England. During the journey from Madrid he often spoke with affection of friends and relatives; and when apparently absorbed by other matters, he would revert to what he thought might then be passing at home. Few incidents worthy of notice occurred on the journey homeward, but one may be mentioned. While travelling in an open conveyance between Madrid and Vittoria, the driver urged his mules down hill at a dangerous

pace. He was requested to slacken speed; but suspecting his passengers to be afraid, he only flogged the brutes into a still more furious gallop. Observing this, Stephenson coolly said, "Let us try him on the other tack; tell him to show us the fastest pace at which Spanish mules can go." The rogue of a driver, when he found his tricks of no avail, pulled up and proceeded at a more moderate speed for the rest of the journey.

Urgent business required Mr. Stephenson's presence in London on the last day of November. They travelled, therefore, almost continuously, day and night; and the fatigue consequent on the journey, added to the privations endured by the engineer while carrying on the survey among the Spanish mountains, began to tell seriously on his health. By the time he reached Paris he was evidently ill, but he nevertheless determined on proceeding. He reached Havre in time for the Southampton boat; but when on board, pleurisy developed itself, and it was necessary to bleed him freely. After a few weeks' rest at home, however, he gradually recovered, though his health remained severely shaken.



CLAY CROSS WORKS



NEWCASTLE, FROM THE HIGH LEVEL BRIDGE [by R. F. Leitch]

CHAPTER XVII.

ROBERT STEPHENSON'S CAREER — THE STEPHENSONS AND BRUNEL — EAST COAST ROUTE TO SCOTLAND — ROYAL BORDER BRIDGE, BERWICK — HIGH LEVEL BRIDGE, NEWCASTLE.

THE career of George Stephenson was drawing to a close. He had for some time been gradually retiring from the more active pursuit of railway engineering, and confining himself to the promotion of only a few undertakings in which he took a more than ordinary personal interest. In 1840, when the extensive main lines in the Midland districts had been finished and opened for traffic, he publicly expressed his intention of withdrawing from the profession. He had reached sixty, and, having spent the greater part of his life in very hard work, he naturally desired rest and retirement in his old age. There was the less necessity for his continuing "in harness," as Robert Stephenson was now in full career as a leading railway engineer, and his father had pleasure in handing over to him, with

the sanction of the Companies concerned, nearly all the railway appointments which he held.

Robert Stephenson amply repaid his father's care. The sound education of which he had laid the foundations at school, improved by his subsequent culture, but more than all by his father's example of application, industry, and thoroughness in all that he undertook, told powerfully in the formation of his character, not less than in the discipline of his intellect. His father had early implanted in him habits of mental activity, familiarized him with the laws of mechanics, and carefully trained and stimulated his inventive faculties, the first great fruits of which, as we have seen, were exhibited in the triumph of the "Rocket" at Rainhill. "I am fully conscious in my own mind," said the son at a meeting of the Mechanical Engineers at Newcastle, in 1858, "how greatly my civil engineering has been regulated and influenced by the mechanical knowledge which I derived directly from my father; and the more my experience has advanced, the more convinced I have become that it is necessary to educate an engineer in the workshop. That is, emphatically, the education which will render the engineer most intelligent, most useful, and the fullest of resources in times of difficulty."

Robert Stephenson was but twenty-six years old when the performances of the "Rocket" established the practicability of steam locomotion on railways. He was shortly after appointed engineer of the Leicester and Swannington Railway; after which, at his father's request, he was made joint engineer with himself in laying out the London and Birmingham Railway, and the execution of that line was afterwards entrusted to him as sole engineer. The stability and excellence of the works of that railway, the difficulties which had been successfully overcome in the course of its construction, and the judgment which was displayed by Robert Stephenson throughout the whole conduct of the under-

taking to its completion, established his reputation as an engineer; and his father could now look with confidence and pride upon his son's achievements. From that time forward, father and son worked together cordially, each jealous of the other's honour; and on the father's retirement it was generally recognised that, in the sphere of railways, Robert Stephenson was the foremost man, the safest guide, and the most active worker.

Robert Stephenson was subsequently appointed engineer of the Eastern Counties, the Northern and Eastern, and the Blackwall Railways, besides many lines in the midland and southern districts. When the speculation of 1844 set in, his services were, of course, greatly in request. Thus, in one session, we find him engaged as engineer for not fewer than thirty-three new schemes. Projectors thought themselves fortunate who could secure his name, and he had only to propose his terms to obtain them. The work which he performed at this period of his life was indeed enormous, and his income was large beyond any previous instance of engineering gain. But much of the labour done was mere hackwork of a very uninteresting character. During the sittings of the Committees of Parliament, much time was also occupied in consultations, and in preparing evidence or in giving it.

The crowded, low-roofed committee-rooms of the old Houses of Parliament were altogether inadequate to accommodate the press of perspiring projectors of Bills, and even the lobbies were sometimes choked with them. To have borne that noisome atmosphere and heat would have tested the constitutions of salamanders, and engineers were only human. With brains kept in a state of excitement during the entire day, no wonder their nervous systems became unstrung. Their only chance of refreshment was during an occasional rush to the bun and sandwich stand in the lobby, though sometimes

even that resource failed them. Then, with mind and body jaded—probably after undergoing a series of consultations upon many Bills after the rising of the committees—the exhausted engineers would seek to stimulate nature by a late, perhaps a heavy, dinner. What chance had any ordinary constitution of surviving such an ordeal? The consequence was, that stomach, brain, and liver were alike injured; and hence the men who bore the heat and brunt of those struggles—Stephenson, Brunel, Locke, and Errington—have already all died, comparatively young men.

In mentioning the name of Brunel, we are reminded of him as the principal rival and competitor of Robert Stephenson. Both were the sons of distinguished men, and both inherited the fame and followed in the footsteps of their fathers. The Stephensons were inventive, practical, and sagacious; the Brunels ingenious, imaginative, and daring. The former were as thoroughly English in their characteristics as the latter perhaps were as thoroughly French. The fathers and the sons were alike successful in their works, though not in the same degree. Measured by practical and profitable results, the Stephensons were unquestionably the safer men to follow.

Robert Stephenson and Isambard Kingdom Brunel were destined often to come into collision in the course of their professional life. Their respective railway districts “marched” with each other, and it became their business to invade or defend those districts, according as the policy of their respective boards might direct. The gauge of 7 feet fixed by Brunel for the Great Western Railway, so entirely different from that of 4 feet 8½ inches adopted by the Stephensons on the Northern and Midland lines,¹ was from the first a great

¹ The original width of the coal tramroads in the North virtually determined the British gauge. It was

the width of the ordinary road-track, —not fixed after any scientific theory, but adopted simply because its use had

cause of contention. But Brunel had always an aversion to follow any man's lead; and that another engineer had fixed the gauge of a railway, or built a bridge, or designed an engine, in one way, was of itself often a sufficient reason with him for adopting an altogether different course. Robert Stephenson, on his part, though less bold, was more practical, preferring to follow the old routes, and to tread in the safe steps of his father.

Mr. Brunel, however, determined that the Great Western should be a giant's road, and that travelling should be conducted upon it at double speed. His ambition was to make the *best* road that imagination could devise; whereas the main object of the Stephensons, both father and son, was to make a road that would *pay*. Although, tried by the Stephenson test, Brunel's magnificent road was a failure so far as the shareholders in the Great Western Company were concerned, the stimulus which his ambitious designs gave to mechanical invention at the time proved a general good. The narrow-gauge engineers exerted themselves to quicken

already been established. George Stephenson introduced it without alteration on the Liverpool and Manchester Railway; and the lines subsequently formed in that district were laid down of the same width. Stephenson from the first anticipated the general extension of railways throughout England; and one of the ideas with which he started was, the essential importance of preserving such a uniformity as would admit of perfect communication between them. When consulted about the gauge of the Canterbury and Whitstable, and Leicester and Swannington Railways, he said, "Make them of the same width: though they may be a long way apart now, depend upon it they will be joined together some day." All the railways, therefore, laid down by himself and his assistants in the neighbourhood of Manchester, extending from thence to London on the south,

and to Leeds on the east, were constructed on the Liverpool and Manchester, or narrow gauge. Besides the Great Western Railway, where the gauge adopted was seven feet, the only other line on which a broader gauge than four feet eight and a-half inches was adopted was the Eastern Counties, where it was five feet, Mr. Braithwaite, the engineer, being of opinion that an increase of three and a-half inches in the width of the line would afford better space for the machinery of the locomotive. But when the northern and eastern extension of the same line was formed, which was to work into the narrow-gauge system of the Midland Railway, Robert Stephenson, its new engineer, strongly recommended the directors of the Eastern Counties Line to alter their gauge accordingly, for the purpose of securing uniformity; and they adopted his recommendation.

their locomotives to the utmost. They improved and re-improved them. The machinery was simplified and perfected. Outside cylinders gave place to inside; the steadier and more rapid and effective action of the engine was secured; and in a few years the highest speed on railways went up from thirty to about fifty miles an hour. For this rapidity of progress we are in no small degree indebted to the stimulus imparted to the narrow-gauge engineers by Mr. Brunel.

It was one of the characteristics of Brunel to *believe* in the success of the schemes for which he was professionally engaged as engineer; and he proved this by investing his savings largely in the Great Western Railway, in the South Devon Atmospheric line, and in the Great Eastern steamship, with what results are well known. Robert Stephenson, on the contrary, with characteristic caution, towards the latter years of his life avoided holding unguaranteed railway shares; and though he might execute magnificent structures, such as the Victoria Bridge across the St. Lawrence, he was careful not to embark any portion of his own fortune in the ordinary capital of these concerns. In 1845, he shrewdly foresaw the inevitable crash that was about to succeed the mania of that year; and while shares were still at a premium he took the opportunity of selling out all that he held. He urged his father to do the same thing, but George's reply was characteristic. "No," said he; "I took my shares for an investment, and not to speculate with, and I am not going to sell them now because people have gone mad about railways." The consequence was, that he continued to hold the 60,000*l.* which he had invested in the shares of various railways until his death, when they were at once sold out by his son, though at a great depreciation on their original cost.

One of the hardest battles fought between the Stephensons and Brunel was for the railway between Newcastle

and Berwick, forming part of the great East Coast route to Scotland. As early as 1836, George Stephenson had surveyed two lines to connect Edinburgh with Newcastle: one by Berwick and Dunbar along the coast, and the other, more inland, by Carter Fell, up the vale of the Gala, to the northern capital. Two years later, he made a further examination of the intervening country, and reported in favour of the coast line. The inland route, however, was not without its advocates. But both projects lay dormant for several years longer, until the completion of the Midland and other main lines as far north as Newcastle had the effect of again reviving the subject of the extension of the route as far as Edinburgh.

On the 18th of June, 1844, the Newcastle and Darlington line—an important link of the great main highway to the north—was completed and publicly opened, thus connecting the Thames and the Tyne by a continuous line of railway. On that day George Stephenson and a distinguished party of railway men travelled by express train from London to Newcastle in about nine hours. It was a great event, and was worthily celebrated. The population of Newcastle held holiday; and a banquet given in the Assembly Rooms the same evening assumed the form of an ovation to Mr. Stephenson and his son.

After the opening of this railway, the project of the East Coast line from Newcastle to Berwick was revived; and George Stephenson, who had already identified himself with the question, and was intimately acquainted with every foot of the ground, was again called upon to assist the promoters with his judgment and experience. He again recommended as strongly as before the line he had previously surveyed; and on its being adopted by the local committee, the necessary steps were taken to have the scheme brought before Parliament in the ensuing session. The East Coast line was

not, however, to be allowed to pass without a fight. On the contrary, it had to encounter as stout an opposition as Stephenson had ever experienced.

We have already stated that about this time the plan of substituting atmospheric pressure for locomotive steam-power in the working of railways, had become very popular. Many eminent engineers avowedly supported atmospheric in preference to locomotive lines; and many members of Parliament, headed by the Prime Minister, were strongly disposed in their favour. Mr. Brunel warmly espoused the atmospheric principle, and his persuasive manner, as well as his admitted scientific ability, unquestionably exercised considerable influence in determining the views of many leading members of both Houses. Among others, Lord Howick, one of the members for Northumberland, advocated the new principle, and, possessing great local influence, he succeeded in forming a powerful confederacy of the landed gentry in favour of Brunel's atmospheric railway through the county.

George Stephenson could not brook the idea of seeing the locomotive, for which he had fought so many stout battles, pushed to one side, and that in the very county in which its great powers had been first developed. Nor did he relish the appearance of Mr. Brunel as the engineer of Lord Howick's scheme, in opposition to the line which had occupied his thoughts and been the object of his strenuous advocacy for so many years. When Stephenson first met Brunel in Newcastle, he good-naturedly shook him by the collar, and asked "what business he had north of the Tyne?" George gave him to understand that they were to have a fair stand-up fight for the ground, and shaking hands before the battle like Englishmen, they parted in good humour. A public meeting was held at Newcastle in the following December, when, after a full discussion of the merits

of the respective plans, Stephenson's line was almost unanimously adopted as the best.

The rival projects went before Parliament in 1845, and a severe contest ensued. The display of ability and tactics on both sides was great. Robert Stephenson was examined at great length as to the merits of the locomotive line, and Brunel at equally great length as to the merits of the atmospheric. Mr. Brunel, in his evidence, said that after numerous experiments, he had arrived at the conclusion that the mechanical contrivance of the atmospheric system was perfectly applicable, and he believed that it would likewise be more economical in most cases than locomotive power. "In short," said he, "rapidity, comfort, safety, and economy, are its chief recommendations."

Notwithstanding the promise of Mr. Sergeant Wrangham, the counsel for Lord Howick's scheme, that the Northumberland atmospheric was to be "a *respectable* line, and not one that was to be converted into a road for the accommodation of the coal-owners of the district," the locomotive again triumphed. The Stephenson Coast line secured the approval of Parliament; and the shareholders in the Atmospheric Company were happily prevented investing their capital in what would unquestionably have proved a gigantic blunder. For, less than three years later, the whole of the atmospheric tubes which had been laid down on other lines were pulled up and the materials sold—including Mr. Brunel's immense tube on the South Devon Railway¹—to make

¹ The atmospheric lines had for some time been working very irregularly and very expensively. Robert Stephenson, in a letter to Mr. T. Sopwith, F.R.S., dated the 8th Jan., 1846, wrote:—"Since my return [from Italy] I have learned that your atmospheric friends are very sickly. A slow typhus has followed the high

fever I left them in about three months ago. I don't anticipate, however, that the patient will expire suddenly. There is every appearance of the case being a protracted one, though a fatal termination is inevitable. When the pipes are sold by auction, I intend to buy one and present it to the British Museum." During the last half-year of the

way for the working of the locomotive engine. George Stephenson's first verdict of "It won't do," was thus conclusively confirmed.

Robert Stephenson used afterwards to describe with gusto an interview which took place between Lord Howick and his father, at his office in Great George Street, during the progress of the Bill in Parliament. His father was in the outer office, where he used to spend a good deal of his spare time ; occasionally taking a quiet wrestle with a friend when nothing else was stirring.¹ On the day in question, George was standing with his back to the fire, when Lord Howick called to see Robert. Oh ! thought George, he has come to try and talk Robert over about that atmospheric gim-crack ; but I'll tackle his Lordship. "Come in, my Lord," said he, "Robert's busy ; but I'll answer your purpose quite as well ; sit down here, if you please." George began, "Now, my Lord, I know very well what you have come about : it's that atmospheric line in the north ; I will show you in less than five minutes that it can never answer." "If Mr. Robert Stephenson is not at liberty, I can call again," said his Lordship. "He's certainly occupied on important business just at present," was George's answer, "but I can tell you far better than he can what nonsense the atmospheric system is : Robert's good-natured, you see, and if your Lordship were to get alongside of him you might talk him over ; so you have been quite lucky in meeting with me. Now, just look at the question of expense,"

atmospheric experiment on the South Devon line, in 1848, the expenditure exceeded the gross income (26,782*l.*) by 2487*l.*, or about 9½ per cent. excess of working expenses beyond the gross receipts.

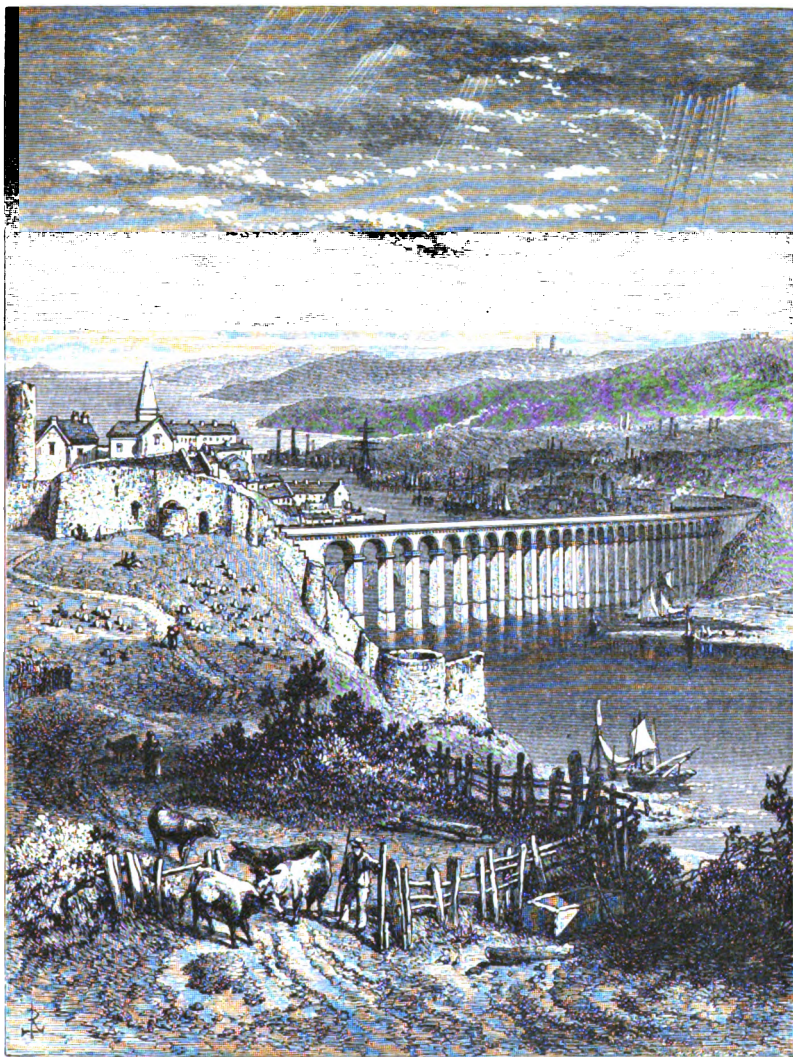
¹ "When my father came about the office," said Robert, "he sometimes did not well know what to do with himself. So he used to invite

Bidder to have a quiet wrestle with him, for old acquaintance sake. And the two wrestled together so often, and had so many 'falls' (sometimes I thought they would bring the house down between them), that they broke half the chairs in my outer office. I remember once sending my father in a joiner's bill of about 2*l.* 10*s.* for the mending of broken chairs."

and then he proceeded in his strong Doric to explain his views in detail, until Lord Howick could stand it no longer, and he rose and walked towards the door. George followed him down stairs, to finish his demolition of the atmospheric system, and his parting words were, "You may take my word for it, my Lord, it will never answer." George afterwards told his son with glee of "the settler" he had given Lord Howick.

