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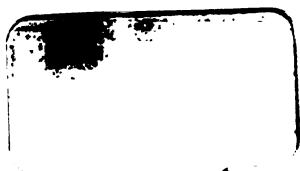
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Lives of the engineers

Samuel Smiles

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George Stephenson :

Engraved by W. Holt, after the portrait by John Lucas

London John Murray, Albemarle Street 1868.



LIVES
OF
THE ENGINEERS,
WITH
AN ACCOUNT OF THEIR PRINCIPAL WORKS;
COMPRISING ALSO
A HISTORY OF INLAND COMMUNICATION IN BRITAIN.

BY SAMUEL SMILES.

" Bid Harbours open, Public Ways extend ;
Bid Temples, worthier of God, ascend ;
Bid the broad Arch the dang'rous flood contain,
The Mole projected, break the roaring main ;
Back to his bounds their subject sea command,
And roll obedient rivers through the land.
These honours, Peace to happy Britain brings ;
These are imperial works, and worthy kings."

POPE.

VOL. III.

[GEORGE AND ROBERT STEPHENSON.]

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By SAMUEL SMILES.

A NEW EDITION, REVISED AND ENLARGED.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1868.

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P R E F A C E.

THE present is a revised edition of the Life of George Stephenson and of his son Robert Stephenson, to which is prefixed a history of the Railway and the Locomotive in its earlier stages, uniform with the early history of the Steam-engine given in vol. iv. of 'Lives of the Engineers' containing the memoirs of Boulton and Watt. A memoir of Richard Trevithick has also been included in this introductory portion of the book, which will probably be found more complete than any notice which has yet appeared of that distinguished mechanical engineer.

Since the appearance of this Life in its original form ten years ago, the construction of Railways has continued to make extraordinary progress. The length of lines then open in Europe was estimated at about 18,000 miles: it is now more than 50,000 miles. Although Great Britain, first in the field, had then, after about twenty-five years' work, expended nearly 300 millions sterling in the construction of 8300 miles of double railway, it has during the last ten years expended about 200 millions more in constructing 5600 additional miles.

But the construction of railways has proceeded with equal rapidity on the Continent. France has now 9624 miles at work; Germany (including Austria)

13,392 miles; Spain 3161 miles; Sweden 1100 miles; Belgium 1073 miles; Switzerland 795 miles; Holland 617 miles; besides railways in other states. These have for the most part been constructed and opened during the last ten years; while a considerable length is still under construction. Austria is actively engaged in carrying new lines across the plains of Hungary to the frontier of Turkey, which Turkey is preparing to meet by lines carried up the valley of the Lower Danube; and Russia, with 2800 miles already at work, is occupied with extensive schemes for connecting Petersburg and Moscow with her ports in the Black Sea on the one hand, and with the frontier towns of her Asiatic empire on the other.

Italy also is employing her new-born liberty in vigorously extending railways throughout her dominions. The length of Italian lines in operation in 1866 was 2752 miles, of which not less than 680 were opened in that year. Already has a direct line of communication been opened between Germany and Italy through the Brenner Pass, by which it is now possible to make the entire journey by railway (excepting only the short sea-passage across the English Channel) from London to Brindisi on the south-eastern extremity of the Italian peninsula; and, in the course of a few more years, a still shorter route will be opened through France, when that most formidable of all railway borings, the seven-mile tunnel under Mont Cenis, has been completed.

During the last ten years, nearly the whole of the existing Indian railways have been made. When Edmund Burke in 1783 arraigned the British Govern-

ment for their neglect of India in his speech on Mr. Fox's Bill, he said, "England has built no bridges, made no high roads, cut no navigations, dug out no reservoirs. . . . Were we to be driven out of India this day, nothing would remain to tell that it had been possessed, during the inglorious period of our dominion, by anything better than the ourang-outang or the tiger." But that reproach no longer applies. Some of the greatest bridges erected in modern times—such as those over the Sone near Patna, and over the Jamna at Allahabad—have been erected in connection with the Indian railways, of which there are already 3637 miles at work, and above 2000 more under construction. When these lines have been completed, at an expenditure of about 88,000,000*l.* of British capital guaranteed by the British Government, India will be provided with a magnificent system of internal communication, connecting the capitals of the three Presidencies—uniting Bombay with Madras on the south, and with Calcutta on the north-east—while a great main line, 2200 miles in extent, passing through the north-western provinces, and connecting Calcutta with Lucknow, Delhi, Lahore, Moultan, and Kurrachee, will unite the mouths of the Hooghly in the Bay of Bengal with those of the Indus in the Arabian Sea.

When the first edition of this work appeared in the beginning of 1857, the Canadian system of railways was but in its infancy. The Grand Trunk was only begun, and the Victoria Bridge—the greatest of all railway structures—was not half erected. Now, that fine colony has more than 2200 miles in active operation along the great valley of the St. Lawrence, con-

necting Rivière du Loup at the mouth of that river, and the harbour of Portland in the State of Maine, *via* Montreal and Toronto, with Sarnia on Lake Huron, and with Windsor, opposite Detroit in the State of Michigan. The Australian Colonies also have during the same time been actively engaged in providing themselves with railways, many of which are at work, and others are in course of formation. Even the Cape of Good Hope has several lines open, and others making. France also has constructed about 400 miles in Algeria, while the Pasha of Egypt is the proprietor of 360 miles in operation across the Egyptian desert.

But in no country has railway construction been prosecuted with greater vigour than in the United States. There the railway furnishes not only the means of intercommunication between already established settlements, as in the Old World, but it is regarded as the pioneer of colonization, and as instrumental in opening up new and fertile territories of vast extent in the west—the food-grounds of future nations. Hence railway construction in that country was scarcely interrupted even by the great Civil War,—at the commencement of which Mr. Seward publicly expressed the opinion that “physical bonds—such as highways, railroads, rivers, and canals—are vastly more powerful for holding civil communities together than any mere covenants, though written on parchment or engraved on iron.”

The people of the United States were the first to follow the example of England, after the practicability of steam locomotion had been proved on the Stockton and Darlington and Liverpool and Manchester Rail-

ways. The first sod of the Baltimore and Ohio Railway was cut on the 4th of July, 1828, and the line was completed and opened for traffic in the following year, when it was worked partly by horse-power, and partly by a locomotive built at Baltimore which is still preserved in the Company's workshops. In 1830, the Hudson and Mohawk Railway was begun, while other lines were under construction in Pennsylvania, Massachusetts, and New Jersey; and in the course of ten years, 1843 miles were finished and in operation. In ten more years, 8827 miles were at work; at the end of 1864, not less than 35,000 miles, mostly single tracks; while about 15,000 miles more were under construction. One of the most extensive trunk-lines still unfinished is the Great Pacific Railroad, connecting the lines in the valleys of the Mississippi and the Missouri with the city of San Francisco on the shores of the Pacific, by which, when completed, it will be possible to make the journey from England to Hong Kong, *viâ* New York, in little more than a month.

The results of the working of railways have been in many respects different from those anticipated by their projectors. One of the most unexpected has been the growth of an immense passenger-traffic. The Stockton and Darlington line was projected as a coal line only, and the Liverpool and Manchester as a merchandise line. Passengers were not taken into account as a source of revenue; for, at the time of their projection, it was not believed that people would trust themselves to be drawn upon a railway by an "explosive machine," as the locomotive was described to be.

Indeed, a writer of eminence declared that he would as soon think of being fired off on a ricochet rocket, as travel on a railway at twice the speed of the old stage-coaches. So great was the alarm which existed as to the locomotive, that the Liverpool and Manchester Committee pledged themselves in their second prospectus, issued in 1825, "not to require any clause empowering its use;" and as late as 1829, the Newcastle and Carlisle Act was conceded on the express condition that it should not be worked by locomotives, but by horses only.

Nevertheless, the Liverpool and Manchester Company obtained powers to make and work their railway without any such restriction; and when the line was made and opened, a locomotive passenger-train was advertised to be run upon it by way of experiment. Greatly to the surprise of the directors, more passengers presented themselves as travellers by the train than could conveniently be carried.

The first arrangements as to passenger-traffic were of a very primitive character, being mainly copied from the old stage-coach system. The passengers were "booked" at the railway office, and their names were entered in a way-bill which was given to the guard when the train started. Though the usual stage-coach bugleman could not conveniently accompany the passengers, the trains were at first played out of the terminal stations by a lively tune performed by a trumpeter at the end of the platform; and this continued to be done at the Manchester Station until a comparatively recent date.

But the number of passengers carried by the Liverpool and Manchester line was so unexpectedly great,

that it was very soon found necessary to remodel the entire system. Tickets were introduced, by which a great saving of time was effected. More roomy and commodious carriages were provided, the original first-class compartments being seated for four passengers only. Everything was found to have been in the first instance made too light and too slight. The prize 'Rocket,' which weighed only $4\frac{1}{2}$ tons when loaded with its coke and water, was found quite unsuited for drawing the increasingly heavy loads of passengers. There was also this essential difference between the old stage-coach and the new railway train, that, whereas the former was "full" with six inside and ten outside, the latter must be able to accommodate whatever number of passengers came to be carried. Hence heavier and more powerful engines, and larger and more substantial carriages, were from time to time added to the carrying stock of the railway.

The speed of the trains was also increased. The first locomotives used in hauling coal-trains ran at from four to six miles an hour. On the Stockton and Darlington line the speed was increased to about ten miles an hour; and on the Liverpool and Manchester line the first passenger-trains were run at the average speed of seventeen miles an hour, which at that time was considered very fast. But this was not enough. When the London and Birmingham line was opened, the mail-trains were run at twenty-three miles an hour; and gradually the speed went up, until now the fast trains are run at from fifty to sixty miles an hour,—the pistons in the cylinders, at sixty miles, travelling at the inconceivable rapidity of 800 feet per minute!

To bear the load of heavy engines run at high speeds, a much stronger and heavier road was found necessary ; and shortly after the opening of the Liverpool and Manchester line, it was entirely relaid with stronger materials. Now that express passenger-engines are from thirty to thirty-five tons each, the weight of the rails has been increased from 35 lbs. to 75 lbs. or 86 lbs. to the yard. Stone blocks have given place to wooden sleepers ; rails with loose ends resting on the chairs, to rails with their ends firmly "fished" together ; and in many places, where the traffic is unusually heavy, iron rails have been replaced by those of steel.

And now see the enormous magnitude to which railway passenger-traffic has grown. In the year 1866, 274,293,668 passengers were carried by day tickets in Great Britain alone. But this was not all. For in that year 110,227 periodical tickets were issued by the different railways ; and assuming half of them to be annual, one-fourth half-yearly, and the remainder quarterly tickets, and that their holders made only five journeys each way weekly, this would give an additional number of 39,405,600 journeys, or a total of 313,699,268 passengers carried in Great Britain in one year.

It is difficult to grasp the idea of the enormous number of persons represented by these figures. The mind is merely bewildered by them, and can form no adequate notion of their magnitude. To reckon them singly would occupy twenty years, counting at the rate of one a second for twelve hours every day. Or take another illustration. Supposing every man, woman, and child in Great Britain to make ten

journeys by rail yearly, the number would fall short of the passengers carried in 1866.

Mr. Porter, in his 'Progress of the Nation,' estimated that thirty millions of passengers, or about eighty-two thousand a day, travelled by coaches in Great Britain in 1834, an average distance of twelve miles each, at an average cost of 5s. a passenger, or at the rate of 5*d.* a mile; whereas above 313 millions are now carried by railway an average distance of $8\frac{1}{2}$ miles each, at an average cost of 1s. $1\frac{1}{2}$ *d.* per passenger or about three halfpence per mile, in considerably less than half the time.

But besides the above number of passengers, one hundred and twenty-four million tons of minerals and merchandise were carried by railway in the United Kingdom in 1866, and fifteen millions of cattle, besides mails, parcels, and other traffic. The distance run by passenger and goods trains in the year was 142,807,853 miles; to accomplish which it is estimated that four miles of railway on an average must be covered by running trains during every second all the year round.

To perform this service, there were, in 1866, 8125 locomotives at work in the United Kingdom, consuming about three million tons of coal and coke, and flashing into the air every minute some thirty tons of water in the form of steam in a high state of elasticity. There were also 19,228 passenger-carriages, 7276 vans and breaks attached to passenger-trains, and 242,947 trucks, waggons, and other vehicles appropriated to merchandise. Buckled together, buffer to buffer, the locomotives and tenders would extend for a length of about 54 miles, or more than the distance from London to Brighton;

while the carrying vehicles, joined together, would form two trains occupying a double line of railway extending from London to beyond Inverness.

A notable feature in the growth of railway traffic of late years has been the increase in the number of third-class passengers, compared with first and second class. Sixteen years since, the third-class passengers constituted only about one-third; ten years later, they were about one-half; whereas now they form nearly two-thirds of the whole number carried. Thus George Stephenson's prediction "that the time would come when it would be cheaper for a working man to make a journey by railway than to walk on foot" is already realised.

The degree of safety with which this great traffic has been conducted, is not the least remarkable of its features. Of course, so long as railways are worked by men they will be liable to the imperfections belonging to all things human. Though their machinery may be perfect and their organisation as complete as skill and forethought can make it, workmen will at times be forgetful and listless; and a moment's carelessness may lead to the most disastrous results. Yet, taking all circumstances into account, the wonder is that travelling by railway at high speeds should have been rendered comparatively so safe.

To be struck by lightning is one of the rarest of all causes of death; yet more persons were killed by lightning in Great Britain, in 1866, than were killed on railways from causes beyond their own control; the number in the former case having been nineteen, and in the latter fifteen, or one in every twenty millions

of passengers carried. Most persons would consider the probability of their dying by hanging to be extremely remote; yet, according to the Registrar-General's returns for 1867, it is thirty times greater than that of being killed by railway accident. Taking the number of persons who travelled in Great Britain in 1866 at 313,699,268, of whom fifteen were accidentally killed, it would appear that, even supposing a person to have a permanent existence and to make a journey by railway daily, the probability of his being killed in an accident would occur on an average once in above 50,000 years.

The remarkable safety with which railway traffic is on the whole conducted, is due to constant watchfulness and highly-applied skill. The men who work the railways are for the most part the picked men of the country, and every railway station may be regarded as a practical school of industry, attention, and punctuality. Where railways fail in these respects, it will usually be found that it is because the men are personally defective, or because better men are not to be had. It must also be added that the onerous and responsible duties which railway workmen are called upon to perform, require a degree of consideration on the part of the public which is not very often extended to them.

Few are aware of the complicated means and agencies that are in constant operation on railways day and night, to ensure the safety of the passengers to their journeys' end. The road is under a system of continuous inspection, under gangs of men—about twelve to every five miles, under a foreman or "ganger"—whose

duty it is to see that the rails and chairs are sound, all their fastenings complete, and the line clear of obstructions.

Then, at all the junctions, sidings, and crossings, pointsmen are stationed, with definite instructions as to the duties to be performed by them. At these places, signals are provided, worked from the station platforms, or from special signal-boxes, for the purpose of protecting the stopping or passing trains. When the first railways were opened, the signals were of a very simple kind. The station men gave them with their arms stretched out in different positions; then flags of different colours were used; next fixed signals, with arms or discs, or of rectangular or triangular shape. These were followed by a complete system of semaphore signals, near and distant, protecting all junctions, sidings, and crossings.

When Government Inspectors were first appointed by the Board of Trade to examine and report upon the working of railways, they were alarmed by the number of trains following each other at some stations in what then seemed to be a very rapid succession. A passage from a Report written in 1840 by Sir Frederick Smith, as to the traffic at "Taylor's Junction" on the York and North Midland Railway, contrasts curiously with the railway life and activity of the present day:—"Here," wrote the alarmed Inspector, "the passenger trains from York, as well as Leeds and Selby, meet four times a day. No less than 23 passenger-trains stop at or pass this station in the 24 hours—an amount of traffic requiring not only the most perfect arrangements on the part of the management, but the utmost

vigilance and energy in the servants of the Company employed at this place." Contrast this with the state of things now. On the Metropolitan Line, 667 trains pass a given point in one direction or the other during the eighteen hours of the working day, or an average of 36 trains an hour. At the Cannon Street Station of the South-Eastern Railway, 527 trains pass in and out daily, many of them crossing each others' tracks under the protection of the station signals. Forty-five trains run in and out between 9 and 10 A.M., and an equal number between 4 and 5 P.M. Again, at the Clapham Junction, near London, about 700 trains pass or stop daily; and though to the casual observer the succession of trains coming and going, running and stopping, coupling and shunting, appears a scene of inextricable confusion and danger, the whole is clearly intelligible to the signal-men in their boxes, who work the trains in and out with extraordinary precision and regularity.

The inside of a signal-box reminds one of a pianoforte on a large scale, the lever-handles corresponding with the keys of the instrument; and, to an uninstructed person, to work the one would be as difficult as to play a tune on the other. The signal-box outside Cannon Street Station contains 67 lever-handles, by means of which the signal-men are enabled at the same moment to communicate with the drivers of all the engines on the line within an area of 800 yards. They direct by signs, which are quite as intelligible as words, the drivers of the trains starting from inside the station, as well as those of the trains arriving from outside. By pulling a lever-handle, a distant signal, perhaps out of sight, is set some hundred yards off, which the ap-

proaching driver—reading it quickly as he comes along—at once interprets, and stops or advances as the signal may direct.

The precision and accuracy of the signal-machinery employed at important stations and junctions have of late years been much improved by an ingenious contrivance, by means of which the setting of the signal prepares the road for the coming train. When the signal is set at “Danger,” the points are at the same time worked, and the road is “locked” against it; and when at “Safety,” the road is open,—the signal and the points exactly corresponding.

The Electric Telegraph has also been found a valuable auxiliary in ensuring the safe working of large railway traffics. Though the locomotive may run at 60 miles an hour, electricity, when at its fastest, travels at the rate of 288,000 miles a second, and is therefore always able to herald the coming train. The electric telegraph may, indeed, be regarded as the nervous system of the railway. By its means the whole line is kept throbbing with intelligence. The method of working electric signals varies on different lines; but the usual practice is, to divide a line into so many lengths, each protected by its signal-stations,—the fundamental law of telegraph working being, that two engines are not to be allowed to run on the same line between two signal-stations at the same time. When a train passes one of such stations, it is immediately signalled on—usually by electric signal-bells—to the station in advance, and that interval of railway is “blocked” until the signal has been received from the station in advance that the train has passed it. Thus *an interval*

of space is always secured between trains following each other, which are thereby alike protected before and behind. And thus, when a train starts on a journey of it may be hundreds of miles, it is signalled on from station to station and “lives along the line,” until at length it reaches its destination and the last signal of “train in” is given. By this means an immense number of trains can be worked with regularity and safety. On the South-Eastern Railway, where the system has been brought to a state of high efficiency, it is no unusual thing during Easter week to send 570,000 passengers through the London Bridge Station alone; and on some days as many as 1200 trains a-day.

While such are the expedients adopted to ensure safety, others equally ingenious are adopted to ensure speed. In the case of express and mail trains, the frequent stopping of the engines to take in a fresh supply of water occasions a considerable loss of time on a long journey, each stoppage for this purpose occupying from ten to fifteen minutes. To avoid such stoppages larger tenders have been provided, capable of carrying as much as 2000 gallons of water each. But as a considerable time is occupied in filling these, a plan has been contrived by Mr. Ramsbottom, the Locomotive Engineer of the London and North-Western Railway, by which the engines are made to *feed themselves* while running at full speed! The plan is as follows:—An open trough, about 440 feet long, is laid longitudinally between the rails. Into this trough, which is filled with water, a dip-pipe or scoop attached to the bottom of the tender of the running train is

lowered; and, at a speed of 50 miles an hour, as much as 1070 gallons of water are scooped up in the course of a few minutes. The first of such troughs was laid down between Chester and Holyhead, to enable the Express Mail to run the distance of 84½ miles in two hours and five minutes without stopping; and similar troughs have since been laid down at Bushey near London, at Castlethorpe near Wolverton, and at Parkside near Liverpool. At these four troughs about 130,000 gallons of water are scooped up daily.

Wherever railways have been made, new towns have sprung up, and old towns and cities been quickened into new life. When the first English lines were projected, great were the prophecies of disaster to the inhabitants of the districts through which they were proposed to be forced. Such fears have long since been dispelled in this country. The same prejudices existed in France. When the railway from Paris to Marseilles was projected to pass through Lyons, a local prophet predicted that if the line were made the city would be ruined—" *Ville traversée, ville perdue*;" while a local priest denounced the locomotive and the electric telegraph as heralding the reign of Antichrist. But such nonsense is no longer uttered. Now it is the city without the railway that is regarded as the "city lost:" for it is in a measure shut out from the rest of the world, and left outside the pale of civilisation.

Perhaps the most striking of all the illustrations that could be offered of the extent to which railways facilitate the locomotion, the industry, and the subsistence of the population of large towns and cities, is afforded

by the working of the railway system in connection with the capital of Great Britain.

The extension of railways to London has been of comparatively recent date; the whole of the lines connecting it with the provinces and terminating at its outskirts, having been opened during the last thirty years, while the lines inside London have for the most part been opened within the last ten years.

The first London line was the Greenwich Railway, part of which was opened for traffic to Deptford in February, 1836. The working of this railway was first exhibited as a show, and the usual attractions were employed to make it "draw." A band of musicians in the garb of the Beef-eaters was stationed at the London end, and another band at Deptford. For cheapness' sake the Deptford band was shortly superseded by a large barrel-organ, which played in the passengers; but when the traffic became established, the barrel-organ, as well as the Beef-eater band at the London end, were both discontinued. The whole length of the line was lit up at night by a row of lamps on either side like a street, as if to enable the locomotives or the passengers to see their way in the dark; but these lamps also were eventually discontinued as unnecessary.

As a show, the Greenwich Railway proved tolerably successful. During the first eleven months it carried 456,750 passengers, or an average of about 1300 a day. But the railway having been found more convenient to the public than either the river boats or the omnibuses, the number of passengers rapidly increased. When the Croydon, Brighton, and South-Eastern Railways began to pour their streams of traffic over the

Greenwich Viaduct, its accommodation was found much too limited; and it was widened from time to time, until now nine lines of railway are laid side by side, over which more than twenty millions of passengers are carried yearly, or an average of about 60,000 a day all the year round.

Since the partial opening of the Greenwich Railway in 1836, a large extent of railways has been constructed in and about the metropolis, and convenient stations have been established almost in the heart of the city. Sixteen of these stations are within a circle of half a mile radius from the Mansion House, and above three hundred stations are in actual use or in course of construction within about five miles of Charing Cross. The most important lines recently opened for the accommodation of the London local traffic have been the London, Chatham and Dover Metropolitan Extensions (1861), the Metropolitan (1863), the North London Extension to Liverpool Street (1865), the Charing Cross and Cannon Street Extensions of the South-Eastern Railway (1864-6), and the South London Extension of the Brighton Railway (1866). Of these railways, the London, Chatham and Dover carried 5,228,418 passengers in 1867; the Metropolitan, 23,405,282; the North London, 17,535,502; the South-Eastern, 17,473,934; and the Brighton, 12,686,417. The total number carried into and out of London, as well as from station to station in London, in the same year, was 104 millions of passengers.

To accommodate this vast traffic, not fewer than 3600 local trains are run in and out daily, besides 340 trains which depart to and arrive from distant

places, north, south, east, and west. In the morning hours, between 8·30 and 10·30, when business men are proceeding inwards to their offices and counting-houses, and in the afternoon between four and six, when they are returning outwards to their homes, as many as two thousand stoppages are made in the hour, within the metropolitan district, for the purpose of taking up and setting down passengers, while about two miles of railway are covered by the running trains.

One of the remarkable effects of railways has been to extend the residential area of all large towns and cities. This is especially notable in the case of London. Before the introduction of railways, the residential area of the metropolis was limited by the time occupied by business men in making the journey outwards and inwards daily; and it was for the most part bounded by Bow on the east, by Hampstead and Highgate on the north, by Paddington and Kensington on the west, and by Clapham and Brixton on the south. But now that stations have been established near the centre of the city, and places so distant as Waltham, Barnet, Watford, Hanwell, Richmond, Epsom, Croydon, Reigate, and Erith, can be more quickly reached by rail than the old suburban quarters were by omnibus, the metropolis has become extended in all directions along its railway lines, and the population of London, instead of living in the city or its immediate vicinity as formerly, have come to occupy a residential area of not less than six hundred square miles!

The number of new towns which have consequently sprung into existence near London within the last twenty years has been very great; towns numbering

from ten to twenty thousand inhabitants, which before were but villages, if, indeed, they existed. This has especially been the case along the lines south of the Thames, principally in consequence of the termini of those lines being more conveniently situated for city men of business. Hence the rapid growth of the suburban towns up and down the river, from Richmond and Staines on the west, to Erith and Gravesend on the east, and the hives of population which have settled on the high grounds south of the Thames, in the neighbourhood of Norwood and the Crystal Palace, rapidly spreading over the Surrey Downs, from Wimbledon to Guildford, and from Bromley to Croydon, Epsom, and Dorking. And now that the towns on the south and south-east coast can be reached by city men in little more time than it takes to travel to Clapham or Bayswater by omnibus, such places have become as it were parts of the great metropolis, and Brighton and Hastings are but marine suburbs of London.

The improved state of the communications of the City with the country has had a marked effect upon its population. While the action of the railways has been to add largely to the number of persons living in London, it has also been accompanied by their dispersion over a much larger area. Thus the population of the central parts of London is constantly decreasing, whereas that of the suburban districts is as constantly increasing. The population of the City fell off more than 10,000 between 1851 and 1861; and during the same period, that of Holborn, the Strand, St. Martin's-in-the-Fields, St. James's, Westminster, East and West London, showed a considerable decrease. But, as regards the

whole mass of the metropolitan population, the increase has been enormous, especially since the introduction of railways. Thus, starting from 1801, when the population of London was 958,863, we find it increasing in each decennial period at the rate of between two and three hundred thousand, until the year 1841, when it amounted to 1,948,369. Railways had by that time reached London, after which its population increased at nearly double the former ratio. In the ten years ending 1851, the increase was 413,867; and in the ten years ending 1861, 441,753: until now, to quote the words of the Registrar-General in his last annual Report, "the population within the registration limits is by estimate 2,993,513; but beyond this central mass there is a ring of life growing rapidly, and extending along railway lines over a circle of fifteen miles from Charing Cross. The population within that circle, patrolled by the metropolitan police, is about 3,463,771"!

The aggregation of so vast a number of persons within so comparatively limited an area—the immense quantity of food required for their daily sustenance, as well as of fuel, clothing, and other necessities—would be attended with no small inconvenience and danger, but for the facilities again provided by the railways. The provisioning of a garrison of even four thousand men is considered a formidable affair; how much more so the provisioning of nearly four millions of people!

The whole mystery is explained by the admirable organisation of the railway service, and the regularity and despatch with which it is conducted. We are enabled by the courtesy of the General Managers of the London railways to bring together the following brief

summary of facts relating to the food supply of London, which will probably be regarded by most readers as of a very remarkable character.

Generally speaking, the railways to the south of the Thames contribute comparatively little towards the feeding of London. They are for the most part passenger and residential lines, traversing a limited and not very fertile district bounded by the sea-coast; and, excepting in fruit and vegetables, milk and hops, they probably carry more food from London than they bring to it. The principal supplies of grain, flour, potatoes, and fish, are brought by railway from the eastern counties of England and Scotland; and of cattle and sheep, beef and mutton, from the grazing counties of the west and north-west of Britain, as far as from the Highlands of Scotland, which, through the instrumentality of railways, have become part of the great grazing-grounds of the metropolis.

Take first "the staff of life"—bread and its constituents. Of wheat, not less than 222,080 quarters were brought into London by railway in 1867, besides what was brought by sea; of oats 151,757 quarters; of barley 70,282 quarters; of beans and peas 51,448 quarters. Of the wheat and barley, by far the largest proportion was brought by the Great Eastern Railway, which delivered in London last year 155,000 quarters of wheat and 45,500 quarters of barley, besides 600,429 quarters more in the form of malt. The largest quantity of oats was brought by the Great Northern Railway, principally from the north of England and the east of Scotland,—the quantity delivered by that Company in 1867 having been 97,500 quarters, besides 24,664 quar-

ters of wheat, 5560 quarters of barley, and 103,917 quarters of malt. Again, of 1,250,566 sacks of flour and meal delivered in London last year, the Great Eastern brought 654,000 sacks, the Great Northern 232,022 sacks, and the Great Western 136,312 sacks; the principal contribution of the London and North-Western Railway towards the London breadstores being 100,760 boxes of American flour, besides 24,300 sacks of English. The total quantity of malt delivered at the London railway stations in 1867 was thirteen hundred thousand sacks.

Next, as to flesh meat. Last year not fewer than 172,300 head of cattle were brought into London by railway,—though this was considerably less than the number carried before the cattle plague, the Great Eastern Railway alone having carried 44,672 less than in 1864. But this loss has since been more than made up by the increased quantities of fresh beef, mutton, and other kinds of meat imported in lieu of the live animals. The principal supplies of cattle are brought, as we have said, by the Western, Northern, and Eastern lines: by the Great Western from the western counties and Ireland; by the London and North-Western, the Midland, and the Great Northern, from the northern counties and from Scotland; and by the Great Eastern from the eastern counties and from the ports of Harwich and Lowestoft.

Last year also, 1,147,609 sheep were brought to London by railway, of which the Great Eastern delivered not less than 265,371 head. The London and North-Western and Great Northern between them brought 390,000 head from the northern English

counties, with a large proportion from the Scotch Highlands; while the Great Western brought up 130,000 head from the Welsh mountains and from the rich grazing districts of Wilts, Gloucester, Somerset, and Devon. Another important freight of the London and North-Western Railway consists of pigs, of which they delivered 54,700 in London last year, principally Irish; while the Great Eastern brought up 27,500 of the same animal, partly foreign.

While the cattle plague has had the effect of greatly reducing the number of live stock brought into London yearly, it has given a considerable impetus to the Fresh Meat traffic. Thus, in addition to the above large numbers of cattle and sheep delivered in London last year, the railways brought 76,175 tons of meat, which—taking the meat of an average beast at 800 lbs., and of an average sheep at 64 lbs.—would be equivalent to about 112,000 more cattle, and 1,267,500 more sheep. The Great Northern brought the largest quantity; next the London and North-Western;—these two Companies having brought up between them, from distances as remote as Aberdeen and Inverness, about 42,000 tons of fresh meat in 1867, at an average freight of about $\frac{1}{2}d.$ a lb.

Again as regards Fish, of which six-tenths of the whole quantity consumed in London is now brought by rail. The Great Eastern and the Great Northern are by far the largest importers of this article, and justify their claim to be regarded as the great food lines of London. Of the 61,358 tons of fish brought by railway in 1867, not less than 24,500 tons were delivered by the former, and 22,000 tons, brought from

much longer distances, by the latter Company. The London and North-Western brought about 6000 tons last year, the principal part of which was salmon from Scotland and Ireland. The Great Western also brought about 4000 tons, partly salmon, but the greater part mackerel from the south-west coast. During the mackerel season, as much as a hundred tons at a time are brought into the Paddington Station by express fish-train from Cornwall.