So closely were the Stephensons identified with this measure, and so great was the personal interest which they were both known to take in its success, that, on the news of the passing of the Bill reaching Newcastle, a sort of general holiday took place, and the workmen belonging to the Stephenson Locomotive Factory, upwards of eight hundred in number, walked in procession through the principal streets of the town, accompanied by music and banners.

It is unnecessary to enter into any description of the works of the Newcastle and Berwick Railway. There are no fewer than a hundred and ten bridges of all sorts on the line—some under and some over it—the viaducts over the Ouseburn, the Wansbeck, and the Coquet, being of considerable importance. But by far the most formidable piece of masonry work on this railway is at its northern extremity, where it passes across the Tweed into Scotland, immediately opposite the formerly redoubtable castle of Berwick. Not many centuries had passed since the district amidst which this bridge stands was the scene of almost constant warfare. Berwick was regarded as the key of Scotland, and was fiercely fought for, being sometimes held by a Scotch and sometimes by an English garrison. Though strongly fortified, it was repeatedly taken by assault. On its capture by Edward I., Boetius says, 17,000 persons were slain, so that its streets "ran with blood like a river." Within sight of the ramparts, a little to the west, is Halidon Hill, where a famous victory was gained by Edward



ROYAL BORDER BRIDGE, BERWICK. [By R. P. Leitch, after his original Drawing.]

III., over the Scottish army under Douglas; and there is scarcely a foot of ground in the neighbourhood but has been the scene of contention in days long past. In the reigns of James I. and Charles I., a bridge of fifteen arches was built across the Tweed at Berwick; and

now a railway-bridge of twenty-eight arches was built a little above the old one, but at a much higher level. The bridge built by the Kings, out of the national resources, cost 15,000*l.*, and occupied twenty-four years and four months in the building; the bridge built by the Railway Company, with funds drawn from private resources, cost 120,000*l.*, and was finished in three years and four months from the day of laying the foundation stone.

This important viaduct, built after the designs of Robert Stephenson, consists of a series of twenty-eight semicircular arches, each 61 feet 6 inches in span, the greatest height above the bed of the river being 126 feet. The whole is built of ashlar, with a hearting of rubble; excepting the river parts of the arches, which are constructed with bricks laid in cement. The total length of the work is 2160 feet. The foundations of the piers were got in by coffer-dams in the ordinary way, Nasmyth's steam-hammer being extensively used in driving the piles. The bearing piles, from which the foundations of the piers were built up, were each capable of carrying 70 tons.

Another bridge, of still greater importance, necessary to complete the continuity of the East Coast route, was the masterwork erected by Robert Stephenson between the north and south banks of the Tyne at Newcastle, commonly known as the High Level Bridge. Mr. R. W. Brandling, George Stephenson's early friend, is entitled to the merit of originating the idea of this bridge, as it was eventually carried out, with a central terminus for the northern railways in the Castle Garth. The plan was first promulgated by him in 1841; and in the following year it was resolved that George Stephenson should be consulted as to the most advisable site for the proposed structure. A prospectus of a High Level Bridge Company was issued in 1843, the names of George Stephenson and George Hudson

appearing on the committee of management, Robert Stephenson being the consulting engineer. The project was eventually taken up by the Newcastle and Darlington Railway Company, and an Act for the construction of the bridge was obtained in 1845.

The rapid extension of railways had given an extraordinary stimulus to the art of bridge-building; the number of such structures erected in Great Britain alone, since 1830, having been above thirty thousand, or far more than all that previously existed in the country. Instead of the erection of a single large bridge constituting, as formerly, an epoch in engineering, hundreds of extensive bridges of novel design were simultaneously constructed. The necessity which existed for carrying rigid roads, capable of bearing heavy railway trains at high speeds, over extensive gaps free of support, rendered it apparent that the methods which had up to that time been employed for bridging space were altogether insufficient. The railway engineer could not, like the ordinary road engineer, divert his road, and make choice of the best point for crossing a river or a valley. He must take such ground as lay in the line of his railway, be it bog, or mud, or shifting sand. Navigable rivers and crowded thoroughfares had to be crossed without interruption to the existing traffic, sometimes by bridges at right angles to the river or road, sometimes by arches more or less oblique. In many cases great difficulty arose from the limited nature of the headway; but, as the level of the original road must generally be preserved, and that of the railway was in a measure fixed and determined, it was necessary to modify the form and structure of the bridge in almost every case, in order to comply with the public requirements. Novel conditions were met by fresh inventions, and difficulties of an unusual character were one after another successfully surmounted. In executing these extraordinary works, iron has been throughout the

sheet-anchor of the engineer. In its various forms of cast and wrought iron, it offered a valuable resource, where rapidity of execution, great strength and cheapness of construction in the first instance, were elements of prime importance; and by its skilful use, the railway architect was enabled to achieve results which thirty years since would scarcely have been thought possible.

In many of the early cast-iron bridges, the old form of the arch was adopted, the stability of the structure depending wholly on compression, the only novel feature consisting in the use of iron instead of stone. But in a large proportion of cases, the arch, with the railroad over it, was found inapplicable in consequence of the limited headway which it provided. Hence it early occurred to George Stephenson, when constructing the Liverpool and Manchester Railway, to adopt the simple cast-iron beam for the crossing of several roads and canals along that line—this beam resembling in some measure the lintel of the early temples—the pressure on the abutments being purely vertical. One of the earliest instances of this kind of bridge was that erected over Water Street, Manchester, in 1829; after which, cast-iron girders, with their lower webs considerably larger than their upper, were ordinarily employed where the span was moderate; and wrought-iron tie-rods below were added to give increased strength where the span was greater.

The next step was the contrivance of arched beams or bowstring girders, firmly held together by horizontal ties to resist the thrust, instead of abutments. Numerous excellent specimens of this description of bridge were erected by Robert Stephenson on the original London and Birmingham Railway; but by far the grandest work of the kind—perfect as a specimen of modern constructive skill—was the High Level Bridge, which we owe to the genius of the same engineer.

The problem was, to throw a railway bridge across

the deep ravine which lies between the towns of Newcastle and Gateshead, at the bottom of which flows the navigable river Tyne. Along and up the sides of the valley—on the Newcastle bank especially—run streets of old-fashioned houses, clustered together in the strange forms peculiar to the older cities. The ravine is of great depth—so deep and gloomy-looking towards dusk, that local tradition records that when the Duke of Cumberland arrived late in the evening, at the brow of the hill overlooking the Tyne, on his way to Culloden, he exclaimed to his attendants, on looking down into the black gorge before him, “For God’s sake, don’t think of taking me down that coal-pit at this time of night!” The road down the Gateshead High Street is almost as steep as the roof of a house, and up the Newcastle Side, as the street there is called, it is little better. During many centuries the traffic north and south passed along this dangerous and difficult route, across the old bridge which spans the river in the bottom of the valley. For some thirty years the Newcastle Corporation had discussed various methods of improving the communication between the towns; and the discussion might have gone on for thirty years more, but for the advent of railways, when the skill and enterprise to which they gave birth speedily solved the difficulty and bridged the ravine. The local authorities adroitly took advantage of the opportunity, and insisted on the provision of a road for ordinary vehicles and foot passengers in addition to the railroad. In this circumstance originated one of the most remarkable peculiarities of the High Level Bridge, which serves two purposes, being a railway above with a carriage roadway underneath.

The breadth of the river at the point of crossing is 515 feet, but the length of the bridge and viaduct between the Gateshead station and the terminus on the Newcastle side is about 4000 feet. It springs from

Pipewell Gate Bank, on the south, directly across to Castle Garth, where, nearly fronting the bridge, stands the fine old Norman keep of the *New Castle*, now nearly eight hundred years old; and a little beyond it is the spire of St. Nicholas Church, with its light and graceful Gothic crown; the whole forming a grand architectural group of unusual historic interest. The bridge passes completely over the roofs of the houses which fill both sides of the valley, and the extraordinary height of the upper parapet, which is about 130 feet above the bed of the river, offers a prospect to the passing traveller the like of which is perhaps nowhere else to be seen. Far below lie the queer chares and closes, the wynds and lanes of old Newcastle; the water is crowded with pudgy, black, coal keels; and, when there is a lull in the great clouds of smoke which usually obscure the sky, the funnels of steamers and the masts of the shipping may be seen far down the river. The old bridge lies so far beneath that the passengers crossing it seem like so many bees passing to and fro.

The first difficulty encountered in building the bridge was in securing a solid foundation for the piers. The dimensions of the piles to be driven were so huge, that the engineer found it necessary to employ some extraordinary means for the purpose. He called Nasmyth's Titanic steam-hammer to his aid—the first occasion, we believe, on which this prodigious power was employed in bridge pile-driving. A temporary staging was erected for the steam-engine and hammer apparatus, which rested on two keels, and, notwithstanding the newness and stiffness of the machinery, the first pile was driven on the 6th of October, 1846, to a depth of 32 feet, in four minutes. Two hammers of 30 cwt. each were kept in regular use, making from 60 to 70 strokes per minute; and the results were astounding to those who had been accustomed to the old style of pile-driving by means of the ordinary pile-frame, con-

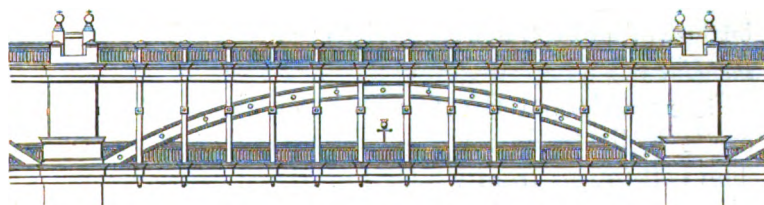
sisting of slide, ram, and monkey. By the old system, the pile was driven by a comparatively small mass of iron descending with great velocity from a considerable height—the velocity being in excess and the mass deficient, and calculated, like the momentum of a cannon ball, rather for destructive than impulsive action. In the case of the steam pile-driver, on the contrary, the whole weight of a heavy mass is delivered rapidly upon a driving-block of several tons weight placed directly over the head of the pile, the weight never ceasing, and the blows being repeated at the rate of a blow a second, until the pile is driven home. It is a curious fact, that the rapid strokes of the steam-hammer evolved so much heat, that on many occasions the pile-head burst into flame during the process of driving. The elastic force of steam is the power that lifts the ram, the escape permitting its entire force to fall upon the head of the driving block; while the steam above the piston on the upper part of the cylinder, acting as a buffer or recoil-spring, materially enhances the effect of the downward blow. As soon as one pile was driven, the traveller, hovering overhead, presented another, and down it went into the solid bed of the river, with almost as much ease as a lady sticks pins into a cushion. By the aid of this formidable machine, what before was among the most costly and tedious of engineering operations, was rendered simple, easy, and economical.

When the piles had been driven and the coffer-dams formed and puddled, the water within the enclosed spaces was pumped out by the aid of powerful engines, so as to lay bare the bed of the river. Considerable difficulty was experienced in getting in the foundations of the middle pier, in consequence of the water forcing itself through the quicksand beneath as fast as it was removed. This fruitless labour went on for months, and many expedients were tried. Chalk was thrown in in large quantities, outside the piling, but without

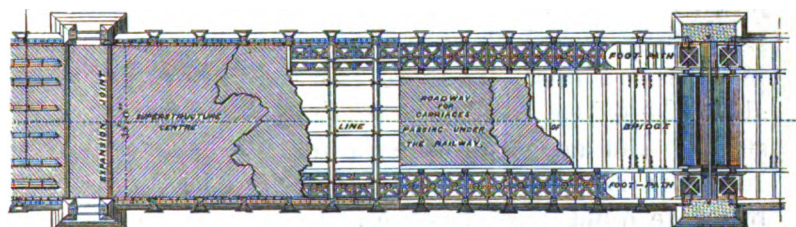
effect. Cement concrete was at last put within the coffer-dam, until it set, and the bottom was then found to be secure. A bed of concrete was laid up to the level of the heads of the piles, the foundation course of stone blocks being commenced about two feet below low water, and the building proceeded without further difficulty. It may serve to give an idea of the magnitude of the work, when we state that 400,000 cubic feet of ashlar, rubble, and concrete were worked up in the piers, and 450,000 cubic feet in the land-arches and approaches.

The most novel feature of the structure is the use of cast and wrought iron in forming the double bridge, which admirably combines the two principles of the arch and suspension, the railway being carried over the back of the ribbed arches in the usual manner, while the carriage-road and footpaths, forming a long gallery or aisle, are suspended from these arches by wrought-iron vertical rods, with horizontal tie-bars to resist the thrust. The suspension-bolts are enclosed within spandril pillars of cast iron, which give great stiffness to the superstructure. This system of longitudinal and vertical bracing has been much admired, for it not only accomplishes the primary object of securing rigidity in the roadway, but at the same time, by its graceful arrangement, heightens the beauty of the structure. The arches consist of four main ribs, disposed in pairs, with a clear distance between the two inner arches of 20 feet 4 inches, forming the carriage-road, while between each of the inner and outer ribs there is a space of 6 feet 2 inches, constituting the footpaths. Each arch is cast in five separate lengths or segments, strongly bolted together. The ribs spring from horizontal plates of cast iron, bedded and secured on the stone piers. All the abutting joints were carefully executed by machinery, the fitting being of the most perfect kind. In order to provide for the expan-

sion and contraction of the iron arching, and to preserve the equilibrium of the piers without disturbance or racking of the other parts of the bridge, it was arranged that the ribs of every two adjoining arches resting on the same pier should be secured to the springing-plates by keys and joggles; while on the next piers, on either side, the ribs remained free and were at liberty to expand or contract according to temperature—a space being left for the purpose. Hence each arch is complete and independent in itself, the piers having simply to sustain their vertical pressure. The arches are six in number, of 125 feet span each; the two approaches to the bridge being formed of cast-iron pillars and bearers in keeping with the arches.



HIGH LEVEL BRIDGE—ELEVATION OF ONE ARCH



PLAN OF ONE ARCH.

The result is a bridge that for massive solidity may be pronounced unrivalled. It is one of the most magnificent and striking of the bridges to which railways have given birth, and has been worthily styled "the King of railway structures." It is a monument of the highest engineering skill of our time, with the impress of power grandly stamped upon it. It will also be observed from the drawing placed as the frontispiece

to this Life, that the High Level Bridge forms a very fine object in a picture of great interest, full of striking architectural variety and beauty. The bridge was opened on the 15th of August, 1849. A few days after, the royal train passed over it, halting for a few minutes to enable her Majesty to survey the wonderful scene below. In the course of the following year, the Queen opened the extensive stone viaduct across the Tweed, above described, by which the last link was completed of the continuous line of railway between London and Edinburgh. Over the entrance to the Berwick station, occupying the site of the once redoubtable Border fortress, so often the deadly battle-ground of the ancient Scots and English, was erected an arch under which the royal train passed, bearing in large letters of gold the appropriate words, "*The last act of the Union.*"

The warders at Berwick no longer look out from the castle walls to descry the glitter of southron spears. The bell-tower, from which the alarm was sounded of old, though still standing, is deserted; the only bell heard within the precincts of the old castle being the railway porter's bell announcing the arrival and departure of trains. You see the Scotch Express pass along the bridge and speed southward on the wings of steam. But no alarm spreads along the Border now. Northumbrian beeves are safe. Chevy-Chase and Otterburn are quiet sheep-pastures. The only men-at-arms on the battlements of Alnwick Castle are of stone. Bamborough Castle has become an asylum for shipwrecked mariners, and the Norman Keep at Newcastle has been converted into a Museum of Antiquities. The railway has indeed consummated the Union.

CHAPTER XVIII.

CHESTER AND HOLYHEAD RAILWAY — MENAI AND CONWAY
BRIDGES.

WE have now to describe briefly another great undertaking, begun by George Stephenson, and taken up and completed by his son, in the course of which the latter carried out some of his greatest works—we mean the Chester and Holyhead Railway, completing the railway connection with Dublin, as the Newcastle and Berwick line completed the connection with Edinburgh. It will thus be seen how closely Telford was followed by the Stephensons in perfecting the highways of their respective epochs; the former by means of turnpike roads, and the latter by means of railways.

George Stephenson surveyed a line from Chester to Holyhead in 1838, and at the same time reported on the line through North Wales to Port Dynllaen, as proposed by the Irish Railway Commissioners. His advice was strongly in favour of adopting the line to Holyhead, as less costly and presenting better gradients. A public meeting was held at Chester, in January, 1839, in support of the latter measure, at which he was present to give explanations. Mr. Uniacke, the Mayor, in opening the proceedings, observed, that it clearly appeared that the rival line through Shrewsbury was quite impracticable. Mr. Stephenson, he added, was present in the room, ready to answer any questions which might be put to him on the subject; and "it would be better that he should be asked questions than required to make a speech; for, though a very good engineer, he was a bad speaker."

One of the questions then put to Mr. Stephenson related to the mode by which he proposed to haul the passenger-carriages over the Menai Suspension Bridge by horse-power; and he was asked whether he knew the pressure the bridge was capable of sustaining. His answer was, that "he had not yet made any calculations; but he proposed getting data which would enable him to arrive at an accurate calculation of the actual strain upon the bridge during the late gale. He had, however, no hesitation in saying that it was more than twenty times as much as the strain of a train of carriages and a locomotive engine. The only reason why he proposed to convey the carriages over by horses, was in order that he might, by distributing the weight, not increase the wavy motion. All the train would be on at once; but distributed. This he thought better than passing them linked together, by a locomotive engine." It will thus be observed that the practicability of throwing a rigid railway bridge across the Straits had not yet been contemplated.

The Dublin Chamber of Commerce passed resolutions in favour of Stephenson's line, after hearing his explanations of its essential features. The project, after undergoing much discussion, was at length embodied in an Act passed in 1844; and the work was brought to a successful completion by his son, with several important modifications, including the grand original feature of the tubular bridges across the Menai Straits and the estuary of the Conway. Excepting these great works, the construction of this line presented no unusual features; though the remarkable terrace cut for the accommodation of the railway under the steep slope of Penmaen Mawr is worthy of a passing notice.

About midway between Conway and Bangor, Penmaen Mawr forms a bold and almost precipitous headland, at the base of which, in rough weather, the ocean dashes with great fury. There was not space enough between

the mountain and the strand for the passage of the railway; hence in some places the rock had to be blasted to form a terrace, and in others sea walls had to be built up to the proper level, on which to form an embankment of sufficient width to enable the road



PENMAEN MAWR. [By Percival Skelton, after his original Drawing.]

to be laid. A tunnel of $10\frac{1}{2}$ chains in length was cut through the headland itself; and on its east and west sides the line was formed by a terrace cut out of the cliff, and by embankments protected by sea walls; the terrace being three times interrupted by embankments in its course of about a mile and a quarter. The road

lies so close under the steep mountain face, that it was even found necessary at certain places to protect it against possible accidents from falling stones, by means of a covered way. The terrace on the east side of the headland was, however, in some measure protected against the roll of the sea by the mass of stone run out from the tunnel, which formed a deep shingle-bank in front of the wall.

The part of the work which lies to the westward of the headland penetrated by the tunnel, was exposed to the full force of the sea ; and the formation of the road at that point was attended with great difficulty. While the sea wall was still in progress, its strength was severely tried by a strong north-westerly gale which blew in October, 1846, accompanied with a spring tide of 17 feet. On the following morning it was found that a large portion of the rubble was irreparably injured, and 200 yards of the wall were then replaced by an open viaduct, with the piers placed edgeways to the sea, the openings between them being spanned by ten cast-iron girders 42 feet long. This accident further induced the engineer to alter the contour of the sea wall, so that it should present a diminished resistance to the force of the waves.

But the sea repeated its assaults, and made further havock with the work, entailing heavy expenses and a complete reorganisation of the contract. Increased solidity was then given to the masonry, and the face of the wall underwent further change. At some points outworks were constructed, and piles were driven into the beach about 15 feet from the base of the wall for the purpose of protecting its foundations and breaking the force of the waves. The work was at length finished after about three years' anxious labour ; but Mr. Stephenson confessed that if a long tunnel had been made in the first instance through the solid rock of Penmaen Mawr, a saving of from 25,000*l.* to 30,000*l.*

would have been effected. He also said he had arrived at the conclusion that in railway works engineers should endeavour as far as possible to avoid the necessity of contending with the sea ;¹ but if he were ever again compelled to go within its reach, he would adopt, instead of retaining walls, an open viaduct, placing all the piers edgewise to the force of the sea, and allowing the waves to break upon a natural slope of beach. He was ready enough to admit the errors he had committed in the original design of this work ; but he said he had always gained more information from studying the causes of failures and endeavouring to surmount them, than he had done from easily-won successes. While many of the latter had been forgotten, the former were indelibly fixed in his memory.

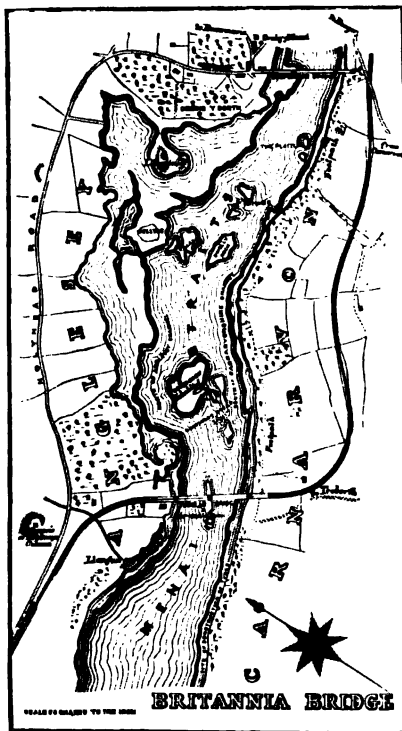
But by far the greatest difficulty which Robert Stephenson had to encounter in executing this railway was in carrying it across the Straits of Menai and the estuary of the Conway, where, like his predecessor Telford, when forming his high road through North Wales, he was under the necessity of resorting to new and altogether untried methods of bridge construction. At Menai, the waters of the Irish Sea are perpetually vibrating along the precipitous shores of the Strait, rising and falling from 20 to 25 feet at each successive tide ; the width and depth of the channel being such as to render it available for navigation by the largest ships. The problem was, to throw a bridge across this wide chasm—a bridge of unusual span and dimensions—of such strength as to be capable of bearing the heaviest loads at high speeds, and of such a uniform height throughout as not in any way to interfere

¹ The simple fact that in a heavy storm the force of impact of the waves is from one and a-half to two tons per square foot, must necessarily dictate the greatest possible caution in approaching so formidable an element.

Mr. R. Stevenson (Edinburgh) registered a force of three tons per square foot at Skerryvore, during a gale in the Atlantic, when the waves were supposed to run twenty feet high.

with the navigation of the Strait. From an early period, Mr. Stephenson had fixed upon the spot where the Britannia Rock occurs, nearly in the middle of the channel, as the most eligible point for crossing; the water width from shore to shore at high water being there about 1100 feet.

The engineer's first idea was to construct the bridge



of two cast-iron arches of 350 feet span each. There was no novelty in this idea; for, as early as the year 1801, Mr. Rennie prepared a design of a cast-iron bridge across the Strait at the Swilly rocks, the great centre arch of which was to be 450 feet span; and at a later period, in 1810, Telford submitted a design of a similar bridge at Inys-y-Moch, with a single cast-iron arch of 500 feet. But the same objections which led to the rejection of Rennie's and Telford's designs proved fatal to Robert Stephen-

son's, and his iron-arched railway bridge was rejected by the Admiralty. The navigation of the strait was under no circumstances to be interfered with; and even the erection of scaffolding from below, to support the bridge during construction, was not to be permitted. The idea of a suspension bridge was dismissed as inapplicable; a degree of rigidity and strength

greater than could be secured by any bridge erected on the principle of suspension, being considered an indispensable condition of the proposed structure.

Mr. Stephenson next considered the expediency of erecting a bridge by means of suspended centering, after the ingenious method proposed by Telford in 1810;¹ by which the arching was to be carried out by placing equal and corresponding voussoirs on opposite sides of the pier at the same time, tying them together by horizontal tie-bolts. The arching thus extended outwards from each pier and held in equilibrium, would have been connected at the crown with the extremity of the arch advanced in like manner from the adjoining pier. It was, however, found that this method of construction was not applicable at the crossing of the Conway, and it was eventually abandoned. Various other plans were suggested; but the whole question remained unsettled even down to the time when the Company went before Parliament in 1844 for power to construct the proposed bridges. No existing kind of structure seemed to be capable of bearing the severe extension to which rigid bridges of the necessary spans would be subjected; and some new expedient of engineering therefore became necessary.

Mr. Stephenson was then led to reconsider a design which he had made in 1841 for a road bridge over the river Lea at Ware, with a span of 50 feet,—the conditions only admitting of a platform 18 or 20 inches thick. For this purpose a wrought-iron platform was designed, consisting of a series of simple cells, formed of boiler-plates rivetted together with angle-iron. The bridge was not, however, carried out after this design,

¹ See 'Lives of the Engineers,' vol. ii. p. 445. It appears that Mr. Fairbairn suggested this idea in his letter to Mr. Stephenson, dated the 3rd

June, 1845, accompanied by a drawing. See his 'Account of the Construction of the Britannia and Conway Tubular Bridges,' &c. London, 1849.

but was made of separate wrought-iron girders composed of rivetted plates.¹ Recurring to his first idea of this bridge, the engineer thought that a stiff platform might be constructed, with sides of strongly-trussed framework of wrought iron, braced together at top and bottom with plates of like material rivetted together with angle-iron, after a method adopted by Mr. Rendel in stiffening the suspension bridge at Montrose with wooden trellis-work a few years before; and that such platform might be suspended by strong chains on either side to give it increased security. "It was now," says Mr. Stephenson, "that I came to regard the tubular platform as a beam, and that the chains should be looked upon as auxiliaries." It appeared to him, nevertheless, that without a system of diagonal struts inside, which of course would have prevented the passage of trains *through* it, this kind of structure was ill-suited for maintaining its form, and would be very liable to become lozenge-shaped. Besides, the rectangular figure was deemed objectionable, from the large surface which it presented to the wind.

It then occurred to him that circular or elliptical tubes might better answer the intended purpose; and in March, 1845, he gave instructions to two of his assistants to prepare drawings of such a structure, the tubes being made with a double thickness of plate at top and bottom. The results of the calculations made as to the strength of such a tube were considered so satisfactory, that Mr. Stephenson says he determined to fall back upon a bridge of this description, on the rejection of his design of the two cast-iron arches by the Parliamentary Committee. Indeed, it became evident that a tubular wrought-iron beam was the only structure which combined the necessary strength and

¹ Robert Stephenson's narrative of the early history of the design, in Edwin Clark's 'Britannia and Conway Tubular Bridges,' vol. i. p. 25. London, 1850.

stability for a railway, with the conditions deemed essential for the protection of the navigation:—

“I stood,” says Mr. Stephenson, “on the verge of a responsibility from which, I confess, I had nearly shrunk. The construction of a tubular beam of such gigantic dimensions, on a platform elevated and supported by chains at such a height, did at first present itself as a difficulty of a very formidable nature. Reflection, however, satisfied me that the principles upon which the idea was founded were nothing more than an extension of those daily in use in the profession of the engineer. The method, moreover, of calculating the strength of the structure which I had adopted, was of the simplest and most elementary character; and whatever might be the form of the tube, the principle on which the calculations were founded was equally applicable, and could not fail to lead to equally accurate results.”¹

Mr. Stephenson accordingly announced to the directors of the railway that he was prepared to carry out a bridge of this general description, and they adopted his views, though not without considerable misgivings.

While the engineer's mind was still occupied with the subject, an accident occurred to the *Prince of Wales* iron steamship, at Blackwall, which singularly corroborated his views as to the strength of wrought-iron beams of large dimensions. When this vessel was being launched, the cleet on the bow gave way, in consequence of the bolts breaking, and let the vessel down so that the bilge came in contact with the wharf, and she remained suspended between the water and the wharf for a length of about 110 feet, but without any injury to the plates of the ship; satisfactorily proving the great strength of this form of construction. Thus, Mr. Stephenson became gradually confirmed in his opinion that the most feasible method of bridging the strait at Menai and the river at Conway was by means of a hollow beam of wrought iron. As the time was

¹ Robert Stephenson's narrative in Clark's 'Britannia and Conway Tubular Bridges,' vol. i. p. 27.

approaching for giving evidence before Parliament on the subject, it was necessary for him to settle some definite plan for submission to the Committee.

"My late revered father," says he, "having always taken a deep interest in the various proposals which had been considered for carrying a railway across the Menai Straits, requested me to explain fully to him the views which led me to suggest the use of a tube, and also the nature of the calculations I had made in reference to it. It was during this personal conference that Mr. William Fairbairn accidentally called upon me, to whom I also explained the principles of the structure I had proposed. He at once acquiesced in their truth, and expressed confidence in the feasibility of my project, giving me at the same time some facts relative to the remarkable strength of iron steamships, and invited me to his works at Millwall to examine the construction of an iron steamship which was then in progress."¹

The date of this consultation was early in April, 1845, and Mr. Fairbairn states that, on that occasion,—

"Mr. Stephenson asked whether such a design was practicable, and whether I could accomplish it: and it was ultimately arranged that the subject should be investigated experimentally, to determine not only the value of Mr. Stephenson's original conception (of a circular or egg-shaped wrought-iron tube, supported by chains), but that of any other tubular form of bridge which might present itself in the prosecution of my researches. The matter was placed unreservedly in my hands; the entire conduct of the investigation was entrusted to me; and, as an experimenter, I was to be left free to exercise my own discretion in the investigation of whatever forms or conditions of the structure might appear to me best calculated to secure a safe passage across the Straits."²

Mr. Fairbairn then proceeded to construct a number of experimental models, for the purpose of testing the strength of tubes of different forms. The short period

¹ Robert Stephenson's narrative in Clark's 'Britannia and Conway Tubular Bridges,' vol. i. p. 27.

the Britannia and Conway Tubular Bridges.' By W. Fairbairn, C.E. London, 1849.

² 'Account of the Construction of

which elapsed, however, before the Bill was in committee, did not admit of much progress being made with those experiments; but from the evidence in chief given by Mr. Stephenson on the subject, on the 5th of May following, it appears that the idea which prevailed in his mind was that of a bridge with openings of 450 feet (afterwards increased to 460 feet); with a roadway formed of a hollow wrought-iron beam about 25 feet in diameter, presenting a rigid platform suspended by chains. At the same time, he expressed the confident opinion that a tube of wrought iron would possess sufficient strength and rigidity to support a railway train running inside of it without the help of the chains.

While the Bill was still in progress, Mr. Fairbairn proceeded with his experiments. He first tested tubes of a cylindrical form, in consequence of the favourable opinion entertained by Mr. Stephenson of tubes in that shape, extending them subsequently to those of an elliptical form.¹ He found tubes thus shaped more or less defective, and proceeded to test those of a rectangular kind. After the Bill had received the royal assent, on the 30th of June, 1845, the directors of the Company, with great liberality, voted a sum for the purpose of enabling the experiments to be prosecuted, and upwards of 6000*l.* were thus expended to make the assurance of their engineer doubly sure.

Mr. Fairbairn's tests were of the most elaborate and eventually conclusive character, bringing to light many new and important facts of great practical value. The due proportions and thicknesses of the top, bottom, and sides of the tubes were arrived at after a

¹ Mr. Stephenson continued to hold that the elliptical tube was the right idea, and that sufficient justice had not been done to it. A year or two before his death, Mr. Stephenson remarked to the author, that had the

same arrangement for stiffening been adopted to which the oblong rectangular tubes owe a great part of their strength, a very different result would have been obtained.

vast number of separate trials; one of the results of the experiments being the adoption of Mr. Fairbairn's invention of rectangular hollow cells in the top of the beam for the purpose of giving it the requisite degree of strength. About the end of August it was thought desirable to obtain the assistance of a mathematician, who should prepare a formula by which the strength of a full-sized tube might be calculated from the results of the experiments made with tubes of smaller dimensions. Professor Hodgkinson was accordingly called in, and he proceeded to verify and confirm the experiments which Mr. Fairbairn had made, and afterwards reduced them to the required formulæ; though Mr. Fairbairn states that they did not appear in time to be of any practical service in proportioning the parts of the largest tubes.¹

Mr. Stephenson's time was so much engrossed with his extensive engineering business that he was in a great measure precluded from devoting himself to the consideration of the practical details, which he felt were safe in the hands of Mr. Fairbairn—"a gentleman," as he stated to the Committee of the Commons, "whose experience was greater than that of any other man in England." The results of the experiments were communicated to him from time to time, and were regarded by him as exceedingly satisfactory. It would appear, however, that while Mr. Fairbairn urged the sufficient rigidity and strength of the tubes without the aid of chains, Mr. Stephenson had not quite made up his mind upon the point. Mr. Hodgkinson, also, was strongly inclined to retain them.² Mr. Fairbairn held

¹ 'Mr. Fairbairn's Account,' p. 22.

² The following passage occurs in Robert Stephenson's report to the directors of the Chester and Holyhead Railway, dated the 9th February, 1846:—"You will observe in Mr. Fairbairn's remarks, that he contemplates the feasibility of stripping the

tube entirely of all the chains that may be required in the erection of the bridge; whereas, on the other hand, Mr. Hodgkinson thinks the chains will be an essential, or at all events a useful auxiliary, to give the tube the requisite strength and rigidity. This, however, will be determined by the

that it was quite practicable to make the tubes "sufficiently strong to sustain not only their own weight, but, in addition to that load, 2000 tons equally distributed over the surface of the platform,—a load ten times greater than they will ever be called upon to support."

It was thoroughly characteristic of Mr. Stephenson, and of the caution with which he proceeded in every step of this great undertaking—probing every inch of the ground before he set his foot down upon it—that he should, early in 1846, have appointed his able assistant, Mr. Edwin Clark, to scrutinise carefully the results of every experiment, whether made by Mr. Fairbairn or Mr. Hodgkinson, and subject them to a separate and independent analysis before finally deciding upon the form or dimensions of the structure, or upon any mode of procedure connected with it. That great progress had been made by the two chief experimenters before the end of 1846, appears from the papers on the subject read by Messrs. Fairbairn and Hodgkinson before the British Association at Southampton in September of that year. In the course of the following month Mr. Stephenson had become satisfied that the use of auxiliary chains was unnecessary, and that the tubular bridge might be made of such strength as to be entirely self-supporting.¹

proposed additional experiments, and does not interfere with the construction of the masonry, which is designed so as to admit of the tube, with or without chains. The application of chains as an auxiliary has occupied much of my attention, and I am satisfied that the ordinary mode of applying them to suspension bridges is wholly inadmissible in the present instance; if, therefore, it be hereafter found necessary or desirable to employ them in conjunction with the tube, another mode of employing them must be devised, as it is absolutely essential to attach them in such a manner as to preclude the possibility of the smallest oscillation."