The Great Eastern and Great Northern Companies are also the principal carriers of turkeys, geese, fowls, and game; the quantity delivered in London last year by the former Company having been 5042 tons. In Christmas week no fewer than 30,000 turkeys and geese were delivered at the Bishopsgate Station, besides about 300 tons of poultry, 10,000 barrels of beer, and immense quantities of fish, oysters, and other kinds of food. As much as 1600 tons of poultry and game were brought last year by the South-Western Railway; 600 tons by the Great Northern Railway; and 130 tons of turkeys, geese, and fowls, by the London, Chatham and Dover line, principally from France.

Of miscellaneous articles, the Great Northern and the Midland each brought about 3000 tons of cheese, the South-Western 2600 tons, and the London and North-Western 10,034 cheeses in number; while the South-Western and Brighton lines brought a splendid contribution to the London breakfast-table in the shape of 11,259 *tons* of French eggs; these two Companies delivering between them an average of more than three millions of eggs a week all the year round! The same Companies last year delivered in London 14,819

tons of butter, for the most part the produce of the farms of Normandy,—the greater cleanness and neatness with which the Normandy butter is prepared for market rendering it a favourite both with dealers and consumers of late years compared with Irish butter. The London, Chatham and Dover Company also brought from Calais 96 tons of eggs.

Next, as to the potatoes, vegetables, and fruit, brought by rail. Forty years since, the inhabitants of London relied for their supply of vegetables on the garden-grounds in the immediate neighbourhood of the metropolis, and the consequence was that they were both very dear and limited in quantity. But railways, while they have extended the grazing-grounds of London as far as the Highlands, have at the same time extended the garden-grounds of London into all the adjoining counties—into East Kent, Essex, Suffolk, and Norfolk, the vale of Gloucester, and even as far as Penzance in Cornwall. The London, Chatham and Dover, one of the youngest of our main lines, brought up from East Kent last year 5279 tons of potatoes, 1046 tons of vegetables, and 5386 tons of fruit, besides 542 tons of vegetables from France. The South-Eastern brought 25,163 tons of the same produce. The Great Eastern brought from the eastern counties 21,315 tons of potatoes, and 3596 tons of vegetables and fruit; while the Great Northern brought no less than 78,505 tons of potatoes—a large part of them from the east of Scotland—and 3768 tons of vegetables and fruit. About 6000 tons of early potatoes were last year brought from Cornwall, with about 5000 tons of brocoli, and the quantities are steadily increasing. “Truly London hath

a large belly," said old Fuller, two hundred years since. But how much more capacious is it now !

One of the most striking illustrations of the utility of railways in contributing to the supply of wholesome articles of food to the population of large cities, is to be found in the rapid growth of the traffic in Milk. Readers of newspapers may remember the descriptions published some years since of the horrid dens in which London cows were penned, and of the odious compound sold by the name of milk, of which the least deleterious ingredient in it was supplied by the "cow with the iron tail." That state of affairs is now completely changed. What with the greatly improved state of the London dairies and the better quality of the milk supplied by them, together with the large quantities brought by railway from a range of a hundred miles and more all round London, even the poorest classes in the metropolis are now enabled to obtain as wholesome a supply of the article as the inhabitants of most country towns.

The milk traffic has in some cases been rapid, almost sudden, in its growth. Though the Great Western is at present the greatest of the milk lines, it brought very little into London prior to the year 1865. In the month of August in that year it brought 23,474 gallons, and in the month of October following the quantity had increased to 103,214 gallons. Last year the total quantity delivered in London by this single railway was 1,514,836 gallons, or an average of 30,000 gallons a week. The largest proportion of this milk was brought from beyond Swindon in Wiltshire, about 100 miles from London ; but considerable quantities were also

brought from the vale of Gloucester and from Somerset. The London and South-Western also is a great milk-carrying line, having brought as much as 1,480,272 gallons to London last year, or an average of 28,000 gallons a week. The Great Eastern brought nearly the same quantity, 1,322,429 gallons, or an average of about 25,400 gallons a week. The London and North-Western ranks next, having brought 643,432 gallons in 1867; then the Great Northern, 455,916 gallons; the South-Eastern, 435,668 gallons; and the Brighton, 419,254 gallons. The total quantity of milk delivered in London by railway last year was 6,309,446 gallons, or above 120,000 gallons a week. Yet this traffic, large though it may appear, is as yet but in its infancy, and in the course of a few more years it will be found very largely increased, according as facilities are provided for its accommodation and transit.

These great streams of food, which we have thus so summarily described, flow into London so continuously and uninterruptedly, that comparatively few persons are aware of the magnitude and importance of the process thus daily going forward. Though gathered from an immense extent of country—embracing England, Scotland, Wales, and Ireland—the influx is so unintermitted that it is relied upon with as much certainty as if it only came from the counties immediately adjoining London. The express meat-train from Aberdeen arrives in town as punctually as the Clapham omnibus, and the express milk-train from Aylesbury is as regular in its delivery as the penny post. Indeed London now depends so much upon railways for its subsistence, that it may be said to be fed by them from day to

day, having never more than a few days' food in stock. And the supply is so regular and continuous, that the possibility of its being interrupted never for a moment occurs to any one. Yet in these days of strikes amongst workmen, such a contingency is quite within the limits of possibility. Another contingency, arising in a state of war, is probably still more remote. But were it possible for a war to occur between England and a combination of foreign powers possessed of stronger ironclads than ours, and that they were able to ram our ships back into port and land an enemy of overpowering force on the Essex coast, it would be sufficient for them to occupy or cut the railways leading from the north, to starve London into submission in less than a fortnight.

Besides supplying London with food, railways have also been instrumental in ensuring the more regular and economical supply of fuel,—a matter of almost as vital importance to the population in a climate such as that of England. So long as the market was supplied with coal brought by sea in sailing ships, fuel in winter often rose to a famine price, especially during long-continued easterly winds. But now that railways are in full work, the price is almost as steady in winter as in summer, and the supply is more regular at all seasons. The following statement of the coals brought into London by sea and by railway, at decennial periods since 1827, as supplied by Mr. J. R. Scott, Registrar of the Coal Exchange, shows the effect of railways in increasing the supply of fuel at the same time that they have lowered the price to the consumer :—

Years.	Seaborne Coal.	Coals brought by Railway.	Price per Ton.
	Tons.	Tons.	s. d.
1827	1,882,321	nil	28 6
1847	3,280,420	19,336	20 10
1857	3,133,459	1,206,775	18 8
1867	3,016,416	3,295,652	20 8

Thus the price of coal has been reduced 7s. 10d. a ton since 1827, while the quantity delivered has been enormously increased, the total saving on the quantity consumed in the metropolis in 1867, compared with 1827, being equal to 2,388,000*l*.

But the carriage of food and fuel to London forms but a small part of the merchandise traffic carried by railway. Above 600,000 tons of goods of various kinds yearly pass through one station only, that of the London and North-Western Company, at Camden Town; and sometimes as many as 20,000 parcels daily. Every other metropolitan station is similarly alive with traffic inwards and outwards, London having since the introduction of railways become more than ever a great distributive centre, to which merchandise of all kinds converges, and from which it is distributed to all parts of the country. Mr. Bazley, M.P., stated at a late public meeting at Manchester, that it would probably require ten millions of horses to convey by road the merchandise traffic which is now annually carried by railway.

Railways have also proved of great value in connection with the Cheap Postage system. By their means it has become possible to carry letters, newspapers, books and post parcels, in any quantity, expeditiously

and cheaply. The Liverpool and Manchester line was no sooner opened in 1830, than the Post Office authorities recognised its utility, and used it for carrying the mails between the two towns. When the London and Birmingham line was opened eight years later, mail trains were at once put on,—the directors undertaking to perform the distance of 113 miles within 5 hours by day and 5½ hours by night. As additional lines were opened, the old four-horse mail coaches were gradually discontinued, until, in 1858, the last of them, the “Derby Dilly,” which ran between Manchester and Derby, was taken off on the opening of the Midland line to Rowsley.

The increased accommodation provided by railways was found of essential importance, more particularly after the adoption of the Cheap Postage system ; and that such accommodation was needed will be obvious from the extraordinary increase which has taken place in the number of letters and packets sent by post. Thus, in 1839, the number of chargeable letters carried was only 76 millions, and of newspapers 44½ millions ; whereas, in 1865, the number of letters had increased to 720 millions, and in 1867 to 775 millions, or more than ten-fold, while the number of newspapers, books, samples and patterns (a new branch of postal business begun in 1864) had increased, in 1865, to 98½ millions.

To accommodate this largely-increasing traffic, the bulk of which is carried by railway, the mileage run by mail trains in the United Kingdom has increased from 25,000 miles a day in 1854 (the first year of which we have any return of the mileage run) to 60,000 miles a day in 1867, or an increase of 240 per

cent. The Post Office expenditure on railway service has also increased, but not in like proportion, having been 364,000*l.* in the former year, and 559,575*l.* in the latter, or an increase of 154 per cent. The revenue, gross and net, has increased still more rapidly. In 1841, the first complete year of the Cheap Postage system, the gross revenue was 1,359,466*l.* and the net revenue 500,789*l.*; in 1854, the gross revenue was 2,574,407*l.*, and the net revenue 1,173,723*l.*; and in 1867, the gross revenue was 4,548,129*l.*, and the net revenue 2,127,125*l.*, being an increase of 420 per cent. compared with 1841, and of 180 per cent. compared with 1854. How much of this net increase might fairly be credited to the Railway Postal service we shall not pretend to say; but assuredly the proportion must be very considerable.

One of the great advantages of railways in connexion with the postal service is the greatly increased frequency of communication which they provide between all the large towns. Thus Liverpool has now six deliveries of Manchester letters daily; while every large town in the kingdom has two or more deliveries of London letters daily. In 1863, 393 towns had two mails daily from London; 50 had three mails daily; 7 had four mails a day *from* London, and 15 had four mails a day *to* London; while 3 towns had five mails a day *from* London, and 6 had five mails a day *to* London.

Another feature of the railway mail train, as of the passenger train, is its capacity to carry any quantity of letters and post parcels that may require to be carried. In 1838, the aggregate weight of all the evening mails despatched from London by twenty-eight mail coaches

was 4 tons 6 cwt., or an average of about $3\frac{1}{2}$ cwt. each, though the maximum contract weight was 15 cwt. The mails now are necessarily much heavier, the number of letters and packets having, as we have seen, increased more than ten-fold since 1839. But it is not the ordinary so much as the extraordinary mails that are of considerable weight,—more particularly the American, the Continental, and the Australian mails. It is no unusual thing, we are informed, for the last-mentioned mail to weigh as much as 40 tons. How many of the old mail coaches it would take to carry such a mail the 79 miles' journey to Southampton, with a relay of four horses every five or seven miles, is a problem for the arithmetician to solve. But even supposing each coach to be loaded to the maximum weight of 15 cwt. per coach, it would require about sixty vehicles and about 1700 horses to carry the 40 tons, besides the coachmen and guards.

A few words, in conclusion, as to the number of men employed in working and maintaining railways. According to Mr. Mills,* 166,047 men and officers were employed in the working of 13,289 miles open in the United Kingdom in 1865, besides 53,923 employed on lines then under construction. The most numerous body of workmen is that of the labourers (81,284) employed in the maintenance of the permanent way. Being mostly picked men from the labouring class of the adjoining districts, they are paid considerably higher wages; and hence one of the direct effects

* 'The Railway Service, its Exigencies, Provisions, and Requirements. By W. F. Mills. London, 1867.

of railways on the labouring population (besides affording them greater facilities for locomotion) has been to raise the standard of wages of ordinary labour at least 2s. a week in all the districts into which they have penetrated. The workmen next in number is that of the artificers (40,167), employed in constructing and repairing the rolling-stock; the porters (25,381), the plate-layers (12,901), guards and brakemen (5799), firemen (5266), and engine-drivers (5171). But besides the employes directly engaged in the working and maintenance of railways, large numbers of workmen are also occupied in the manufacture of locomotives and rolling-stock, and in providing the requisite materials for the permanent way. Thus, the consumption of rails alone averages nearly 400,000 tons a year in the United Kingdom alone; while the replacing of decayed sleepers requires about 10,000 acres of forest to be cut down annually and sawn into sleepers. Taking the various railway workmen into account, with their families, it will be found that they represent a total of about three-quarters of a million persons, or about one in fifty of our population, who are dependent on railways for their subsistence.

While the practical working of railways has, on the whole, been so satisfactory, the case has been very different as regards their direction and financial management. The men employed in the working of railways make it their business to learn it, and, being responsible, they are under the necessity of taking pains to do it well; whereas the men who govern and direct them are practically irresponsible, and may possess no

qualification whatever for the office excepting only the holding of so much stock. The consequence has been, much blundering on the part of these amateurs, and great loss on the part of the public. Indeed, what between the confused, contradictory, and often unjust legislation of Parliament on the one hand, and the carelessness or incompetency of directors on the other, many once flourishing concerns have been thrown into a state of utter confusion and muddle, until railway government has become a byword of reproach.

And this state of things will probably continue until the fatal defect of government by Boards—an extremely limited responsibility, or no responsibility at all—has been rectified by the appointment, as in France, of executives consisting of a few men of special ability and trained administrative skill, personally responsible to their constituents for the due performance of their respective functions. But the discussion of this subject would require a treatise, whereas we are now but writing a preface.

Whatever may be said of the financial mismanagement of railways, there can be no doubt as to the great benefits conferred by them on the public wherever made. Even those railways which have exhibited the most “frightful examples” of scheming and financing, so soon as placed in the hands of practical men to work, have been found to prove of unquestionable public convenience and utility. And notwithstanding all the faults and imperfections that are alleged against railways have been admitted, we think that they must, nevertheless, be recognised as by far the most valuable means of

communication between men and nations that has yet been given to the world.

The author's object in publishing this book in its original form, some ten years since, was to describe, in connection with the 'Life of George Stephenson,' the origin and progress of the railway system, and to show by what moral and material agencies its founders were enabled to carry their ideas into effect, and to work out results which even then were of a remarkable character, though they have since, as above described, become so much more extraordinary. The favour with which successive editions of the book have been received, has justified the author in his anticipation that such a narrative would prove of general, if not of permanent interest; and he has taken pains, in preparing for the press the present, and probably final edition, to render it, by careful amendment and revision, more worthy of the public acceptance.

London, May, 1868.

P R E F A C E

TO THE EIGHTH EDITION, 1864.

THE following is a revised and improved Edition of 'The Life of George Stephenson,' with which is incorporated a Memoir of his son Robert, late President of the Institute of Civil Engineers. Since its original appearance, in 1857, much additional information has been communicated to the author relative to the early history of Railways and the men principally concerned in establishing them, of which he has availed himself in the present edition.

In preparing the original work for publication, the author enjoyed the advantage of the cordial co-operation and assistance of Robert Stephenson, on whom he mainly relied for information as to the various stages through which the Locomotive passed, and especially as to his father's share in its improvement. Through Mr. Stephenson's instrumentality also, the author was enabled to obtain much valuable information from gentlemen who had been intimately connected with his father and himself in their early undertakings—amongst others, from Mr. Edward Pease, of Darlington; Mr. Dixon, C.E.; Mr. Sopwith, F.R.S.; Mr. Charles Parker; and Sir Joshua Walmsley.

Most of the facts relating to the early period of George Stephenson's career were collected from colliers,

brakesmen, enginemen, and others, who had known him intimately, or been fellow workmen with him, and were proud to communicate what they remembered of his early life. The information obtained from these old men—most of them illiterate, and some broken down by hard work—though valuable in many respects, was confused, and sometimes contradictory; but, to ensure as much accuracy and consistency of narrative as possible, the author submitted the MS. to Mr. Stephenson, and had the benefit of his revision of it previous to publication.

Mr. Stephenson took a lively interest in the improvement of the 'Life' of his father, and continued to furnish corrections and additions for insertion in the successive editions of the book which were called for by the public. After the first two editions had appeared, he induced several gentlemen, well qualified to supply additional authentic information, to communicate their recollections of his father; amongst whom may be mentioned Mr. T. L. Gooch, C.E.; Mr. Vaughan, of Snibston; Mr. F. Swanwick, C.E.; and Mr. Binns, of Claycross, who had officiated as private secretaries to George Stephenson at different periods of his life, and afterwards held responsible offices either under him or in conjunction with him.

The author states these facts to show that the information contained in this book is of an authentic character, and has been obtained from the most trustworthy sources. Whether he has used it to the best purpose or not, he leaves others to judge. This much, however, he may himself say—that he has endeavoured, to the best of his ability, to set forth the facts commu-

nicated to him in a simple, faithful, and straightforward manner ; and, even if he has not wholly succeeded in doing this, he has at all events been the means of collecting information on a subject originally unattractive to professional literary men, and thereby rendered its further prosecution comparatively easy to those who may feel called upon to undertake it.

The author does not pretend to have steered clear of errors in treating a subject so extensive and, before he undertook the labour, comparatively uninvestigated ; but, wherever errors have been pointed out, he has taken the earliest opportunity of correcting them. With respect to objections taken to the book because of the undue share of merit alleged to be therein attributed to the Stephensons in respect of the Railway and the Locomotive, there will necessarily be various opinions. There is scarcely an invention or improvement in mechanics but has been the subject of dispute, and it was to be expected that those who had counter claims would put them forward in the present case ; nor has the author any reason to complain of the manner in which this has been done.

While George Stephenson is the principal subject in the following book, his son Robert also forms an essential part of it. Father and son were so intimately associated in the early period of their career, that it is difficult, if not impossible, to describe the one apart from the other. The life and achievements of the son were in a great measure the complement of the life and achievements of the father. The care, also, with which the elder Stephenson, while occupying the position of an obscure engine-wright, devoted himself to his son's

education, and the gratitude with which the latter repaid the affectionate self-denial of his father, furnish some of the most interesting illustrations of the personal character of both.

These views were early adopted by the author and carried out by him in the preparation of the original work, with the concurrence of Robert Stephenson, who supplied the necessary particulars relating to himself. Such portions of these were accordingly embodied in the narrative as could with propriety be published during his life-time, and the remaining portions are now added with the object of rendering more complete the record of the son's life, as well as the early history of the Railway system.

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LIVES OF THE ENGINEERS.

E A R L Y
INVENTORS IN LOCOMOTION.

VOL. III.

B



RICHARD TREVITHICK, C.E.

EARLY INVENTORS IN LOCOMOTION.

CHAPTER I.

SCHEMERS AND PROJECTORS.

It is easy to understand how rapid transit from place to place should, from the earliest times, have been an object of desire. The marvellous gift of speed conferred by Fortunatus's Wishing Cap was what all must have envied : it conferred power. It also conferred pleasure. "Life has not many things better than this," said Samuel Johnson as he rolled along in the post-chaise. But it also conferred comfort and well-being ; and hence the easy and rapid transit of persons and commodities became in all countries an object of desire in proportion to their growth in civilisation.

We have elsewhere¹ endeavoured to describe the obstructions to the progress of society occasioned by the defective internal communications of Britain in early times, which were to a considerable extent removed by the adoption of the canal system, and the improvement of our roads and highways, towards the end of last century. But the progress of industry was so rapid,—the invention of new tools, machines, and engines, so greatly increased the productive wealth of the nation,—that some forty years since it was found that these roads and canals, numerous and excellent though they might be, were altogether inadequate for the accommodation of the traffic of the country, which

¹ 'Lives of the Engineers,' vols. i. and ii.

was increasing in almost a direct ratio with the increased application of steam-power to the purposes of productive industry.

The inventive minds of the nation, always on the alert,—the “schemers” and the “projectors,” to whom society has in all times been so greatly indebted,—proceeded to apply themselves to the solution of the problem of how the communications of the country were best to be improved; and the result was, that the power of steam itself was applied to remedy the inconveniences which it had caused.

Like most inventions, that of the Steam Locomotive was very gradually made. The idea of it, born in one age, was revived in the ages that followed. It was embodied, first in one model, then in another; the labours of one inventor being taken up by his successors; until at length, after many disappointments and many failures, the practicable working Locomotive was achieved.

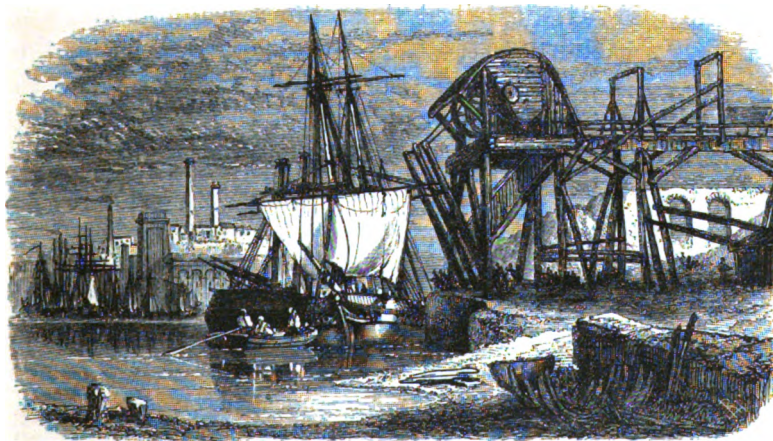
The locomotive engine was not, however, sufficient for the purposes of cheap and rapid transit. Another expedient was absolutely essential to its success—that of the Railway: the smooth rail to bear the load, as well as the steam-engine to draw it.

Expedients were early adopted for the purpose of diminishing friction between the wheels of vehicles and the roads along which they were dragged by horse-power. The Romans employed stone blocks with that object; and the streets of the long-buried city of Pompeii still bear the marks of the ancient Roman chariot-wheels, as the stone track for heavy vehicles on our modern London Bridge shows the wheel-marks of the waggons which cross it. These stone blocks were merely a simple expedient to diminish friction, and were the first step towards a railroad.

The railway proper doubtless originated in the coal districts of the North of England and of Wales, where

it was found useful in facilitating the transport of coals from the pits to the shipping-places. At an early period the coal was carried to the boats in panniers, or in sacks upon horses' backs. Next, carts were used, and tramways of flag-stone were laid down, along which they were easily hauled. The carts were then converted into waggons, and mounted on four wheels instead of two.

Still further to facilitate the haulage of the waggons, pieces of planking were laid parallel upon wooden sleepers, or imbedded in the ordinary track. It is said that these wooden rails were first employed by a Mr. Beaumont, a gentleman from the South, who, about the year 1630, adventured in the northern mines with about thirty thousand pounds, and after introducing many improvements in the working of the coal, as well as in the methods of transporting it to the staithes on the river, was ruined by his enterprise, and "within a few Years," to use the words of the ancient chronicler, "he consumed all his Money, and rode Home upon his light Horse."¹



COALSTAITH ON THE TYNE. [By R. P. Letch.]

¹ Harleian MSS., vol. iii. 269.

The use of wooden rails gradually extended, and they were laid down between most of the collieries on the Tyne and the places at which the coal was shipped. Roger North, in 1676, found the practice had become extensively adopted, and he speaks of the large sums then paid for way-leave—that is, the permission granted by the owners of lands lying between the coal-pits and the river-side to lay down a tramway for the purpose of connecting the one with the other.

A century later, Arthur Young observed that not only had these roads become greatly multiplied, but formidable works had been constructed to carry them along upon the same level. “The coal waggon-roads from the pits to the water,” he says, “are great works, carried over all sorts of inequalities of ground, so far as the distance of nine or ten miles. The tracks of the wheels are marked with pieces of wood let into the road for the wheels of the waggons to run on, by which one horse is enabled to draw, and that with ease, fifty or sixty bushels of coals.”¹

Saint-Fond, the French traveller, who visited Newcastle in 1791, described the colliery waggon-ways in that neighbourhood as superior to anything of the kind he had seen. The wooden rails were formed with a rounded upper surface, like a projecting moulding, and the waggon-wheels being “made of cast iron, and hollowed in the manner of a metal pulley,” readily fitted the rounded surface of the rails. The economy with which the coal was thus hauled to the shipping-places was urged by Saint-Fond as an inducement to his own countrymen to adopt a like method of transit.²

Similar waggon-roads were early laid down in the coal districts of Wales, Cumberland, and Scotland. At the time of the Scotch rebellion, in 1745, a tramroad

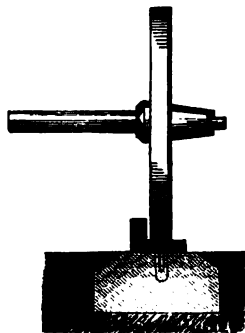
¹ ‘Six Months’ Tour,’ vol. iii. 9.

² ‘Travels in England, Scotland, and the Hebrides,’ vol. i. 142.

existed between the Tranent coal-pits and the small harbour of Cockenzie in East Lothian; and a portion of the line was selected by General Cope as a position for his cannon at the battle of Prestonpans.

In these rude wooden tracks we find the germ of the modern railroad. Improvements were gradually made in them. Thus, at some collieries, thin plates of iron were nailed upon their upper surface, for the purpose of protecting the parts most exposed to friction. Cast-iron rails were also tried, the wooden rails having been found liable to rot. The first iron rails are supposed to have been laid down at Whitehaven as early as 1738. This cast-iron road was denominated a "plate-way," from the plate-like form in which the rails were cast. In 1767, as appears from the books of the Coalbrookdale Iron Works, in Shropshire, five or six tons of rails were cast, as an experiment, on the suggestion of Mr. Reynolds, one of the partners; and they were shortly after laid down to form a road.

In 1776, a cast-iron tramway, nailed to wooden sleepers, was laid down at the Duke of Norfolk's colliery near Sheffield. The person who designed and constructed this coal line was Mr. John Curr, whose son has erroneously claimed for him the invention of the cast-iron railway. He certainly adopted it early, and thereby met the fate of men before their age; for his plan was opposed by the labouring people of the colliery, who got up a riot in which they tore up the road and burnt the coal-staith, whilst Mr. Curr fled into a neighbouring wood for concealment, and lay there *perdu* for three days and nights, to escape the fury of the populace.¹ The plates



¹ 'Railway Locomotion and Steam Navigation, their Principles and Practice.' By John Curr. London, 1847.

of these early tramways had a ledge cast on their outer edge to guide the wheel along the road, after the manner shown in the preceding cut.

In 1789, Mr. William Jessop constructed a railway at Loughborough, in Leicestershire, and there introduced the cast-iron edge-rail, with flanches cast upon the tire of the waggon-wheels to keep them on the track, instead of having the margin or flanch cast upon the rail itself; and this plan was shortly after adopted in other places. In 1800, Mr. Benjamin Outram, of Little Eaton, in Derbyshire (father of the distinguished General Outram), used stone props instead of timber for supporting the ends or joinings of the rails. Thus the use of railroads, in various forms, gradually extended, until they became generally adopted in the mining districts.

Such was the growth of the railroad, which, it will be observed, originated in necessity, and was modified according to experience: progress in this, as in all departments of mechanics, having been effected by the exertions of many men; one generation entering upon the labours of that which preceded it, and carrying them onward to farther stages of improvement. The invention of the locomotive was in like manner made by successive steps. It was not the invention of one man, but of a succession of men, each working at the proper hour, and according to the needs of that hour; one inventor interpreting only the first word of the problem which his successors were to solve after long and laborious efforts and experiments. "The locomotive is not the invention of one man," said Robert Stephenson at Newcastle, "but of a nation of mechanical engineers."

Down to the end of last century, and indeed down almost to our own time, the only power used in haulage was that of the horse. Along the common roads of the country the poor horses were "tearing their hearts out" in dragging cumbersome vehicles behind them;

and the transport of merchandize continued to be slow, dear, and in all respects unsatisfactory. Many expedients were suggested with the view of getting rid of the horse. The power of wind was one of the first expedients proposed. It was cheap, though by no means regular. It impelled ships by sea; why should it not be used to impel carriages on land?

The first sailing-coach was invented by one Simon Stevinus, or Stevins, a Fleming, towards the end of the sixteenth century. Pierre Gassendi gives an account of its performances as follows :—

Purposing to visit Grotius, Peireskios went to Scheveling that he might satisfy himself of the carriage and swiftness of a coach a few years before invented, and made with that artifice that with expanded sails it would fly upon the shore as a ship upon the sea. He had formerly heard that Count Maurice, a little after his victory at Nieuport [1600], had put himself thereinto, together with Francis Mendoza, his prisoner, on purpose to make trial thereof, and that, within two hours, they arrived at Putten, which is distant from Scheveling fourteen leagues, or two-and-forty miles. He had, therefore, a mind to make the experiment himself, and he would often tell us with what admiration he was seized when he was carried with a quick wind and yet perceived it not, the coach's motion being equally quick.”¹

The sailing-coach, however, was only a curiosity. As a practicable machine, it proved worthless; for the wind could not be depended upon for land locomotion. The coach could not tack as the ship did. Sometimes the wind did not blow at all, while at other times it blew a hurricane. After being used for some time as a toy, the sailing-coach was given up as impracticable, and the project speedily dropped out of sight.

But, strange to say, the expedient of driving coal-waggons by the wind was revived in Wales about a

¹ A curious account of this early project is to be found in the library of the British Museum, under the name ‘Stevin, 1652.’

century later. On this occasion, Sir Humphry Mackworth, an ingenious coalminer at Neath, was the projector. Waller, in his 'Essay on Mines,' published in 1698, takes the opportunity of eulogizing Sir Humphry's "new sailing-waggon, for the cheap carriage of his coal to the water-side, whereby one horse does the work of ten at all times; but when any wind is stirring (which is seldom wanting near the sea), one man and a small sail do the work of twenty."¹ It does not, however, appear that any other coal-owner had the courage to follow Sir Humphry's example, and the sailing-waggon was forgotten until, after the lapse of another century, it was revived by Mr. Edgeworth.

The employment of Steam-power as a means of land locomotion was the subject of much curious speculation long before any practical attempt was made to carry it into effect. The merit of promulgating the first idea with reference to it probably belongs to no other than the great Sir Isaac Newton. In his 'Explanation of the Newtonian Philosophy,' written in 1680, he figured a spherical generator, supported on wheels, and provided with a seat for a passenger in front, and a long jet-pipe behind, and stated that "the whole is to be mounted on little wheels, so as to move easily on a horizontal plane, and if the hole, or jet-pipe, be opened, the vapour will rush out violently one way, and the wheels and the ball at the same time will be carried the contrary way." This, it will be observed, was but a modification of the earliest known steam-engine, or *œolipile*, of Hero of Alexandria. It is not believed that Sir Isaac Newton ever made any experiment of his proposed method of locomotion, or did more than merely throw out the idea for other minds to work upon.