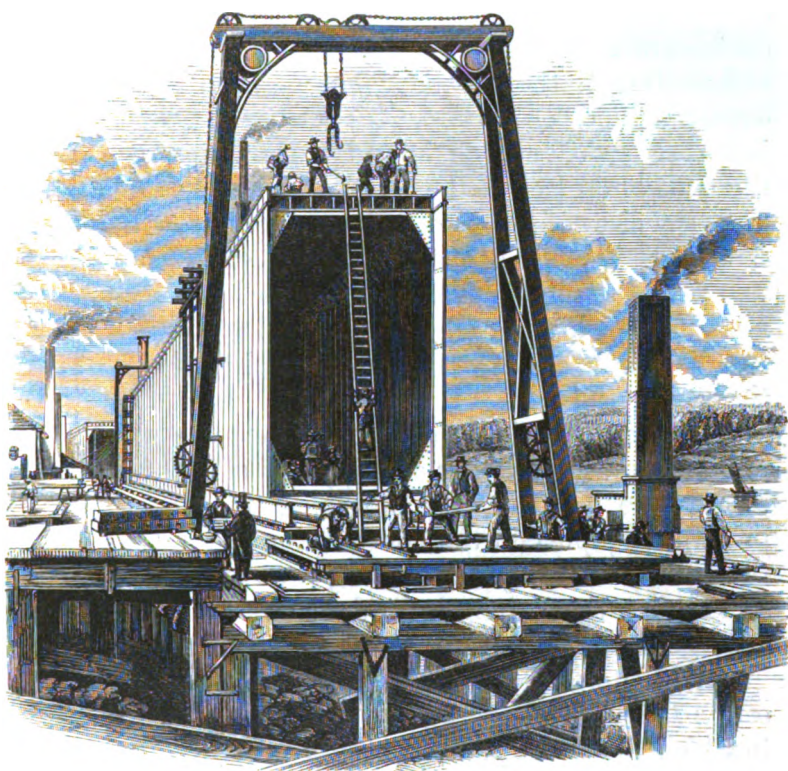
¹ In a letter of Mr. Fairbairn to Mr. Stephenson, dated July 18th, 1846, he says:—"To get rid of the chains will be a desideratum; and I have made the tube of such strength, and intend putting it together upon such a principle, as will insure its carrying a dead weight, equally distributed over its hollow surface, of 4000 tons. With a bridge of such powers, what have we to fear? and why, in the name of truth and in the face of conclusive facts, should we hesitate to adopt measures, calculated not only to establish the principle as a triumph of art, but what is of infinitely more importance to the shareholders, the saving of a large sum of money,

While these important discussions were in progress, measures were taken to proceed with the masonry of the bridges simultaneously at Conway and the Menai Strait. The foundation-stone of the Britannia Bridge was laid by Mr. Frank Forster, the resident engineer, on the 10th of April, 1846; and on the 12th of May following that of the Conway Bridge was laid by Mr. A. M. Ross, resident engineer at that part of the works. Suitable platforms and workshops were also erected for proceeding with the punching, fitting, and rivetting of the tubes; and when these operations were in full progress, the neighbourhood of the Conway and Britannia Bridges presented scenes of extraordinary bustle and industry. On the 11th of July, 1847, Mr. Clark informed Mr. Stephenson that "the masonry gets on rapidly. The abutments on the Anglesea side resemble the foundations of a great city rather than of a single structure, and nothing appears to stand still here." About 1500 men were employed on the Britannia Bridge alone, and they mostly lived upon the ground in wooden cottages erected for the occasion. The iron plates were brought in shiploads from Liverpool, Anglesea marble from Penmon, and red sandstone from Runcorn, in Cheshire, as wind and tide, and shipping and convenience, might determine. There was an unremitting clank of hammers, grinding of machinery, and blasting of rock, going on from morning to night. In fitting the Britannia tubes together, not less than 2,000,000 of bolts were rivetted, weighing some 900 tons.

The Britannia Bridge consists of two independent continuous tubular beams, each 1511 feet in length, and each weighing 4680 tons, independent of the cast-iron frames inserted at their bearings on the masonry of the towers. These immense beams are supported at five

nearly equal to half the cost of the bridge? I have been ably assisted by Mr. Clark in all these contrivances;

but in a matter of such importance we must have your sanction and support."
—'Mr. Fairbairn's Account,' p. 93.



CONSTRUCTION OF MAIN BRITANNIA TUBE ON THE STAGING.

places, namely, on the abutments and on three towers, the central of which is known as the Great Britannia Tower, 230 feet high, built on a rock in the middle of the Strait. The side towers are 18 feet less in height than the central one, and the abutments 35 feet lower than the side towers. The design of the masonry is such as to accord with the form of the tubes, being somewhat of an Egyptian character, massive and gigantic rather than beautiful, but bearing the unmistakable impress of power.

The bridge has four spans,—two of 460 feet over the water, and two of 230 feet over the land. The weight of the longer spans, at the points where the tubes repose

on the masonry, is not less than 1587 tons. On the centre tower the tubes lie solid ; but on the land towers and abutments they lie on roller-beds, so as to allow of expansion and contraction. The road within each tube is 15 feet wide, and the height varies from 23 feet at the ends to 30 feet at the centre. To give an idea of the vast size of the tubes by comparison with other structures, it may be mentioned that each length constituting the main spans is twice as long as London Monument is high ; and if it could be set on end in St. Paul's Churchyard, it would reach nearly 100 feet above the cross.

The Conway Bridge is, in most respects similar to the Britannia, consisting of two tubes of 400 feet span, placed side by side, each weighing 1180 tons. The principle adopted in the construction of the tubes, and the mode of floating and raising them, was nearly the same as at the Britannia Bridge, though the general arrangement of the plates is in many respects different.

It was determined to construct the shorter outer tubes of the Britannia Bridge on scaffoldings in the positions in which they were permanently to remain, and to erect the larger tubes upon wooden platforms at high-water-mark on the Caernarvon shore, from whence they were to be floated in pontoons,—in like manner as Rennie had floated into their places the centerings of his Waterloo and other bridges,—and then raised into their proper places by means of hydraulic power, after a method originally suggested by Mr. Edwin Clark. The tubes of the Conway Bridge also were to be constructed on shore, and floated to their places on pontoons; as in the case of the main centre tubes of the Britannia Bridge.

The floating of these tubes on pontoons, from the places where they had been constructed to the recesses in the masonry of the towers, up which they were to be hoisted to the places they were permanently to occupy,

was an anxious and exciting operation. The first proceeding of this nature was at Conway, where Mr. Stephenson directed it in person, assisted by Captain Claxton, Mr. Brunel, and other engineering friends. On the 6th of March, 1848, the pontoons bearing the first great tube of the up-line were floated round quietly



CONWAY BRIDGE. [By Percival Skelton.]

and majestically into their place between the towers in about twenty minutes. Unfortunately, one of the sets of pontoons had become slightly slued by the stream, by which the Conway end of the tube was prevented from being brought home; and five anxious days to all concerned intervened before it could be set in its place. In the mean time, the presses and raising machinery had been fitted in the towers above, and the lifting process

was begun on the 8th of April, when the immense mass was raised 8 feet, at the rate of about 2 inches a minute. On the 16th, the tube had been raised and finally lowered into its permanent bed; the rails were laid within it; and, on the 18th, Mr. Stephenson passed through with the first locomotive. The second tube was proceeded with on the removal of the first from the platform, and was completed and floated in seven months. The rapidity with which this second tube was constructed was in no small degree owing to the Jacquard punching-machine, contrived for the purpose of punching the holes for the rivets by Mr. Roberts of Manchester. The tube was finally fixed in its permanent bed on the 2nd of January, 1849.

The floating and fixing of the great Britannia tubes was a still more formidable enterprise, though the experience gained at Conway rendered it easy compared with what it otherwise would have been. Mr. Stephenson superintended the operation of floating the first in person, giving the arranged signals from the top of the tube on which he was mounted; the active part of the business being performed by a numerous corps of sailors, under the immediate direction of Captain Claxton. Thousands of spectators lined the shores of the Strait on the evening of the 19th of June, 1849. On the land attachments being cut, the pontoons began to float off; but one of the capstans having given way from the too great strain put upon it, the tube was brought home again for the night. By next morning the defective capstan was restored, and all was in readiness for another trial. At half-past seven in the evening the tube was afloat, and the pontoons swung out into the current like a monster pendulum, held steady by the shore guide-lines, but increasing in speed to almost a fearful extent as they neared their destined place between the piers.

"The success of this operation," says Mr. Clark, "depended mainly on properly striking the 'butt' beneath the Anglesey tower, on which, as upon a centre, the tube was to be veered round into its position across the opening. This position was determined by a 12-inch line, which was to be paid out to a fixed mark from the Llanfair capstan. The coils of the rope unfortunately over-rode each other upon this capstan, so that it could not be paid out. In resisting the motion of the tube, the capstan was bodily dragged out of the platform by the action of the palls, and the tube was in imminent danger of being carried away by the stream, or the pontoons crushed upon the rocks. The men at the capstan were all knocked down, and some of them thrown into the water, though they made every exertion to arrest the motion of the capstan-bars. In this dilemma Mr. Charles Rolfe, who had charge of the capstan, with great presence of mind called the visitors on shore to his assistance; and handing out the spare coil of the 12-inch line into the field at the back of the capstan, it was carried with great rapidity up the field, and a crowd of people, men, women, and children, holding on to this huge cable, arrested the progress of the tube, which was at length brought safely against the butt and veered round. The Britannia end was then drawn into the recess of the masonry by a chain passing through the tower to a crab on the far side. The violence of the tide abated, though the wind increased, and the Anglesey end was drawn into its place beneath the corbelling in the masonry; and as the tide went down, the pontoons deposited their valuable cargo on the welcome shelf at each end. The successful issue was greeted by cannon from the shore and the hearty cheers of many thousands of spectators, whose sympathy and anxiety were but too clearly indicated by the unbroken silence with which the whole operation had been accompanied."¹

By midnight all the pontoons had been got clear of the tube, which now hung suspended over the waters of the Strait by its two ends, which rested upon the edges cut in the rock for the purpose at the base of the Britannia and Anglesey towers respectively, up which the tube had now to be lifted by hydraulic power

¹ 'The Britannia and Conway Tubular Bridges.' By Edwin Clark. Vol. ii. pp. 683-4.

to its permanent place near the summit. The accuracy with which the gigantic beam had been constructed may be inferred from the fact that, after passing into its place, a clear space remained between the iron plating and the rock outside of it of only about three-quarters of an inch !

Mr. Stephenson's anxiety was, of course, very great up to the time of effecting this perilous operation. When he had got the first tube floated at Conway, and saw all safe, he said to Captain Moorsom, "Now I shall go to bed." But the Britannia Bridge was a still more difficult enterprise, and cost him many a sleepless night. Afterwards describing his feelings to his friend Mr. Gooch, he said : "It was a most anxious and harassing time with me. Often at night I would lie tossing about, seeking sleep in vain. The tubes filled my head. I went to bed with them and got up with them. In the grey of the morning, when I looked across the Square,¹ it seemed an immense distance across to the houses on the opposite side. It was nearly the same length as the span of my tubular bridge!" When the first tube had been floated, a friend observed to him, "This great work has made you ten years older." "I have not slept sound," he replied, "for three weeks." Sir F. Head, however, relates, that when he revisited the spot on the following morning, he observed, sitting on a platform overlooking the suspended tube, a gentleman, reclining entirely by himself, smoking a cigar, and gazing, as if indolently, at the aërial gallery beneath him. It was the engineer himself, contemplating his new-born child. He had strolled down from the neighbouring village, after his first sound and refreshing sleep for weeks, to behold in sunshine and solitude, that which during a weary period of gestation had been either mysteriously moving in his brain, or, like a

¹ No. 34, Gloucester Square, Hyde Park, where he lived.

vision—sometimes of good omen, and sometimes of evil—had, by night as well as by day, been flitting across his mind.

The next process was the lifting of the tube into its place, which was performed very deliberately and cautiously. It was raised by powerful hydraulic presses, only a few feet at a time, and carefully under-built, before being raised to a farther height. When it had been got up by successive stages of this kind to about 24 feet, an extraordinary accident occurred, during Mr. Stephenson's absence in London, which he afterwards described to the author in as nearly as possible the following words :—"In a work of such novelty and magnitude, you may readily imagine how anxious I was that every possible contingency should be provided for. Where one chain or rope was required, I provided two. I was not satisfied with 'enough : ' I must have absolute security, so far as that was possible. I knew the consequences of failure would be most disastrous to the Company, and that the wisest economy was to provide for all contingencies at whatever cost. When the first tube at the Britannia had been successfully floated between the piers, ready for being raised, my young engineers were very much elated ; and when the hoisting apparatus had been fixed, they wrote to me, saying, —' We are now all ready for raising her : we could do it in a day, or in two at the most.' But my reply was, No ; you must only raise the tube inch by inch, and you must build up under it as you rise. Every inch must be made good. Nothing must be left to chance or good luck. And fortunate it was that I insisted upon this cautious course being pursued ; for, one day, while the hydraulic presses were at work, the bottom of one of them burst clean away ! The cross-head and the chains, weighing more than 50 tons, descended with a fearful crash upon the press, and the tube itself fell down upon the packing beneath. Though the fall

of the tube was not more than nine inches, it crunched solid castings, weighing tons, as if they had been nuts. The tube itself was slightly strained and deflected, though it still remained sufficiently serviceable. But it was a tremendous test to which it was put, for a weight of upwards of 5000 tons falling even a few inches must be admitted to be a very serious matter. That it stood so well was extraordinary. Clark immediately wrote me an account of the circumstance, in which he said, 'Thank God you have been so obstinate. For if this accident had occurred without a bed for the end of the tube to fall on, the whole would now have been lying across the bottom of the Straits.' Five thousand pounds extra expense was caused by this accident, slight though it might seem. But careful provision was made against future failure; a new and improved cylinder was provided; and the work was very soon advancing satisfactorily towards completion."¹

¹ The hydraulic-presses were of an extraordinary character. The cylinders of those first constructed were of wrought-iron (cast-iron being found altogether useless), not less than 8 inches thick. They were tested by being subjected to an internal pressure of 3 or 3½ tons to the circular inch. The pressure was such that it squeezed the fibres of the iron together; so that after a few tests of this character the piston, which at first fitted it quite closely, was found considerably too small. "A new piston," says Mr. Clark, "was then made to suit the enlarged cylinder; and a further enlargement occurring again and again with subsequent use, the new pistons became as formidable an obstacle as the cylinders. The wrought-iron cylinder was on the point of being abandoned, when Mr. Amos (the iron manufacturer), having carefully gauged the cylinder inside and out, found to his surprise, that although the internal diameter had increased considerably, the external diameter had re-

tained precisely its original dimensions. He consequently persevered in the construction of new pistons; and ultimately found that the cylinder enlarged no longer, and to this day it continues in constant use. Layer after layer having attained additional permanent set, sufficient material was at length brought into play, with sufficient tenacity to withstand the pressure; and thus an obstacle, apparently insurmountable, and which threatened at one time to render much valuable machinery useless, was entirely overcome. The workman may be excused for calling the stretched cylinder stronger than the new one, though it is only stronger as regards the amount of its yielding to a given force."—Clark, vol. i. p. 306. The hydraulic-presses used in raising the tubes of the Britannia Bridge, it may be remembered, were afterwards used in starting the *Great Eastern* from her berth on the shore at Milwall, where she had been built.

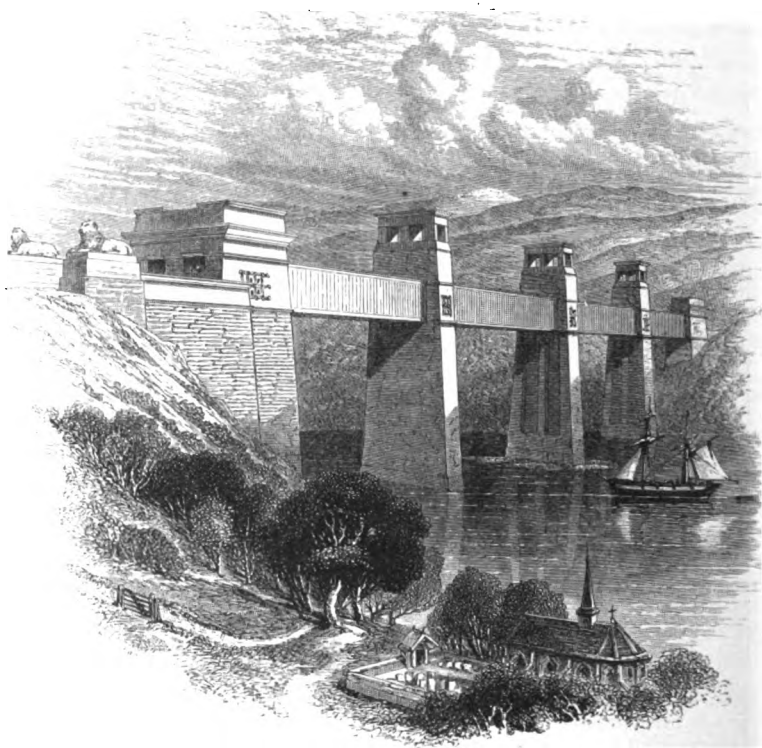
When the Queen first visited the Britannia Bridge, on her return from the North in 1852, Robert Stephenson accompanied Her Majesty and Prince Albert over the works, explaining the principles on which the bridge had been built, and the difficulties which had attended its erection. He conducted the Royal party to near the margin of the sea, and, after describing to them the incident of the fall of the tube, and the reason of its preservation, he pointed with pardonable pride to a pile of stones which the workmen had there raised to commemorate the event. While nearly all the other marks of the work during its progress had been obliterated, that cairn had been left standing in commemoration of the caution and foresight of their chief.

The floating and raising of the remaining tubes need not be described in detail. The second was floated on the 3rd December, and set in its permanent place on the 7th January, 1850. The others¹ were floated and raised in due course; on the 5th of March, Mr. Stephenson put the last rivet in the tube, and passed through the completed bridge, accompanied by about a thousand persons, drawn by three locomotives. The bridge was found almost entirely rigid, scarcely showing the slightest

¹ While the preparations were in progress for floating the third tube, Mr. Stephenson received a pressing invitation to a public railway celebration at Darlington, in honour of his old friend, Edward Pease. His reply, dated the 15th May, 1850, was as follows:—"I am prevented having the pleasure of a visit to Darlington, on the 22nd, owing to that or the following day having been fixed upon for floating the next tube at the Menai Straits; and as this movement depends on the tide, it is, of course, impossible for me to alter the arrangements. I sincerely regret this circumstance, for every early association connected with my profession, would have tended to render my visit a gratifying one. It would, moreover,

have given me an opportunity of saying publicly how much the wonderful progress of railways was dependent upon the successful issue of the first great experiment, and how much that issue was influenced by your great discernment, and your confidence in my late revered father. In my remembrance you stand amongst the foremost of his patrons and early advisers; and I know that throughout his life he regarded you as one of his very best friends. One of the things in which he took especial delight, was in frequently and very graphically describing his first visit to Darlington, on foot, to confer with you on the subject of the Stockton and Darlington Railway."

deflection. When, in the course of the day, a train of 200 tons of coal was allowed to rest with all its weight, for two hours, in the centre of the eastern land tube, the deflection was only four-tenths of an inch, or less



MENAI BRIDGE [By Percival Skelton after his original Drawing]

than that produced upon the structure by half an hour's sunshine;¹ while the whole bridge might with safety,

¹ The effect of sunshine in deflecting the bridge is very curious. When the first main tube was tested, ballast-waggons loaded with iron were drawn into the centre and left standing there. The first 20 tons increased the deflection an eighth of an inch, and with

50 tons, the deflection was 9 inches. After standing all night, the deflection in the morning was found to be only $8\frac{3}{4}$ inches. How was this to be accounted for? Mr. Clark says:—"This was attributed at the time to an error made in the reading; but this, and

and without injury to itself, be deflected to the extent of 13 inches. The bridge was opened for public traffic on the 18th of March. The cost of the whole work was 234,450*l*.

The Britannia Bridge is one of the most remarkable monuments of the enterprise and skill of the present century. Robert Stephenson was the master spirit of the undertaking. To him belongs the merit of first seizing the ideal conception of the structure best adapted to meet the necessities of the case, and of selecting the best men to work out his idea, himself watching, controlling, and testing every result by independent check and counter-check. And finally, he organised and directed, through his assistants, the vast band of skilled workmen and labourers who were for so many years occupied in carrying his magnificent original conception to a successful practical issue.

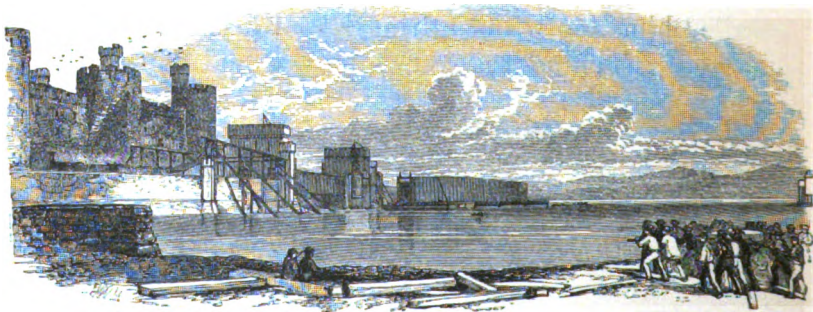
But it was not accomplished without the greatest anxiety and mental pressure. Mr. Clark has well observed that few persons who merely witness the results of the engineer's labours, can form any conception of the real difficulties overcome, and the intense anxiety involved in their elaboration. "If the stranger," he says, "who contemplates the finished reality, requires so much thought to appreciate its principles and comprehend its detail, what weary hours must he have undergone who first conceived its bold proportions,—who, combating, almost alone, every prejudice that assailed him, and with untiring labour discussing every objection, listening to every opinion, and embodying

many other anomalies in the deflection, were afterwards fully accounted for by local changes of temperature. *A gleam of sunshine* on the top of the tube raised it on one occasion nearly an inch in half an hour with 200 tons at the centre, the top plates being expanded by increase of temperature, while the lower plates remained con-

stant from radiation to the water immediately beneath them. In a similar manner, the tube was drawn sidewise to the extent of an inch from *the sun shining on one side*, and returned immediately as clouds passed over the sun, being in fact a most delicate thermometer in constant motion, both vertically and laterally."

every inquiry, at length matured, step by step, this noble monument?" On the occasion of raising the last tube into its place, Mr. Stephenson declared, in reply to the felicitations of a large company who had witnessed the proceedings with intense interest, that not all the triumph which attended this great work, and the solution of the difficult problem of carrying a rigid roadway across an arm of the sea at such a height as to allow the largest vessels to pass with all their sails set beneath it, could repay him for the anxieties he had gone through, the friendships he had compromised, and the unworthy motives which had been attributed to him; and that were another work of the same magnitude offered to him with like consequences, he would not for worlds undertake it!

The Britannia Bridge was indeed the result of a vast combination of skill and industry. But for the perfection of our tools and the ability of our mechanics to use them to the greatest advantage,—but for the matured powers of the steam-engine,—but for the improvements in the iron manufacture, which enabled blooms to be puddled of sizes before deemed impracticable, and plates and bars of immense size to be rolled and forged,—but for these, the Britannia Bridge would have been designed in vain. Thus, it was not the product of the genius of the railway engineer alone, but of the collective mechanical genius of the English nation.



CONWAY BRIDGE—FLOATING THE FIRST TUBE



VIEW IN TAPTON GARDENS. [By Percival Skelton]

CHAPTER XIX.

CLOSING YEARS OF GEORGE STEPHENSON'S LIFE — ILLNESS AND DEATH — CHARACTER.

IN describing the completion of the series of great works detailed in the preceding chapter, we have somewhat anticipated the closing years of George Stephenson's life. He could not fail to take an anxious interest in the success of his son's designs, and he paid many visits to Conway and to Menai during the progress of the bridges. He was present on the occasion of the floating and raising of the first Conway tube, and there witnessed a proof of the soundness of Robert's judgment as to the efficiency and strength of the structure, of which he had at first expressed some doubt; but before the like test could be applied at the Britannia Bridge, George Stephenson's mortal anxieties were at an end, for he had then ceased from all his labours.

Towards the close of his life, George Stephenson almost entirely withdrew from the active pursuit of his profession. He devoted himself chiefly to his extensive

collieries and lime-works, taking a local interest only in such projected railways as were calculated to open up new markets for their products.

At home he lived the life of a country gentleman, enjoying his garden and grounds, and indulging his love of nature, which, through all his busy life, had never left him. It was not until the year 1845 that he took an active interest in horticultural pursuits. Then he began to build new melon-houses, pineries, and vineries, of great extent; and he now seemed as eager to excel all other growers of exotic plants in his neighbourhood, as he had been some thirty years before to surpass the villagers of Killingworth in the production of cabbages and cauliflowers. He had a pine-house built 68 feet in length and a pinery 140 feet. Workmen were constantly employed in enlarging them, until at length he had no fewer than ten glass forcing-houses. He did not take so much pleasure in flowers as in fruits. At one of the county agricultural meetings he said that he intended yet to grow pine-apples at Tapton as big as pumpkins. The only man to whom he would "knock under" was his friend Paxton, the gardener to the Duke of Devonshire; but he was so old in the service, and so skilful, that he could scarcely hope to beat him. Yet his "Queen" pines did take the first prize at a competition with the Duke,—though this was not until shortly after his death, when the plants had become fully grown. Stephenson's grapes also took the first prize at Rotherham, at a competition open to all England. He was extremely successful in producing melons, having invented a method of suspending them in baskets of wire gauze, which, by relieving the stalk from tension, allowed nutrition to proceed more freely, and better enabled the fruit to grow and ripen.

He also took much pride in his growth of cucumbers. He raised them very fine and large, but he could not make them grow straight. Place them as he would,

notwithstanding all his propping and humouring of them by modifying the application of heat and the admission of light, they would still insist on growing crooked in their own way. At last he had a number of glass cylinders made at Newcastle, and into these the growing cucumbers were inserted, when at last he succeeded in growing them perfectly straight. Carrying one of the new products into his house one day, and exhibiting it to a party of visitors, he told them of the expedient he had adopted, and added, "I think I have bothered them noo!"

Farming operations were also carried on by him with success. He experimented on manure, and fed cattle after methods of his own. He was very particular as to breed and build in stock-breeding. "You see, sir," he said to one gentleman, "I like to see the *coo's* back at a gradient something like this" (drawing an imaginary line with his hand), "and then the ribs or girders will carry more flesh than if they were so—or so." When he attended the county agricultural meetings, which he frequently did, he was accustomed to take part in the discussions, and he brought the same vigorous practical mind to bear upon questions of tillage, drainage, and farm economy, which he had before been accustomed to exercise on mechanical and engineering matters.

All his early affection for birds and animals revived. He had favourite dogs, and cows, and horses; and again he began to keep rabbits, and to pride himself on the beauty of his breed. There was not a bird's nest in the grounds that he did not know of; and from day to day he went round watching the progress which the birds made with their building, carefully guarding them from harm. His minute knowledge of the habits of British birds was the result of a long, loving, and close observation of nature.

At Tapton he remembered the failure of his early

experiment in hatching birds' eggs by heat, and he now performed it successfully, being able to secure a proper apparatus for maintaining a uniform temperature. He was also curious about the breeding and fattening of fowls; and when his friend Edward Pease, of Darlington, visited him at Tapton, he explained a method which he had invented of fattening chickens in half the usual time. The chickens were confined in boxes, which were so made as to exclude the light. Dividing the day into two or three periods, the birds were shut up at the end of each after a heavy feed, and went to sleep. The plan proved very successful, and Mr. Stephenson jocularly said that if he were to devote himself to chickens he could soon make a little fortune.

Mrs. Stephenson tried to keep bees, but found they would not thrive at Tapton. Many hives perished, and there was no case of success. The cause of failure was long a mystery to the engineer; but one day his acute powers of observation enabled him to unravel it. At the foot of the hill on which Tapton House stands, he saw some bees trying to rise up from amongst the grass, laden with honey and wax. They were already exhausted, as if with long flying; and then it occurred to him that the height at which the house stood above the bees' feeding ground rendered it difficult for them to reach their hives when heavy laden, and hence they sank exhausted. He afterwards incidentally mentioned the circumstance to Mr. Jesse, the naturalist, who concurred in his view as to the cause of failure, and was much struck by the keen observation which had led to its solution.

George Stephenson had none of the habits of the student. He read very little; for reading is a habit which is generally acquired in youth; and his youth and manhood had been for the most part spent in hard work. Books wearied him and sent him to sleep. Novels excited his feelings too much, and he avoided

them, though he would occasionally read through a philosophical work on a subject in which he felt particularly interested. He wrote very few letters with his own hand. Nearly all his letters were dictated, and he avoided even dictation when he could. His greatest pleasure was in conversation, from which he gathered most of his imparted information.

It was his practice, when about to set out on a journey by railway, to walk along the train before it started, and look into the carriages to see if he could find "a conversable face." On one of such occasions, at the Euston Station, he discovered in a carriage a very handsome, manly, and intelligent face, which he afterwards found was that of the late Lord Denman. He was on his way down to his seat at Stony Middleton in Derbyshire. Stephenson entered the carriage, and the two were shortly engaged in interesting conversation. It turned upon chronometry and horology, and the engineer amazed his lordship by the extent of his knowledge on the subject, in which he displayed as much minute information, even down to the latest improvements in watch-making, as if he had been bred a watchmaker and lived by the trade. Lord Denman was curious to know how a man whose time must have been mainly engrossed by engineering, had gathered so much knowledge on a subject quite out of his own line, and he asked the question. "I learnt clockmaking and watchmaking," was the answer, "while a working man at Killingworth, when I made a little money in my spare hours, by cleaning the pitmen's clocks and watches; and since then I have kept up my information on the subject." This led to further questions, and then he proceeded to tell Lord Denman the interesting story of his life, which held him entranced during the remainder of the journey.

Many of his friends readily accepted invitations to Tapton House to enjoy his hospitality, which never

failed. With them he would "fight his battles o'er again," reverting often to his battle for the locomotive; and he was never tired of telling, nor were his auditors of listening to, the lively anecdotes with which he was accustomed to illustrate the struggles of his early career. While walking in the woods or through the grounds, he would arrest his friends' attention by allusion to some simple object,—such as a leaf, a blade of grass, a bit of bark, a nest of birds, or an ant carrying its eggs across the path,—and descant in glowing terms on the creative power of the Divine Mechanician, whose contrivances were so exhaustless and so wonderful. This was a theme upon which he was often accustomed to dwell in reverential admiration, when in the society of his more intimate friends.

One night, when walking under the stars, and gazing up into the field of suns, each the probable centre of a system, forming the Milky Way, a friend observed, "What an insignificant creature is man in sight of so immense a creation as this!" "Yes!" was his reply "but how wonderful a creature also is man, to be able to think and reason, and even in some measure to comprehend works so infinite!"

A microscope, which he had brought down to Tapton was a source of immense enjoyment; and he was never tired of contemplating the minute wonders which it revealed. One evening, when some friends were visiting him, he induced each of them to puncture his skin so as to draw blood, in order that he might examine the globules through the microscope. One of the gentlemen present was a teetotaller, and Stephenson pronounced his blood to be the most lively of the whole. He had a theory of his own about the movement of the globules in the blood, which has since become familiar. It was, that they were respectively charged with electricity, positive at one end and negative at the other, and that they thus attracted and repelled each other, causing a

circulation. No sooner did he observe anything new, than he immediately set about devising a reason for it. His training in mechanics, his practical familiarity with matter in all its forms, and the strong bent of his mind, led him first of all to seek for a mechanical explanation. And yet he was ready to admit that there was a something in the principle of *life*—so mysterious and inexplicable—which baffled mechanics, and seemed to dominate over and control them. He did not care much, either, for abstruse mechanics, but only for the experimental and practical, as is usually the case with those whose knowledge has been self-acquired.

Even at his advanced age, the spirit of frolic had not left him. When proceeding from Chesterfield station to Tapton House with his friends, he would almost invariably challenge them to a race up the steep path, partly formed of stone steps, along the hill side. And he would struggle, as of old, to keep the front place, though by this time his “wind” greatly failed him. He would occasionally invite an old friend to take a wrestle with him on the lawn, to keep up his skill, and perhaps to try some new “knack” of throwing. In the evening, he would sometimes indulge his visitors by reciting the old pastoral of “Damon



and Phyllis," or singing his favourite song of "John Anderson my Joe."

But his greatest enjoyment on such occasion, was "a crowdie." "Let's have a crowdie night," he would say; and forthwith a kettle of boiling water was ordered in, with a basin of oatmeal. Taking a large bowl, containing a sufficiency of hot water, and placing it between his knees, he poured in oatmeal with one hand, and stirred the mixture vigorously with the other. When enough meal had been added, and the stirring was completed, the crowdie was made. It was then supped with new milk, and Mr. Stephenson generally pronounced it "capital!" It was the diet to which he had been accustomed when a working man, and all the dainties with which he had become familiar in recent years had not spoiled his simple tastes. To enjoy crowdie at his years, besides, indicated that he still possessed that quality on which no doubt much of his practical success in life had depended,—a strong and healthy digestion.

He would also frequently invite to his house the humbler companions of his early life, and take pleasure in talking over old times with them. He never assumed any of the bearings of the great man on such occasions, but treated his visitors with the same friendliness and respect as if they had been his equals, sending them away pleased with themselves and delighted with him. At other times, needy men who had known him in their youth would knock at his door, and they were never refused access. But if he had heard of any misconduct on their part, he would rate them soundly. One who knew him intimately in private life has seen him exhorting such backsliders, and denouncing their misconduct and imprudence, with the tears streaming down his cheeks. And he would generally conclude by opening his purse, and giving them the help which they needed "to make a fresh start in the world."

His life at Tapton during his later years was occasionally diversified by a visit to London. His engineering business having become limited, he generally went there for the purpose of visiting friends, or "to see what there was fresh going on." He found a new race of engineers springing up on all sides—men who knew him not; and his London journeys gradually ceased to yield him pleasure. A friend used to take him to the opera, but by the end of the first act he was generally observed in a profound slumber. Yet on one occasion he enjoyed a visit to the Haymarket, with a party of friends on his birthday, to see T. P. Cooke, in "Black-eyed Susan;"—if that can be called enjoyment which kept him in a state of tears during half the performance. At other times he visited Newcastle, which always gave him great pleasure. He would, on such occasions, go out to Killingworth and seek up old friends, and if the people whom he knew were too retiring and shrunk into their cottages, he went and sought them there. Striking the floor with his stick, and holding his noble person upright, he would say, in his own kind way, "Well, and how's all here to-day?" To the last he had always a warm heart for Newcastle and its neighbourhood.

Sir Robert Peel, on more than one occasion, invited George Stephenson to his mansion at Drayton, where he was accustomed to assemble round him men of the highest distinction in art, science, and legislation, during the intervals of his parliamentary life. The first invitations were respectfully declined; but Sir Robert again pressing him to come down to Tamworth, where he would meet Buckland, Follett, and others well known to both, he at last consented.

Stephenson's strong powers of observation, together with his native humour and shrewdness, imparted to his conversation at all times much vigour and originality. Though mainly an engineer, he was also a

profound thinker on many scientific questions: and there was scarcely a subject of speculation, or a department of recondite science, on which he had not employed his faculties in such a way as to have formed large and original views. Mr. Sopwith, F.R.S., has informed us that the conversation at Drayton, on one occasion, turned on the theory of the formation of coal, in the course of which Stephenson had an animated discussion with Dr. Buckland. But the result was, that Dr. Buckland, a much greater master of tongue-fence, completely silenced him. Next morning, before breakfast, when he was walking in the grounds deeply pondering, Sir William Follett came up and asked what he was thinking about? "Why, Sir William, I am thinking over that argument I had with Buckland last night! I know I am right, and that if I had only the command of words which he has, I'd have beaten him." "Let me know all about it," said Sir William, "and I'll see what I can do for you." The two sat down in an arbour, where the astute lawyer made himself thoroughly acquainted with the points of the case; entering into it with the zeal of an advocate about to plead the interests of his client. After he had mastered the subject, Sir William said, "Now I am ready for him." Sir Robert Peel was made acquainted with the plot, and adroitly introduced the subject of the controversy after dinner. The result was, that in the argument which followed, the man of science was overcome by man of law. "And what do *you* say, Mr. Stephenson?" asked Sir Robert, laughing. "Why," said he, "I say this, that of all the powers above and under the earth, there seems to me to be no power so great as the gift of the gab."