¹ The writer adds,—"I believe he (Sir Humphry Mackworth) is the first gentleman in this part of the world that hath set up sailing engines on land, driven by the wind; not for

any curiosity or vain applause, but for real profit: whereby he could not fail of Bishop Malkin's blessing on his undertakings, in case he were in a capacity to bestow it."

The idea of employing steam in locomotion was revived from time to time, and formed the subject of much curious speculation. About the middle of last century we find Benjamin Franklin, then agent in London for the United Provinces of America, Matthew Boulton of Birmingham, and Erasmus Darwin of Lichfield, engaged in a correspondence relative to steam as a motive power. Boulton had made a model of a fire-engine, which he sent to London for Franklin's inspection; and though the original purpose for which the engine had been contrived was the pumping of water, it was believed to be practicable to employ it also as a means of locomotion. Franklin was too much occupied at the time by grave political questions to pursue the subject; but the sanguine and speculative mind of Erasmus Darwin was inflamed by the idea of a "fiery chariot," and he pressed his friend Boulton to prosecute the contrivance of the necessary steam machine.¹

Erasmus Darwin was in many respects a remarkable man. In his own neighbourhood he was highly esteemed as a physician, and by many intelligent readers of his day he was greatly prized as a poet. Horace Walpole said of his 'Botanic Garden' that it was "the most delicious poem upon earth," and he declared that he "could read it over and over again for ever." The doctor was accustomed to write his poems with a pencil on little scraps of paper while riding about among his patients in his "sulky." The vehicle, which was worn and bespattered outside, had room within it for the doctor and his appurtenances only. On one side of him was a pile of books reaching from the floor to nearly the front window of the carriage, while on the other was a hamper containing fruit and sweetmeats, with a store of cream and

¹ See further, 'Lives of the Engineers,' vol. iv., Boulton and Watt, pp. 182-4.

sugar, with which the occupant regaled himself during his journey. Lashed on to the place usually appropriated to the "boot," was a large pail for watering the horses, together with a bag of oats and a bundle of hay. Such was the equipage of a fashionable country physician of the last century.

Dr. Darwin was a man of large and massive person, bearing a rather striking resemblance to his distinguished townsman, Dr. Johnson, in manner, deportment, and force of character. He was full of anecdote, and his conversation was most original and entertaining. He was a very out-spoken man, vehemently enunciating theories which some thought original and others dangerous. As he drove through the country in his "sulky," his mind teemed with speculation on all subjects, from zoonomy, botany, and physiology, to physics, æsthetics, and mental philosophy. Though his speculations were not always sound, they were clever and ingenious, and, at all events, they had the effect of setting other minds a-thinking and speculating on science and the methods for its advancement. From his 'Loves of the Plants'—afterwards so cleverly parodied by George Canning in his 'Loves of the Triangles'—it would appear that the doctor even entertained a theory of managing the winds by a little philosophic artifice. His scheme of a steam locomotive was of a more practical character. This idea, like so many others, first occurred to him in his "sulky."

"As I was riding home yesterday," he wrote to his friend Boulton in the year 1765, "I considered the scheme of the fiery chariot, and the longer I contemplated this favourite idea, the more practicable it appeared to me. I shall lay my thoughts before you, crude and undigested though they may appear to be, telling you as well what I thought would not do, as what would do; as by those hints you may be led into various trains of thinking upon this subject, and by that means (if any hints can assist your genius, which, without hints, is above all others

I am acquainted with) be more likely to improve or disapprove. And as I am quite mad of this scheme, I beg you will not mention it, or show this paper to Wyat or anybody.

"These things are required:—1st, a rotary motion; 2nd, easily altering its direction to any other direction; 3rd, to be accelerated, retarded, destroyed, revived instantly and easily; 4th, the bulk, the weight, and expense of the machine to be as small as possible in proportion to its use."¹

He then goes on to throw out various suggestions as to the form and arrangement of the machine, the number of wheels on which it was to run, and the mode of applying the power. The text of this letter is illustrated by rough diagrams, showing a vehicle mounted on three wheels, the foremost or guiding wheel being under the control of the driver; but in a subsequent passage he says, "I think four wheels will be better."

"Let there be two cylinders," he proceeds. "Suppose one piston up and the vacuum made under it by the *jet d'eau froid*. That piston cannot yet descend because the cock is not yet opened which admits the steam into its antagonist cylinder. Hence the two pistons are in equilibrio, being either of them pressed by the atmosphere. Then, I say, if the cock which admits the steam into the antagonist cylinder be opened gradually and not with a jerk, that the first-mentioned [piston in the] cylinder will descend gradually and not less forcibly. Hence, by the management of the steam cocks, the motion may be accelerated, retarded, destroyed, revived instantly and easily. And if this answers in practice as it does in theory, the machine cannot fail of success! Eureka!

"The cocks of the cold water may be moved by the great work, but the steam cocks must be managed by the hand of the charioteer, who also directs the rudder-wheel. [Then follow his rough diagrams.] The central wheel ought to have been under the rollers, so as it may be out of the way of the boiler."²

After further explaining himself, he goes on to say:—

"If you could learn the expense of coals to a common fire-engine and the weight of water it draws, some certain estimate

¹ Soho MSS.

² Ibid.

may be made if such a scheme as this would answer. Pray don't show Wyat this scheme, for if you think it feasible and will send me a critique upon it, I will certainly, if I can get somebody to bear half the expense with me, endeavour to build a fiery chariot, and, if it answers, get a patent. If you choose to be partner with me in the profit and expense and trouble, let me know, as I am determined to execute it if you approve of it.

"Please to remember the pulses of the common fire-engines, and say in what manner the piston is so made as to keep out the air in its motion. By what way is the *jet d'eau froid* let out of the cylinder? How full of water is the boiler? How is it supplied, and what is the quantity of its waste of water?"¹

It will be observed from these remarks that the doctor's notions were of the crudest sort, and, as he obviously contemplated but a modification of the Newcomen engine, then chiefly employed in pumping water from mines, the action of which was slow, clumsy, and expensive, the steam being condensed by injection of cold water, it is clear that even though Boulton had taken up and prosecuted Darwin's idea, it could not have issued in a practicable or economical working locomotive.

But, although Darwin himself—his time engrossed by his increasing medical practice—proceeded no further with his scheme of a "fiery chariot," he succeeded in inflaming the mind of his young friend, Richard Lovell Edgeworth, who had settled for a time in his neighbourhood, and induced him to direct his attention to the introduction of improved means of locomotion by steam. In a letter written by Dr. Small to Watt, in 1768, we find him describing Edgeworth as "a gentleman of fortune, young, mechanical, and indefatigable, who has taken a resolution to move land and water carriages by steam, and has made considerable progress in the short space of time that he has devoted to the study."

One of the first fruits of Edgeworth's investigations was his paper 'On Railroads,' which he read before the

¹ Soho MSS.

Society of Arts in 1768, and for which he was awarded the Society's gold medal. He there proposed that four iron railroads be laid down on one of the great roads out of London; two for carts and waggons and two for light carriages and stage-coaches. The post-chaises and gentlemen's carriages might, he thought, be made to go at eight miles an hour, and the stage-coaches at six miles an hour, drawn by a single horse. He urged that such a method of transport would be attended with great economy of power and consequent cheapness. Many years later, in 1802, he published his views on the same subject in a more matured form. By that time Watt's steam-engine had come into general use, and he suggested that small stationary engines should be fixed along his proposed railroad, and made, by means of circulating chains, to draw the carriages along with a great diminution of horse labour and expense.

It is creditable to Mr. Edgeworth's forethought that both the methods proposed by him have since been adopted. Horse-traction of carriages on railways is now in general use in the towns of the United States; and omnibuses on the same principle regularly ply between the Place de la Concorde at Paris and St. Cloud, both being found highly convenient for the public, and profitable to the proprietors. The system of working railways by fixed engines was also regularly employed on some lines in the infancy of the railway system, though it has since fallen into disuse, in consequence of the increased power given to the modern locomotive, which enables it to surmount gradients formerly considered impracticable.

Besides his speculations on railways worked by horse and steam power, Mr. Edgeworth—unconscious of the early experiments of Stevins and Mackworth—made many attempts to apply the power of the wind with the same object. It is stated in his 'Memoirs' that he devoted himself to locomotive traction by various

methods for a period of about forty years, during which he made above a hundred working models, in a great variety of forms ; and though none of his schemes were attended with practical success, he adds that he gained far more in amusement than he lost by his unsuccessful labours. "The only mortification that affected me," he says, "was my discovery, many years after I had taken out my patent [for the sailing-carriage], that the rudiments of my whole scheme were mentioned in an obscure memoir of the French Academy."

The sailing-waggon scheme, as revived by Mr. Edgeworth, was doubtless of a highly ingenious character, though it was not practicable. One of his expedients was a portable railway, of a kind somewhat similar to that since revived by Mr. Boydell. Many experiments were tried with the new waggons on Hare Hatch Common ; but they were attended with so much danger when the wind blew strong—the vehicles seeming to fly rather than roll along the ground—that further experiments were abandoned, and Mr. Edgeworth himself at length came to the conclusion that a power so uncertain as that of the wind could never be relied upon for the safe conduct of ordinary traffic. His thoughts finally settled on steam as the only practicable power for this purpose ; but though his enthusiasm in the cause of improved transit of persons and of goods remained unabated, he was now too far advanced in life to prosecute his investigations in that direction. When an old man of seventy he wrote to James Watt (7th August, 1813):—"I have always thought that steam would become the universal lord, and that we should in time scorn post-horses. An iron railroad would be a cheaper thing than a road on the common construction." Four years later he died, and left the problem, which he had nearly all his life been trying ineffectually to solve, to be worked out by younger men.

Dr. Darwin had long before preceded him into the

silent land. Down to his death in 1802, Edgeworth had kept up a continuous correspondence with him on his favourite topic; but it does not appear that Darwin ever revived his project of the "fiery chariot." He was satisfied to prophesy its eventual success in the lines which are perhaps more generally known than any he has written—for, though Horace Walpole declared that he could "read the Botanic Garden over and over again for ever," the poetry of Darwin is now all but forgotten. The following was his prophecy, published in 1791, before any practicable locomotive or steamboat had been invented:—

"Soon shall thy arm, unconquered steam, afar
Drag the slow barge, or drive the rapid car;
Or on wide-waving wings expanded bear
The flying chariot through the fields of air.
Fair crews triumphant, leaning from above,
Shall wave their flutt'ring kerchiefs as they move;
Or warrior bands alarm the gaping crowd,
And armies shrink beneath the shadowy cloud."

The prophecy embodied in the first two lines of the passage has certainly been fulfilled; but the triumph of the steam balloon has yet to come!

CHAPTER II.

EARLY LOCOMOTIVE MODELS.

THE application of steam-power to the driving of wheel-carriages on common roads, was in 1759 brought under the notice of James Watt by his young friend John Robison, then a student at the University of Glasgow. Robison prepared a rough sketch of his suggested steam-carriage, in which he proposed to place the cylinder with its open end downwards, to avoid the necessity for using a working beam. Watt was then only twenty-three years old, and was very much occupied in conducting his business of a mathematical instrument maker, which he had only recently established. Nevertheless, he proceeded to construct a model locomotive provided with two cylinders of tin-plate; intending that the pistons and their connecting-rods should act alternately on two pinions attached to the axles of the carriage-wheels. But the model when made did not answer Watt's expectations; and when, shortly after, Robison left college to go to sea, he laid the project aside, and did not resume it for many years.

In the mean time, an ingenious French mechanic had taken up the subject, and proceeded to make a self-moving road engine worked by steam-power. It has been incidentally stated that a M. Pouillet was the first to make a locomotive machine,¹ but no particulars are given of the invention, which is more usually attributed to Nicholas Joseph Cugnot, a native of Void in Lorraine, where he was born in 1729. Not much is known of

¹ 'Portfeuille du Conservatoire des Arts et Métiers,' Livraison 1, p. 3.

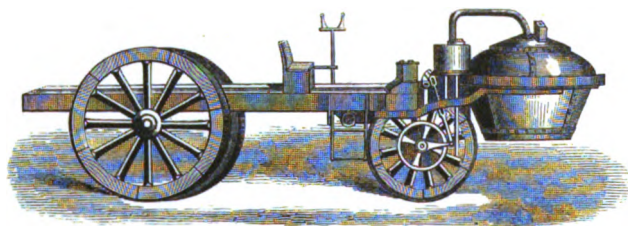
Cugnot's early history, beyond that he was an officer in the army,—that he published several works on military science,—and that on leaving the army he devoted himself to the invention of a steam-carriage to run on common roads.

It appears from documents collected by M. Morin, that Cugnot constructed his first carriage at the Arsenal in 1769 at the cost of the Comte de Saxe, by whom he was patronized and liberally helped. It ran on three wheels, and was put in motion by an engine composed of two single-acting cylinders, the pistons of which acted alternately on the single front wheel. While this machine was in course of construction; a Swiss officer, named Planta, brought forward a similar project; but on perceiving that Cugnot's carriage was superior to his own, he proceeded no further with it.

When Cugnot's engine was ready, it was tried in the presence of the Duc de Choiseul, the Comte de Saxe, and other military officers. On being first set in motion, it ran against a stone wall which stood in its way, and threw it down. There was thus no doubt about its power; though there were many doubts about its manageableness. At length it was got out of the Arsenal and put upon the road, when it was found that, though loaded with only four persons, it could not travel faster than about two and a quarter miles an hour; and that, the size of the boiler not being sufficient, it would not continue at work for more than twelve or fifteen minutes, when it was necessary to wait until sufficient steam had been raised to enabled it to proceed further.

The experiment was looked upon with great interest, and admitted to be of a very remarkable character; and, considering that it was a first attempt, it was not by any means regarded as unsuccessful. As it was believed that such a machine, if properly proportioned, might be employed to drag cannon into the field inde-

pendent of horse-power, the Minister of War authorised Cugnot to proceed with the construction of a new and improved machine, which was finished and ready for trial in the course of the following year. The new locomotive was composed of two parts,—one being a carriage supported on two wheels, somewhat resembling a small brewer's cart, furnished with a seat for the driver, —while the other contained the machinery, which was supported on a single driving-wheel 4 ft. 2 in. in diameter. The engine consisted of a round copper boiler with a furnace inside provided with two small chimneys, two single-acting 13-in. brass cylinders communicating with the boiler by a steam-pipe, and the arrangements for communicating the motion of the pistons to the driving-wheel, together with the steering gear.



CUGNOT'S ENGINE

The two parts of the machine were united by a moveable pin and a toothed sector fixed on the framing of the front or machine part of the carriage. When one of the pistons descended, the piston-rod drew with it a crank, the catch of which caused the driving-wheel to make a quarter of a revolution by means of the ratchet-wheel fixed on the axle of the driving-wheel. At the same time, a chain fixed to the crank on the same side also descended and moved a lever, the opposite end of which was thereby raised, restoring the second piston to its original position at the top of the cylinder by the interposition of a second chain and crank. The piston-rod of the descending piston, by means of a catch, set

other levers in motion, the chain fixed to them turning a half-way cock so as to open the second cylinder to the steam and the first to the atmosphere. The second piston, then descending in turn, caused the driving-wheel to make another quarter revolution, restoring the first piston to its original position; and the process being repeated, the machine was thereby kept in motion. To enable it to run backwards, the catch of the crank was arranged in such a manner that it could be made to act either above or below, and thereby reverse the action of the machinery on the driving-wheel. It will thus be observed that Cugnot's locomotive presented a simple and ingenious form of a high-pressure engine; and, though of rude construction, it was a highly-creditable piece of work considering the time of its appearance and the circumstances under which it was constructed.

Several successful trials were made with the new locomotive in the streets of Paris, which excited no small degree of interest. Unhappily, however, an accident which occurred to it in one of the trials, had the effect of putting a stop to further experiments. Turning the corner of a street near the Madeleine one day, when the machine was running at a speed of about three miles an hour, it became overbalanced and fell over with a crash; after which, the running of the vehicle being considered dangerous, it was thenceforward locked up securely in the Arsenal to prevent its doing further mischief.

The merit of Cugnot was, however, duly recognised. He was granted a pension of 300 livres, which continued to be paid to him until the outbreak of the Revolution. The Girondist Roland was appointed to examine the engine and report upon it to the Convention; but his report, which was favourable, was not adopted; on which the inventor's pension was stopped, and he was left for a time without the means of living. Some years later, Bonaparte, on his return from Italy after

the peace of Campo Formio, interested himself in Cugnot's invention, and expressed a favourable opinion of his locomotive before the Academy ; but his attention was shortly after diverted from the subject by the Expedition to Egypt. Napoleon, however, succeeded in restoring Cugnot's pension, and thus soothed his declining years. He died at Paris in 1804, at the age of seventy-five. Cugnot's locomotive is still to be seen in the Museum of the Conservatoire des Arts et Métiers at Paris ; and it is, without exception, the most venerable and interesting of all the machines extant connected with the early history of locomotion.

While Cugnot was constructing his first machine at Paris, one Francis Moore, a linendraper, was taking out a patent in London for moving wheel-carriages by steam. On the 14th of March, 1769, he gave notice of a patent for " a machine made of wood or metal, and worked by fire, water, or air, for the purpose of moving bodies on land or water," and on the 13th of July following, he gave notice of another " for machines made of wood and metal, moved by power, for the carriage of persons and goods, and for accelerating boats, barges, and other vessels." But it does not appear that Moore did anything beyond lodging the titles of his inventions ; so that we are left in the dark as to what was their precise character.

James Watt's friend and correspondent, Dr. Small of Birmingham, when he heard of Moore's intended project, wrote to the Glasgow inventor with the object of stimulating him to perfect his steam-engine, then in hand, and urging him to apply it, among other things, to purposes of locomotion. " I hope soon," said Small, " to travel in a fiery chariot of your invention." Watt replied to the effect that " if linendraper Moore does not use my engines to drive his carriages, he can't drive them by steam. If he does, I will stop them." But Watt was still a long way from perfecting his

invention. The steam-engine capable of driving carriages was a problem that remained to be solved; and it was a problem to the solution of which Watt never fairly applied himself. It was enough for him to accomplish the great work of perfecting his condensing engine, and with that he rested content.

But Watt continued to be so strongly urged by those about him to apply steam-power to purposes of locomotion that, in his comprehensive patent of the 24th of August, 1784, he included an arrangement with that object. From his specification we learn that he proposed a cylindrical or globular boiler, protected outside by wood strongly hooped together, with a furnace inside entirely surrounded by the water to be heated except at the ends. Two cylinders working alternately were to be employed, and the pistons working within them were to be moved by the elastic force of the steam; "and after it has performed its office," he says, "I discharge it into the atmosphere by a proper regulating valve; or I discharge it into a condensing vessel made air-tight, and formed of thin plates and pipes of metal, having their outsides exposed to the wind;" the object of this latter arrangement being to economise the water, which would otherwise be lost. The power was to be communicated by a rotative motion (of the nature of the "sun and planet" arrangement) to the axle of one or more of the wheels of the carriage, or to another axis connected with the axle by means of toothed wheels; and in other cases he proposed, instead of the rotative machinery, to employ "toothed racks, or sectors of circles, worked with reciprocating motion by the engines, and acting upon ratched wheels fixed on the axles of the carriage." To drive an engine containing two persons would, he estimated, require an engine with a cylinder 7 in. in diameter, making sixty strokes per minute of 1 ft. each, and so constructed as to act both on the ascent and descent of the piston; and, finally,

the elastic force of the steam in the boiler must be such as to be occasionally equal to supporting a pillar of mercury 30 in. high.

Though Watt repeatedly expressed his intention of constructing a model locomotive after his specification, it does not appear that he ever carried it out. He was too much engrossed with other work; and besides, he never entertained very sanguine views as to the practicability of road locomotion by steam. He continued, however, to discuss the subject with his partner Boulton; and from his letters we gather that his mind continued undetermined as to the best plan to be pursued. Only four days after the date of the above specification (*i.e.*, on the 28th August, 1784) we find him communicating his views on the subject to Boulton at great length, and explaining his ideas as to how the proposed object might best be accomplished. He first addressed himself to the point of whether 80 lb. was a sufficient power to move a post-chaise on a tolerably good and level road at four miles an hour; secondly, whether 8 ft. of boiler surface exposed to the fire would be sufficient to evaporate a cube foot of water per hour without much waste of fuel; thirdly, whether it would require steam of more than eleven and a-half times atmospheric density to cause the engine to exert a power equal to 6 lb. on the inch. "I think," he observed, "the cylinder must either be made larger or make more than sixty strokes per minute. As to working gear, stopping and backing, with steering the carriage, I think these things perfectly manageable."

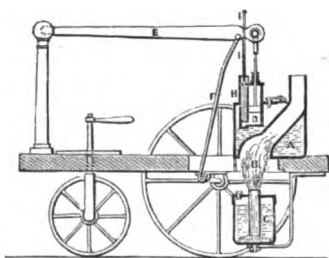
"My original ideas on the subject," he continued, "were prior to my invention of these improved engines, or before the crank, or any other of the rotative motions were thought of. My plan then was to have two inverted cylinders with toothed racks, instead of piston-rods, which were to be applied to two ratchet-wheels on the axletree, and to act alternately; and I am partly of opinion that this method might be applied with advantage

yet, because it needs no fly and has some other conveniences. From what I have said, and from much more which a little reflection will suggest to you, you will see that without several circumstances turn out more favourable than has been stated, the machine will be clumsy and defective, and that it will cost much time to bring it to any tolerable degree of perfection, and that for me to interrupt the career of our business would be imprudent; I even grudge the time I have taken to make these comments on it. There is, however, another way in which much mechanism might be saved if it be in itself practicable, which is to apply to it one of the self-moving rotatives, which has no regulators, but turns like a mill-wheel by the constant influx and efflux of steam; but this would not abridge the size of the boiler, and I am not sure that such engines are practicable."

It will be observed from these explanations that Watt's views as to road locomotion were still crude and undefined; and, indeed, he never carried them further. While he was thus discussing the subject with Boulton, William Murdock, one of the most skilled and ingenious workmen of the Soho firm,—then living at Redruth in Cornwall,—was occupying himself during his leisure hours, which were but few, in constructing a model locomotive after a design of his own. He had doubtless heard of the proposal to apply steam to locomotion; and, being a clever inventor, he forthwith set himself to work out the problem. The plan he pursued was very simple and yet efficient. His model was of small dimensions, standing little more than a foot high, but it was sufficiently large to demonstrate the soundness of the principle on which it was constructed. It was supported on three wheels, and carried a small copper boiler, heated by a spirit lamp, with a flue passing obliquely through it. The cylinder, of $\frac{3}{4}$ in. diameter and 2 in. stroke, was fixed in the top of the boiler, the piston-rod being connected with the vibrating beam attached to the connecting-rod which worked the crank of the driving-wheel. This little engine worked

by the expansive force of the steam only, which was discharged into the atmosphere after it had done its work of alternately raising and depressing the piston in the cylinder.

Mr. Murdock's son informed the author that this model was invented and constructed in 1781; but,



SECTION OF MURDOCK'S MODEL.

from the correspondence of Boulton and Watt, we infer that it was not ready for trial until 1784. The first experiment with it was made in Murdock's own house at Redruth, when it successfully hauled a model waggon round the room,—the single

wheel placed in front of the engine and working in a swivel frame, enabling it to run round in a circle.

Another experiment was made out of doors, on which occasion, small though the engine was, it fairly outran the speed of its inventor. It seems that one night after returning from his duties at the Redruth mine, Murdock determined to try the working of his model locomotive. For this purpose he had recourse to the walk leading to the church, about a mile from the town. It was rather narrow, and was bounded on each side by high hedges. The night was dark, and Murdock set out alone to try his experiment. Having lit his lamp, the water soon boiled, when off started the engine with the inventor after it. Shortly after he heard distant shouts of terror. It was too dark to perceive objects; but he found, on following up the machine, that the cries proceeded from the worthy pastor of the parish, who, going towards the town, was met on this lonely road by the hissing and fiery little monster, which he subsequently declared he had taken to be the Evil One in *propria persona*!

Watt was by no means pleased when he learnt that

Murdock was giving his mind to these experiments. He feared that it might have the effect of withdrawing him from the employment of the firm, to which his services had become almost indispensable; for there was no more active, skilful, or ingenious workman in all their concern. Watt accordingly wrote to Boulton, recommending him to advise Murdock to give up his locomotive-engine scheme; but if he could not succeed in that, then, rather than lose Murdock's services, Watt proposed that he should be allowed an advance of 100*l.* to enable him to prosecute his experiments, and if he succeeded within a year in making an engine capable of drawing a post chaise carrying two passengers and the driver at four miles an hour, it was suggested that he should be taken as partner into the locomotive business, for which Boulton and Watt were to provide the necessary capital.

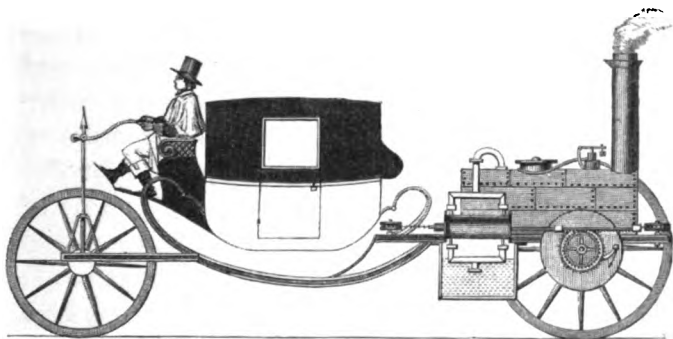
Two years later (in September, 1786), we find Watt again expressing his regret to Boulton that Murdock was "busying himself with the steam-carriage." "I have still," said he, "the same opinion concerning it that I had, but to prevent as much as possible more fruitless argument about it, I have one of some size under hand, and am resolved to try if God will work a miracle in favour of these carriages. I shall in some future letter send you the words of my specification on that subject. In the mean time I wish William could be brought to do as we do, to mind the business in hand, and let such as Symington and Sadler throw away their time and money in hunting shadows." In a subsequent letter Watt expressed his gratification at finding "that William applies to his business." From that time Murdock as well as Watt dropped all further speculation on the subject, and left it to others to work out the problem of the locomotive engine. Murdock's model remained but a curious toy, which he himself took pleasure in exhibiting to his intimate

friends; and though he long continued to speculate about road locomotion, and was persuaded of its practicability, he refrained from embodying his ideas of it in any more complete working form.

Symington and Sadler, the "hunters of shadows" referred to by Watt, did little to advance the question. Of Sadler we know nothing, beyond that in 1786 he was making experiments as to the application of steam-power to the driving of wheel-carriages. This came to the knowledge of Boulton and Watt, who gave him notice, on the 4th of July of the same year, that "the sole privilege of making steam-engines by the elastic force of steam acting on a piston, with or without condensation, had been granted to Mr. Watt by Act of Parliament, and also that amongst other improvements and applications of his principle he hath particularly specified the application of steam-engines for driving wheel carriages, in a patent which he took out in the year 1784." They accordingly cautioned him against proceeding further in the matter; and as we hear no more of Sadler's steam-carriage, it is probable that the notice had its effect.

The name of William Symington is better known in connection with the history of steam locomotion by sea. He was born at Leadhills, in Scotland, in 1763. His father was a practical mechanic, who superintended the engines and machinery of the Mining Company at Wanlockhead, where one of Boulton and Watt's pumping-engines was at work. Young Symington was of an ingenious turn of mind from his boyhood; and at an early period he seems to have conceived the idea of employing the steam-engine to drive wheel-carriages. His father and he worked together, and by the year 1786, when the son was only twenty-three years of age, they succeeded in completing a working model of a road locomotive. Mr. Meason, the manager of the mine, was so much pleased with the model, the merit

of which principally belonged to young Symington, that he sent him to Edinburgh for the purpose of exhibiting it before the scientific gentlemen of that city, in the hope that it might lead, in some way, to his future advancement in life. Mr. Meason also allowed the model to be exhibited at his own house there, and he invited many gentlemen of distinction to inspect it.



SYMINGTON'S MODEL STEAM-CARRIAGE, 1796.

The machine consisted of a carriage and locomotive behind, supported on four wheels. The boiler was cylindrical, communicating by a steam-pipe with the two horizontal cylinders, one on each side of the engine. When the piston was raised by the action of the steam, a vacuum was produced by the condensation of the steam in a cold-water tank placed underneath the engine, on which the piston was again forced back by the pressure of the atmosphere. The motion was communicated to the wheels by rack-rods connected with the piston-rod, which worked on each side of a drum fixed on the hind axle; the alternate action of which rods upon the tooth and ratchet wheels with which the drum was provided, producing the rotary motion. It will thus be observed that Symington's engine was partly atmospheric and partly condensing,—the condensation being effected by a separate vessel and air-pump, as patented by Watt; and though the

arrangement was ingenious, it is clear that, had it ever been brought into use, the traction by means of such an engine would have been of the very slowest kind.

But Symington's engine was not destined to be applied to road locomotion. He was completely diverted from employing it for that purpose by his connection with Mr. Miller, of Dalswinton, then engaged in experimenting on the application of mechanical power to the driving of his double paddle-boat. The power of men was first tried, but the labour was found too severe; and when Mr. Miller went to see Symington's model, and informed the inventor of his difficulty in obtaining a regular and effective power for driving his boat, Symington—his mind naturally full of his own invention—at once suggested his steam-engine for the purpose. The suggestion was adopted, and Mr. Miller authorised him to proceed with the construction of a steam-engine to be fitted into his double pleasure boat on Dalswinton Lock, where it was tried in October, 1788. This was followed by further experiments, which eventually led to the construction of the *Charlotte Dundas*, in 1801, which may be regarded as the first practical steamboat ever built.

Symington took out letters patent in the same year, securing the invention, or rather the novel combination of inventions, embodied in his steamboat; but he never succeeded in getting it introduced into practical use. From the date of completing his invention, fortune seemed to run steadily against him. The Duke of Bridgewater, who had ordered a number of Symington's steamboats for his canal, died, and his executors countermanded the order. Symington failed in inducing any other canal company to make trial of his invention. Lord Dundas also took the *Charlotte Dundas* off the Forth and Clyde Canal, where she had been at work, and from that time the vessel was never more tried. Symington had no capital of his own to work upon,

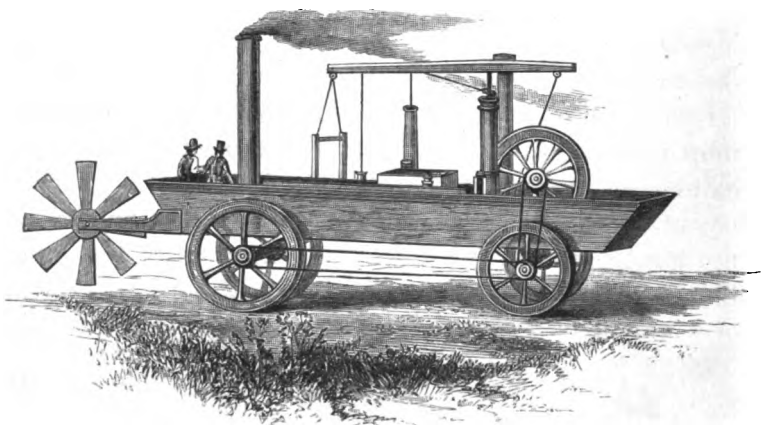
and he seems to have been unable to make friends among capitalists. The rest of his life was for the most part thrown away. Towards the close of it his principal haunt was London, amidst whose vast population he was one of the many waifs and strays. He succeeded in obtaining a grant of 100*l.* from the Privy Purse in 1824, and afterwards an annuity of 50*l.*, but he did not live long to enjoy it, for he died in March, 1831, and was buried in the churchyard of St. Botolph, Aldgate, where there is not even a stone to mark the grave of the inventor of the first practicable steamboat.