One Sunday, when the party had just returned from church, they were standing together on the terrace near the Hall, and observed in the distance a railway train flashing along, tossing behind its long white

plume of steam. "Now, Buckland," said Stephenson, "I have a poser for you. Can you tell me what is the power that is driving that train?" "Well," said the other, "I suppose it is one of your big engines." "But what drives the engine?" "Oh, very likely a canny Newcastle driver." "What do you say to the light of the sun?" "How can that be?" asked the doctor. "It is nothing else," said the engineer: "it is light bottled up in the earth for tens of thousands of years,—light, absorbed by plants and vegetables, being necessary for the condensation of carbon during the process of their growth, if it be not carbon in another form,—and now, after being buried in the earth for long ages in fields of coal, that latent light is again brought forth and liberated, made to work as in that locomotive, for great human purposes."¹

During the same visit, Mr. Stephenson one evening repeated his experiment with blood drawn from the finger, submitting it to the microscope in order to show the curious circulation of the globules. He set the example by pricking his own thumb; and the other guests, by turns, in like manner gave up a small portion of their blood for the purpose of ascertaining the comparative liveliness of their circulation. When Sir

¹ This was a favourite notion of George Stephenson's, and he held that what produced light and heat had originally been light and heat. Mr. Fearon, solicitor, has informed the author, that he accompanied Stephenson on one of his visits to Belgium; when it seemed to him that the engineer did not take much interest in the towns, churches, or public buildings of Belgium, probably because he knew little of history and they recalled no associations with the past. One day, the party went to see the beautiful Hôtel de Ville at Brussels, but Stephenson did not seem moved by it. On passing out of the square, however, by the little street which leads towards the Montagne de la Cour, his interest was

thoroughly roused by the sight of an immense fat pig hung up in a butcher's shop. He immediately took out his foot-rule, measured the pig, and expressed a desire to have some conversation with the butcher as to how it had been fed. The butcher accordingly waited upon them at the hotel, and told all he knew about the feeding of the pig; and then, says Mr. Fearon, "George went off into his favourite theory of the sun's light, which he said had fattened the pig; for the light had gone into the pease, and the pease had gone into the fat, and the fat pig was like a field of coal in this respect, that they were for the most part neither more nor less than bottled sunshine."

Robert Peel's turn came, Stephenson said he was curious to know "how the blood globules of a great politician would conduct themselves." Sir Robert held forth his finger for the purpose of being pricked; but once, and again, he sensitively shrunk back, and at length the experiment, so far as he was concerned, was abandoned. Sir Robert Peel's sensitiveness to pain was extreme, and yet he was destined, a few years after, to die a death of the most distressing agony.

In 1847, the year before his death, George Stephenson was again invited to join a distinguished party at Drayton Manor, and to assist in the ceremony of formally opening the Trent Valley Railway, which had been originally designed and laid out by himself many years before. The first sod of the railway had been cut by the Prime Minister, in November, 1845; and the formal opening took place on the 26th of June, 1847, the line having thus been constructed in less than two years.

What a change had come over the spirit of the landed gentry since the time when George Stephenson had first projected a railway through that district! Then they were up in arms against him, characterising him as the devastator and spoiler of their estates; whereas now he was hailed as one of the greatest benefactors of the age. Sir Robert Peel, the chief political personage in England, welcomed him as a guest and friend, and spoke of him as the chief among practical philosophers. A dozen members of Parliament, seven baronets, with all the landed magnates of the district, assembled to celebrate the opening of the railway. The clergy were there to bless the enterprise, and to bid all hail to railway progress, as "enabling them to carry on with greater facility those operations in connexion with religion which were calculated to be so beneficial to the country." The army, speaking through the mouth of General A'Court, acknowledged the vast importance

of railways, as tending to improve the military defences of the country. And representatives from eight corporations were there to acknowledge the great benefits which railways had conferred upon the merchants, tradesmen, and working classes of their respective towns and cities.

In the spring of 1848, George Stephenson was invited to Whittington House, near Chesterfield, the residence of his friend and former pupil, Mr. Swanwick, to meet the distinguished American, Emerson. On being introduced to each other they did not immediately engage in conversation; but presently Stephenson jumped up, took Emerson by the collar, and, giving him one of his friendly shakes, asked how it was that in England we could always tell an American? This led to an interesting conversation, in the course of which Emerson said how much he had everywhere been struck by the haleness and comeliness of the English men and women; from which they diverged into a discussion of the influences which air, climate, moisture, soil, and other conditions exercised on the physical and moral development of a people. The conversation was next directed to the subject of electricity, on which Stephenson launched out enthusiastically, explaining his views by several simple and some striking illustrations. From thence it gradually turned to the events of his own life, which he related in so graphic a manner as completely to rivet the attention of the American. Afterwards Emerson said, "that it was worth crossing the Atlantic were it only to have seen Stephenson—he had such force of character and vigour of intellect."

The rest of George Stephenson's days were spent quietly at Tapton, among his dogs, his rabbits, and his birds. When not engaged about the works connected with his collieries, he was occupied in horticulture and farming. He continued proud of his flowers, his fruits, and his crops, while the old spirit of competition was

still strong within him. Although he had for some time been in delicate health, and his hand shook from nervous debility, he appeared to possess a sound constitution. Emerson had observed of him that he had the lives of many men in him. But perhaps the American spoke figuratively, in reference to his vast stores of experience. It appeared that he had never completely recovered from the attack of pleurisy which seized him during his return from Spain. As late, however, as the 26th of July, 1848, he felt himself sufficiently well to be able to attend a meeting of the Institute of Mechanical Engineers at Birmingham, and to read to the members his paper "On the Fallacies of the Rotatory Engine."

It was his last public appearance. Shortly after his return to Tapton, he had an attack of intermittent fever, from which he seemed to be recovering, when a sudden effusion of blood from the lungs carried him off, on the 12th of August, 1848, in the sixty-seventh year of his age. When all was over, Robert wrote to Edmund Pease, "With deep pain I inform you, as one of his oldest friends, of the death of my dear father this morning at 12 o'clock, after about ten days' illness from severe fever." Mr. Starbuck, who was also present, wrote: "The favourable symptoms of yesterday morning were towards evening followed by a serious change for the worse. This continued during the night, and early this morning it became evident that he was sinking. At a few minutes before 12 today he breathed his last. All that the most devoted and unremitting care of Mrs. Stephenson¹ and the skill of medicine could accomplish, has been done, but in vain."

George Stephenson's remains were followed to the

¹ The second Mrs. Stephenson having died in 1845, George married a third time in 1848, about six months before his death. The third Mrs.

Stephenson was an intelligent and respectable lady, who had for some time officiated as his housekeeper.

grave by a large body of his workpeople, by whom he was greatly admired and beloved. They remembered him as a kind master, who was ever ready actively to promote all measures for their moral, physical, and mental improvement. The inhabitants of Chesterfield evinced their respect for the deceased by suspending business, closing their shops, and joining in the funeral procession, which was headed by the corporation of the town. Many of the surrounding gentry also attended. The body was interred in Trinity Church, Chesterfield, where a simple tablet marks the great engineer's last resting-place.



TRINITY CHURCH, CHESTERFIELD

The statue of George Stephenson, which the Liverpool and Manchester and Grand Junction Companies had commissioned, was on its way to England when his death occurred; and it served for a monument, though his best monument will always be his works. The statue referred to was placed in St. George's Hall, Liverpool. A full-length statue of him, by Bailey, was also erected a few years later, in the noble vestibule of the London and North-Western Station, in Euston

Square. A subscription for the purpose was set on foot by the Society of Mechanical Engineers, of which he had been the founder and president. A few advertisements were inserted in the newspapers, inviting subscriptions; and it is a notable fact that the voluntary offerings included an average of two shillings each from 3150 working men, who embraced this opportunity of doing honour to their distinguished fellow workman.

But the finest and most appropriate statue to the memory of George Stephenson is that which was erected in 1862, after the design of John Lough, at Newcastle-upon-Tyne. It is in the immediate neighbourhood of the Literary and Philosophical Institute, to which both George and his son Robert were so much indebted in their early years; close to the great Stephenson locomotive foundry established by the shrewdness of the father; and in the vicinity of the High Level Bridge, one of the grandest products of the genius of the son. The head of Stephenson, as expressed in this noble work, is massive, characteristic, and faithful; and the attitude of the figure is simple yet manly and energetic. It stands on a pedestal, at the respective corners of which are sculptured the recumbent figures of a pitman, a mechanic, an engine-driver, and a plate-layer. The statue appropriately stands in a very thoroughfare of working-men, thousands of whom see it daily as they pass to and from their work; and we can imagine them, as they look up to Stephenson's manly figure, applying to it the words addressed by Robert Nicoll to Robert Burns, with perhaps still greater appropriateness:—

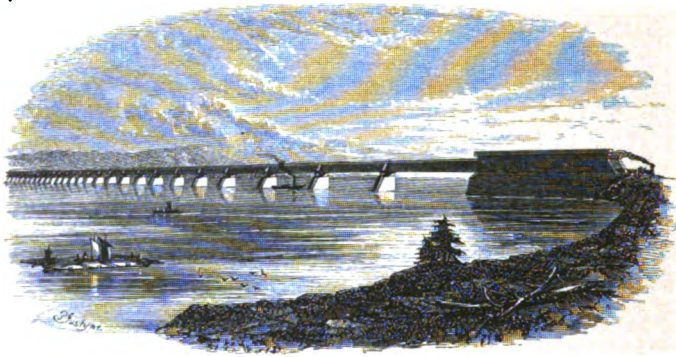
“ Before the proudest of the earth
We stand, with an uplifted brow;
Like us, thou wast a toiling man,—
And we are noble, now!”

The portrait prefixed to this volume gives a good indication of George Stephenson's shrewd, kind, honest,

manly face. His fair, clear countenance was ruddy, and seemingly glowed with health. The forehead was large and high, projecting over the eyes, and there was that massive breadth across the lower part which is usually observed in men of eminent constructive skill. The mouth was firmly marked, and shrewdness and humour lurked there as well as in the keen grey eye. His frame was compact, well-knit, and rather spare. His hair became grey at an early age, and towards the close of his life it was of a pure silky whiteness. He dressed neatly in black, wearing a white neckcloth; and his face, his person, and his deportment at once arrested attention, and marked the Gentleman.



TABLET IN TRINITY CHURCH, CHESTERFIELD.



VICTORIA BRIDGE, MONTREAL

CHAPTER XX.

ROBERT STEPHENSON'S VICTORIA BRIDGE, LOWER CANADA — ILLNESS AND DEATH.

GEORGE Stephenson bequeathed to his son his valuable collieries, his share in the engine manufactory at Newcastle, and his large accumulation of savings, which, together with the fortune he had himself amassed by railway work, gave Robert the position of an engineer millionaire—the first of his order. He continued, however, to live in a quiet style; and although he bought occasional pictures and statues, and indulged in the luxury of a yacht, he did not live up to his income, which went on accumulating until his death.

There was no longer the necessity for applying himself to the laborious business of a parliamentary engineer, in which he had now been occupied for some fifteen years. Shortly after his father's death, Edward Pease strongly recommended him to give up the more harassing work of his profession; and his reply (15th June, 1850) was as follows:—

“The suggestion which your kind note contains is quite in accordance with my own feelings and intentions respecting retirement; but I find it a very difficult matter to bring to a

close so complicated a connexion in business as that which has been established by twenty-five years of active and arduous professional duty. Comparative retirement is, however, my intention: and I trust that your prayer for the Divine blessing to grant me happiness and quiet comfort will be fulfilled. I cannot but feel deeply grateful to the Great Disposer of events for the success which has hitherto attended my exertions in life; and I trust that the future will also be marked by a continuance of His mercies."

Although Robert Stephenson, in conformity with this expressed intention, for the most part declined to undertake new business, he did not altogether lay aside his harness; and he lived to repeat his tubular bridges both in Egypt and Canada. The success of the tubular system, as adopted at Menai and Conway, was such as to recommend it for adoption wherever great span was required; and the peculiar circumstances connected with the navigation of the Nile and the St. Lawrence may be said to have compelled its adoption in carrying railways across both those rivers.

Two tubular bridges were built after our engineer's designs across the Nile, near Damietta, in Lower Egypt. That near Benha contains eight spans or openings of 80 feet each, and two centre spans, formed by one of the largest swing-bridges ever constructed, the total length of the swing-beam being 157 feet, a clear waterway of 60 feet being provided on either side of the centre pier. The only novelty in these bridges consisted in the road being carried upon the tubes instead of within them, their erection being carried out in the usual manner, by means of workmen, materials, and plant sent out from England. The Tubular Bridge constructed in Canada, after Mr. Stephenson's designs, was of a much more important character, and deserves a fuller description.

The important uses of railways had been recognised at an early period by the inhabitants of North America, and in the course of about thirty years more than 25,000 miles of railway, mostly single, were constructed in the United States alone. The Canadians were more deliberate in their proceedings, and it was not until the year 1840 that their first railway, 14 miles in length, was constructed between Laprairie and St. John's, for the purpose of connecting Lake Champlain with the river St. Lawrence. From this date, however, new lines were rapidly projected; more particularly the Great Western of Canada, and the Atlantic and St. Lawrence (now forming part of the Grand Trunk), until in the course of a few years Canada had a length of nearly 2000 miles of railway open or in course of construction, intersecting the provinces almost in a continuous line from Rivière du Loup, near the mouth of the St. Lawrence, to Port Sarnia, on the shores of Lake Huron.

But there still remained one most important and essential link to connect the lines on the south of the St. Lawrence with those on the north, and at the same time place the city of Montreal in direct railway connexion with the western parts of Canada. The completion of this link was also necessary in order to maintain the commercial communication of Canada with the rest of the world during five months in every year. For though the St. Lawrence in summer affords a splendid outlet to the ocean—towards which the commerce of the colony naturally tends—the frost in winter is so severe, that during that season Canada is completely frozen in, and the navigation hermetically closed by the ice.

The Grand Trunk Railway was designed to furnish a line of land communication along the great valley of the St. Lawrence at all seasons, following the course of the river, and connecting the principal towns of the

colony. But stopping short on the north shore, nearly opposite Montreal, with which it was connected by a dangerous and often impracticable ferry, it was felt that until the St. Lawrence was bridged by a railway, the Canadian system of railways was manifestly incomplete. But how to bridge this wide and rapid river! Never before, perhaps, was a problem of such difficulty proposed for solution by an engineer. Opposite Montreal, the St. Lawrence is about two miles wide, running at the rate of about ten miles an hour; and at the close of each winter it carries down the ice of 2000 square miles of lakes and rivers with their numerous tributaries.

As early as the year 1846, the construction of a bridge at Montreal was strongly advocated by the local press as the only means of connecting that city with the projected Atlantic and St. Lawrence Railway. But the difficulties of executing such a work seemed almost insurmountable to those best acquainted with the locality. The greatest difficulty was apprehended from the tremendous shoving and pressure of the ice at the break up of winter. At such times, opposite Montreal, the whole river is packed with huge blocks of ice, and it is often seen piled up to a height of from 40 to 50 feet along the banks, placing the surrounding country under water, and occasionally doing severe damage to the massive stone buildings erected along the noble river front of the city.

But no other expedient presented itself but a bridge, and a survey was made accordingly at the instance of the Hon. John Young, one of the Directors of the railway. A period of colonial depression having shortly after occurred, the project slept for a time, and it was not until six years later, in 1852, when the Grand Trunk Railway was under construction, that the subject was again brought under discussion. In that year,

Mr. Alexander M. Ross, who had superintended the construction of Robert Stephenson's tubular bridge at Conway, visited Canada, and inspected the site of the proposed structure, when he at once formed the opinion that a tubular bridge carrying a railway was the most suitable means of crossing the St. Lawrence and connecting Montreal with the lines on the north of the river.

The directors felt that such a work would necessarily be of a most formidable and difficult character; and before coming to any conclusion, they determined to call to their assistance Mr. Robert Stephenson, as the engineer most competent to advise them in the matter. Mr. Stephenson considered the subject of so much interest and importance, that in the summer of 1853 he proceeded to Canada, to inquire as to all the facts, and examine carefully the site of the proposed work. He then formed the opinion that a tubular bridge across the river was not only practicable, but by far the most suitable for the purpose intended; and early in the following year he sent an elaborate report on the whole subject to the directors of the railway. The result was, the adoption of his recommendation, and the erection of the Victoria Bridge, of which Robert Stephenson was the designer and engineer, and Mr. A. M. Ross the joint and resident engineer in directly superintending the execution of the undertaking. The details of the plans were principally worked out in Mr. Stephenson's office in London, under the supervision of his cousin, Mr. George Robert Stephenson; while the iron-work was for the most part constructed at the Canada Works, Liverpool, from whence it was shipped ready for being fixed in position on the spot.

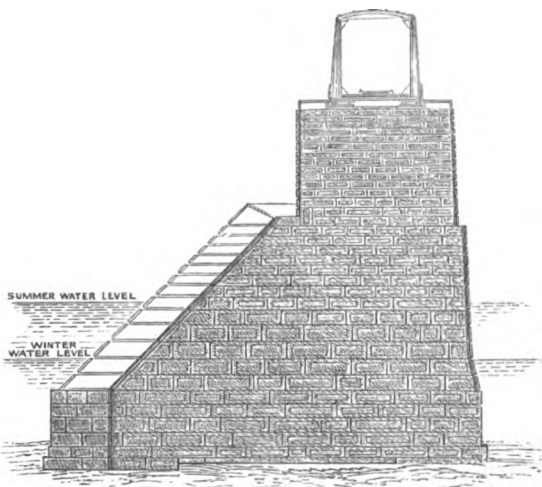
The Victoria Bridge is, without exception, the greatest work of its kind in the world. For gigantic propor-

tions and vast length and strength there is nothing to compare with it in ancient or modern times. The entire bridge, with its approaches, is only about sixty yards short of *two miles* in length, being five times longer than the Britannia Bridge across the Menai Straits, seven and a half times longer than Waterloo Bridge, and more than ten times longer than Chelsea Bridge. The two-mile tube across the St. Lawrence rests on twenty-four piers, which, with the abutments, leave twenty-five spaces or spans for the several parts of the tube. Twenty-four of these spans are 242 feet wide; the centre span—itself a huge bridge—being 330 feet. The road is carried within the tube 60 feet above the level of the river, so as not to interfere with its navigation.

As one of the principal difficulties apprehended in the erection of the bridge was that arising from the tremendous “shoving”

and ramming of the ice at the break-up of winter, the plans were carefully designed so as to avert all danger from this cause. Hence the peculiarity in the form of the piers,

which, though greatly increasing their strength for the purpose intended, must be admitted to detract considerably from the symmetry of the structure as a whole.



SIDE ELEVATION OF PIER.

The western face of each pier—that is, the up-river side—has a large wedge-shaped cutwater of stone-work, presenting an inclined plane towards the current, for the purpose of arresting and breaking up the ice-blocks, and thereby preventing them from piling up and damaging the tube carrying the railway. The piers are of immense strength. Those close to the abutments contain about 6000 tons of masonry each; while those which support the great centre tube contain about 12,000 tons. The former are 15 feet wide, and the latter 18. Scarcely a block of stone used in the piers is less than seven tons in weight, while many of those opposed to the force of the breaking-up ice weigh fully ten tons.

As might naturally be expected, the getting in of the foundations of these enormous piers in so wide and rapid a river was attended with many difficulties. To give an idea of the water-power of the St. Lawrence, it may be mentioned that when the river comes down in its greatest might, large stone boulders weighing upwards of a ton are rolled along by the sheer force of the current. The depth of the river, however, was not so great as might be supposed, varying from only five to fifteen feet during summer, when the foundation-work was carried on.

The method first employed to get in the foundations was by means of dams or caissons, which were constructed on shore, floated into position, and scuttled over the places at which the foundations were to be laid, thus at once forming a nucleus from which the dams could be constructed. The first of such dams was floated, got into position, scuttled, and sunk, and the piling fairly begun, on the 19th June, 1854. By the 15th of the following month the sheet-piling and puddling was finished, when the pumping of the water out of the enclosed space by steam-power was pro-

ceeded with, and in a few hours the bed of the river was laid almost dry, the toe of every pile being distinctly visible. By the 22nd, the first stone of the pier was laid; and on the 14th of August the masonry was above water-level.

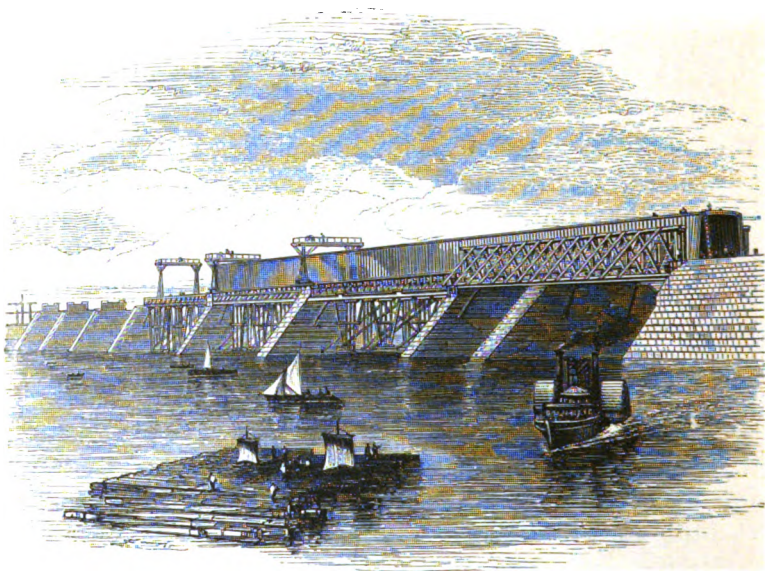
The getting in of the foundations of the other piers was proceeded with in like manner, though frequently interrupted by storms, inundations, and collisions of timber-rafts, which occasionally carried away the moorings of the dams. Considerable difficulty was in some places experienced from the huge boulder-stones lying in the bed of the river, to remove which sometimes cost the divers several months of hard labour. In getting in the foundations of the later piers, the method first employed of sinking the floating caissons in position was abandoned; and the dams were constructed of "crib-work,"¹ which was found more convenient and less liable to interruption by accident from collision or otherwise.

By the spring of 1857 a sufficient number of piers had been finished to enable the erection of the tubes to be proceeded with. The operations connected with this portion of the work were also of a novel character. Instead of floating the tubes between the piers and raising them into position by hydraulic power, as at Conway and Menai, which the rapid current of the St. Lawrence would not permit, the tubes were erected

¹ The dams of "crib-work" were formed by laying flattened pine-logs along the whole outer edge of the work, and at intervals of from 5 to 10 feet parallel therewith throughout the whole of the breadth, connected with transverse timbers firmly tre-nailed and notched into them. When one course was formed, another was laid upon and firmly tre-nailed to it. After two or three courses were laid, transverse timbers were placed over them close together, so as to form a flooring,

on which stone was placed to suit the crib as the work progressed. When the underside of the crib touched the bottom, it was carefully filled with loose stones and clay puddle to the water level. The process of puddling and pumping out the water, and building up the pier within the dam thus formed, then proceeded in the usual manner. In some cases a powerful steam-dredge was employed to clear out the puddle-chambers.

in situ on a staging prepared for the purpose, as shown in the following engraving.



WORKS IN PROGRESS. 1877.—VIEW FROM ABOVE THE SOUTH ABUTMENT.

Floating scows, each 60 feet by 20, were moored in position, and kept in their place by piles sliding in grooves. These piles, when firmly fixed in the bed of the river, were bolted to the sides of the scows, and the tops were levelled to receive the sills upon which the framing carrying the truss and platform was erected. Timbers were laid on the lower chords of the truss, forming a platform 24 feet wide, closely planked with deals. The upper chords carried rails, along which moved the "travellers" used in erecting the tubes. The plates forming the bottom of each tube having been accurately laid and rivetted, and adjusted to level and centre by oak wedges, the erection of the sides was next proceeded with, extending outwards from the centre on either side, this work being closely followed

by the plating of the top. Each tube between the respective pairs of piers was in the first place erected separate and independent of its adjoining tubes; but after completion, the tubes were joined in pairs and firmly bolted to the masonry over which they were united, their outer ends being placed upon rollers so arranged on the adjoining piers that they might expand or contract according to variations of temperature.

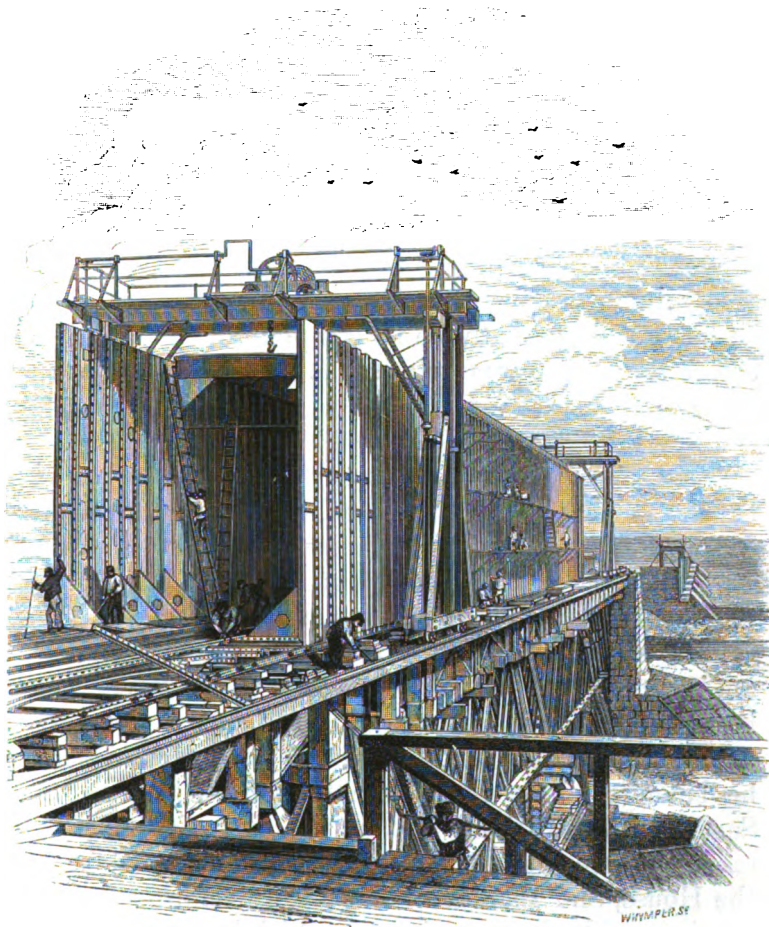
The work continued to make satisfactory progress down to the spring of 1858, by which time fourteen out of the twenty-four piers were finished, together with the formidable abutments and approaches to the bridge. Considerable apprehensions were entertained as to the security of the piers and the unfinished parts of the work at the usual breaking-up of the ice. We take the following account from a letter written by Mr. Ross to Mr. Stephenson descriptive of the scene.

On the 29th of March, the ice above Montreal began to show signs of weakness, but it was not until the 31st that a general movement became observable, which continued for an hour, when it suddenly stopped, and the water rose rapidly. On the following day, at noon, a grand movement commenced; the waters rose about four feet in two minutes, up to a level with many of the Montreal streets. The fields of ice at the same time were suddenly elevated to an incredible height; and so overwhelming were they in appearance, that crowds of the townspeople, who had assembled on the quay to watch the progress of the flood, ran for their lives. This movement lasted about twenty minutes, during which the jammed ice destroyed several portions of the quay-wall, grinding the hardest blocks to atoms. The embanked approaches to the Victoria Bridge had tremendous forces to resist. In the full channel of the stream, the ice in its passage between the piers was broken up by the force of the blow immediately on its coming in contact with the cutwaters. Sometimes thick sheets of ice were seen to rise up and rear on end against the piers, but by the force of the current they were speedily made to roll over into the stream, and in a moment after were out of sight. For the two next days the river was still high, until on the 4th of April the waters seemed suddenly to give way,

and by the following day the river was flowing clear and smooth as a millpond, nothing of winter remaining except the masses of bordage ice which were strewn along the shores of the stream. On examination of the piers of the bridge, it was found that they had admirably resisted the tremendous pressure; and though the timber "cribwork" erected to facilitate the placing of floating pontoons to form the dams, was found considerably disturbed and in some places seriously damaged, the piers, with the exception of one or two heavy stone blocks, which were still unfinished, escaped uninjured. One block of many tons' weight was carried to a considerable distance, and must have been torn out of its place by sheer force, as several of the broken fragments were found left in the pier.

Towards the end of January, 1859, the plating of the bottom of the great central tube was begun. The execution of this part of the undertaking was of a very formidable and difficult character. The gangs of men employed upon it were required to work night and day, though the season was mid-winter, as it was of great importance to the navigation that the staging should be removed by the time that the ice broke up and the river became open. The night gangs were lighted at their work by wood-fires filling huge braziers, the bright glow of which illumined the vast snow-covered ice-field in the midst of which they worked at so lofty an elevation; and the sight as well the sounds of the hammering and rivetting, the puffing of the steam-engines, and the various operations thus carried on, presented a scene the like of which has rarely been witnessed. The work was not conducted without considerable risk to the men, arising from the intense cold. The temperature was often 20° below zero, and notwithstanding that they all worked in thick gloves, and that care was taken to protect every exposed part, many of them were severely frostbitten. Sometimes when thick mist rose from the river, they would become covered with icicles, and be driven from their work.

Notwithstanding these difficulties, the laying of the great central tube made steady progress. By the 17th of February, the first pair of side-plates was erected; on the 28th, the bottom was rivetted and completed;



ERECTION OF MAIN CENTRAL TUBE

180 feet of the sides was also in place, and 100 feet of the top was plated; and on the 21st of March the whole of the plating was finished. A few days later,

the wedges were knocked away, and the tube hung suspended between the adjoining piers. On the 18th of May following, the staging was all cleared away, with the moored scows and the crib-work; and the centre span of the bridge was again clear for the navigation of the river.

The first stone of the bridge was laid on the 22nd of July, 1854. The works continued in progress for a period of five and a half years, until the 17th of December, 1859, when the first train passed over the bridge; and on the 25th of August, 1860, it was formally opened for traffic by the Prince of Wales. It was the greatest of Robert Stephenson's bridges, and worthy of being the crowning and closing work of his life. But he was not destined to see its completion. Two months before the bridge was finished, he had passed from the scene of all his labours.

We have little to add as to the closing events in Robert Stephenson's life. Retired in a great measure from the business of an engineer, he occupied himself for the most part in society, in yachting, and in attending the House of Commons and the Clubs. It was in the year 1847 that he entered the House as Member for Whitby; but he does not seem to have been very regular in his attendance, and only appeared on divisions when there was a "whip" of the party to which he belonged. He was a member of the Sewage and Sanitary Commissions, and of the Commission which sat on Westminster Bridge. He very seldom addressed the House, and then only on matters relating to engineering. The last occasions on which he spoke were on the Suez Canal¹ and the cleansing of the Serpentine.

¹ Mr. Stephenson entertained a very strong opinion as to the inexpediency of making this canal, and the impracticability of keeping it open except at

an enormous expense. Of course it was possible to make the canal provided there was money enough raised for the purpose. But even if made,

Besides constructing the railway between Alexandria and Cairo, he was consulted, like his father, by the King of Belgium as to the railways of that country; and he was made Knight of the Order of Leopold because of the improvements which he had made in locomotive engines, so much to the advantage of the Belgian system of inland transit. He was consulted by the King of Sweden as to the railway between Christiana and Lake Mïösen, and in consideration of his services was decorated with the Grand Cross of the Order of St.

he held that it would not long be used, for there would not be traffic enough to pay working expenses. In 1846, Mr. Stephenson carefully examined the country along the line of the proposed canal, from Tineh on the Mediterranean, to Suez on the Red Sea, in company with the agents of M. Talabot, a French engineer, and M. de Negrelli, an Austrian engineer. They ascertained that there was no difference of level between the two seas, and that consequently a canal capable of being scoured by the waters of either was impracticable. On the occasion of Captain Pim's reading a paper on the subject of the revived project of the canal before the Geographical Society on the 11th of April, 1859, Mr. Stephenson took part in the discussion which followed. He held that any harbour constructed at Port Said, however far it might be extended into the sea, would only act as a mud-trap, and that it would be impracticable to keep such a port open. Mr. George Rennie had compared the proposed breakwater at Pelusium with the breakwater at Portland, on which Mr. Stephenson observed—"Why, at Portland the stones are carried out from the shore and thrown into the sea, but at Pelusium there is no solid shore, and all the stones must be brought 100 miles. Can there be any comparison between a breakwater at Portland and one in the Mediterranean on a lee shore, where there is no stone and no foundation whatever? It is only the silt of the Nile. The Nile brings down millions of tons of mud yearly, and

hence the Delta formed at its mouth. The moment you construct a harbour at Port Said and project piers into the sea, you immediately arrest the course of the mud, and will never be able to keep the port open. It would be the most extraordinary thing in the world to project two jetties into an open sea on a lee shore, which has for almost three months in the year a north-east wind blowing upon it. 'There is no seaman, except in fair weather, who would venture to approach such a place. To render it at all accessible and safe, there must be a harbour of refuge made, and we know from experience in our own country what a large question that would open up. But even suppose such a harbour to be made. The current carries the mud of the Nile in an easterly direction; and if you provide a harbour of refuge, which means a quiescent harbour, it will act merely as a gigantic mud-trap. I believe it to be nearly if not absolutely true, that there is no large harbour in the world maintained on the delta of a large river. Any such harbour would be silted up in a few years. And whoever has travelled over the district between Port Said and Suez, and seen the moving sands, must see that it would be necessary to dredge, not only that harbour but the canal itself.' Mr. Stephenson's conclusion accordingly was that the scheme was impracticable, that it would not justify the expenditure necessary to complete it, and that if ever executed it would prove a commercial failure.

Olaf. He also visited Switzerland, Piedmont, and Denmark, to advise as to the system of railway communication best suited for those countries. At the Paris Exhibition of 1855 the Emperor of France decorated him with the Legion of Honour in consideration of his public services; and at home the University of Oxford made him a Doctor of Civil Laws. In 1855 he was elected President of the Institute of Civil Engineers, which office he held with honour and filled with distinguished ability for two years, giving place to his friend Mr. Locke at the end of 1857.

Mr. Stephenson was frequently called upon to act as arbitrator between contractors and railway companies, or between one company and another,—great value being attached to his opinion on account of his weighty judgment, his great experience, and his upright character; and we believe his decisions were invariably stamped by the qualities of impartiality and justice. He was always ready to lend a helping hand to a friend, and no petty jealousy stood between him and his rivals in the engineering world. The author remembers being with Mr. Stephenson one evening at his house in Gloucester Square, when a note was put into his hand from his friend Brunel, then engaged in his first fruitless efforts to launch the *Great Eastern*. It was to ask Stephenson to come down to Blackwall early next morning, and give him the benefit of his judgment. Shortly after six next morning Stephenson was in Scott Russell's building-yard, and he remained there until dusk. About midday, while superintending the launching operations, the baulk of timber on which he stood canted up, and he fell up to his middle in the Thames mud. He was dressed as usual, without great-coat (though the day was bitter cold) and with only thin boots upon his feet. He was urged to leave the yard and change his dress, or at least dry himself; but, with his usual disregard of health, he replied, "Oh,

never mind me—I'm quite used to this sort of thing;" and he went paddling about in the mud, smoking his cigar, until almost dark, when the day's work was brought to an end. The result of this exposure was an attack of inflammation of the lungs, which kept him to his bed for a fortnight.