While the inventive minds of England were thus occupied, those of America were not idle. The idea of applying steam-power to the propulsion of carriages on land is said to have occurred to John Fitch in 1785; but he did not pursue the idea "for more than a week," being diverted from it by his scheme of applying the same power to the propulsion of vessels on the water.¹ About the same time, Oliver Evans, a native of Newport, Delaware, was occupied with a project for driving steam-carriages on common roads; and in 1786 the legislature of Maryland granted him the exclusive right for that State. Several years, however, passed before he could raise the means for erecting a model carriage, most of his friends regarding the project as altogether chimerical and impracticable. In 1800 or 1801, Evans began a steam-carriage at his own expense; but he had not proceeded far with it when he altered his intention, and applied the engine intended for the driving of a carriage to the driving of a small grinding-mill,

¹ This statement is made in 'The Life of John Fitch,' by Thompson Westcott, Philadelphia, 1857. Mr. Thompson there states that the idea of employing a steam-engine to propel carriages on land occurred to John Fitch at a time when, he avers, "he was altogether ignorant that a steam-

engine had ever been invented" (p. 120). Such a statement is calculated to damage the credibility of the entire book, in which the invention of the steamboat, as well as of the screw-propeller, is unhesitatingly claimed for John Fitch.

in which it was found efficient. In 1804, he constructed, at Philadelphia, a second engine of five-horse power, working on the high-pressure principle, which was placed upon a large flat or scow, mounted upon wheels. "This," says his biographer," was considered a fine opportunity to show the public that his engine could propel both land and water conveyances. When the machine was finished, Evans fixed under it, in a rough and temporary manner, wheels with wooden axletrees. Although the whole weight was equal to two hundred barrels of flour, yet his small engine propelled it up Market Street, and round the circle to the water-works, where it was launched into the Schuylkill. A paddle-wheel was then applied to its stern, and it thus sailed down that river to the Delaware, a distance of sixteen miles, in the presence of thousands of spectators."¹ It does not, however, appear that any further trial was made of this engine as a locomotive; and, having been dismantled and applied to the driving of a small grinding-mill, its employment as a travelling engine was shortly forgotten.



OLIVER EVANS'S MODEL. LOCOMOTIVE.

¹ Horne's 'Memoirs of the Most Eminent American Mechanics,' New York, 1858, p. 76.

CHAPTER III.

THE CORNISH LOCOMOTIVE — MEMOIR OF RICHARD
TREVITHICK.

WHILE the discussion of steam-power as a means of locomotion was proceeding in England, other projectors were advocating the extension of waggon-ways and railroads. Mr. Thomas, of Denton, near Newcastle-on-Tyne, read a paper before the Philosophical Society of that town in 1800, in which he urged the laying down of railways throughout the country, on the principle of the coal waggon-ways, for the general carriage of goods and merchandise; and Dr. James Anderson, of Edinburgh, about the same time published his 'Recreations of Agriculture,' wherein he recommended that railways should be laid along the principal turnpike-roads, and worked by horse-power, which, he alleged, would have the effect of greatly reducing the cost of transport, and thereby stimulating all branches of industry.

Railways were indeed already becoming adopted in places where the haulage of heavy loads was for short distances; and in some cases lines were laid down of considerable length. One of the first of such lines constructed under the powers of an Act of Parliament, was the Cardiff and Merthyr railway or tram-road, about twenty-seven miles in length, for the accommodation of the iron-works of Plymouth, Pen-y-darran, and Dowlais, all in South Wales,—the necessary Act for which was obtained in 1794. Another, the Sirhoway railroad, about twenty-eight miles in length, was constructed under the powers of an Act obtained in 1801; it accommodated the Tredegar and Sirhoway Iron-works and

the Trevill Lime-works, as well as the collieries along its route.

In the immediate neighbourhood of London, there was another very early railroad, the Wandsworth and Croydon tramway, about ten miles long, which was afterwards extended southwards to Merstham, in Surrey, for about eight miles more, making a total length of nearly eighteen miles. The first Act for the purpose of authorising the construction of this road was obtained in 1800.

All these lines were, however, worked by horses, and in the case of the Croydon and Merstham line, donkeys shared in the work, which consisted chiefly in the haulage of stone, coal, and lime. No proposal had yet been made to apply the power of steam as a substitute for horses on railways; nor were the rails then laid down of a strength sufficient to bear more than a loaded waggon of the weight of three tons, or, at the very outside, of three-and-a-quarter tons.

It was, however, observed from the first that there was an immense saving in the cost of haulage; and on the day of opening the southern portion of the Merstham railroad, in 1805, a train of twelve waggons laden with stone, weighing in all thirty-eight tons, was drawn six miles in an hour by one horse, with apparent ease, down an incline of 1 in 120; and this was bruited about as an extraordinary feat, highly illustrative of the important uses of the new iron-ways.

About the same time, the subject of road locomotion was again brought into prominent notice by an important practical experiment conducted in a remote corner of the kingdom. The experimenter was a young man, then obscure, but afterwards famous, who may be fairly regarded as the inventor of the railway locomotive, if any single individual be entitled to that appellation. This was Richard Trevithick, a person of extraordinary mechanical skill, but of marvellous ill-fortune, who,

though the inventor of many ingenious contrivances, and the founder of the fortunes of many, himself died in cold obstruction and in extreme poverty, leaving behind him nothing but his great inventions and the recollection of his genius.

Richard Trevithick was born on the 13th of April, 1771, in the parish of Illogan, a few miles west of Redruth, in Cornwall. In the immediate neighbourhood rises Castle-Carn-brea, a rocky eminence, supposed by Borlase to have been the principal seat of Druidic worship in the West of England. The hill commands an extraordinary view over one of the richest mining fields of Cornwall, from Chacewater and Redruth to Camborne.

Trevithick's father acted as purser at several of the mines. Though a man in good position and circumstances, he does not seem to have taken much pains with his son's education. Being an only child, he was very much indulged,—amongst other things, in his dislike for the restraints and discipline of school; and he was left to wander about among the mines, spending his time in the engine-rooms, picking up information about pumping-engines and mining machinery.

His father, observing the boy's strong bent towards mechanics, placed him for a time as pupil with William Murdock, while the latter lived at Redruth superintending the working and repairs of Boulton and Watt's pumping-engines in that neighbourhood. During his pupilage, young Trevithick doubtless learned much from that able mechanic. It is probable that he got his first idea of the high-pressure road locomotive which he afterwards constructed, from Murdock's ingenious little model, above described, the construction and action of which must have been quite familiar to him, for no secret was ever made of it, and its performances were often exhibited.

Many new pumping-engines being in course of erection in the neighbourhood about that time, there was an unusual demand for engineers, which it was found difficult to supply; and young Trevithick, whose skill was acknowledged, had no difficulty in getting an appointment. The father was astonished at his boy's presumption (as he supposed it to be) in undertaking such a responsibility, and he begged the mine agents to reconsider their decision. But the result showed that they were justified in making the appointment; for young Trevithick, though he had not yet attained his majority, proved fully competent to perform the duties devolving upon him as engineer.

So long as Boulton and Watt's patent continued to run, constant attempts were made in Cornwall and elsewhere to upset it. Their engines had cleared the mines of water, and thereby rescued the mine lords from ruin, but it was felt to be a great hardship that they should have to pay for the right to use them. They accordingly stimulated the ingenuity of the local engineers to contrive an engine that should answer the same purpose, and enable them to evade making any further payments to Boulton and Watt. The first to produce an engine that seemed likely to answer the purpose was Jonathan Hornblower, who had been employed in erecting Watt's engines in Cornwall. After him one Edward Bull, who had been first a stoker and then an assistant-tender of Watt's engines, turned out another pumping-engine, which promised to prove an equally safe evasion of the existing patent. But Boulton and Watt having taken the necessary steps to defend their right, several actions were tried, in which they proved successful; and then the mine lords were compelled to disgorge. When they found that Hornblower could be of no further use to them, they abandoned him—threw him away like a sucked orange; and shortly after we

find him a prisoner for debt in the King's Bench, almost in a state of starvation. Nor do we hear anything more of Edward Bull after the issue of the Boulton and Watt trial.

Like the other Cornish engineers, young Trevithick took an active part from the first in opposing the Birmingham patent, and he is said to have constructed several engines with the assistance of William Bull (formerly an erector of Watt's machines), with the object of evading it. These engines are said to have been highly creditable to their makers, working to the entire satisfaction of the mine-owners. The issue of the Watt trial, however, which declared all such engines to be piracies, brought to an end for a time a business which would otherwise have proved a very profitable one; and Trevithick's partnership with Bull then came to an end.

While carrying on his business, Trevithick had frequent occasion to visit Mr. Harvey's iron foundry at Hayle, then a small work, but now one of the largest in the West of England, the Cornish pumping-engines turned out by Harvey and Co. being the very best of their kind. During these visits Trevithick became acquainted with the various members of Mr. Harvey's family, and in course of time he contracted an engagement with one of his daughters, Miss Jane Harvey, to whom he was married in November, 1797.

A few years later, we find Trevithick engaged in partnership with his cousin, Andrew Vivian, also an engineer. They carried on their business of engine-making at Camborne, a mining town situated in the midst of the mining district, a few miles south of Redruth. Watt's patent right expired in 1800, and from that time the Cornish engineers were free to make engines after their own methods. Trevithick was not content to follow in the beaten paths, but, being of a highly speculative turn, he occupied himself in con-

triving various new methods of employing steam with the object of economising fuel and increasing the effective power of the engine.

From an early period, he entertained the idea of making the expansive force of steam act directly on both sides of the piston on the high-pressure principle, and thus getting rid of the process of condensation as in Watt's engines. Although Cugnot had employed high-pressure steam in his road locomotive, and Murdock in his model, and although Watt had distinctly specified the action of steam at high-pressure as well as low in his patents of 1769, 1782, and 1784, the idea was not embodied in any practicable working engine until the subject was taken in hand by Trevithick. The results of his long and careful study were embodied in the patent which he took out in 1802, in his own and Vivian's name, for an improved steam-engine, and "the application thereof for driving carriages and for other purposes."

The arrangement of Trevithick's engine was exceedingly ingenious. It exhibited a beautiful simplicity of parts; the machinery was arranged in a highly effective form, uniting strength with solidity and portability, and enabling the power of steam to be employed with very great rapidity, economy, and force. Watt's principal objection to using high-pressure steam consisted in the danger to which the boiler was exposed of being burst by internal pressure. In Trevithick's engine, this was avoided by using a cylindrical wrought-iron boiler, being the form capable of presenting the greatest resistance to the expansive force of steam. Boilers of this kind were not, however, new. Oliver Evans, of Delaware, had made use of them in his high-pressure engines prior to the date of Trevithick's patent; and, as Evans did not claim the cylindrical boiler, it is probable that the invention was in use before his time. Nevertheless, Trevithick had the merit of introducing the round boilers into

Cornwall, where they are still known as "Trevithick boilers." The saving in fuel effected by their use was such that in 1812 the Messrs. Williams, of Scorrier, made Trevithick a present of 300*l.*, in acknowledgment of the benefits arising to their mines from that source alone.

Trevithick's steam-carriage was the most compact and handsome vehicle of the kind that had yet been invented, and, indeed, as regards arrangement it has scarcely to this day been surpassed. It consisted of a carriage capable of accommodating some half-dozen passengers, underneath which was the engine and machinery enclosed, about the size of an orchestra drum, the whole being supported on four wheels—two in front, by which it was guided, and two behind, by which it was driven. The engine had but one cylinder. The piston-rod outside the cylinder was double, and drove a cross piece, working in guides, on the opposite side of the cranked axle to the cylinder, the crank of the axle revolving between the double parts of the piston-rod. Toothed wheels were attached to this axle, which worked into other toothed wheels fixed on the axle of the driving-wheels. The steam-cocks were opened and shut by a connection with the crank-axle; and the force-pump, with which the boiler was supplied with water, was also worked from it, as were the bellows to blow the fire and thereby keep up the combustion in the furnace.

The specification clearly alludes to the use of the engine on railroads as follows:—"It is also to be noticed that we do occasionally, or in certain cases, make the external periphery of the wheels uneven by projecting heads of nails or bolts, or cross grooves or fittings to railroads where required, and that in cases of hard pull we cause a lever, belt, or claw to project through the rim of one or both of the said wheels, so as to take hold of the ground, but that in general the ordinary structure

or figure of the external surface of those wheels will be found to answer the intended purpose."

The specification also shows the application of the high-pressure engine on the same principle to the driving of a sugar mill, or for other purposes where a fixed power is required, dispensing with condenser, cistern, air-pump, and cold-water pump. In the year 1803, a small engine of this kind was erected after Trevithick's plan, at Marazion, which worked by steam of at least 30 lb. on the inch above atmospheric pressure, and gave much satisfaction.

The first experimental steam-carriage was constructed by Trevithick and Vivian in their workshops at Camborne, in 1803, and was tried by them on the public road adjoining the town, as well as in the street of the town itself. John Petherick, a native of Camborne, who was alive in 1858, stated in a letter to Mr. Edward Williams, that he well remembered seeing the engine, worked by Trevithick himself, come through the place, to the great wonder of the inhabitants. He says, "the experiment was satisfactory only as long as the steam pressure could be kept up. During that continuance Trevithick called upon the people to 'jump up,' so as to create a load on the engine; and it soon became covered with men, which did not seem to make any difference to the power or speed, so long as the steam was kept up. This was sought to be done by the application of a cylindrical horizontal bellows worked by the engine itself; but the attempt to keep up the power of the steam for any considerable time proved a failure."

Trevithick, however, made several alterations in the engine which had the effect of improving it, and its success was such that he determined to take it to London and exhibit it there as the most recent novelty in steam mechanism. It was successfully run by road from Camborne to Plymouth, a distance of about ninety miles. At Plymouth it was shipped for London, where

it shortly after arrived in safety, and excited considerable curiosity. It was run on the waste ground in the vicinity of the present Bethlehem Hospital, as well as on Lord's cricket ground. There Sir Humphry Davy, Mr. Davies Gilbert, and other scientific gentlemen inspected the machine and rode upon it. Several of them took the steering of the carriage by turns, and they expressed their satisfaction with the mechanism by which it was directed. Sir Humphry, writing to a friend in Cornwall, said, "I shall soon hope to hear that the roads of England are the haunts of Captain Trevithick's dragons—a characteristic name." After the experiment at Lord's, the carriage was run along the New-road, and down Gray's-inn-lane, to the premises of a carriage builder in Long-acre. To show the adaptability of the engine for fixed uses, Trevithick had it taken from the carriage on the day after this trial and removed to the shop of a cutler, where he applied it with success to the driving of the machinery.

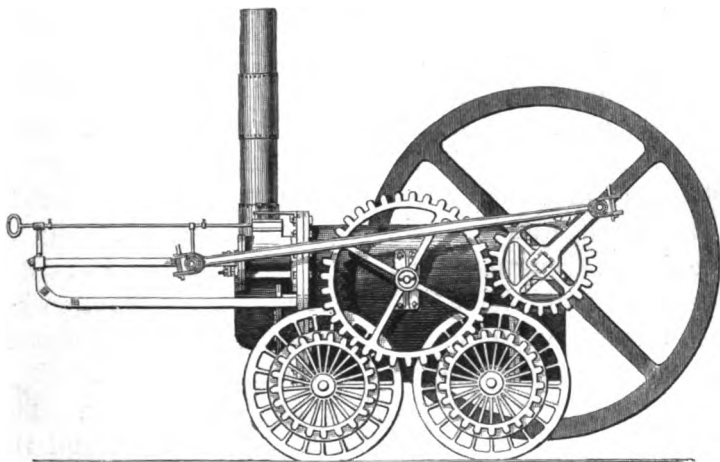
The steam-carriage shortly became the talk of the town, and the public curiosity being on the increase, Trevithick resolved on enclosing a piece of ground on the site of the present Euston station of the London and North-Western Railway, and admitting persons to see the exhibition of his engine at so much a head. He had a tram-road laid down in an elliptical form within the enclosure, and the carriage was run round it on the rails, in the sight of a great number of spectators. On the second day another crowd collected to see the exhibition, but, for what reason is not known, although it is said to have been through one of Trevithick's freaks of temper, the place was closed and the engine removed. It is, however, not improbable that the inventor had come to the conclusion that the state of the roads at that time was such as to preclude its coming into general use for purposes of ordinary traffic.

While the steam-carriage was being exhibited, a

gentleman was laying heavy wagers as to the weight which could be hauled by a single horse on the Wandsworth and Croydon iron tramway; and the number and weight of waggons drawn by the horse were something surprising. Trevithick very probably put the two things together—the steam-horse and the iron-way,—and kept the performance in mind when he proceeded to construct his second or railway locomotive. In the mean time, having dismantled his steam-carriage, sent back the phaeton to the coachbuilder to whom it belonged, and sold the little engine which had worked the machine, he returned to Camborne to carry on his business. In the course of the year 1803 he went to Pen-y-darran, in South Wales, to erect a forge engine for the iron-works there; and, when it was finished, he began the erection of a railway locomotive—the first ever constructed. There were already, as above stated, several lines of rail laid down in the district for the accommodation of the coal and iron works. That between Merthyr Tydvil and Cardiff was the longest and most important, and it had been at work for some years. It had probably occurred to Trevithick that here was a fine opportunity for putting to practical test the powers of the locomotive, and he proceeded to construct one accordingly in the workshops at Pen-y-darran.

This first railway locomotive was finished and tried upon the Merthyr tram-road on the 21st of February, 1804. It had a cylindrical wrought-iron boiler with flat ends. The furnace and flue were inside the boiler, the flue returning, having its exit at the same end at which it entered, so as to increase the heating surface. The cylinder, $4\frac{1}{2}$ in. in diameter, was placed horizontally in the end of the boiler, and the waste steam was thrown into the stack. The wheels were worked in the same manner as in the carriage engine already described; and a fly-wheel was added on one side to secure a continuous

rotary motion at the end of each stroke of the piston. The pressure of the steam was about 40 lbs. on the inch. The engine ran upon four wheels, coupled by cog-wheels, and those who remember the engine say that the four wheels were smooth.



TREVITHICK'S HIGH PRESSURE TRAM-ENGINE.

On the first trial, this engine drew for a distance of nine miles ten tons of bar iron, together with the necessary carriages, water, and fuel, at the rate of five-and-a-half miles an hour. Rees Jones, an old engine fitter, who helped to erect the engine, and was alive in 1858, gave Mr. Menelaus the following account of its performances:—"When the engine was finished, she was used for bringing down metal from the Old Forge. She worked very well; but frequently, from her weight, broke the tram plates, and also the hooks between the trams. After working for some time in this way, she took a journey of iron from Pen-y-darran down the Basin-road, upon which road she was intended to work. On the journey she broke a great many of the tram plates; and, before reaching the Basin, she ran off the road, and was brought back to Pen-y-darran by horses. The engine was never used as a locomotive after this.

But she was used as a stationary engine, and worked in this way for several years."

So far as the locomotive was concerned it was a remarkable success. The defect lay not in the engine, so much as in the road. This was formed of plate rails of cast iron, with a guiding flange upon the rail instead of on the engine wheels, as in the modern locomotive. the rails were also of a very weak form, considering the quantity of iron in them; and, though they were sufficient to bear the loaded waggons mounted upon small wheels, as ordinarily drawn along them by horses, they were found quite insufficient to bear the weight of Trevithick's engine. To relay the road of sufficient strength would have involved a heavy outlay, which the owners were unwilling to incur, not yet perceiving the advantage, in an economical point of view, of employing engine in lieu of horse power. The locomotive was accordingly taken off the road, and the experiment, successful though it had been, was brought to an end.

Trevithick had, however, by means of his Pen-y-darran engine, in a great measure solved the problem of steam locomotion on railways. He had produced a compact engine, working on the high pressure principle, capable of carrying fuel and water sufficient for a journey of considerable length, and of drawing loaded waggons at five-and-a-half miles an hour. He had shown by his smooth-wheeled locomotive that the weight of the engine had given sufficient adhesion for the haulage of the load. He had discharged the steam into the chimney, though not for the purpose of increasing the draught, as he employed bellows for that purpose. It appears, however, that Trevithick's friend, Mr. Davies Gilbert, afterwards President of the Royal Society, especially noticed the effect of discharging the waste steam into the chimney of the Pen-y-darran engine. He observed that when the engine moved, at each puff the

fire brightened, while scarcely any visible steam or smoke came from the chimney.

Mr. Gilbert published the result of his observations in 'Nicholson's Journal' for September, 1805, and the attention of Mr. Nicholson, the editor, having thereby been called to the subject, he proceeded to make a series of experiments, the result of which was that in 1806 he took out a patent for a steam-blasting apparatus, by which he proposed to apply high-pressure steam to force along currents of air for various useful purposes, including the urging of furnace and other fires. It is thus obvious that the principle of the blast-pipe was known to both Gilbert and Nicholson at this early period; but it is somewhat remarkable that Trevithick himself should have remained sceptical as to its use, for as late as 1815, we find him taking out a patent, in which, among other improvements, he included a method of urging his fire by fanners, similar to a winnowing machine.

In the mean time Trevithick occupied himself in carrying on the various business of a general engineer, and was ready to embark in any enterprise likely to give scope for his inventive skill. In whatever work he was employed, he was sure to introduce new methods and arrangements, if not new inventions. He was full of speculative enthusiasm, a great theorist, and yet an indefatigable experimenter. At the beginning of 1806—the year after the locomotive had been taken off the Merthyr Tydvil tram-road—he made arrangements for entering into a contract for ballasting all the shipping in the Thames. At the end of a letter written by him on the 18th of February in that year to Davies Gilbert, respecting a *puffer* engine, he said, "I am about to enter into a contract with the Trinity Board for lifting up ballast out of the bottom of the Thames for all the shipping. The first quantity stated was 300,000 tons a year, but now they state 500,000 tons. I am to do

nothing but wind up the chain for 6*l.* per ton, which is now done by men. They never lift it above twenty-five feet high—a man will now get up ten tons for 7*s.* My engine at Dalcoath has lifted about 100 tons that height with one bushel of coals. I have two engines already finished for the purpose, and shall be in town in about fifteen days for to set them to work. They propose to engage with me for twenty-one years.”¹ The contract was not, however, entered into. Trevithick quarrelled with the capitalists who had found the money for the trials, and the ‘Blazer’ and ‘Plymouth,’ the vessels in which his engines and machinery had been fitted, fell into other hands.

Trevithick, nevertheless, seems to have been on the highway to fortune, for, at the beginning of 1806, he had received orders for nine engines in one month, all for Cornwall; and he expected orders for four others. He had also in view the construction of a railway; but nothing came of this project. More hopeful still, as regarded immediate returns, was the Cornish engine business, which presented a very wide field. Now that the trade had been thrown open by the expiry of Boulton and Watt’s patent, competition had sprung up, and many new makers and inventors of engines were ready to supply the demand.

Among the most prominent of these were Trevithick and Woolf. Trevithick was the most original and speculative, Woolf the most plodding and practical, and the most successful. Trevithick’s ingenuity exhibited itself in his schemes for working Boulton and Watt’s pumping-engine by high-pressure steam, by means of his cylindrical wrought-iron boiler. He proposed to expand the steam down to low pressure previous to condensation, thereby anticipating by many years the Cornish engine now in use. The suggestion was not, however, then acted

¹ Weale’s ‘Papers on Engineering,’ vol. i., ‘On the Dredging Machine,’ p. 7.

on, and he fell back on his original design of a simple non-condensing high-pressure engine. One of these was erected at Dalcoath mine to draw the ores there. It was called "the puffer" by the mining people, from its puffing the steam direct into the air; but its performances did not compare favourably with those of the ordinary condensing engines of Boulton and Watt, and the engine did not come into general use.

Trevithick was not satisfied to carry on a prosperous engine business in Cornwall. Camborne was too small for him, and the Cornish mining district presented too limited a field for his ambitious spirit. So he came to London, the Patent-office drawing him as the loadstone does the needle. In 1808 he took out two patents, one for "certain machinery for towing, driving, or forcing and discharging ships and other vessels of their cargoes," and the other for "a new method of stowing cargoes of ships." In 1809 he took out another patent for constructing docks, ships, &c., and propelling vessels.

In these patents, Trevithick was associated with one Robert Dickinson, of Great Queen-street, but his name stands first in the specification, wherein he describes himself as "of Rotherhithe, in the county of Surrey, engineer." By the first of these patents he proposed to tow vessels by means of a rowing wheel shaped like an undershot water-wheel furnished with floats placed vertically in a box, and worked by a steam-engine, which he also proposed to employ in the loading and unloading of the vessel, but it is not known that the plan was ever introduced into practical use. The patent of 1809 included a floating dock or caisson made of wrought-iron plates, in which a ship might be docked while afloat, and, after the water had been pumped out of the caisson, repaired without moving her stores, masts, or furniture. This invention has since been carried out in practice by the Messrs. Rennie in the floating iron dock which they have recently constructed

for the Spanish Government. Another invention included in the specification, was the construction of merchant and war ships of wrought-iron plates strongly rivetted together, with their decks supported by wrought-iron beams, and the masts, bowsprits, and booms also of tubular wrought-iron, thereby anticipating by many years the form and structure of vessels now in common use.

While Trevithick lived at Rotherhithe, he entered upon a remarkable enterprise—no less than the construction of a tunnel under the Thames—a work which was carried out with so much difficulty by Sir Isambard Brunel some twenty years later. Several schemes had been proposed at different times for connecting the two banks of the river by an underground communication. As early as 1798, Ralph Dodd suggested a tunnel under the Thames between Gravesend and Tilbury, and in 1802 Mr. Vazie projected a tunnel from Rotherhithe to Limehouse. A company was formed to carry out the latter scheme, and a shaft was sunk, at considerable expense, to a depth of 76 feet below high-water. The works were from time to time suspended, and it was not until the year 1807, when Trevithick was appointed engineer of the work, that arrangements were made for proceeding with the driftway under the bed of the Thames. After about five months working, the drift was driven for a length of 953 feet, when the roof gave way and the water burst in. The opening was, however, plugged by clay in bags thrown into the river, and the work proceeded until 1028 feet had been accomplished. Then the water burst in again, and the process of plugging and pumping the water out of the drift was repeated. After seventy more feet had been added to the excavation, there was another irruption, which completely flooded the driftway, and the water rose nearly to the top of the shaft. This difficulty was, however, again overcome, and with great danger twenty more feet were accomplished; but the bursts of water became

so frequent and unmanageable that at length the face of the drift was timbered up and the work abandoned. Trevithick, who had been promised a reward of 1000*l.* if the tunnel succeeded, thus lost both his labour and his reward. The only remuneration he received from the Company was a hundred guineas, which were paid to him according to agreement, provided he carried the excavation to the extent of 1000 yards, which he did.

Trevithick returned to Camborne in 1809, where we find him busily occupied with new projects, and introducing his new engine worked by water-power, the first of which was put up at the Druid mine, as well as in perfecting his high-pressure engine and its working by expansion. One of the first of such engines was erected at the Huel Prosper mine, of which he was engineer; and this, as well as others subsequently constructed on the same principle, proved quite successful.

In 1815, Trevithick took out a further patent, embodying several important applications of steam-power. One of these consisted in "causing steam of a high pressure to spout out against the atmosphere, and by its recoiling force to produce motion in a direction contrary to the issuing steam, similar to the motion produced in a rocket, or to the recoil of a gun." This was, however, but a revival of the ancient *Œolipile* described by Hero, and known as "Hero's engine."

In another part of his specification, Trevithick described the screw-propeller as "a screw or a number of leaves placed obliquely round an axis similar to the vanes of a smoke-jack, which shall be made to revolve with great speed in a line with the required motion of the ship, or parallel to the same line of motion." In a second part of the specification, he described a plunger or pole-engine in which the steam worked at high-pressure. The first engine of this kind was erected by Trevithick at Herland, in 1815, but the result was not equal to his expectations, though the principle was afterwards suc-

cessfully applied by Mr. Wm. Sims, who purchased the patent right.

In this specification, Trevithick also described a tubular boiler of a new construction for the purpose of more rapidly producing high-pressure steam, the heating-surface being extended by constructing the boiler of a number of small perpendicular tubes, closed at the bottom, but all opening at the top into a common reservoir, from whence they received their water, and into which the steam of all the tubes was united.

While Trevithick was engaged in these ingenious projects, an event occurred which, though it promised to issue in the most splendid results, proved the greatest misfortune of his life. We refer to his adventures in connection with the gold mines of Peru. Many of the richest of them had been drowned out, the pumping machinery of the country being incapable of clearing them of water. The districts in which they were situated were almost inaccessible to ordinary traffic, all transport being conducted on the backs of men or of mules. The parts of an ordinary condensing engine were too ponderous to be carried up these mountain heights, and it was evident that unless some lighter sort of engine could be employed, the mines in question must be abandoned.

Mr. Uvillé, a Swiss gentleman interested in South American mining, came over from Peru to England in 1811 for the purpose of making inquiries about such an engine, but he received no encouragement. He was about to return to Lima, in despair of accomplishing his object, when, one day accidentally passing a shop-window in Fitzroy Square, he caught sight of an engine exposed for sale which immediately attracted his attention. It was the engine constructed by Trevithick for his first locomotive, which he had sold some years before, on the sudden abandonment of the exhibition of its performances in London. Mr. Uvillé was so much pleased

with its construction and mode of action that he at once purchased it and took it out with him to South America. Arrived there, he had the engine transported across the mountains, to the rich mining district of Pasco, about a hundred miles north of Lima, to try its effects on the highest mountain ridges.

The experiment was so satisfactory that an association of influential gentlemen was immediately formed to introduce the engine on a large scale and enter into contracts with the mine-owners for clearing their shafts of the water which drowned them. The Viceroy of Peru approved the plan, and the association despatched Mr. Uvillé to England to purchase the requisite engines. He took ship for Falmouth about the end of 1812, for the purpose of finding out Trevithick. He only knew of Trevithick by name, and that he lived in Cornwall, but nothing further. Being full of his subject, however, he could not refrain from conversing on the subject with the passengers on board the ship by which he sailed, and it so happened that one of them—a Mr. Teague—was a relative of Trevithick, who promised, shortly after their landing, to introduce him to the inventor.

Mr. Teague was as good as his word, and in the course of a few days Uvillé was enabled to discuss the scheme with Trevithick at his own house at Camborne, where he still resided. The result was an order for a number of high-pressure pumping-engines, which were put in hand at once; and on the 1st of September, 1814, nine of them were shipped at Portsmouth for Lima, accompanied by Uvillé and three Cornish engineers, one of whom was William Bull, of Chasewater, Trevithick's first partner.

The engines reached Lima in safety, and were welcomed by a royal salute and with public rejoicings. Such, however, was the difficulty of transporting the materials across the mountains, that it was not until the middle of the year 1816 that the first engine was erected and set

to work to pump out the shaft of the Santa Rosa mine, in the royal mineral territory of Yauricocha. The association of gentleman to whom the engines belonged, had entered into a contract to drain this amongst other mines, on condition of sharing in the gross produce of the ores to the extent of about 25 per cent. of the whole amount raised. The result of the first working of the engine was so satisfactory, that the projectors were filled with no less astonishment than delight, and they characterised the undertaking as one from which they "anticipated a torrent of silver that would fill surrounding nations with astonishment."

In the mean time Trevithick was proceeding at home with the manufacture of the remaining engines, as well as new coining apparatus for the Peruvian mint, and furnaces for purifying silver ore by fusion: and with these engines and apparatus he set sail for America in October, 1816, reaching Lima in safety in the following February. He was received with almost royal honours. The government 'Gazette' officially announced "the arrival of Don Ricardo Trevithick, an eminent professor of mechanics, machinery, and mineralogy, inventor and constructor of the engines of the last patent, and who directed in England the execution of the machinery now at work in Pasco." The Lord Warden was ordered by the Viceroy to escort Trevithick to the mines accompanied by a guard of honour. The news of his expected arrival there occasioned great rejoicings; and the chief men of the district came down the mountains to meet and welcome him. Uvillé wrote to his associates that Trevithick had been sent out "by heaven for the prosperity of the mines, and that the Lord Warden proposed to erect his statue in solid silver." Trevithick himself wrote home to his friends in Cornwall that he had before him the prospect of almost boundless wealth, having, in addition to his emoluments as patentee, obtained a fifth share in the Lima Company, which, he

expected, on a moderate computation, would yield him about 100,000*l.* a-year!

But these brilliant prospects were suddenly blasted by the Peruvian revolution which broke out in the following year. While Mr. Boaze was reading his paper¹ before the Royal Geological Society of Cornwall, in which these anticipations of Trevithick's fame and fortune were so glowingly described, Lord Cochrane was on his way to South America to take the command of the Chilian fleet in its attack of the ports of Peru, still in the possession of the Spaniards.

Towards the end of 1818, Lord Cochrane hoisted his flag, and shortly after proceeded to assail the Spanish fleet in Callao harbour. This proved the signal for a general insurrection, during the continuance of which the commercial and industrial affairs of the province were completely paralysed. The pumping-engines of Trevithick were now of comparatively little use in pumping water out of mines in which the miners would no longer work. Although Lima was abandoned by the Spaniards towards the end of 1821, the civil war continued to rage for several years longer, until at length the independence of Peru was achieved; but it was long before the population were content to settle down as before, and follow the ordinary pursuits of industry and commerce.

The result to Trevithick was, that he and his partners in the Mining Company were consigned to ruin. It has been said that the engineer joined the patriotic party, and invented for Lord Cochrane an ingenious gun-carriage centred and equally balanced on pivots, and easily worked by machinery; but of this no mention is made by Lord Cochrane in his 'Memoirs.' The patriots kept Trevithick on the mountains as a sort of

¹ Paper read by Henry Boaze, Esq.,
'On Captain Trevithick's Adventures,' at the Anniversary Meeting of

September, 1817.—'Transactions of
Royal Geological Society of Cornwall,'
vol. i. p. 212.

patron and protector of their interests ; but for this very reason he became proportionately obnoxious to the royalists, who, looking upon him as the agent through whom the patriotic party obtained the sinews of war, destroyed his engines, and broke up his machinery wherever they could. At length he determined to escape from Peru, and fled northward across the mountains, accompanied by a single friend, making for the Isthmus of Panama. In the course of this long, toilsome, and dangerous journey, he encountered great privations ; he slept in the forest at night, travelled on foot by day, and crossed the streams by swimming. At length, his clothes torn, worn, and hanging almost in shreds, and his baggage all lost, he succeeded in reaching the port of Cartagena on the Gulf of Darien, almost destitute.

Here he encountered Robert Stephenson, who was waiting at the one inn of the place until a ship was ready to set sail for England. Stephenson had finished his engagement with the Colombian Mining Company for which he had been working, and was eager to return home. When Trevithick entered the room in which he was sitting, Stephenson at once saw that he was an Englishman. He stood some six feet in height, and, though well proportioned when in ordinary health, he was now gaunt and hollow, the picture of privation and misery.

Stephenson made up to the stranger, and was not a little surprised to find that he was no other than the famous engineer, Trevithick, the builder of the first patent locomotive, and who, when he last heard of him, was accumulating so gigantic a fortune in Peru. Though now penniless, Trevithick was as full of speculation as ever, and related to Stephenson that he was on his way home for the purpose of organizing another gold-mining company, which should make the fortunes of all who took part in it. He was, however, in the mean time unable to pay for his passage, and Stephenson lent

him the requisite money for the purpose of reaching his home in Cornwall.

As there was no vessel likely to sail for England for some time, Stephenson and Trevithick took the first ship bound for New York. After a stormy passage, full of adventure and peril, the vessel was driven on a lee shore, and the passengers and crew barely escaped with their lives. On reaching New York, Trevithick immediately set sail for England, and he landed safe at Falmouth in October, 1827, bringing back with him a pair of silver spurs, the only remnant which he had preserved of those "torrents of silver" which his engines were to raise from the mines of Peru.

Immediately on his return home, Trevithick memorialized the Government for some remuneration adequate to the great benefit which the country had derived from his invention of the high-pressure steam-engine, and his introduction of the cylindrical boiler. The petition was prepared in December, 1827, and was cheerfully signed by the leading mine-owners and engineers in Cornwall; but there their efforts on his behalf ended.

He took out two more patents—one, in 1831, for a new method of heating apartments, and another, in 1832, for improvements in the steam-engine, and the application of steam-power to navigation and locomotion; but neither of them seems to have proved of any service to him. His new improvement in the steam-engine was neither more nor less than the invention of an apparatus similar to that which has quite recently come into use for employing superheated steam as a means of working the engine more effectively and economically. The patent also included a method of propelling ships by ejecting water through a tube with great force and speed in a direction opposite to the course of the vessel, a method since re-invented in many forms, though not yet successfully introduced in practice.

Strange to say, though Trevithick had been so inti-

mately connected with the practical introduction of the Locomotive, he seems to have taken but little interest in its introduction upon railways, but confined himself to advocating its employment on common roads as its most useful application.¹ Though in many things he was before his age, here he was unquestionably behind it. But Trevithick was now an old man; his constitution was broken, and his energy worked out. Younger men were in the field, less ingenious and speculative but more practical and energetic; and in the blaze of their fame the Cornish engineer was forgotten.

During the last year of his life, Trevithick resided at Dartford, in Kent. He had induced the Messrs. Hall, the engineers of that place, to give him an opportunity of testing the value of his last invention—that of a vessel driven by the ejection of water through a tube,—and he went there to superintend the construction of the necessary engine and apparatus. The vessel was duly fitted up, and several experiments were made with it in the adjoining creek, but it did not realise a speed of more than four miles an hour. Trevithick, being of opinion that the engine-power was insufficient, proceeded to have a new engine constructed, to the boiler of which, within the furnace, numerous tubes were attached, round which the fire played. So much steam was raised by this arrangement, that the piston “blew;” but still the result of the experiments was unsatisfactory. While labouring at these inventions, and planning new arrangements, never to be carried out, the engineer was seized by the

¹ On the 12th of August, 1831, by which time the Liverpool and Manchester line was in full work, Trevithick appeared as a witness before the select committee of the House of Commons on the employment of steam-carriages on common roads. He said, “he had been abroad a good many years, and had had nothing to do with

steam-carriages until very lately. He had it now, however, in contemplation to do a great deal on common roads, and, with that view, had taken out a patent for an entirely new engine, the arrangements in which were calculated to obviate all the difficulties which had hitherto stood in the way of travelling on common roads.”

illness of which he died, on the 22nd of April, 1833, in the 62nd year of his age.

As Trevithick was entirely without means at his death, besides being some sixty pounds in debt to the landlord of the Bull Inn, where he had been lodging for nearly a year, he would probably have been buried at the expense of the parish, but for the Messrs. Hall and their workmen, who raised a sum sufficient to give the "great inventor" a decent burial; and they followed his remains to the grave in Deptford Churchyard, where he lies without a stone to mark his resting-place.

There can be no doubt as to the great mechanical ability of Trevithick. He was a man of original and intuitive genius in invention. Every mechanical arrangement which he undertook to study, issued from his hands transformed and improved. But there he rested. He struck out many inventions, and left them to take care of themselves. His great failing was the want of perseverance. His mind was always full of projects; but his very genius led him astray in search of new things, while his imagination often outran his judgment. Hence his life was but a series of beginnings.

Look at the extraordinary things that Trevithick began. He made the first railway locomotive, and cast the invention aside, leaving it to others to take it up and prosecute it to a successful issue. He introduced, if he did not invent, the cylindrical boiler and the high-pressure engine, which increased so enormously the steam-power of the world; but he reaped the profits of neither. He invented an oscillating engine and a screw-propeller; he took out a patent for using superheated steam, as well as for wrought-iron ships, and wrought-iron floating docks; but he left it to others to introduce these several inventions.

Never was there such a series of splendid mechanical beginnings. He began a Thames Tunnel and abandoned it. He went to South America with the prospect of making a gigantic fortune, but he had scarcely begun to gather in his gold than he was forced to fly, and returned home destitute. This last event, however, was a misfortune which no efforts on his part could have prevented. But even when he had the best chances, Trevithick threw them away. When he had brought his road locomotive to London to exhibit, and was beginning to excite the curiosity of the public respecting it, he suddenly closed the exhibition in a fit of caprice, removed the engine, and returned to Cornwall in a tiff. The failure also of the railroad on which his locomotive travelled, so provoked him, that he at once abandoned the enterprise in disgust.

There may have been some moral twist in the engineer's character, into which we do not seek to pry; but it seems clear that he was wanting in that resolute perseverance, that power of fighting an up-hill battle, without which no great enterprise can be conducted to a successful issue. In this respect the character of Richard Trevithick presents a remarkable contrast to that of George Stephenson, who took up only one of the many projects which the other had cast aside, and by dint of application, industry, and perseverance, carried into effect one of the most remarkable but peaceful revolutions which has ever been accomplished in any age or country.

We now proceed to describe the history of this revolution in connection with the Life of George Stephenson, and to trace the locomotive through its several stages of development until we find it recognized as one of the most vigorous and untiring workers in the entire world of industry.

LIVES
OF
GEORGE AND ROBERT STEPHENSON.



NEWCASTLE-UPON-TYNE AND THE HIGH-LEVEL BRIDGE.

[By R P Leitch, after his original drawing.]

L I F E
OF
GEORGE STEPHENSON, &c.

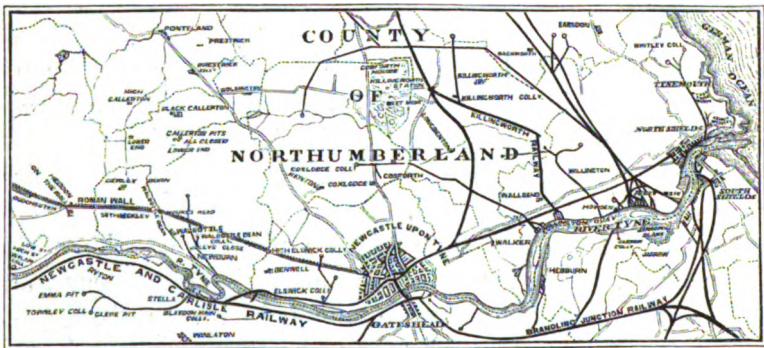
CHAPTER I.

THE NEWCASTLE COAL-FIELD — GEORGE STEPHENSON'S
EARLY YEARS.

IN no quarter of England have greater changes been wrought by the successive advances made in the practical science of engineering than in the extensive colliery districts of the North, of which Newcastle-upon-Tyne is the centre and the capital.

In ancient times the Romans planted a colony at Newcastle, throwing a bridge across the Tyne near the site of the low-level bridge shown in the prefixed engraving, and erecting a strong fortification above it on the high ground now occupied by the Central Railway Station. North and north-west lay a wild country, abounding in moors, mountains, and morasses, but occupied to a certain extent by fierce and barbarous tribes. To defend the young colony against their ravages, a strong wall was built by the Romans, extending from Wallsend on the north bank of the Tyne, a few miles below Newcastle, across the country to Burgh-upon-Sands on the Solway Frith. The remains of the wall are still to be traced in the less populous hill-districts of Northumberland. In the neighbourhood of Newcastle they have been gradually effaced by the works of succeeding generations, though the "Wallsend" coal consumed in our household fires still serves to remind us of the great Roman work

After the withdrawal of the Romans, Northumbria became planted by immigrant Saxons from North Germany and Norsemen from Scandinavia, whose Eorls or Earls made Newcastle their principal seat. Then came the Normans, from whose *New Castle*, built some eight hundred years since, the town derives its present name. The keep of this venerable structure, black with age and smoke, still stands entire at the northern end of the noble high-level bridge—the utilitarian work of modern times thus confronting the warlike relic of the older civilisation.



MAP OF NEWCASTLE DISTRICT.

The nearness of Newcastle to the Scotch Border was a great hindrance to its security and progress in the middle ages of English history. Indeed, the district between it and Berwick continued to be ravaged by moss-troopers long after the union of the Crowns. The gentry lived in their strong Peel castles; even the larger farm-houses were fortified; and bloodhounds were trained for the purpose of tracking the cattle-reavers to their retreats in the hills. The Judges of Assize rode from Carlisle to Newcastle guarded by an escort armed to the teeth. A tribute called "dagger and protection money" was annually paid by the Sheriff of Newcastle for the purpose of providing daggers and other weapons for the escort; and, though the need of such protection has

long since ceased, the tribute continues to be paid in broad gold pieces of the time of Charles the First.

Until about the middle of last century the roads across Northumberland were little better than horse-tracks, and not many years since the primitive agricultural cart with solid wooden wheels was almost as common in the western parts of the county as it is in Spain now. The track of the old Roman road long continued to be the most practicable route between Newcastle and Carlisle, the traffic between the two towns having been carried on pack-horses until within a comparatively recent period.

Since that time great changes have taken place on the Tyne. When wood for firing became scarce and dear, and the forests of the South of England were found inadequate to supply the increasing demand for fuel, attention was turned to the rich stores of coal lying underground in the neighbourhood of Newcastle and Durham. It then became an article of increasing export, and "seacoal" fires gradually superseded those of wood. Hence an old writer describes Newcastle as "the Eye of the North, and the Hearth that warmeth the South parts of this kingdom with Fire." Fuel became the staple product of the district, the quantity exported increasing from year to year, until the coal raised from these northern mines amounts to upwards of sixteen millions of tons a year, of which not less than nine millions are annually conveyed away by sea.

Newcastle has in the mean time spread in all directions far beyond its ancient boundaries. From a walled mediæval town of monks and merchants, it has been converted into a busy centre of commerce and manufactures inhabited by nearly 100,000 people. It is no longer a Border fortress—a "shield and defence against the invasions and frequent insults of the Scots" as described in ancient charters—but a busy centre of peaceful industry, and the outlet for a vast amount of steam-power, which is exported in the form of coal to all parts of the

world. Newcastle is in many respects a town of singular and curious interest, especially in its older parts, which are full of crooked lanes and narrow streets, wynds, and chares, formed by tall, antique houses, rising tier above tier along the steep northern bank of the Tyne, as the similarly precipitous streets of Gateshead crowd the opposite shore.

All over the coal region, which extends from the Coquet to the Tees, about fifty miles from north to south, the surface of the soil exhibits the signs of extensive underground workings. As you pass through the country at night, the earth looks as if it were bursting with fire at many points; the blaze of coke-ovens, iron-furnaces, and coal-heaps reddening the sky to such a distance that the horizon seems like a glowing belt of fire.

Among the upper-ground workmen employed at the coal-pits, the principal are the firemen, enginemen, and brakesmen, who fire and work the engines, and superintend the machinery by means of which the collieries are worked. Previous to the introduction of the steam-engine, the usual machine employed for the purpose was what is called a "gin." The gin consists of a large drum placed horizontally, round which ropes attached to buckets and corves are wound, which are thus drawn up or sent down the shafts by a horse travelling in a circular track or "gin race." This method was employed for drawing up both coals and water, and it is still used for the same purpose in small collieries; but where the quantity of water to be raised is great, pumps worked by steam-power are called into requisition.

Newcomen's atmospheric engine was first made use of to work the pumps; and it continued to be so employed long after the more powerful and economical condensing engine of Watt had been invented. In the Newcomen or "fire engine," as it was called, the power is produced by the pressure of the atmosphere forcing down the piston in the cylinder, on a vacuum being produced

within it by condensation of the contained steam by means of cold-water injection. The piston-rod is attached to one end of a lever, while the pump-rod works in connexion with the other,—the hydraulic action employed to raise the water being exactly similar to that of a common sucking-pump.

The working of a Newcomen engine was a clumsy and apparently a very painful process, accompanied by an extraordinary amount of wheezing, sighing, creaking, and bumping. When the pump descended, there was heard a plunge, a heavy sigh, and a loud bump: then, as it rose, and the sucker began to act, there was heard a creak, a wheeze, another bump, and then a rush of water as it was lifted and poured out. Where engines of a more powerful and improved description were used, as is now the case, the quantity of water raised is enormous—as much as a million and a half gallons in the twenty-four hours.

The pitmen, or “the lads below,” who work out the coal below ground, are a peculiar class, quite distinct from the workmen on the surface. They are a people with peculiar habits, manners, and character, as much so as fishermen and sailors, to whom, indeed, they bear, in some respects, a considerable resemblance. Some fifty years since, they were a much rougher and worse educated class than they are now; hard workers, but very wild and uncouth; much given to “steeks,” or strikes; and distinguished, in their hours of leisure and on pay-nights, for their love of cock-fighting, dog-fighting, hard drinking, and cuddy races. The pay-night was a fortnightly saturnalia, in which the pitman’s character was fully brought out, especially when the “yel” was good. Though earning much higher wages than the ordinary labouring population of the upper soil, the latter did not mix nor intermarry with them; so that they were left to form their own communities, and hence their marked peculiarities as a class. Indeed, a sort of

traditional disrepute seems long to have clung to the pitmen, arising perhaps from the nature of their employment, and from the circumstance that the colliers were among the last classes enfranchised in England, as they were certainly the last in Scotland, where they continued bondmen down to the end of last century. The last thirty years, however, have worked a great improvement in the moral condition of the Northumbrian pitmen; the abolition of the twelve months' bond to the mine, and the substitution of a month's notice previous to leaving, having given them greater freedom and opportunity for obtaining employment; and day-schools and Sunday-schools, together with the important influences of railways, have brought them fully up to a level with the other classes of the labouring population.

The coals, when raised from the pits, are emptied into the waggons placed alongside, from whence they are sent along the rails to the staiths erected by the riverside, the waggons sometimes descending by their own gravity along inclined planes, the waggoner standing behind to check the speed by means of a convoy or wooden brake bearing upon the rims of the wheels. Arrived at the staiths, the waggons are emptied at once into the ships waiting alongside for cargo. Any one who has sailed down the Tyne from Newcastle Bridge cannot but have been struck with the appearance of the immense staiths, constructed of timber, which are erected at short distances from each other on both sides of the river.

But a great deal of the coal shipped from the Tyne comes from above-bridge, where sea-going craft cannot reach, and is floated down the river in "keels," in which the coals are sometimes piled up according to convenience when large, or, when the coal is small or tender, it is conveyed in tubs to prevent breakage. These keels are of a very ancient model,—perhaps the oldest extant in England: they are even said to be of the same build as

those in which the Norsemen navigated the Tyne centuries ago. The keel is a tubby, grimy-looking craft, rounded fore and aft, with a single large square sail, which the keel-bullies, as the Tyne watermen are called, manage with great dexterity; the vessel being guided by the aid of the "swape," or great oar, which is used as a kind of rudder at the stern of the vessel. These keelmen are an exceedingly hardy class of workmen, not by any means so quarrelsome as their designation of "bully" would imply—the word being merely derived from the obsolete term "boolie," or beloved, an appellation still in familiar use amongst brother workers in the coal districts. One of the most curious sights on the Tyne is the fleet of hundreds of these black-sailed, black-hulled keels, bringing down at each tide their black cargoes for the ships at anchor in the deep water at Shields and other parts of the river below Newcastle.

These preliminary observations will perhaps be sufficient to explain the meaning of many of the occupations alluded to, and the phrases employed, in the course of the following narrative, some of which might otherwise have been comparatively unintelligible to the reader.

The colliery village of Wylam is situated on the north bank of the Tyne, about eight miles west of Newcastle. The Newcastle and Carlisle Railway runs along the opposite bank; and the traveller by that line sees the usual signs of a colliery in the unsightly pumping-engines surrounded by heaps of ashes, coal-dust, and slag; while a neighbouring iron-furnace in full blast throws out dense smoke and loud jets of steam by day and lurid flames at night. These works form the nucleus of the village, which is almost entirely occupied by coal-miners and iron-furnacemen. The place is remarkable for its large population, but not for its cleanness or neatness as a village; the houses, as in most colliery villages, being the property of the owners

or lessees, who employ them in temporarily accommodating the workpeople, against whose earnings there is a weekly set-off for house and coals. About the end of last century, the estate of which Wylam forms part, belonged to Mr. Blckett, a gentleman of considerable celebrity in coal-mining, then more generally known as the proprietor of the 'Globe' newspaper.



WYLAM COLLIERY AND VILLAGE. [By R. P. Leitch.]

There is nothing to interest one in the village itself. But a few hundred yards from its eastern extremity stands a humble detached dwelling, which will be interesting to many as the birthplace of one of the most remarkable men of our times—George Stephenson, the Railway Engineer. It is a common, two-storied, red-tiled, rubble house, portioned off into four labourers' apartments. It is known by the name of High Street House, and was originally so called because it stands by the side of what used to be the old riding post-road or street between Newcastle and Hexham, along which

the post was carried on horseback within the memory of persons living.

The lower room in the west end of this house was the home of the Stephenson family; and there George Stephenson was born, the second of a family of six children, on the 9th of June, 1781. The apartment is now, what it was then, an ordinary labourer's dwelling,



HIGH-STREET HOUSE, WYLAM [By R. P. Leitch.]

—its walls are unplastered, its floor is of clay, and the bare rafters are exposed overhead.

Robert Stephenson, or “Old Bob,” as the neighbours familiarly called him, and his wife Mabel, were a respectable couple, careful and hard-working. Robert Stephenson's father was a Scotchman, who came into England in the capacity of a gentleman's servant.¹

¹ A tradition exists in the family that Robert Stephenson's father came across the Border on the loss of considerable property. Miss Stephenson, the daughter of Robert's third son

John, has stated that a suit was commenced for recovery of the property, but was dropped for want of the requisite means to prosecute it.

Mabel, his wife, was the second daughter of Robert Carr, a dyer at Ovingham. The Carrs were for several generations the owners of a house in that village adjoining the churchyard; and the family tombstone may still be seen standing against the east end of the chancel of the parish church, underneath the centre lancet window; as the tombstone of Thomas Bewick, the wood-engraver, occupies the western gable. Mabel Stephenson was a woman of somewhat delicate constitution, and troubled occasionally, as her neighbours said, with "the vapours." But those who remembered her concurred in describing her as "a real canny body." And a woman of whom this is said by general consent in the Newcastle district may be pronounced a worthy person indeed; for it is about the highest praise of a woman which Northumbrians can express.

For some time after their marriage, Robert resided with his wife at Walbottle, a village situated between Wylam and Newcastle, where he was employed as a labourer at the colliery; after which the family removed to Wylam, where he found employment as fire-man of the old pumping-engine at that colliery.

George Stephenson was the second of a family of six children.¹

It does not appear that the birth of any of the children was registered in the parish books, the author having

¹ The family bible of Robert and Mabel Stephenson, which seems to have come into their possession in November, 1790, contains the following record of the births of these children, evidently written by one hand and at one time:—

"A Rechester of the children belonging Robert and Mabel Stepheson—

"James Stepheeson Was Born March the 4 day 1779

"George Stepheeson Was Born June 9 day 1781

"Elender Stepheeson Was Born April the 16 day 1784.

"Robert Stepheeson Was Born March the 10 day 1788

"John Stepheeson Was Born November the 4 day 1789

"Ann Stepheeson Was Born July the 19 day 1792."

Of the two daughters, Eleanor married Stephen Liddell, afterwards employed in the Locomotive Factory in Newcastle. Ann married John Nixon, with whom she emigrated to the United States; she died at Pittsburg in 1860. John Stephenson was accidentally killed at the Locomotive Factory in January, 1831.

made an unsuccessful search in the registers of Ovingham and Heddon-on-the-Wall to ascertain the fact.

An old Wylam collier, who remembered George Stephenson's father, thus described him:—"Geordie's fayther war like a peer o' deals nailed thegither, an' a bit o' flesh i' th' inside; he war as queer as Dick's hatband—went thrice aboot, an' wudn't tie. His wife Mabel war a delicat' boddie, an' varry flighty. They war an honest family, but sair hadden doon i' th' world." Indeed, the earnings of old Robert did not amount to more than twelve shillings a week; and, as there were six children to maintain, the family, during their stay at Wylam, were necessarily in very straitened circumstances. The father's wages being barely sufficient, even with the most rigid economy, for the sustenance of the household, there was little to spare for clothing, and nothing for education, so that none of the children were sent to school.

Old Robert was a general favourite in the village, especially amongst the children, whom he was accustomed to draw about him while tending the engine-fire, and feast their young imaginations with tales of Sinbad the Sailor and Robinson Crusoe, besides others of his own invention; so that "Bob's engine-fire" came to be the most popular resort in the village. Another feature in his character, by which he was long remembered, was his affection for birds and animals; and he had many tame favourites of both sorts, which were as fond of resorting to his engine-fire as the boys and girls themselves. In the winter time he had usually a flock of tame robins about him; and they would come hopping familiarly to his feet to pick up the crumbs which he had saved for them out of his humble dinner. At his cottage he was rarely without one or more tame black-birds, which flew about the house, or in and out at the door. In summer time he would go birdnesting with his children; and one day he took his little boy George

to see a blackbird's nest for the first time. Holding him up in his arms, he let the wondering boy peep down, through the branches held aside for the purpose, into a nest full of young birds—a sight which the boy never forgot, but used to speak of with delight to his intimate friends when he himself had grown an old man.

The boy George led the ordinary life of working people's children. He played about the doors; went birdnesting when he could; and ran errands to the village. He was also an eager listener, with the other children, to his father's curious tales; and he early imbibed from him his affection for birds and animals. In course of time he was promoted to the office of carrying his father's dinner to him while at work; and at home he helped to nurse his younger brothers and sisters. One of his earliest duties was to see that the other children were kept out of the way of the chaldron waggons, which were then dragged by horses along the wooden tramroad immediately in front of the cottage door.

This waggon-way was the first in the northern district on which the experiment of a locomotive engine was tried. But at the time of which we speak, the locomotive had scarcely been dreamt of in England as a practicable working power; horses only were used to haul the coal; and one of the first sights with which the boy was familiar was the coal-waggons dragged by them along the wooden railway at Wylam.

Thus eight years passed; after which, the coal having been worked out on the north side, the old engine, which had grown "dismal to look at," as an old workman described it, was pulled down; and then old Robert, having obtained employment as a fireman at the Dewley Burn Colliery, removed with his family to that place.

Dewley Burn, at this day, consists of a few old-fashioned low-roofed cottages standing on either side of a babbling little stream. They are connected by a

rustic wooden bridge, which spans the rift in front of the doors. In the central one-roomed cottage of this group, on the right bank, Robert Stephenson lived for a time with his family; the pit at which he worked standing in the rear of the cottages.

Young though he was, George was now of an age to be able to contribute something towards the family maintenance; for in a poor man's house, every child is a burden until his little hands can be turned to profitable account. That the boy was shrewd and active, and possessed of a ready mother-wit, will be evident enough from the following incident. One day his sister Nell went into Newcastle to buy a bonnet; and Geordie went with her "for company." At a draper's shop in the Bigg Market, Nell found a "chip" quite to her mind, but on pricing it, alas! it was found to be fifteen pence beyond her means. Girl-like, she had set her mind upon that bonnet, and no other would please her. She accordingly left the shop very much dejected. But Geordie said, "Never heed, Nell; come wi' me, and I'll see if I canna win siller enough to buy the bonnet; stand ye there, till I come back." Away ran the boy and disappeared amidst the throng of the market, leaving the girl to wait his return. Long and long she waited, until it grew dusk, and the market people had nearly all left. She had begun to despair, and fears crossed her mind that Geordie must have been run over and killed; when at last up he came running, almost breathless. "I've gotten the siller for the bonnet, Nell!" cried he. "Eh, Geordie!" she said, "but hoo hae ye gotten it?" "Hauddin the gentlemen's horses!" was the exultant reply. The bonnet was forthwith bought, and the two returned to Dewley in triumph.

George's first regular employment was of a very humble sort. A widow, named Grace Ainslie, then occupied the neighbouring farmhouse of Dewley. She kept a number of cows, and had the privilege of grazing

them along the waggon-ways. She needed a boy to herd the cows, to keep them out of the way of the waggons, and prevent their straying or trespassing on the neighbours' "liberties;" the boy's duty was also to bar the gates at night after all the waggons had passed. George petitioned for this post, and, to his great joy, he was appointed, at the wage of twopence a day.

It was light employment, and he had plenty of spare time on his hands, which he spent in birdnesting, making whistles out of reeds and scrannel straws, and erecting Lilliputian mills in the little water-streams that ran into the Dewley bog. But his favourite amusement at this early age was erecting clay engines in conjunction with his playmate, Bill Thirlwall. The place is still pointed out where the future engineers made their first essays in modelling. The boys found the clay for their engines in the adjoining bog, and the hemlocks which grew about supplied them with imaginary steam-pipes. They even proceeded to make a miniature winding-machine in connexion with their engine, and the apparatus was erected upon a bench in front of the Thirlwalls' cottage. Their corves were made out of hollowed corks; their ropes were supplied by twine; and a few bits of wood gleaned from the refuse of the carpenters' shop completed their materials. With this apparatus the boys made a show of sending the corves down the pit and drawing them up again, much to the marvel of the pitmen. But some mischievous person about the place seized the opportunity early one morning of smashing the fragile machinery, greatly to the grief of the young engineers. We may mention, in passing, that George's companion afterwards became a workman of repute, and creditably held the office of engineer at Shilbottle, near Alnwick, for a period of nearly thirty years.