He was habitually careless of his health, and perhaps he indulged in narcotics to a prejudicial extent. Hence he often became "hipped" and sometimes ill. When Mr. Sopwith accompanied him to Egypt in the *Titania*, in 1856, he succeeded in persuading Mr. Stephenson to limit his indulgence in cigars and stimulants, and the consequence was that by the end of the voyage he felt himself, as he said, "quite a new man." Arrived at Marseilles, he telegraphed from thence a message to Great George Street, prescribing certain stringent and salutary rules for observance in the office there on his return. But he was of a facile, social disposition, and the old associations proved too strong for him. When he sailed for Norway, in the autumn of 1859, though then ailing in health, he looked a man who had still plenty of life in him. By the time he returned, his fatal illness had seized him. He was attacked by congestion of the liver, which first developed itself in jaundice, and then ran into dropsy, of which he died on the 12th of October, in the fifty-sixth year of his age. He was buried by the side of Telford in Westminster Abbey, amidst the departed great men of his country, and was attended to his resting-place by many of the intimate friends of his boyhood and his manhood. Among those who assembled round his grave were some of the greatest men of thought and action in England, who embraced the sad occasion to pay the last mark of their respect to this illustrious son of one of England's greatest working men.

It would be out of keeping with the subject thus drawn to a conclusion, to pronounce any panegyric on the character and achievements of George and Robert Stephenson. These for the most part speak for themselves; and both were emphatically true men, exhibiting in their lives many valuable and sterling qualities.

No beginning could have been less promising than that of the elder Stephenson. Born in a poor condition, yet rich in spirit, he was from the first compelled to rely upon himself; every step of advance which he made being conquered by patient labour. Whether working as a brakesman or an engineer, his mind was always full of the work in hand. He gave himself thoroughly up to it. Like the painter, he might say that he had become great "by neglecting nothing." Whatever he was engaged upon, he was as careful of the details as if each were itself the whole. He did all thoroughly and honestly. There was no "scamping" with him. When a workman he put his brains and labour into his work; and when a master he put his conscience and character into it. He would have no slop-work executed merely for the sake of profit. The materials must be as genuine as the workmanship was skilful. The structures which he designed and executed were distinguished for their thoroughness and solidity; his locomotives were famous for their durability and excellent working qualities. The engines which he sent to the United States in 1832 are still in good condition; and even the engines built by him for the Killingworth Colliery, upwards of thirty years since, are working there to this day. All his work was honest, representing the actual character of the man.

He was ready to turn his hand to anything—shoes and clocks, railways and locomotives. He contrived his safety-lamp with the object of saving pitmen's lives, and perilled his own life in testing it. With him to resolve was to do. Many men knew far more than he;

but none was more ready forthwith to apply what he did know to practical purposes. It was while working at Willington as a brakesman that he first learnt how best to handle a spade in throwing ballast out of the ships' holds. This casual employment seems to have left upon his mind the most lasting impression of what "hard work" was; and he often used to revert to it, and say to the young men about him, "Ah, ye lads! there's none o' ye know what *wark* is." Mr. Gooch says he was proud of the dexterity in handling a spade which he had thus acquired, and that he has frequently seen him take the shovel from a labourer in some railway cutting, and show him how to use it more deftly in filling waggons of earth, gravel, or sand. Sir Joshua Walmsley has also informed us that, when examining the works of the Orleans and Tours Railway, Stephenson, seeing a large number of excavators filling and wheeling sand in a cutting, at a great waste of time and labour, went up to the men and said he would show them how to fill their barrows in half the time. He showed them the proper position in which to stand so as to exercise the greatest amount of power with the least expenditure of strength; and he filled the barrow with comparative ease again and again in their presence, to the great delight of the workmen. When passing through his own workshops he would point out to his men how to save labour and get through their work skilfully and with ease. His energy imparted itself to others, quickening and influencing them as strong characters always do,—flowing down into theirs, and bringing out their best powers.

His deportment towards the workmen employed under him was familiar, yet firm and consistent. As he respected their manhood, so they respected his masterhood. Although he comported himself towards his men as if they occupied very much the same level with himself, he yet possessed that peculiar capacity for

governing which enabled him always to preserve among them the strictest discipline, and to secure their cheerful and hearty services. Mr. Ingham, M.P. for South Shields, on going over the workshops at Newcastle, was particularly struck with this quality of the master in his bearing towards his men. "There was nothing," said he, "of undue familiarity in their intercourse, but they spoke to each other as man to man; and nothing seemed to please the master more than to point out illustrations of the ingenuity of his artisans. He took up a rivet, and expatiated on the skill with which it had been fashioned by the workman's hand—its perfectness and truth. He was always proud of his workmen and his pupils; and, while indifferent and careless as to what might be said of himself, he fired up in a moment if disparagement were thrown upon any one whom he had taught or trained."

In manner, George Stephenson was simple, modest, and unassuming, but always manly. He was frank and social in spirit. When a humble workman, he had carefully preserved his sense of self-respect. His companions looked up to him, and his example was worth much more to many of them than books or schools. His devoted love of knowledge made his poverty respectable, and adorned his humble calling. When he rose to a more elevated station, and associated with men of the highest position and influence in Britain, he took his place among them with perfect self-possession. They wondered at the quiet ease and simple dignity of his deportment; and men in the best ranks of life have said of him that "He was one of Nature's gentlemen."

Probably no military chiefs were ever more beloved by their soldiers than were both father and son by the army of men who, under their guidance, worked at labours of profit, made labours of love by their earnest will and purpose. True leaders of men and lords of industry, they were always ready to recognise and

encourage talent in those who worked for and with them. Thus it was pleasant, at the openings of the Stephenson lines, to hear the chief engineers attributing the successful completion of the works to their assistants; while the assistants, on the other hand, ascribed the principal glory to their chiefs.

George Stephenson, though a thrifty and frugal man, was essentially unsordid. His rugged path in early life made him careful of his resources. He never saved to hoard, but saved for a purpose, such as the maintenance of his parents or the education of his son. In his later years he became a prosperous and even a wealthy man; but riches never closed his heart, nor stole away the elasticity of his soul. He enjoyed life cheerfully, because hopefully. When he entered upon a commercial enterprise, whether for others or for himself, he looked carefully at the ways and means. Unless they would "pay," he held back. "He would have nothing to do," he declared, "with stock-jobbing speculations." His refusal to sell his name to the schemes of the railway mania—his survey of the Spanish lines without remuneration—his offer to postpone his claim for payment from a poor Company until their affairs became more prosperous—are instances of the unsordid spirit in which he acted.

Another marked feature in Mr. Stephenson's character was his patience. Notwithstanding the strength of his convictions as to the great uses to which the locomotive might be applied, he waited long and patiently for the opportunity of bringing it into notice; and for years after he had completed an efficient engine, he went on quietly devoting himself to the ordinary work of the colliery. He made no noise nor stir about his locomotive, but allowed another to take credit for the experiments on velocity and friction which he had made with it upon the Killingworth railroad. By patient industry and laborious contrivance he was enabled, with the powerful

help of his son, almost to do for the locomotive what James Watt had done for the condensing engine. He found it clumsy and inefficient ; and he made it powerful, efficient, and useful. Both have been described as the improvers of their respective engines ; but, as to all that is admirable in their structure or vast in their utility, they are rather entitled to be described as their inventors. They have both tended to increase indefinitely the mass of human comforts and enjoyments, and to render them cheap and accessible to all. But Stephenson's invention, by the influence which it is daily exercising upon the civilisation of the world, is even more remarkable than that of Watt, and is calculated to have still more important consequences. In this respect it is to be regarded as the grandest application of steam-power that has yet been discovered.

George Stephenson's close and accurate observation provided him with a fulness of information on many subjects, which often appeared surprising to those who had devoted to them a special study. On one occasion the accuracy of his knowledge of birds came out in a curious way at a convivial meeting of railway men in London. The engineers and railway directors present knew each other as railway men and nothing more. The talk had been all of railways and railway politics. Stephenson was a great talker on those subjects, and was generally allowed, from the interest of his conversation and the extent of his experience, to take the lead. At length one of the party broke in with— "Come now, Stephenson, we have had nothing but railways ! cannot we have a change and try if we can talk a little about something else ?" "Well," said Stephenson, "I'll give you a wide range of subjects ; what shall it be about ?" "Say *birds' nests* !" rejoined the other, who prided himself on his special knowledge of the subject. "Then birds' nests be it." A long and animated conversation ensued : the bird-nesting of his

boyhood—the blackbird's nest which his father had held him up in his arms to look at when a child at Wylam—the hedges in which he had found the thrush's and the linnet's nests—the mossy bank where the robin built—the cleft in the branch of the young tree where the chaffinch had reared its dwelling—all rose up clear in his mind's eye, and led him back to the scenes of his boyhood at Callerton and Dewley Burn. The colour and number of the birds' eggs—the period of their incubation—the materials employed by them for the walls and lining of their nests—were described by him so vividly, and illustrated by such graphic anecdotes, that one of the party remarked that, if George Stephenson had not been the greatest engineer of his day, he might have been one of the greatest naturalists.

His powers of conversation were very great. He was so thoughtful, original, and suggestive. There was scarcely a department of science on which he had not formed some novel and sometimes daring theory. Thus Mr. Gooch, his pupil, who lived with him when at Liverpool, informs us that when sitting over the fire, he would frequently broach his favourite theory of the sun's light and heat being the original source of the light and heat given forth by the burning coal. "It fed the plants of which that coal is made," he would say, "and has been bottled up in the earth ever since, to be given out again now for the use of man." His son Robert once said of him, "My father flashed his bull's eye full upon a subject, and brought it out in its most vivid light in an instant: his strong common sense and his varied experience, operating on a thoughtful mind, were his most powerful illuminators."

The Bishop of Oxford related the following anecdote of him at a recent public meeting in London:—"He heard the other day of an answer given by the great self-taught man, Stephenson, when he was speaking with something of distrust of what were called com-

petitive examinations. Stephenson said, 'I distrust them for this reason—they will lead, it seems to me, to an unlimited power of cram;' and he added, 'Let me give you one piece of advice, never to judge of your goose by its stuffing!'"

George Stephenson had once a conversation with a watchmaker, whom he astonished by the extent and minuteness of his knowledge as to the parts of a watch. The watchmaker knew him to be an eminent engineer, and asked how he had acquired so extensive a knowledge of a branch of business so much out of his sphere. "It is very easily to be explained," said Stephenson; "I worked long at watch-cleaning myself, and when I was at a loss, I was never ashamed to ask for information."

His hand was open to his former fellow-workmen whom old age had left in poverty. To poor Robert Gray, of Newburn, who acted as his bridesman on his marriage to Fanny Henderson, he left a pension for life. He would slip a five-pound note into the hand of a poor man or a widow in such a way as not to offend their delicacy, but to make them feel as if the obligation were all on his side. When Farmer Paterson, who married a sister of George's first wife, Fanny Henderson, died and left a large young family fatherless, poverty stared them in the face. "But ye ken," said our informant, "*George struck in fayther for them.*" And perhaps the providential character of the act could not have been more graphically expressed than in these simple words.

On his visit to Newcastle, he would frequently meet the friends of his early days, occupying very nearly the same station in life, while he had meanwhile risen to almost world-wide fame. But he was not less hearty in his greeting of them than if their relative position had remained the same. Thus, one day, after shaking hands with Mr. Brandling on alighting from his car-

riage, he proceeded to shake hands with his coachman, Anthony Wigham, a still older friend, though he only sat on the box.

Robert Stephenson inherited his father's kindly spirit and benevolent disposition. We have already stated that he was often called in as an umpire to mediate between conflicting parties, more particularly between contractors and engineers. On one occasion Brunel complained to him that he could not get on with his contractors, who were never satisfied, and were always quarrelling with him. "You hold them too tightly to the letter of your agreement," said Stephenson; "treat them fairly and liberally." "But they try to take advantage of me at all points," rejoined Brunel. "Perhaps you suspect them too much?" said Stephenson. "I suspect all men to be rogues," said the other, "till I find them to be honest." "For my part," said Stephenson, "I take all men to be honest till I find them to be rogues." "Ah! then, I fear we shall never agree," concluded Brunel.

Robert almost worshipped his father's memory, and was ever ready to attribute to him the chief merit of his own achievements as an engineer. "It was his thorough training," we once heard him say, "his example, and his character, which made me the man I am." On a more public occasion he said, "It is my great pride to remember, that whatever may have been done, and however extensive may have been my own connection with railway development, all I know and all I have done is primarily due to the parent whose memory I cherish and revere."¹ To Mr. Lough, the sculptor, he said he had never had but two loves—one for his father, the other for his wife.

¹ Address as President of the Institution of Civil Engineers, January, 1876.

Like his father, he was eminently practical, and yet always open to the influence and guidance of correct theory. His main consideration in laying out his lines of railway was what would best answer the intended purpose, or, to use his own words, to secure the maximum of result with the minimum of means. He was pre-eminently a safe man, because cautious, tentative, and experimental; following closely the lines of conduct trodden by his father, and often quoting his maxims.

In society Robert Stephenson was simple, unobtrusive, and modest; but charming and even fascinating in an eminent degree. Sir John Lawrence has said of him that he was, of all others, the man he most delighted to meet in England—he was so manly yet gentle, and withal so great. While admired and beloved by men of such calibre, he was equally a favourite with women and children. He put himself upon the level of all, and charmed them no less by his inexpressible kindness of manner than by his simple yet impressive conversation.

His great wealth enabled him to perform many generous acts in a right noble and yet modest manner, not letting his right hand know what his left hand did. Of the numerous kindly acts of his which have been made public, we may mention the graceful manner in which he repaid the obligations which both himself and his father owed to the Newcastle Literary and Philosophical Institute when working together as fellow experimenters many years before in their humble cottage at Killingworth. The Institute was struggling under a debt of 6200*l.*, which impaired its usefulness as an educational agency. Mr. Stephenson offered to pay one-half the sum, provided the local supporters of the Institute would raise the remainder; and conditional also on the annual subscription being reduced

from two guineas to one, in order that the usefulness of the institution might be extended. His generous offer was accepted and the debt extinguished.

Both father and son were offered knighthood, and both declined it. During the summer of 1847, George Stephenson was invited to offer himself as a candidate for the representation of South Shields in Parliament. But his politics were at best of a very undefined sort. Indeed his life had been so much occupied with subjects of a practical character, that he had scarcely troubled himself to form any decided opinion on the party political topics of the day; and to stand the cross fire of the electors on the hustings might possibly have proved an even more distressing ordeal than the cross-questioning of the barristers in the Committees of the House of Commons. "Politics," he used to say, "are all matters of theory—there is no stability in them; they shift about like the sands of the sea: and I should feel quite out of my element amongst them." He had accordingly the good sense respectfully to decline the honour of contesting the representation of South Shields.

We have, however, been informed by Sir Joseph Paxton, that although George Stephenson held no strong opinions on political questions generally, there was one question on which he entertained a decided conviction, and that was the question of Free-Trade. The words used by him on one occasion to Sir Joseph were very strong. "England," said he, "is, and must be a shopkeeper; and our docks and harbours are only so many wholesale shops, the doors of which should always be kept wide open." It is curious that his son should have taken precisely the opposite view of this question, and acted throughout with the most rigid party among the protectionists, supporting the Navigation Laws and opposing Free Trade, even to the extent

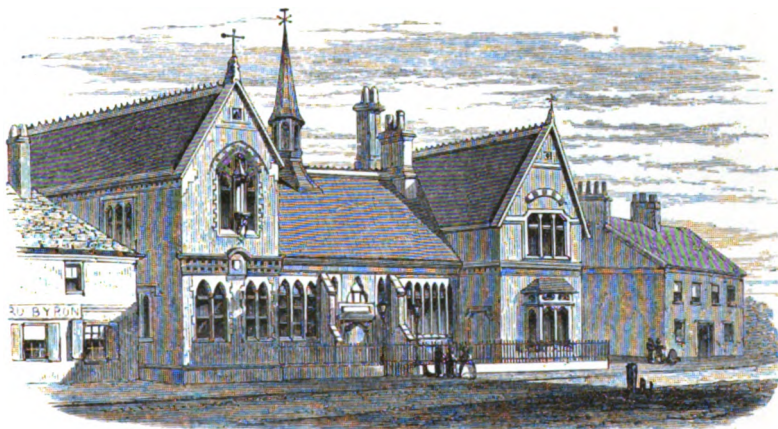
of going into the lobby with Colonel Sibthorp, Mr. Spooner, and the fifty-three "cannon-balls," on the 26th of November, 1852. Robert Stephenson to the last spoke in strong terms as to the "betrayal of the protectionist party" by their chosen leader, and he went so far as to say that he "could never forgive Peel."

But Robert Stephenson will be judged in after times by his achievements as an engineer, rather than by his acts as a politician; and happily these last were far outweighed in value by the immense practical services which he rendered to trade, commerce, and civilisation, through the facilities which the railways constructed by him afforded for free intercommunication between men in all parts of the world. Speaking in the midst of his friends at Newcastle, in 1850, he observed:—

"It seems to me but as yesterday that I was engaged as an assistant in laying out the Stockton and Darlington Railway. Since then, the Liverpool and Manchester and a hundred other great works have sprung into existence. As I look back upon these stupendous undertakings, accomplished in so short a time, it seems as though we had realised in our generation the fabled powers of the magician's wand. Hills have been cut down and valleys filled up; and when these simple expedients have not sufficed, high and magnificent viaducts have been raised, and if mountains stood in the way, tunnels of unexampled magnitude have pierced them through, bearing their triumphant attestation to the indomitable energy of the nation, and the unrivalled skill of our artisans."

As respects the immense advantages of railways to mankind, there cannot be two opinions. They exhibit, probably, the grandest organisation of capital and labour that the world has yet seen. Although they have unhappily occasioned great loss to many, the loss has been that of individuals; while, as a national system, the gain has already been enormous. As tending to multiply and spread abroad the conveniences

of life, opening up new fields of industry, bringing nations nearer to each other, and thus promoting the great ends of civilisation, the founding of the railway system by George Stephenson and his son must be regarded as one of the most important events, if not the very greatest, in the first half of this nineteenth century.



THE STEPHENSON MEMORIAL SCHOOLS, WILLINGTON QUAY

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