As Stephenson grew older and abler to work, he was set to lead the horses when ploughing, though scarce big enough to stride across the furrows; and he used

afterwards to say that he rode to his work in the mornings at an hour when most other children of his age were asleep in their beds. He was also employed to hoe turnips, and do similar farm work, for which he was paid the advanced wage of fourpence a-day. But his highest ambition was to be taken on at the colliery where his father worked; and he shortly joined his elder brother James there as a "corf-bitter," or "picker," to clear the coal of stones, bats, and dross. His wages were then advanced to sixpence a-day, and afterwards to eightpence when he was set to drive the gin-horse.

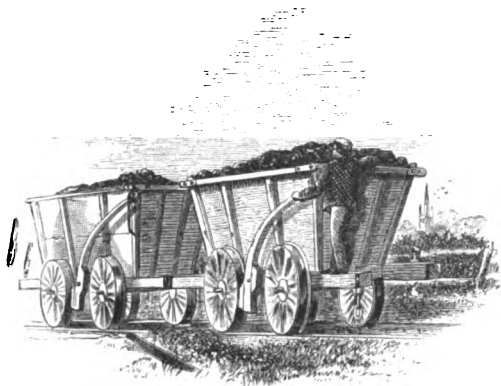
Shortly after, George went to Black Callerton Colliery to drive the gin there; and as that colliery lies about two miles across the fields from Dewley Burn, the boy walked that distance early in the morning to his work, returning home late in the evening. One of the old residents at Black Callerton, who remembered him at that time, described him to the author as "a grit growing lad, with bare legs an' feet;" adding that he was "very quick-witted and full of fun and tricks: indeed, there was nothing under the sun but he tried to imitate." He was usually foremost also in the sports and pastimes of youth.

Among his first strongly developed tastes was the love of birds and animals, which he inherited from his father. Blackbirds were his special favourites. The hedges between Dewley and Black Callerton were capital birdnesting places; and there was not a nest there that he did not know of. When the young birds were old enough, he would bring them home with him, feed them, and teach them to fly about the cottage unconfined by cages. One of his blackbirds became so tame, that, after flying about the doors all day, and in and out of the cottage, it would take up its roost upon the bed-head at night. And most singular of all, the bird would disappear in the spring and summer months, when it was supposed to go into the woods to pair and rear its

young, after which it would reappear at the cottage, and resume its social habits during the winter. This went on for several years. George had also a stock of tame rabbits, for which he built a little house behind the cottage, and for many years he continued to pride himself upon the superiority of his breed.

After he had driven the gin for some time at Dewley and Black Callerton, he was taken on as assistant to his father in firing the engine at Dewley. This was a step of promotion which he had anxiously desired ; his only fear being lest he should be found too young for the work. Indeed, he afterwards used to relate how he was wont to hide himself when the owner of the colliery went round, in case he should be thought too little a boy to earn the wages paid him. Since he had modelled his clay engines in the bog, his young ambition was to be an engineman ; and to be an assistant fireman was the first step towards this position. Great, therefore, was his joy when, at about fourteen years of age, he was appointed assistant fireman, at the wage of a shilling a-day.

But the coal at Dewley Burn being at length worked out, the pit was ordered to be "laid in," and old Robert and his family were again under the necessity of shifting their home ; for, to use the common phrase, they must "follow the wark."





NEWBURN ON THE TYNE [By R. P. Leitch.]

CHAPTER II.

NEWBURN AND CALLERTON — GEORGE STEPHENSON LEARNS TO BE AN ENGINEMAN.

ON quitting their humble home at Dewley Burn, the Stephenson family removed to a place called Jolly's Close, a few miles to the south, close behind the village of Newburn, where another coal-mine belonging to the Duke of Northumberland, called "the Duke's Winnin," had recently been opened out.

One of the old persons in the neighbourhood, who knew the family well, describes the dwelling in which they lived as a poor cottage of only one room, in which the father, mother, four sons, and two daughters lived and slept. It was crowded with three low-poled

beds. The one apartment served for parlour, kitchen, sleeping-room, and all.

The children of the Stephenson family were now growing apace, and several of them were old enough to be able to earn money at various kinds of colliery work. James and George, the two eldest sons, worked as assistant firemen; and the younger boys worked as wheelers or pickers on the bank-tops; while the two girls helped their mother with the household work.

Other workings of the coal were opened out in the neighbourhood, and to one of these George was removed as fireman on his own account. This was called the "Mid Mill Winnin," where he had for his mate a young man named Coe. They worked together there for about two years, by twelve-hour shifts, George firing the engine at the wage of a shilling a-day. He was now fifteen years old. His ambition was as yet limited to attaining the standing of a full workman, at a man's wages; and with that view he endeavoured to attain such a knowledge of his engine as would eventually lead to his employment as engineman, with its accompanying advantage of higher pay. He was a steady, sober, hard-working young man, but nothing more in the estimation of his fellow-workmen.

One of his favourite pastimes in by-hours was trying feats of strength with his companions. Although in frame he was not particularly robust, yet he was big and bony, and considered very strong for his age. At throwing the hammer George had no compeer. At lifting heavy weights off the ground from between his feet, by means of a bar of iron passed through them—placing the bar against his knees as a fulcrum, and then straightening his spine and lifting them sheer up—he was also very successful. On one occasion he lifted as much as sixty stones weight—a striking indication of his strength of bone and muscle.

When the pit at Mid Mill was closed, George and his

companion Coe were sent to work another pumping-engine erected near Throckley Bridge, where they continued for some months. It was while working at this place that his wages were raised to 12s. a week—an event to him of great importance. On coming out of the foreman's office that Saturday evening on which he received the advance, he announced the fact to his fellow-workmen, adding triumphantly, "I am now a made man for life!"

The pit opened at Newburn, at which old Robert Stephenson worked, proving a failure, it was closed; and a new pit was sunk at Water-row, on a strip of land lying between the Wylam waggon-way and the river Tyne, about half-a-mile west of Newburn Church. A pumping-engine was erected there by Robert Hawthorn, the Duke's engineer; and old Stephenson went to work it as fireman, his son George acting as the engineman or plugman. At that time he was about seventeen years old—a very youthful age at which to fill so responsible a post. He had thus already got ahead of his father in his station as a workman; for the plugman holds a higher grade than the fireman, requiring more practical knowledge and skill, and usually receiving higher wages.

George's duties as plugman were to watch the engine, to see that it kept well in work, and that the pumps were efficient in drawing the water. When the water level in the pit was lowered, and the suction became incomplete through the exposure of the suction-holes, it was then his duty to proceed to the bottom of the shaft and plug the tube so that the pump should draw: hence the designation of "plugman." If a stoppage in the engine took place through any defect which he was incapable of remedying, it was his duty call in the aid of the chief engineer to set it to rights.

But from the time that George Stephenson was appointed fireman, and more particularly afterwards as

engineman, he applied himself so assiduously and successfully to the study of the engine and its gearing—taking the machine to pieces in his leisure hours for the purpose of cleaning it and understanding its various parts—that he soon acquired a thorough practical knowledge of its construction and mode of working, and very rarely needed to call the engineer of the colliery to his aid. His engine became a sort of pet with him, and he was never wearied of watching and inspecting it with admiration.

There is indeed a peculiar fascination about an engine to the person whose duty it is to watch and work it. It is almost sublime in its untiring industry and quiet power: capable of performing the most gigantic work, yet so docile that a child's hand may guide it. No wonder, therefore, that the workman who is the daily companion of this life-like machine, and is constantly watching it with anxious care, at length comes to regard it with a degree of personal interest and regard. This daily contemplation of the steam-engine, and the sight of its steady action, is an education of itself to an ingenious and thoughtful man. And it is a remarkable fact, that nearly all that has been done for the improvement of this machine has been accomplished, not by philosophers and scientific men, but by labourers, mechanics, and enginemen. Indeed it would appear as if this were one of the departments of practical science in which the higher powers of the human mind must bend to mechanical instinct.

Stephenson was now in his eighteenth year, but, like many of his fellow-workmen, he had not yet learnt to read. All that he could do was to get some one to read for him by his engine-fire, out of any book or stray newspaper which found its way into the neighbourhood. Buonaparte was then overrunning Italy, and astounding Europe by his brilliant succession of victories; and there was no more eager auditor of his exploits, as read from

the newspaper accounts, than the young engineman at the Water-row Pit.

There were also numerous stray bits of information and intelligence contained in these papers, which excited Stephenson's interest. One of them related to the Egyptian method of hatching birds' eggs by means of artificial heat. Curious about everything relating to birds, he determined to test it by experiment. It was spring time, and he forthwith went birdnesting in the adjoining woods and hedges. He gathered a collection of eggs of various sorts, set them in flour in a warm place in the engine-house, covered the whole with wool, and waited the issue. The heat was kept as steady as possible, and the eggs were carefully turned every twelve hours, but though they chipped, and some of them exhibited well-grown chicks, they never hatched. The experiment failed, but the incident shows that the inquiring mind of the youth was fairly at work.

Modelling of engines in clay continued to be another of his favourite occupations. He made models of engines which he had seen, and of others which were described to him. These attempts were an improvement upon his first trials at Dewley Burn bog, when occupied there as a herd-boy. He was, however, anxious to know something of the wonderful engines of Boulton and Watt, and was told that they were to be found fully described in books, which he must search for information as to their construction, action, and uses. But, alas! Stephenson could not read; he had not yet learnt even his letters.

Thus he shortly found, when gazing wistfully in the direction of knowledge, that to advance further as a skilled workman, he must master this wonderful art of reading—the key to so many other arts. Only thus could he gain an access to books, the depositories of the wisdom and experience of the past. Although a grown man, and doing the work of a man, he was not ashamed

to confess his ignorance, and go to school, big as he was, to learn his letters. Perhaps, too, he foresaw that, in laying out a little of his spare earnings for this purpose, he was investing money judiciously, and that, in every hour he spent at school, he was really working for better wages.

His first schoolmaster was Robin Cowens, a poor teacher in the village of Walbottle. He kept a night-school, which was attended by a few of the colliers' and labourers' sons in the neighbourhood. George took lessons in spelling and reading three nights in the week. Robin Cowen's teaching cost threepence a week; and though it was not very good, yet George, being hungry for knowledge and eager to acquire it, soon learnt to read. He also practised "pot-hooks," and at the age of nineteen he was proud to be able to write his own name.

A Scotch dominie, named Andrew Robertson, set up a night-school in the village of Newburn, in the winter of 1799. It was more convenient for George to attend this school, as it was nearer his work, being only a few minutes' walk from Jolly's Close. Besides, Andrew had the reputation of being a good arithmetician; and this was a branch of knowledge that Stephenson was very desirous of acquiring. He accordingly began taking lessons from him, paying fourpence a week. Robert Gray, junior fireman at the Water-row Pit, began arithmetic at the same time; and Gray afterwards told the author that George learnt "figuring" so much faster than he did, that he could not make out how it was—"he took to figures so wonderful." Although the two started together from the same point, at the end of the winter George had mastered "reduction," while Robert Gray was still struggling with the difficulties of simple division. But George's secret was his perseverance. He worked out the sums in his by-hours, improving every minute of his spare time by the engine-fire, there studying

the arithmetical problems set for him upon his slate by the master. In the evenings he took to Robertson the sums which he had "worked," and new ones were "set" for him to study out the following day. Thus his progress was rapid, and, with a willing heart and mind, he soon became well advanced in arithmetic. Indeed, Andrew Robertson became very proud of his scholar; and shortly after, when the Water-row Pit was closed, and George removed to Black Callerton to work there, the poor schoolmaster, not having a very extensive connexion in Newburn, went with his pupils, and set up his night-school at Black Callerton, where he continued his lessons.

George still found time to attend to his favourite animals while working at the Water-row Pit. Like his father, he used to tempt the robin-redbreasts to hop and fly about him at the engine-fire, by the bait of bread-crumbs saved from his dinner. But his chief favourite was his dog—so sagacious that he almost daily carried George's dinner to him at the pit. The tin containing the meal was suspended from the dog's neck, and, thus laden, he proceeded faithfully from Jolly's Close to Water-row Pit, quite through the village of Newburn. He turned neither to left nor right, nor heeded the barking of curs at his heels. But his course was not unattended with perils. One day the big strange dog of a passing butcher espying the engineman's messenger with the tin can about his neck, ran after and fell upon him. There was a terrible tussle and worrying, which lasted for a brief while, and, shortly after, the dog's master, anxious for his dinner, saw his faithful servant approaching, bleeding but triumphant. The tin can was still round his neck, but the dinner had been spilt in the struggle. Though George went without his dinner that day, he was prouder of his dog than ever when the circumstances of the combat were related to him by the villagers who had seen it.

It was while working at the Water-row Pit that Stephenson learnt the art of brakeing an engine. This being one of the higher departments of colliery labour, and among the best paid, George was very anxious to learn it. A small winding-engine having been put up for the purpose of drawing the coals from the pit, Bill Coe, his friend and fellow-workman, was appointed the brakesman. He frequently allowed George to try his hand at the machine, and instructed him how to proceed. Coe was, however, opposed in this by several of the other workmen—one of whom, a banksman named William Locke,¹ went so far as to stop the working of the pit because Stephenson had been called in to the brake. But one day as Mr. Charles Nixon, the manager of the pit, was observed approaching, Coe adopted an expedient which put a stop to the opposition. He called upon Stephenson to “come into the brake-house, and take hold of the machine.” Locke, as usual, sat down, and the working of the pit was stopped. When requested by the manager to give an explanation, he said that “young Stephenson couldn’t brake, and, what was more, never would learn, he was so clumsy.” Mr. Nixon, however, ordered Locke to go on with the work, which he did; and Stephenson, after some further practice, acquired the art of brakeing.

After working at the Water-row Pit and at other engines near Newburn for about three years, George and Coe went to Black Callerton early in 1801. Though only twenty years of age, his employers thought so well of him that they appointed him to the responsible office of brakesman at the Dolly Pit. For convenience’ sake, he took lodgings at a small farmer’s in the village, finding his own victuals, and paying so much a week for lodging and attendance. In the locality this was called “picklin in his awn poke neuk.” It not unfrequently

¹ Father of Mr. Locke, M.P., the engineer. He afterwards removed to Barnsley, in Yorkshire.

happens that the young workman about the collieries, when selecting a lodging, contrives to pitch his tent where the daughter of the house ultimately becomes his wife. This is often the real attraction that draws the youth from home, though a very different one may be pretended.

George Stephenson's duties as brakesman may be briefly described. The work was somewhat monotonous, and consisted in superintending the working of the engine and machinery by means of which the coals were drawn out of the pit. Brakesmen are almost invariably selected from those who have had considerable experience as engine-firemen, and borne a good character for steadiness, punctuality, watchfulness, and "mother wit." In George Stephenson's day the coals were drawn out of the pit in corves, or large baskets made of hazel rods. The corves were placed together in a cage, between which and the pit-ropes there was usually from fifteen to twenty feet of chain. The approach of the corves towards the pit mouth was signalled by a bell, brought into action by a piece of mechanism worked from the shaft of the engine. When the bell sounded, the brakesman checked the speed by taking hold of the hand-gear connected with the steam-valves, which were so arranged that by their means he could regulate the speed of the engine, and stop or set it in motion when required. Connected with the fly-wheel was a powerful wooden brake, acting by pressure against its rim, something like the brake of a railway-carriage against its wheels. On catching sight of the chain attached to the ascending corve-cage, the brakesman, by pressing his foot upon a foot-step near him, was enabled, with great precision, to stop the revolutions of the wheel, and arrest the ascent of the corves at the pit mouth, when they were forthwith landed on the "settle board." On the full corves being replaced by empty ones, it was then the duty of

the brakesman to reverse the engine, and send the corves down the pit to be filled again.

The monotony of George Stephenson's occupation as a brakesman was somewhat varied by the change which he made, in his turn, from the day to the night shift. His duty, on the latter occasions, consisted chiefly in sending men and materials into the mine, and in drawing other men and materials out. Most of the workmen enter the pit during the night shift, and leave it in the latter part of the day, while coal-drawing is proceeding. The requirements of the work at night are such, that the brakesman has a good deal of spare time on his hands, which he is at liberty to employ in his own way. From an early period, George was accustomed to employ those vacant night hours in working the sums set for him by Andrew Robertson upon his slate, practising writing in his copy-book, and mending the shoes of his fellow-workmen. His wages while working at the Dolly Pit amounted to from 1*l.* 15*s.* to 2*l.* in the fortnight; but he gradually added to them as he became more expert at shoe-mending, and afterwards at shoe-making.

Probably he was stimulated to take in hand this extra work by the attachment he had by this time formed for a young woman named Fanny Henderson, who officiated as servant in the small farmer's house in which he lodged. We have been informed that the personal attractions of Fanny, though these were considerable, were the least of her charms. Mr. William Fairbairn, who afterwards saw her in her home at Willington Quay, describes her as a very comely woman. But her temper was one of the sweetest: and those who knew her were accustomed to speak of the charming modesty of her demeanour, her kindness of disposition, and withal her sound good sense.

Amongst his various mendings of old shoes at Callerton, George was on one occasion favoured with the

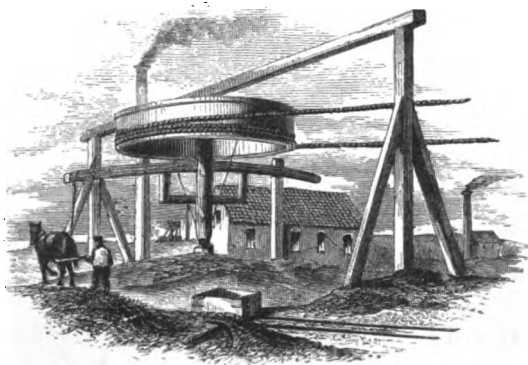
shoes of his sweetheart to sole. One can imagine the pleasure with which he would linger over such a piece of work, and the pride with which he would execute it. A friend of his, still living, relates that, after he had finished the shoes, he carried them about with him in his pocket on the Sunday afternoon, and that from time to time he would pull them out and hold them up, exclaiming "what a capital job he had made of them!"

Not long after he began to work at Black Callerton as brakesman, he had a quarrel with a pitman named Ned Nelson, a roistering bully, who was the terror of the village. Nelson was a great fighter; and it was therefore considered dangerous to quarrel with him. Stephenson was so unfortunate as not to be able to please this pitman by the way in which he drew him out of the pit; and Nelson swore at him grossly because of the alleged clumsiness of his brakeing. George defended himself, and appealed to the testimony of the other workmen. Nelson had not been accustomed to George's style of self-assertion; and, after a great deal of abuse, he threatened to kick the brakesman, who defied him to do so. Nelson ended by challenging Stephenson to a pitched battle; and the latter accepted the challenge, when a day was fixed on which the fight was to come off.

Great was the excitement at Black Callerton when it was known that George Stephenson had accepted Nelson's challenge. Everybody said he would be killed. The villagers, the young men, and especially the boys of the place, with whom George was a great favourite, all wished that he might beat Nelson, but they scarcely dared to say so. They came about him while he was at work in the engine-house, to inquire if it was really true that he was "goin' to fight Nelson?" "Ay; never fear for me; I'll fight him." And fight him he did. For some days previous to the appointed day of battle,

Nelson went entirely off work for the purpose of keeping himself fresh and strong, whereas Stephenson went on doing his daily work as usual, and appeared not in the least disconcerted by the prospect of the affair. So, on the evening appointed, after George had done his day's labour, he went into the Dolly Pit Field, where his already exulting rival was ready to meet him. George stripped, and "went in" like a practised pugilist—though it was his first and last fight. After a few rounds, George's wiry muscles and practised strength enabled him severely to punish his adversary, and to secure an easy victory.

This circumstance is related in illustration of Stephenson's personal pluck and courage; and it was thoroughly characteristic of the man. He was no pugilist, and the reverse of quarrelsome. But he would not be put down by the bully of the colliery, and he fought him. There his pugilism ended; they afterwards shook hands, and continued good friends. In after life, Stephenson's mettle was often as hardly tried, though in a different way; and he did not fail to exhibit the same courage in contending with the bullies of the railway world, as he showed in his encounter with Ned Nelson, the fighting pitman of Callerton.





STEPHENSON'S COTTAGE AT WILLINGTON QUAY. [By R. P. Leitch.]

CHAPTER III.

ENGINEMAN AT WILLINGTON QUAY AND KILLINGWORTH.

GEORGE STEPHENSON had now acquired the character of an expert workman. He was diligent and observant while at work, and sober and studious when the day's work was done. His friend Coe described him to the author as "a standing example of manly character." On pay-Saturday afternoons, when the pitmen held their fortnightly holiday, occupying themselves chiefly in cock-fighting and dog-fighting in the adjoining fields, followed by adjournments to the "yel-house," George was accustomed to take his engine to pieces, for the purpose of obtaining "insight," and he cleaned all the parts and put the machine in thorough working order before leaving her. His amusements continued to be principally of the athletic kind ; and he found few that

could beat him at lifting heavy weights, leaping, and throwing the hammer.

In the evenings he improved himself in the arts of reading and writing, and occasionally he took a turn at modelling. It was at Callerton, his son Robert informed us, that he began to try his hand at original invention; and for some time he applied his attention to a machine of the nature of an engine-brake, which reversed itself by its own action. But nothing came of the contrivance, and it was eventually thrown aside as useless. Yet not altogether so; for even the highest skill must undergo the inevitable discipline of experiment, and submit to the wholesome correction of occasional failure.

After working at Callerton for about two years, Stephenson received an offer to take charge of the engine on Willington Ballast Hill at an advanced wage. He determined to accept it, and at the same time to marry Fanny Henderson, and begin housekeeping on his own account. Though he was only twenty-one years old, he had contrived, by thrift, steadiness, and industry, to save as much money as enabled him, with the help of Fanny's small hoard, to take a cottage-dwelling at Willington Quay, and furnish it in a humble but comfortable style for the reception of his bride.

Willington Quay lies on the north bank of the Tyne, about six miles below Newcastle. It consists of a line of houses straggling along the river side; and high behind it towers up the huge mound of ballast emptied out of the ships which resort to the quay for their cargoes of coal for the London market. The ballast is thrown out of the ships' holds into waggons laid alongside. When filled, a train of these is dragged to the summit of the Ballast Hill, where they are run out, and their contents emptied on to the monstrous accumulation of earth, chalk, and Thames mud already laid there, probably to form a puzzle for future antiquaries

and geologists, when the origin of these immense hills along the Tyne has been forgotten. At the foot of this great mound of shot rubbish was a fixed engine, which drew the trains of laden waggons up the incline by means of ropes working over pullies; and of this engine George Stephenson acted as brakesman.

The cottage in which he took up his abode was a small two-storied dwelling, standing a little back from the quay, with a bit of garden ground in front;¹ but he only occupied the upper room in the west end of the cottage. Close behind rose the Ballast Hill.

When the cottage-dwelling had been made snug, and was ready for his wife's reception, the marriage took place. It was celebrated in Newburn Church, on the 28th of November, 1802. George Stephenson's signature, as it stands in the register, is that of a person who seems to have just learnt to write. With all the writer's care, however, he had not been able to avoid a blotch. The name of Frances Henderson has the appearance of being written by the same hand.



After the ceremony, George and his newly-wedded partner proceeded to the house of old Robert Stephenson and his wife Mabel at Jolly Close. The old man was now becoming infirm, though he still worked as an engine-fireman, and contrived with difficulty "to keep his head above water." When the visit had been paid,

¹ The Stephenson Memorial Schools have since been erected on the site of the old cottage at Willington Quay represented in the engraving at the

head of this chapter. A vignette of the Memorial Schools will be found at the end of the volume.

the bridal party prepared to set out for their new home at Willington Quay. They went in a style which was quite common before travelling by railway had been invented. Two farm horses borrowed from a neighbouring farmer, were each provided with a saddle and a pillion, and George having mounted one, his wife seated herself behind him, holding on by her arms round his waist. The bridesman and bridesmaid in like manner mounted the other horse ; and in this wise the wedding party rode across the country, passing through the old streets of Newcastle, and then by Wallsend to Willington Quay—a long ride of about fifteen miles.

George Stephenson's daily life at Willington was that of a steady workman. By the manner, however, in which he continued to improve his spare hours in the evening, he was silently and surely paving the way for being something more than a manual labourer. He diligently set himself to study the principles of mechanics, and to master the laws by which his engine worked. For a workman, he was even at that time more than ordinarily speculative,—often taking up strange theories, and trying to sift out the truth that was in them. While sitting by the side of his young wife in his cottage-dwelling in the winter evenings, he was usually occupied in studying mechanical subjects, or in modelling experimental machines.

Among his various speculations while at Willington, he tried to discover a means of Perpetual Motion. Although he failed, as so many others had done before him, the very efforts he made tended to whet his inventive faculties, and to call forth his dormant powers. He actually went so far as to construct the model of a machine for the purpose. It consisted of a wooden wheel, the periphery of which was furnished with glass tubes filled with quicksilver ; as the wheel rotated, the quicksilver poured itself down into the lower tubes, and thus a sort of self-acting motion was kept up in the

apparatus, which, however, did not prove to be perpetual. Where he had first obtained the idea of this machine—whether from conversation, or reading, or his own thoughts, is not known; but his son Robert was of opinion that he had heard of an apparatus of this kind as described in the ‘History of Inventions.’ As he had then no access to books, and indeed could scarcely yet read, it is probable that he had been told of the invention, and set about testing its value according to his own methods.

Much of his spare time continued to be occupied by labour more immediately profitable, regarded in a pecuniary point of view. In the evenings, after his day’s labour at his engine, he would occasionally employ himself for a few hours in casting ballast out of the collier ships, by which means he was enabled to earn a few shillings weekly. Mr. William Fairbairn of Manchester has informed the author that while Stephenson was employed at the Willington Ballast Hill he himself was working in the neighbourhood as an engine apprentice at the Percy Main Colliery. He was very fond of George, who was a fine hearty fellow, besides being a capital workman. In the summer evenings, young Fairbairn was accustomed to go down to Willington to see his friend, and on such occasions he would frequently take charge of George’s engine for a few hours to enable him to take a two or three hours’ turn at heaving ballast out of the ships’ holds. It is pleasant to think of the future President of the British Association thus helping the future Railway Engineer to earn a few extra shillings by overwork in the evenings, at a time when both occupied the rank but of humble working men in an obscure northern village.

Mr. Fairbairn was also a frequent visitor at George’s cottage on the Quay, where, though there was no luxury, there was comfort, cleanness, and a pervading spirit of industry. Even at home George was never

for a moment idle. When there was no ballast to heave, he took in shoes to mend; and from mending he proceeded to making them, as well as shoe-lasts, in which he was admitted to be very expert. William Coe, who continued to live at Willington in 1851, informed the author that he bought a pair of shoes from George Stephenson for 7s. 6d., and he remembered that they were a capital fit, and wore very well.

But an accident occurred in Stephenson's household about this time, which had the effect of directing his industry into a new and still more profitable channel. The cottage chimney took fire one day in his absence, when the alarmed neighbours, rushing in, threw quantities of water upon the flames; and some, in their zeal, even mounted the ridge of the house, and poured buckets of water down the chimney. The fire was soon put out, but the house was thoroughly soaked. When George came home, he found the water running out of the door, everything in disorder, and his new furniture covered with soot. The eight-day clock, which hung against the wall—one of the most highly-prized articles in the house—was seriously damaged by the steam with which the room had been filled. Its wheels were so clogged by the dust and soot, that it was brought to a complete stand-still.

George was advised to send the article to the clock-maker, but that would cost money: and he declared that he would repair it himself—at least he would try. The clock was accordingly taken to pieces and cleaned; the tools which he had been accumulating for the purpose of constructing his Perpetual Motion machine, readily enabled him to do this; and he succeeded so well that, shortly after, the neighbours sent him their clocks to clean, and he soon became one of the most expert clock-cleaners in the neighbourhood.

It was while living at Willington Quay, that George Stephenson's only son was born on the 16th of October,

1803.¹ The child was from the first, as may well be imagined, a great favourite with his father, and added much to the happiness of his evening hours. George Stephenson's strong "philoprogenitiveness," as phrenologists call it, had in his boyhood expended itself on birds, and dogs, and rabbits, and even on the poor old gin-horses which he had driven at the Callerton Pit; and now he found in his child a more genial object for the exercise of his affection.

The christening of the boy took place in the school-house at Wallsend, the old parish church being at the time in so dilapidated a condition from the "creeping" or subsidence of the ground, consequent upon the excavation of the coal, that it was considered dangerous to enter it.² On this occasion, Robert Gray and Anne Henderson, who had officiated as bridesman and bridesmaid at the wedding, came over again to Willington, and stood godfather and godmother to little Robert, as the child was named, after his grandfather.

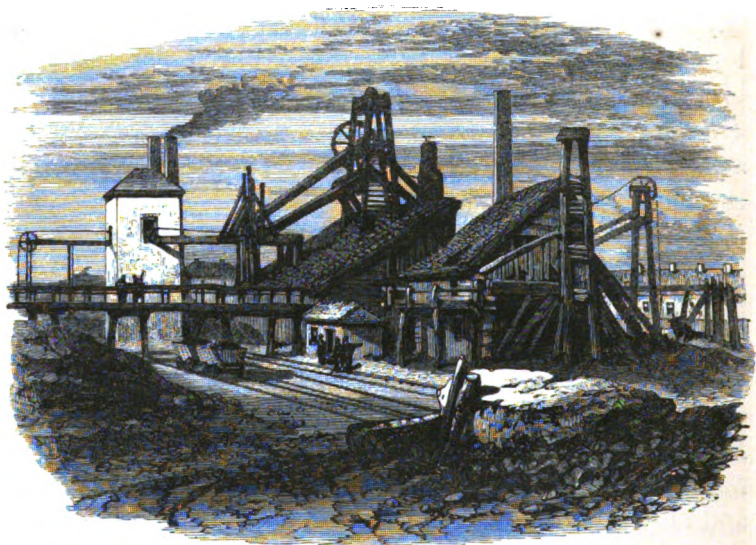
After working for about three years as a brakesman at the Willington machine, George Stephenson was induced to leave his situation there for a similar one at the West Moor Colliery, Killingworth. It was not without considerable persuasion that he was induced to leave the Quay, as he knew that he should thereby give up the chance of earning extra money by casting ballast

¹ No register was made of Robert Stephenson's birth, and he himself was in doubt whether he was born in October, November, or December. For instance, a dinner was given to him by the contractors of the London and Birmingham Railway on the 16th November, 1839, that day being then supposed by his father to have been his birthday. When preparing the 'Life of George Stephenson,' Robert stated to the author that the 16th of December was the correct day. But after the book had passed through four editions he desired the date to be corrected to the 16th of October, which on the

whole he thought the right date, and it was so altered accordingly.

² The congregation in a church near Newcastle were one Sunday morning plentifully powdered with chips from the white ceiling of the church, which had been *crept under*, being above an old mine. "It is only the pit a-creeping," said the parish clerk, by way of encouragement to the people to remain. But it would not do; for there was a sudden *creep out* of the congregation. The clerk went at last, with a powdered head, crying out, "It's only a creep."—"Our Coal-Fields and our Coal-Pits."

from the keels. At last, however, he consented, in the hope of making up the loss in some other way.



WEST MOOR COLLIERY. [By R. P. Leitch.]

The village of Killingworth lies about seven miles north of Newcastle, and is one of the best-known collieries in that neighbourhood. The workings of the coal are of vast extent, and give employment to a large number of work-people. To this place Stephenson first came as a brakesman about the end of 1804. He had not been long in his new home, ere his wife died of consumption, leaving him with his only child Robert. George deeply felt the loss, for his wife and he had been very happy together. Their lot had been sweetened by daily successful toil. George was sober and hard-working, and his wife had made his hearth so bright and his home so snug, that no attraction could draw him from her side in the evening hours. But this domestic happiness was all to pass away; and the bereaved husband felt for a time as one that had thenceforth to tread the journey of life alone.

Shortly after this event, while his grief was still fresh, he received an invitation from some gentlemen concerned in large spinning-works near Montrose in Scotland, to proceed thither and superintend the working of one of Boulton and Watt's engines. He accepted the offer, and made arrangements to leave Killingworth for a time.

Having left his boy in charge of a respectable woman who acted as his housekeeper, he set out on the journey to Scotland on foot, with his kit upon his back. While working at Montrose, he gave a striking proof of that practical ability in contrivance for which he was afterwards so distinguished. It appears that the water required for the purposes of his engine, as well as for the use of the works, was pumped from a considerable depth, being supplied from the adjacent extensive sand strata. The pumps frequently got choked by the sand drawn in at the bottom of the well through the snore-holes, or apertures through which the water to be raised is admitted. The barrels soon became worn, and the bucket and clack leathers destroyed, so that it became necessary to devise a remedy; and with this object the engineman proceeded to adopt the following simple but original expedient. He had a wooden box or boot made, twelve feet high, which he placed in the sump or well, and into this he inserted the lower end of the pump. The result was, that the water flowed clear from the outer part of the well over into the boot, and was drawn up without any admixture of sand, and the difficulty was thus conquered.¹

¹ This incident was related by Robert Stephenson during a voyage to the north of Scotland in 1857, when off Montrose, on board his yacht *Titania*; and the reminiscence was immediately communicated to the author by the late Mr. William Kell of Gateshead, who was present, at Mr. Stephenson's request, as being worthy of insertion in his father's biography. Mr. George Elliott, one of the most

skilled coal-viewers in the North, was of the party, and expressed his admiration at the ready skill with which the difficulty had been overcome, the expedient of the boot being then unknown in the Northumberland and Durham mines. He acknowledged it to be "a wrinkle," adding that its application would, in several instances within his own knowledge, have been of great practical value.

During his stay in Scotland, Stephenson, being paid good wages, contrived to save a sum of 28*l.*, which he took back with him to Killingworth, after an absence of about a year. Longing to get back to his kindred, his heart yearning for the boy whom he had left behind, our engineman bade adieu to his Montrose employers, and trudged back to Killingworth on foot as he had gone. He related to his friend Coe, on his return, that when on the borders of Northumberland, late one evening, footsore and wearied with his long day's journey, he knocked at a small farmer's cottage door, and requested shelter for the night. It was refused, and then he entreated that, being sore tired and unable to proceed any further, they would permit him to lie down in the outhouse, for that a little clean straw would serve him. The farmer's wife appeared at the door, looked at the traveller, then retiring with her husband, the two confabulated a little apart, and finally they invited Stephenson into the cottage. Always full of conversation and anecdote, he soon made himself at home in the farmer's family, and spent with them some pleasant hours. He was hospitably entertained for the night, and when he left the cottage in the morning, he pressed them to make some charge for his lodging, but they refused to accept any recompense. They only asked him to remember them kindly, and if he ever came that way, to be sure and call again. Many years after, when Stephenson had become a thriving man, he did not forget the humble pair who had thus succoured and entertained him on his way; he sought their cottage again, when age had silvered their hair; and when he left the aged couple on that occasion, they may have been reminded of the old saying that we may sometimes "entertain angels unawares."

Reaching home, Stephenson found that his father had met with a serious accident at the Blucher Pit, which had reduced him to great distress and poverty.

While engaged in the inside of an engine, making some repairs, a fellow-workman inadvertently let in the steam upon him. The blast struck him full in the face; he was terribly scorched, and his eyesight was irretrievably lost. The helpless and infirm man had struggled for a time with poverty; his sons who were at home, poor as himself, were little able to help him, while George was at a distance in Scotland. On his return, however, with his savings in his pocket, his first step was to pay off his father's debts, amounting to about 15*l.*; and, shortly after, he removed the aged pair from Jolly's Close to a comfortable cottage adjoining the tramroad near the West Moor at Killingworth, where the old man lived for many years, supported by his son.

Stephenson was again taken on as a brakesman at the West Moor Pit. He does not seem to have been very hopeful as to his prospects in life at the time. Indeed the condition of the working classes generally was then very discouraging. England was engaged in a great war, which pressed upon the industry, and severely tried the resources of the country. Heavy taxes were imposed upon all the articles of consumption that would bear them. There was a constant demand for men to fill the army, navy, and militia. Never before had England witnessed such drumming and fifeing for recruits. In 1805, the gross forces of the United Kingdom amounted to nearly 700,000 men, and early in 1808 Lord Castlereagh carried a measure for the establishment of a local militia of 200,000 men. These measures were accompanied by general distress among the labouring classes. There were riots in Manchester, Newcastle, and elsewhere, through scarcity of work and lowness of wages. The working people were also liable to be pressed for the navy, or drawn for the militia; and though people could not fail to be discontented under such circumstances, they scarcely

dared even to mutter their discontent to their neighbours.

George Stephenson was one of those drawn for the militia. He must therefore either quit his work and go a-soldiering, or find a substitute. He adopted the latter course, and borrowed 6*l.*, which, with the remainder of his savings, enabled him to provide a militia-man to serve in his stead. Thus the whole of his hard-won earnings were swept away at a stroke. He was almost in despair, and contemplated the idea of leaving the country, and emigrating to the United States. Although a voyage thither was then a much more formidable thing for a working man to accomplish than a voyage to Australia is now, he seriously entertained the project, and had all but made up his mind to go. His sister Ann, with her husband, emigrated about that time, but George could not raise the requisite money; and they departed without him. After all, it went sore against his heart to leave his home and his kindred, the scenes of his youth and the friends of his boyhood; and he struggled long with the idea, brooding over it in sorrow. Speaking afterwards to a friend of his thoughts at the time, he said: "You know the road from my house at the West Moor to Killingworth. I remember once when I went along that road I wept bitterly, for I knew not where my lot in life would be cast." But his poverty prevented him from prosecuting the idea of emigration, and rooted him to the place where he afterwards worked out his career so manfully and victoriously.

In 1808, Stephenson, with two other brakesmen, took a small contract under the colliery lessees for brakeing the engines at the West Moor Pit. The brakesmen found the oil and tallow; they divided the work amongst them, and were paid so much per score for their labour. There being two engines working night and day, two of the three men were always on

duty ; the average earnings of each amounting to from 18s. to 20s. a week. It was the interest of the brakesmen to economise the working as much as possible, and George no sooner entered upon the contract than he proceeded to devise ways and means of making the contract "pay." He observed that the ropes with which the coal was drawn out of the pit by the winding-engine were badly arranged ; they "glued" and wore each other to tatters by the perpetual friction. There was thus great wear and tear, and a serious increase in the expenses of the pit. George found that the ropes which, at other pits in the neighbourhood, lasted about three months, at the West Moor Pit became worn out in about a month. He accordingly set himself to ascertain the cause of the defect ; and finding that it was occasioned by excessive friction, he proceeded, with the sanction of the head engine-wright and of the colliery owners, to shift the pulley-wheels so that they worked immediately over the centre of the pit. By this expedient, accompanied by an entire rearrangement of the gearing of the machine, he shortly succeeded in greatly lessening the wear and tear of the ropes, to the advantage of the owners as well as of the workmen, who were thus enabled to labour more continuously and profitably.

About the same time he attempted an improvement in the winding-engine which he worked, by placing a valve between the air-pump and condenser. This expedient, although it led to no practical result, showed that his mind was actively engaged in studying new mechanical adaptations. It continued to be his regular habit, on Saturdays, to take his engine to pieces, for the purpose at the same time of familiarising himself with its action, and of placing it in a state of thorough working order. And by mastering the details of the engine, he was enabled, as opportunity occurred, to turn to practical account the knowledge thus diligently and patiently acquired.

Such an opportunity was not long in presenting itself. In the year 1810, a pit was sunk by the "Grand Allies" (the lessees of the mines) at the village of Killingworth, now known as the Killingworth High Pit. An atmospheric or Newcomen engine, originally made by Smeaton, was fixed there for the purpose of pumping out the water from the shaft; but, somehow or other, the engine failed to clear the pit. As one of the workmen has since described the circumstance—"She couldn't keep her jack-head in water: all the enginemen in the neighbourhood were tried, as well as Crowther of the Ouseburn, but they were clean bet." The engine had been fruitlessly pumping for nearly twelve months, and came to be regarded as a total failure. Stephenson had gone to look at it when in course of erection, and then observed to the over-man that he thought it was defective; he also gave it as his opinion that if there were much water in the mine, the engine could never keep it under. Of course, as he was only a brakesman, his opinion was considered to be worth very little on such a point. He continued, however, to make frequent visits to the engine to see "how she was getting on." From the bank-head where he worked his brake he could see the chimney smoking at the High Pit; and as the workmen were passing to and from their work, he would call out and inquire "if they had gotten to the bottom yet?" And the reply was always to the same effect—the pumping made no progress, and the workmen were still "drowned out."

One Saturday afternoon he went over to the High Pit to examine the engine more carefully than he had yet done. He had been turning the subject over in his mind; and after a long examination, he seemed to have satisfied himself as to the cause of the failure. Kit Heppel, one of the sinkers, asked him: "Weel, George, what do you mak' o' her? Do you think you could do

anything to improve her?" "Man," said George in reply, "I could alter her and make her draw: in a week's time from this I could send you to the bottom."

Heppel at once reported this conversation to Ralph Dodds, the head viewer, who, being now quite in despair and hopeless of succeeding with the engine, determined to give George's skill a trial. George had already acquired the character of a very clever and ingenious workman; and, at the worst, he could only fail as the rest had done. In the evening, Dodds went in search of Stephenson, and met him on the road, dressed in his Sunday's suit, on his way to "the preaching" in the Methodist Chapel, which he at that time attended. "Well, George," said Dodds, "they tell me that you think you can put the engine at the High Pit to rights." "Yes, sir," said George, "I think I could." "If that's the case, I'll give you a fair trial, and you must set to work immediately. We are clean drowned out, and cannot get a step further. The engineers hereabouts are all bet; and if you really succeed in accomplishing what they cannot do, you may depend upon it I will make you a man for life."

Stephenson began his operations early next morning. The only condition that he made, before setting to work, was that he should select his own workmen. There was, as he knew, a good deal of jealousy among the "regular" men that a colliery brakesman should pretend to know more about their engine than they themselves did, and attempt to remedy defects which the most skilled men of their craft, including the engineer of the colliery, had failed to do. But George made the condition a *sine qua non*. "The workmen," said he, "must either be all Whigs or all Tories." There was no help for it, so Dodds ordered the old hands to stand aside. The men grumbled, but gave way; and then George and his party went in.

The engine was taken entirely to pieces. The cistern

containing the injection water was raised ten feet; the injection cock, being too small, was enlarged to nearly double its former size, and it was so arranged that it should be shut off quickly at the beginning of the stroke. These and other alterations were necessarily performed in a rough way, but, as the result proved, on true principles. Stephenson also, finding that the boiler would bear a greater pressure than five pounds to the inch, determined to work it at a pressure of ten pounds, though this was contrary to the directions of both Newcomen and Smeaton.

The necessary alterations were made in about three days, and many persons came to see the engine start, including the men who had put her up. The pit being nearly full of water, she had little to do on starting, and, to use George's words, "came bounce into the house." Dodds exclaimed, "Why, she was better as she was; now, she will knock the house down." After a short time, however, the engine got fairly to work, and by ten o'clock that night the water was lower in the pit than it had ever been before. The engine was kept pumping all Thursday, and by the Friday afternoon the pit was cleared of water, and the workmen were "sent to the bottom," as Stephenson had promised. Thus the alterations effected in the pumping-apparatus proved completely successful.¹

Mr. Dodds was particularly gratified with the manner in which the job had been done, and he made Stephenson a present of ten pounds, which, though very inadequate when compared with the value of the work performed, was accepted with gratitude. George was proud of the gift as the first marked recognition of his skill as a workman; and he used afterwards to say that it was the biggest sum of money he had up to that

¹ As different versions have been given of this affair, it may be mentioned that the above statement is made on the authority of the late Robert Stephenson, and of George

Stephenson himself, as communicated by the latter to his friend Thomas L. Gooch, C.E., who has kindly supplied the author with his memoranda on the subject.

time earned in one lump. Ralph Dodds, however, did more than this. He released the brakesman from the handles of his engine at West Moor, and appointed him engineman at the High Pit, at good wages, during the time the pit was sinking,—the job lasting for about a year; and he also kept him in mind for further advancement.

Stephenson's skill as an engine-doctor soon became noised abroad, and he was called upon to prescribe remedies for all the old, wheezy, and ineffective pumping-machines in the neighbourhood. In this capacity he soon left the "regular" men far behind, though they in their turn were very much disposed to treat the Killingworth brakesman as no better than a quack. Nevertheless, his practice was really founded upon a close study of the principles of mechanics, and on an intimate practical acquaintance with the details of the pumping-engine.

Another of his smaller achievements in the same line is still told by the people of the district. At the corner of the road leading to Long Benton, there was a quarry from which a peculiar and scarce kind of ochre was taken. In the course of working it out, the water had collected in considerable quantities; and there being no means of draining it off, it accumulated to such an extent that the further working of the ochre was almost entirely stopped. Ordinary pumps were tried, and failed: and then a windmill was tried, and failed too. On this, George was asked what ought to be done to clear the quarry of the water. He said "he would set up for them an engine little bigger than a kail-pot, that would clear them out in a week." And he did so. A little engine was speedily erected, by means of which the quarry was pumped dry in the course of a few days. Thus his skill as a pump-doctor soon became the marvel of the district.

In elastic muscular vigour, Stephenson was now in

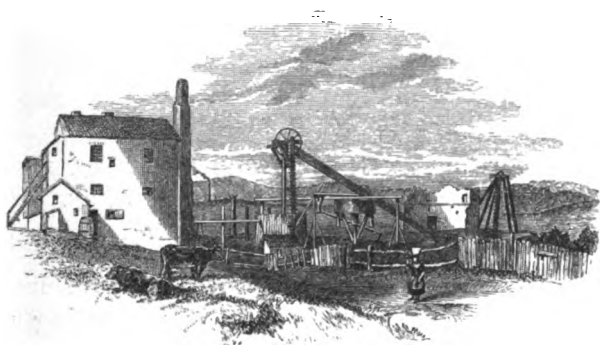
his prime, and he still continued zealous in measuring his strength and agility with his fellow workmen. The competitive element in his nature was always strong; and his success in these feats of rivalry was certainly remarkable. Few, if any, could lift such weights, throw the hammer and put the stone so far, or cover so great a space at a standing or running leap. One day, between the engine hour and the rope-rolling hour, Kit Heppel challenged him to leap from one high wall to another, with a deep gap between. To Heppel's surprise and dismay, George took the standing leap, and cleared the eleven feet at a bound. Had his eye been less accurate, or his limbs less agile and sure, the feat must have cost him his life.

But so full of redundant muscular vigour was he, that leaping, putting, or throwing the hammer, were not enough for him. He was also ambitious of riding on horseback, and, as he had not yet been promoted to an office enabling him to keep a horse of his own, he sometimes borrowed one of the gin-horses for a ride. On one of these occasions he brought the animal back reeking; when Tommy Mitcheson, the bank horse-keeper, a rough-spoken fellow, exclaimed to him: "Set such fellows as you on horseback, and you'll soon ride to the De'il." But Tommy Mitcheson lived to tell the story, and to confess that, after all, there had been a better issue of George's horsemanship than what he had predicted.

Old Cree, the engine-wright at Killingworth High Pit, having been killed by an accident, George Stephenson was, in 1812, appointed engine-wright of the colliery at the salary of 100*l.* a year. He was also allowed the use of a galloway to ride upon in his visits of inspection to the collieries leased by the "Grand Allies" in that neighbourhood.

The "Grand Allies" were a company of gentlemen, consisting of Sir Thomas Liddell (afterwards Lord

Ravensworth), the Earl of Strathmore, and Mr. Stuart Wortley (afterwards Lord Wharnccliffe), the lessees of the Killingworth collieries. Having been informed of the merits of Stephenson, of his indefatigable industry, and the skill which he had displayed in the repairs of the pumping-engines, they readily acceded to Mr. Dodds' recommendation that he should be appointed the colliery engine-wright; and, as we shall afterwards find, they continued to honour him by distinguished marks of their approval.



KILLINGWORTH HIGH PIT.



GLEBE FARM-HOUSE. BENTON. [By R. P. Leitch]

CHAPTER IV.

THE STEPHENSONS AT KILLINGWORTH — EDUCATION AND SELF-EDUCATION OF FATHER AND SON.

GEORGE STEPHENSON had now been diligently employed for several years in the work of self-improvement, and he experienced the usual results in increasing mental strength, capability, and skill. Perhaps the secret of every man's best success in life is to be found in the alacrity and industry with which he takes advantage of the opportunities which present themselves for well-doing. Our engineman was an eminent illustration of the importance of cultivating this habit of life. Every spare moment was laid under contribution by him, either for the purpose of adding to his earnings or to his knowledge. He missed no opportunity of extending his observations, especially in his own department of work, aiming at improvement, and trying to turn all that he did know to useful practical account.

He continued his attempts to solve the mystery of Perpetual Motion, and contrived several model machines

with the object of embodying his ideas in a practical working shape. He afterwards used to lament the time he had lost in these futile efforts, and said that if he had enjoyed the opportunities which most young men now have, of learning from books what previous experimenters had accomplished, he would have been spared much labour and mortification. Not being acquainted with what other mechanics had done, he groped his way in pursuit of some idea originated by his own independent thinking and observation; and, when he had brought it into some definite form, lo! he found that his supposed invention had long been known and recorded in scientific books. Often he thought he had hit upon discoveries, which he subsequently found were but old and exploded fallacies. Yet his very struggle to overcome the difficulties which lay in his way, was of itself an education of the best sort. By wrestling with them, he strengthened his judgment and sharpened his skill, stimulating and cultivating his inventiveness and mechanical ingenuity. Being very much in earnest, he was compelled to consider the subject of his special inquiry in all its relations; and thus he gradually acquired practical ability through his very efforts after the impracticable.

Many of his evenings were spent in the society of John Wigham, whose father occupied the Glebe farm at Benton close at hand. John was a fair penman and a good arithmetician, and Stephenson frequented his society chiefly for the purpose of improving himself in writing and "figuring." Under Andrew Robertson, he had never quite mastered the Rule of Three, and it was only when Wigham took him in hand that he made progress in the higher branches of arithmetic. He generally took his slate with him to the Wighams' cottage, when he had his sums set, that he might work them out while tending his engine on the following day. When too busy with other work to be able to call

upon Wigham in person, he sent the slate by a fellow-workman to have the former sums corrected and new ones set. Sometimes also, at leisure moments, he was enabled to do a little "figuring" with chalk upon the sides of the coal-waggon. So much patient perseverance could not but eventually succeed; and by dint of practice and study, Stephenson was enabled to master the successive rules of arithmetic.

John Wigham was of great use to his pupil in many ways. He was a good talker, fond of argument, an extensive reader as country reading went in those days, and a very suggestive thinker. Though his store of information might be comparatively small when measured with that of more highly-cultivated minds, much of it was entirely new to Stephenson, who regarded him as a very clever and extraordinary person. Wigham also taught him to draw plans and sections; though in this branch Stephenson proved so apt that he soon surpassed his master. A volume of 'Ferguson's Lectures on Mechanics' which fell into their hands, was a great treasure to both the students. One who remembers their evening occupations says he "used to wonder what they meant by weighing the air and water in so odd a way." They were trying the specific gravities of objects; and the devices which they employed, the mechanical shifts to which they were put, were often of the rudest kind. In these evening entertainments, the mechanical contrivances were supplied by Stephenson, while Wigham found the scientific rationale. The opportunity thus afforded to the former of cultivating his mind by contact with one wiser than himself proved of great value, and in afterlife Stephenson gratefully remembered the assistance which, when a humble workman, he had received from John Wigham, the farmer's son.

His leisure moments thus carefully improved, it will be inferred that Stephenson continued a sober man. Though his notions were never extreme on this point,

he was systematically temperate. It appears that on the invitation of his master, Ralph Dodds—and an invitation from a master to a workman is not easy to resist—he had, on one or two occasions, been induced to join him in a forenoon glass of ale in the public-house of the village. But one day, about noon, when Mr. Dodds had got him as far as the public-house door, on his invitation to “come in and take a glass o’ yel,” Stephenson made a dead stop, and said, firmly, “No, sir, you must excuse me; I have made a resolution to drink no more at this time of day.” And he went back. He desired to retain the character of a steady workman; and the instances of men about him who had made shipwreck of their character through intemperance, were then, as now, unhappily too frequent.

But another consideration besides his own self-improvement had already begun to exercise an important influence upon his life. This was the training and education of his son Robert, now growing up an active, intelligent boy, as full of fun and tricks as his father had been. When a little fellow, scarce big enough to reach so high as to put a clock-head on when placed upon the table, his father would make him mount a chair for the purpose; and to “help father” was the proudest work which the boy then, and ever after, could take part in. When the little engine was set up at the Ochre Quarry to pump it dry, Robert was scarcely absent for an hour. He watched the machine very eagerly when it was set to work; and he was very much annoyed at the fire burning away the grates. The man who fired the engine was a sort of wag, and thinking to get a laugh at the boy, he said, “Those bars are getting varra bad, Robert; I think we maun cut up some of that hard wood, and put it in instead.” “What would be the use of that, you fool?” said the boy quickly. “You would no sooner have put them in than they would be burnt out again!”

So soon as Robert was of a proper age, his father sent him over to the road-side school at Long Benton, kept by Rutter, the parish clerk. But the education which he gave was of a very limited kind, scarcely extending beyond the primer and pothooks. While working as a brakesman on the pit-head at Killingworth, the father had often bethought him of the obstructions he had himself encountered in life through his want of schooling; and he formed the determination that no labour, nor pains, nor self-denial on his part should be spared to furnish his son with the best education that it was in his power to bestow.



RUtter's SCHOOL-HOUSE, LONG BENTON. [By R. P. Leitch.]

It is true his earnings were comparatively small at that time. He was still maintaining his infirm parents; and the cost of living continued excessive. But he fell back, as before, upon his old expedient of working up his spare time in the evenings at home, or during the night shifts when it was his turn to tend the engine, in mending and making shoes, cleaning clocks and watches,

making shoe-lasts for the shoemakers of the neighbourhood, and cutting out the pitmen's clothes for their wives; and we have been told that to this day there are clothes worn at Killingworth made after "Geordy Steevie's cut." To give his own words:—"In the earlier period of my career," said he, "when Robert was a little boy, I saw how deficient I was in education, and I made up my mind that he should not labour under the same defect, but that I would put him to a good school, and give him a liberal training. I was, however, a poor man; and how do you think I managed? I betook myself to mending my neighbours' clocks and watches at nights, after my daily labour was done, and thus I procured the means of educating my son."¹

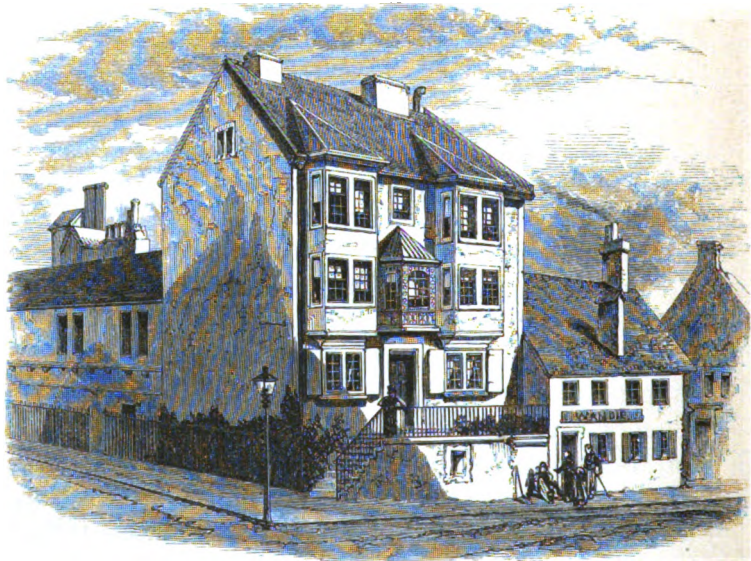
By dint of such extra labour in his bye-hours, with this object, Stephenson contrived to save a sum of 100*l.*, which he accumulated in *guineas*, each of which he afterwards sold to Jews who went about buying up gold coins (then dearer than silver), at twenty-six shillings apiece; and he lent out the proceeds at interest. He was now, therefore, a comparatively thriving man.

When he was appointed engine-wright of the colliery, he was of course still easier in his circumstances; and, carrying out the resolution which he had formed as to his boy's education, Robert was sent to Mr. Bruce's school in Percy Street, Newcastle, at midsummer, 1815, when he was about twelve years old. His father bought for him a donkey, on which he rode into Newcastle and back daily; and there are many still living who remember the little boy, dressed in his suit of homely grey stuff cut out by his father, cantering along to school upon the "cuddy," with his wallet of provisions for the day and his bag of books slung over his shoulder.

When Robert went to Mr. Bruce's school, he was a

¹ Speech at Newcastle, on the 18th of June, 1844, at the meeting held in celebration of the opening of the Newcastle and Darlington Railway.

shy, unpolished country lad, speaking the broad dialect of the pitmen ; and the other boys would occasionally tease him, for the purpose of provoking an outburst of his Killingworth Doric. As the shyness got rubbed off by familiarity, his love of fun began to show itself, and he was found able enough to hold his own amongst the other boys. As a scholar he was steady and diligent, and his master was accustomed to hold him up to the laggards of the school as an example of good



BRUCE'S SCHOOL, NEWCASTLE. [By P. R. Leitch.]

conduct and industry. But his progress, though satisfactory, was by no means extraordinary. He used in after-life to pride himself on his achievements in mensuration, though another boy, John Taylor, beat him at arithmetic. He also made considerable progress in mathematics ; and in a letter written to the son of his teacher, many years after, he said, "It was to Mr. Bruce's tuition and methods of modelling the mind that I attribute much of my success as an engineer ; for it

was from him that I derived my taste for mathematical pursuits and the facility I possess of applying this kind of knowledge to practical purposes and modifying it according to circumstances."

During the time Robert attended school at Newcastle, his father made the boy's education instrumental to his own. Robert was accustomed to spend some of his spare time at the rooms of the Literary and Philosophical Institute; and when he went home in the evening, he would recount to his father the results of his reading. Sometimes he was allowed to take with him to Killingworth a volume of the 'Repertory of Arts and Sciences,' which father and son studied together. But many of the most valuable works belonging to the Newcastle Library were not permitted to be removed from the rooms; these Robert was instructed to read and study, and bring away with him descriptions and sketches for his father's information. His father also practised him in the reading of plans and drawings without at all referring to the written descriptions. He used to observe to his son, "A good drawing or plan should always explain itself;" and, placing a drawing of an engine or machine before the youth, he would say, "There, now, describe that to me—the arrangement and the action." Thus he taught him to read a drawing as easily as he would read a page of a book. Both father and son profited by this excellent practice, which shortly enabled them to apprehend with the greatest facility the details of even the most difficult and complicated mechanical drawing.

While Robert went on with his lessons in the evenings, his father was usually occupied with his watch and clock cleaning; or contriving models of pumping-engines; or endeavouring to embody in a tangible shape the mechanical inventions which he found described in the odd volumes on Mechanics which fell in his way. This daily and unceasing example of industry and ap-

plication, working on before the boy's eyes in the person of a loving and beloved father, imprinted itself deeply upon his mind in characters never to be effaced. A spirit of self-improvement was thus early and carefully planted and fostered in him, which continued to influence his character through life; and towards the close of his career, he was proud to confess that if his professional success had been great, it was mainly to the example and training of his father that he owed it.

Robert was not, however, exclusively devoted to study, but, like most boys full of animal spirits, he was very fond of fun and play, and sometimes of mischief. Dr. Bruce relates that an old Killingworth labourer, when asked by Robert, on one of his last visits to Newcastle, if he remembered him, replied with emotion, "Aye, indeed! Haven't I paid your head many a time when you came with your father's bait, for you were always a sad hempy?"

The author had the pleasure, in the year 1854, of accompanying Robert Stephenson on a visit to his old home and haunts and Killingworth. He had so often travelled the road upon his donkey to and from school, that every foot of it was familiar to him; and each turn in it served to recall to mind some incident of his boyish days.¹ His eyes glistened when he came in sight of Killingworth pit head. Pointing to a humble red-tiled house by the road-side at Benton, he said, "You see that house—that was Rutter's, where I learnt my A B C, and made a beginning of my school learning. And there," pointing to a colliery chimney on the left, "there is Long Benton, where my father put up his first pumping-engine; and a great success it was. And this humble clay-floored cottage you see

¹ At one part of the road he was once pulled off his donkey by some mischievous boys, and released by a young man named James Burnet. Many years after, Burnet was taken on as a workman at the Newcastle factory, probably owing his selection in some measure to the above circumstance.

here, is where my grandfather lived till the close of his life. Many a time have I ridden straight into the house, mounted on my cuddy, and called upon grandfather to admire his points. I remember the old man feeling the animal all over—he was then quite blind—after which he would dilate upon the shape of his ears, fetlocks, and quarters, and usually end by pronouncing him to be a ‘real blood.’ I was a great favourite with the old man, who continued very fond of animals, and cheerful to the last; and I believe nothing gave him greater pleasure than a visit from me and my cuddy.”

On the way from Benton to High Killingworth, Mr. Stephenson pointed to a corner of the road where he had once played a boyish trick upon a Killingworth collier. “Straker,” said he, “was a great bully, a coarse, swearing fellow, and a perfect tyrant amongst the women and children. He would go tearing into old Nanny the huxter’s shop in the village, and demand in a savage voice, ‘What’s ye’r best ham the pund?’ ‘What’s floor the hunder?’ ‘What d’ye ax for prime bacon?’—his categories usually ending with the miserable order, accompanied with a tremendous oath, of ‘Gie’s a penny row (roll) an’ a baubee herrin!’ The poor woman was usually set ‘all of a shake’ by a visit from this fellow. He was also a great boaster, and used to crow over the robbers whom he had put to flight; mere men in buckram, as everybody knew. We boys,” he continued, “believed him to be a great coward, and determined to play him a trick. Two other boys joined me in waylaying Straker one night at that corner,” pointing to it. “We sprang out and called upon him, in as gruff voices as we could assume, to ‘stand and deliver!’ He dropped down upon his knees in the dirt, declaring he was a poor man, with a sma’ family, asking for ‘mercy,’ and imploring us, as ‘gentlemen, for God’s sake, t’ let him a-be!’ We couldn’t stand this any longer, and set up a shout of

laughter. Recognizing our boys' voices, he sprang to his feet again and rattled out a volley of oaths; on which we cut through the hedge, and heard him shortly after swearing his way along the road to the yel-house."

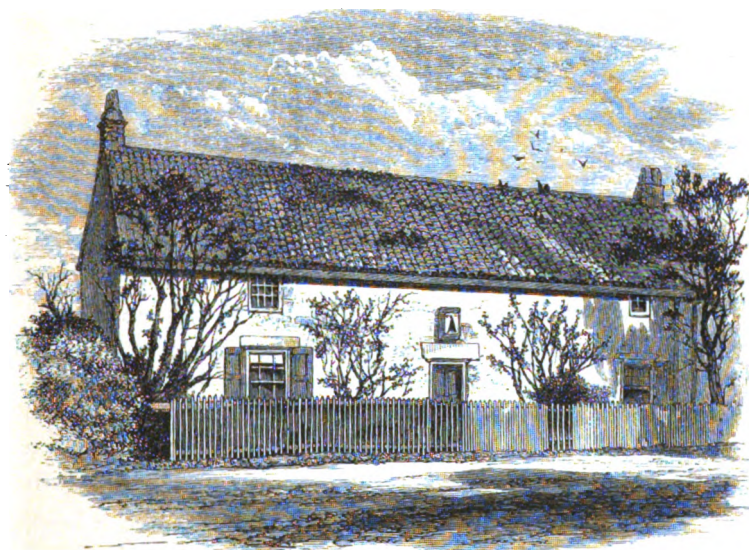
On another occasion, Robert played a series of tricks of a somewhat different character. Like his father, he was very fond of reducing his scientific reading to practice; and after studying Franklin's description of the lightning experiment, he proceeded to expend his store of Saturday pennies in purchasing about half a mile of copper wire at a brazier's shop in Newcastle. Having prepared his kite, he sent it up in the field opposite his father's door, and bringing the wire, insulated by means of a few feet of silk cord, over the backs of some of Farmer Wigham's cows, he soon had them skipping about the field in all directions with their tails up. One day he had his kite flying at the cottage-door as his father's galloway was hanging by the bridle to the paling, waiting for the master to mount. Bringing the end of the wire just over the pony's crupper, so smart an electric shock was given it, that the brute was almost knocked down. At this juncture his father issued from the house, riding-whip in hand, and was witness to the scientific trick just played off upon his galloway. "Ah! you mischievous scoondrel!" cried he to the boy, who ran off,—himself inwardly chuckling with pride, nevertheless, at Robert's successful experiment.¹

At this time, and for many years after, Stephenson dwelt in a cottage standing by the side of the road leading from the West Moor Pit to Killingworth. The

¹ Robert Stephenson was, perhaps, prouder of this little boyish experiment than he was of many of his subsequent achievements. Not having been quite accurately stated in the first edition of this book, Mr. Stephenson noted the correction for the second,

and wrote to the author (Sept. 18th 1857) as follows:—"In the kite experiment, will you say, that the copper-wire was insulated by a few feet of silk cord; without this, the experiment cannot be made."

railway from West Moor crosses this road close by the easternmost end of the cottage. The dwelling originally consisted of but one apartment on the ground-floor, with a garret over-head, to which access was obtained by



STEPHENSON'S COTTAGE, WEST MOOR. [By R. P. Leitch.]

means of a step-ladder. With his own hands Stephenson built an oven, and in the course of time he added rooms to the cottage, until it became expanded into a comfortable four-roomed dwelling, in which he remained as long as he lived at Killingworth.

He continued as fond of birds and animals as ever, and seemed to have the power of attaching them to him in a remarkable degree. He had a blackbird at Killingworth so fond of him, that it would fly about the cottage, and on holding out his finger, the bird would come and perch upon it directly. A cage was built for "blackie" in the partition between the passage and the room, a square of glass forming its outer wall; and Robert used afterwards to take pleasure in describing the oddity of the bird, imitating the manner in which it

would cock its head on his father's entering the house, and follow him with its eye into the inner apartment.

Neighbours were accustomed to call at the cottage and have their clocks and watches set to rights when they went wrong. One day, after looking at the works of a watch left by a pitman's wife, George handed it to his son; "Put her in the oven, Robert," said he, "for a quarter of an hour or so." It seemed an odd way of repairing a watch; nevertheless, the watch was put into the oven, and at the end of the appointed time it was taken out, going all right. The wheels had merely got clogged by the oil congealed by the cold; which at once explains the rationale of the remedy adopted.

There was a little garden attached to the cottage, in which, while a workman, Stephenson took a pride in growing gigantic leeks and astonishing cabbages. There was great competition in the growing of vegetables amongst the villagers, all of whom he excelled, excepting one, whose cabbages sometimes outshone his. To protect his garden-crops from the ravages of the birds, he invented a strange sort of "fley-craw," which moved its arms with the wind; and he fastened his garden-door by means of a piece of ingenious mechanism, so that no one but himself could enter it. His cottage was quite a curiosity-shop of models of engines, self-acting planes, and perpetual-motion machines. The last named contrivances, however, were only unsuccessful attempts to solve a problem which had already baffled hundreds of preceding inventors.

His odd and eccentric contrivances often excited great wonder amongst the Killingworth villagers. He won the women's admiration by connecting their cradles with the smoke-jack, and making them self-acting. Then he astonished the pitmen by attaching an alarum to the clock of the watchman whose duty it was to call them betimes in the morning. He also contrived a wonderful lamp which burned under water, with which

he was afterwards wont to amuse the Brandling family at Gosforth,—going into the fish-pond at night, lamp in hand, attracting and catching the fish, which rushed wildly towards the flame.

Dr. Bruce tells of a competition which Stephenson had with the joiner at Killingworth, as to which of them could make the best shoe-last; and when the former had done his work, either for the humour of the thing, or to secure fair play from the appointed judge, he took it to the Morrisons in Newcastle, and got them to put their stamp upon it. So that it is possible the Killingworth brakesman, afterwards the inventor of a safety-lamp and originator of the locomotive railway system, and John Morrison, the last-maker, afterwards the translator of the Scriptures into the Chinese language, may have confronted each other in solemn contemplation of the successful last, which won the verdict coveted by its maker.

Sometimes George would endeavour to impart to his fellow-workmen the results of his scientific reading. Everything that he learnt from books was so new and so wonderful to him, that he regarded the facts he drew from them in the light of discoveries, as if they had been made but yesterday. Once he tried to explain to some of the pitmen how the earth was round, and kept turning round. But his auditors flatly declared the thing to be impossible, as it was clear that “at the bottom side they must fall off!” “Ah!” said George, “you don’t quite understand it yet.” His son Robert also early endeavoured to communicate to others the information which he had gathered at school; and Dr. Bruce relates that, when visiting Killingworth on one occasion, he found him engaged in teaching algebra to such of the pitmen’s boys as would become his pupils.

While Robert was still at school, his father proposed to him during the holidays that he should construct a sun-dial, to be placed over their cottage-door at West

Moor. "I expostulated with him at first," said Robert, "that I had not learnt sufficient astronomy and mathematics to enable me to make the necessary calculations. But he would have no denial. 'The thing is to be done,' said he; 'so just set about it at once.' Well; we got a 'Ferguson's Astronomy,' and studied the subject together. Many a sore head I had while making the necessary calculations to adapt the dial to the latitude of Killingworth. But at length it was fairly drawn out on paper, and then my father got a stone, and we hewed, and carved, and polished it, until we made a very respectable dial of it; and there it is, you see," pointing to it over the cottage-door, "still quietly



numbering the hours when the sun shines. I assure you, not a little was thought of that piece of work by the pitmen when it was put up, and began to tell its tale of time." The date carved upon the dial is "August 11th, MDCCCXVI." Both father and son were in after-life very proud of their joint production.

Many years after, George took a party of savans, when attending the meeting of the British Association at Newcastle, over to Killingworth to see the pits, and he did not fail to direct their attention to the sun-dial; and Robert, on the last visit which he made to the place, a short time before his death, took a friend into the cottage, and pointed out to him the very desk, still there, at which he had sat when making his calculations of the latitude of Killingworth.

From the time of his appointment as engineer at the Killingworth Pit, George Stephenson was in a measure

relieved from the daily routine of manual labour, having, as we have seen, advanced himself to the grade of a higher class workman. He had not ceased to be a worker, though he employed his industry in a different way. It might, indeed, be inferred that he had now the command of greater leisure; but his spare hours were as much as ever given to work, either necessary or self-imposed. So far as regarded his social position, he had already reached the summit of his ambition; and when he had got his hundred a year, and his dun galloway to ride on, he said he never wanted to be any higher. When Robert Wetherly offered to give him an old gig, his travelling having so much increased of late, he accepted it with great reluctance, observing, that he should be ashamed to get into it, "people would think him so proud."

When the High Pit had been sunk, and the coal was ready for working, Stephenson erected his first winding-engine to draw the coals out of the pit, and also a pumping-engine for Long Benton colliery, both of which proved quite successful. Among other works of this time, he projected and laid down a self-acting incline along the declivity which fell towards the coal-loading place near Willington, where he had formerly officiated as brakesman; and he so arranged it, that the full waggons descending drew the empty waggons up the railroad. This was one of the first self-acting inclines laid down in the district.

The following is Stephenson's own account of his various duties and labours at this period of his life, as given before a Committee of the House of Commons in 1835:¹—

"After making some improvements in the steam-engines above ground, I was requested by the manager of the colliery to go underground along with him, to see if any improve-

¹ Evidence given before the Select Committee on Accidents in Mines, 1835

ments could be made in the mines, by employing machinery as a substitute for manual labour and horse-power in bringing the coals out of the deeper workings of the mine. On my first going down the Killingworth pit, there was a steam-engine underground for the purpose of drawing water from a pit that was sunk at some distance from the first shaft. The Killingworth coal-field is considerably dislocated. After the colliery was opened, at a very short distance from the shaft, one of those dislocations was met with. The coal was thrown down about forty yards. Considerable time was spent in sinking another pit to this depth. And on my going down to examine the work, I proposed making the engine (which had been erected some time previously) to draw the coals up an inclined plane which descended immediately from the place where it was fixed. A considerable change was accordingly made in the mode of working the colliery, not only in applying the machinery, but in employing putters instead of horses in bringing the coals from the hewers; and by those changes the number of horses in the pit was reduced from about 100 to 15 or 16. During the time I was engaged in making these important alterations, I went round the workings in the pit with the viewer, almost every time that he went into the mine,—not only at Killingworth, but at Mountmoor, Derwentrook, Southmoor, all of which collieries belonged to Lord Ravensworth and his partners; and the whole of the machinery in all these collieries was put under my charge."

It will thus be observed that Stephenson had now much better opportunities for improving himself in mechanics than he had heretofore possessed. His practical knowledge of the steam-engine could not fail to prove of the greatest value to him. His shrewd insight, together with his intimate acquaintance with its mechanism, enabled him to apprehend, as if by intuition, its most abstruse and difficult combinations. The study which he had given to it when a workman, and the patient manner in which he had groped his way through all the details of the machine, gave him the power of a master in dealing with it as applied to colliery purposes.

Sir Thomas Liddell was frequently about the works,

and took pleasure in giving every encouragement to the engine-wright in his efforts after improvement. The subject of the locomotive engine was already occupying Stephenson's careful attention; although it was still regarded in the light of a curious and costly toy, of comparatively little real use. But he had at an early period recognised its practical value, and formed an adequate conception of the might which as yet slumbered within it; and he now proceeded to bend the whole faculties of his mind to the development of its powers.



COLLIERS' COTTAGES AT LONG BENTON. [By R. P. Leitch.]

CHAPTER V.

THE LOCOMOTIVE ENGINE—GEORGE STEPHENSON BEGINS ITS IMPROVEMENT.

THE rapid increase in the coal trade of the Tyne about the beginning of the present century had the effect of stimulating the ingenuity of mechanics, and encouraging them to devise improved methods of transporting the coal from the pits to the shipping-places. From our introductory chapter, it will have been observed that the improvements which had thus far been effected were confined almost entirely to the road. The railway waggons still continued to be drawn by horses. By improving and flattening the tramway, considerable economy in horse-power had been secured; but unless some more effective method of mechanical traction could be devised, it was clear that railway improvement had almost reached its limits.

Notwithstanding Trevithick's comparatively successful experiment with the first railway locomotive on the Merthyr Tydvil tramroad in 1804, described in a former chapter, he seems to have taken no further steps to bring his invention into notice. He was probably discouraged by the breakage of the cast-iron plates, of which the road was formed, which were crushed under the load of his engine, and could not induce the owners of the line to relay it with better materials so as to give his locomotive a fair trial.

An imaginary difficulty, also, seems to have tended, amongst other obstacles, to prevent the adoption of the locomotive, viz., the idea that, if a heavy weight were placed behind the engine, the "grip" or "bite" of its

smooth wheels upon the equally smooth iron rail, must necessarily be so slight that they would whirl round upon it, and, consequently, that the machine would not make any progress.¹ Hence Trevithick, in his patent, provided that the periphery of the driving-wheels should be made rough by the projection of bolts or cross-grooves, so that the adhesion of the wheels to the road might thereby be better secured.

Trevithick himself does not seem to have erected another engine, but we gather from the evidence given by Mr. Rastrick in the committee on the Liverpool and Manchester Bill in 1825, that ten or twelve years before that time he had made an engine for Trevithick, after his patent; and that the engine was exhibited in London. "A circular railroad was laid down," said Mr. Rastrick, and it was stated that this engine was to run against a horse, and that which went a sufficient number of miles was to win." It is not known what afterwards became of this engine.

There were, however, at a much earlier period, several wealthy and enterprising men, both in Yorkshire and Northumberland, who were willing to give the locomotive a fair trial; and had Trevithick but possessed the requisite tenacity of purpose—had he not been too soon discouraged by partially successful experiments—he might have risen to both fame and fortune, not only as the inventor of the locomotive, but as the practical introducer of railway locomotion.

One of Trevithick's early friends and admirers was Mr. Blackett, of Wylam. The Wylam waggon-way is one of the oldest in the north of England. Down to

¹ The same fallacy seems long to have held its ground in France; for M. Granier tells us that some time after the first of George Stephenson's locomotives had been placed on the Liverpool and Manchester line, a model of one was exhibited before the Aca-

demy. After it had been examined, a member of that learned body said, smiling, "Yes, this is all very ingenious, no doubt, but unfortunately the machine will never move. The wheels will turn round and round in the same place."

the year 1807 it was formed of wooden spars or rails, laid down between the colliery at Wylam—where old Robert Stephenson worked—and the village of Lemington, some four miles down the Tyne, where the coals were loaded into keels or barges, and floated down past Newcastle, to be shipped for London. Each chaldron-waggon had a man in charge of it, and was originally drawn by one horse. The rate at which the waggons were hauled was so slow that only two journeys were performed by each man and horse in one day, and three on the day following. This primitive waggon-way passed, as before stated, close in front of the cottage in which George Stephenson was born; and one of the earliest sights which met his infant eyes was this wooden tramroad worked by horses.

Mr. Blackett was the first colliery owner in the North who took an active interest in the locomotive. He had witnessed the first performances of Trevithick's steam-carriage in London, and was so taken with the idea of its application to railway locomotion that he resolved to have an engine erected after the new patent for use upon his tramway at Wylam. He accordingly obtained from Trevithick, in October, 1804, a plan of his engine, provided with "friction-wheels," and employed Mr. John Whinfield, of Pipewellgate, Gateshead, to construct it at his foundry there. The engine was made under the superintendence of one John Steele,¹ an

¹ John Steele was one of the many "born mechanics" of the Northumberland district. When a boy at Colliery Dykes, his native place, he was noted for his "turn for machinery." He used to take his playfellows home to see and admire his imitations of pit-engines. While a mere youth he lost his leg by an accident; and those who remember him at Whinfield's speak of his hopping about the locomotive, of which he was very proud, upon his wooden leg. It was a great disappointment to him

when Mr. Blackett refused to take the engine. One day he took a friend to look at it when reduced to its degraded office of blowing the cupola bellows; and, referring to the cause of its rejection, he observed that he was certain it would succeed, if made sufficiently heavy. "Our master," he continued, "will not be at the expense of following it up; but depend upon it the day will come when such an engine will be fairly tried, and then it will be found to answer." Steele was afterwards extensively employed by the

ingenious mechanic, who had been in Wales, and worked under Trevithick in fitting the engine at Pen-y-darran. When the Gateshead locomotive was finished, a temporary way was laid down in the works, on which it was run backwards and forwards many times. For some reason or other, however—it is said because the engine was deemed too light for drawing the coal-trains—it never left the works, but was dismounted from the wheels, and set to blow the cupola of the foundry, in which service it long continued to be employed.

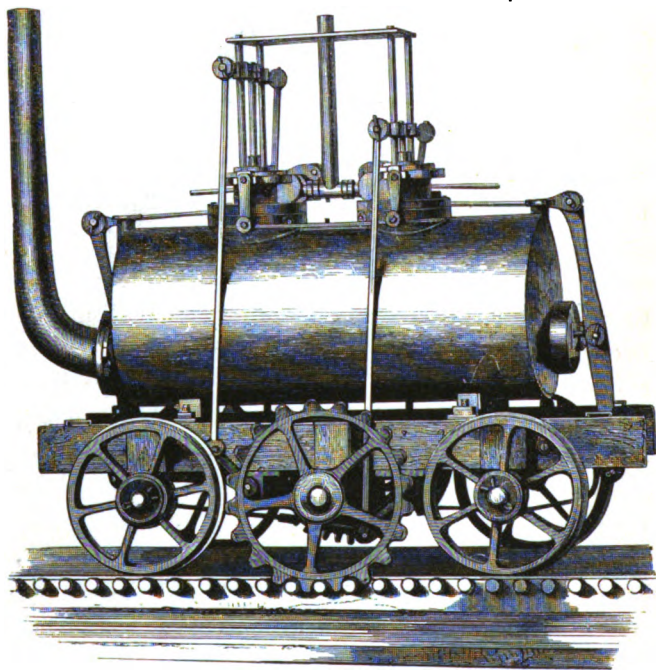
Several years elapsed before Mr. Blackett took any further steps to carry out his idea. The final abandonment of Trevithick's locomotive at Pen-y-darran perhaps contributed to deter him from proceeding further; but he had the Wylam wooden tramway taken up in 1808, and a plate-way of cast iron laid down instead—a single line furnished with sidings to enable the laden waggons to pass the empty ones. The new iron road proved so much smoother than the old wooden one, that a single horse, instead of drawing one, was enabled to draw two, or even three laden waggons.

Although the locomotive seemed about to be lost sight of, it was not forgotten. In 1811, Mr. Blenkinsop, the manager of the Middleton Collieries near Leeds, revived the idea of employing it in lieu of horses to haul the coals along his tramway. Mr. Blenkinsop, in the patent which he took out for his proposed engine, followed in many respects the design of Trevithick; but, with the help of Matthew Murray of Leeds, one of the most ingenious mechanics of his day, he introduced several important and valuable modifications. Thus, he employed two cylinders of 8 in. diameter, instead of one

British Government in raising sunken ships; and later in life he established engine-works at Rouen, where he made marine-engines for the French Government. He was unfortunately killed by the explosion of an engine-

boiler (with the safety-valve of which something had gone wrong), when on an experimental trip with one of the steamers fitted up by himself, and on his way to England to visit his family near Newcastle.

as in Trevithick's engine. These cylinders were placed vertically, and immersed for more than half their length in the steam space of the boiler. The eduction pipes met in a single tube at the top, and threw the steam into the air. The boiler was cylindrical in form, but of cast iron. It had one flue, the fire being at one end and the chimney at the other. The engine was supported on a



BLINKINSOP'S LEEDS ENGINE.

carriage without springs, resting directly upon two pairs of wheels and axles unconnected with the working parts, and which merely served to carry the engine upon the rails. The motion was effected in this way: the piston-rods, by means of cross-heads, worked the connecting-rods, which came down to two cranks on each side below the boiler, placed at right angles in order to pass their centres with certainty. These cranks worked

two shafts fixed across the engine, on which were small-toothed wheels working into a larger one between them ; and on the axis of this large wheel, outside the framing, were the driving-wheels, one of which was toothed and worked into a rack on one side of the railway.

It will be observed that the principal new features in this engine were the two cylinders and the toothed-wheel working into a rack-rail. Mr. Blenkinsop contrived the latter expedient in order to ensure sufficient adhesion between the wheel and the road, supposing that smooth wheels and smooth rails would be insufficient for the purpose. Clumsy and slow though the engine was compared with modern locomotives, it was, nevertheless, a success. It was the first engine that plied regularly upon any railway, doing useful work ; and it continued so employed for more than twenty years. What was more, it was a commercial success, for its employment was found to be economical compared with horse-power. In a letter to Sir John Sinclair, Mr. Blenkinsop stated that his engine weighed five tons ; consumed two-thirds of a hundredweight of coals and fifty gallons of water per hour ; drew twenty-seven waggons, weighing ninety-four tons, on a dead level, at three and a half miles an hour, or fifteen tons up an ascent of 2 in. in the yard ; that when "lightly loaded" it travelled at a speed of ten miles an hour ; that it did the work of sixteen horses in twelve hours ; and that its cost was 400*l*. Such was Mr. Blenkinsop's own account of the performances of his engine, which was for a long time regarded as one of the wonders of the neighbourhood.¹

¹ Thomas Gray, a native of Leeds, was an enthusiastic believer in the new tractive power, and wherever he went he preached up railways and Blenkinsop's locomotive. While he was living at Brussels, in 1816, a canal to Charleroi was under consideration, on which he seized the opportunity of urging the superior merits

of a railway. When he returned to England in 1820, he wrote a book upon the subject, entitled, 'Observations on a General Iron Railway,' in which he strongly advocated the advantages of railways generally, giving as a frontispiece to the book an engraving of Blenkinsop's engine. And several years after the opening of the Liver-

The Messrs. Chapman of Newcastle in 1812 endeavoured to overcome the same fictitious difficulty of the want of adhesion between the wheel and the rail, by patenting a locomotive to work along the road by means of a chain stretched from one end of it to the other. This chain was passed once round a grooved barrel-wheel under the centre of the engine: so that, when the wheel turned, the locomotive, as it were, dragged itself along the railway. An engine, constructed after this plan, was tried on the Heaton Railway, near Newcastle; but it was so clumsy in its action, there was so great a loss of power by friction, and it was found to be so expensive and difficult to keep in repair, that it was very soon abandoned. Another remarkable expedient was adopted by Mr. Brunton, of the Butterley Works, Derbyshire, who, in 1813, patented his Mechanical Traveller, to go *upon legs* working alternately like those of a horse.¹ But this engine never got beyond the experimental state, for, at its very first trial, the driver, to make sure of a good start, overloaded the safety-valve, when the boiler burst and killed a number of the bystanders, wounding many more. These, and other contrivances with the same object, projected about the same time, show that invention was busily at work, and that many minds were anxiously labouring to solve the problem of steam locomotion on railways.

Mr. Blackett, of Wylam, was encouraged by the success of Mr. Blenkinsop's experiment, and again he resolved to make a trial of the locomotive upon his waggon-way. Accordingly, in 1812, he ordered a second engine, which was so designed as to work with a toothed driving-wheel

pool and Manchester Railway we find Thomas Gray, true to his first love, urging in the 'Mechanics' Magazine' the superiority of Blenkinsop's cogged wheel and rail over the smooth road and rail of the modern railway.

¹ Other machines with legs were patented in the following year by

Lewis Gompertz and by Thomas Tindall. In Tindall's specification it is provided that the power of the engine is to be assisted by a *horizontal wind-mill*; and the four pushers, or legs, are to be caused to come successively in contact with the ground, and impel the carriage.

upon a rack-rail as at Leeds. This locomotive was constructed by Thomas Waters, of Gateshead, under the superintendence of Jonathan Foster, Mr. Blackett's principal engine-wright. It was a combination of Trevithick's and Blenkinsop's engines; but it was of a more awkward construction than either. Like Trevithick's, it had a single cylinder with a fly-wheel, which Blenkinsop had discarded. The boiler was of cast iron. Jonathan Foster described it to the author in 1854, as "a strange machine, with lots of pumps, cog-wheels, and plugs, requiring constant attention while at work." The weight of the whole was about six tons.

When finished, it was conveyed to Wylam on a waggon, and there mounted upon a wooden frame, supported by four pairs of wheels, which had been constructed for its reception. A barrel of water, placed on another frame upon wheels, was attached to it as a tender. After a great deal of labour, the cumbrous machine was got upon the road. At first it would not move an inch. Its maker, Tommy Waters, became impatient, and at length enraged, and taking hold of the lever of the safety-valve, declared in his desperation, that "either *she* or *he* should go." At length the machinery was set in motion, on which, as Jonathan Foster described to the author, "she flew all to pieces, and it was the biggest wonder i' the world that we were not all blewn up." The incompetent and useless engine was declared to be a failure; it was shortly after dismounted and sold; and Mr. Blackett's praiseworthy efforts thus far proved in vain.

He was still, however, desirous of testing the practicability of employing locomotive power in working the coal down to Lemington, and he determined on making yet another trial. He accordingly directed his engine-wright, Jonathan Foster, to proceed with the building of a third engine in the Wylam workshops. This new locomotive had a single 8-inch cylinder, was provided

with a flywheel like its predecessor, and the driving-wheel was cogged on one side to enable it to travel in the rack-rail laid along the road. The engine proved more successful than the former one; and it was found capable of dragging eight or nine loaded waggons, though at the rate of little more than a mile an hour, from the colliery to the shipping-place. It sometimes took six hours to perform the journey of five miles. Its weight was found too great for the road, and the cast-iron plates were constantly breaking. It was also very apt to get off the rack-rail, and then it stood still. The driver was one day asked how he got on? "Get on?" said he, "we don't get on; we only get off!" On such occasions, horses had to be sent out to drag the waggons as before, and others to haul the engine back to the workshops. It was constantly getting out of order; its plugs, pumps, or cranks, got wrong; and it was under repair as often as at work. At length it became so cranky that the horses were usually sent after it to drag it along when it gave up; and the workmen generally declared it to be a "perfect plague." Mr. Blackett did not obtain credit among his neighbours for these experiments. Many laughed at his machines, regarding them only in the light of crotchets,—frequently quoting the proverb of "a fool and his money are soon parted." Others regarded them as absurd innovations on the established method of hauling coal, and pronounced that they would "never answer."

Notwithstanding, however, the comparative failure of this second locomotive, Mr. Blackett persevered with his experiments. He was zealously assisted by Jonathan Foster, the engine-wright, and William Hedley, the viewer of the colliery, a highly ingenious person, who proved of great use in carrying out the experiments to a successful issue. One of the chief causes of failure being the rack-rail, the idea occurred to Mr. Hedley that it might be possible to secure sufficient adhesion

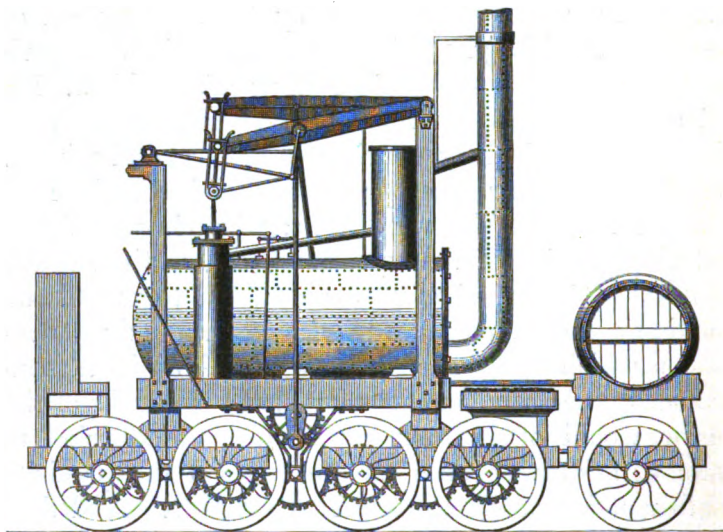
between the wheel and the rail by the mere weight of the engine, and he proceeded to make a series of experiments for the purpose of determining this problem. He had a frame placed on four wheels, and fitted up with windlasses attached by gearing to the several wheels. The frame having been properly weighted, six men were set to work the windlasses; when it was found that the adhesion of the smooth wheels on the smooth rails was quite sufficient to enable them to propel the machine without slipping. Having then found the proportion which the power bore to the weight, he demonstrated by successive experiments that the weight of the engine would of itself produce sufficient adhesion to enable it to draw upon a smooth railroad the requisite number of waggons in all kinds of weather. And thus was the fallacy which had heretofore prevailed on this subject completely exploded, and it was satisfactorily proved that rack-rails, toothed wheels, endless chains, and legs, were alike unnecessary for the efficient traction of loaded waggons upon a moderately level road.¹

From this time forward, considerably less difficulty was experienced in working the coal trains upon the Wylam tramroad. At length the rack-rail was dispensed with. The road was laid with heavier rails; the working of the old engine was improved; and a new engine was shortly after built and placed upon the road, still on eight wheels, driven by seven rack-wheels working inside them—with a wrought-iron boiler through which the flue was returned so as largely to increase the heating surface, and thus give increased power to the engine.² The following is a representation of this improved Wylam engine.

¹ Mr. Hedley took out a patent to secure his invention, dated the 13th March, 1813. Specification No. 3666. If it be true, as alleged, that the wheels of Trevithick's first locomotive were smooth, it seems strange that

the fallacy should ever have existed.

² By the year 1825, the progress made on the Wylam railroad was thus described by Mr. Mackenzie in his 'History of Northumberland.' "A stranger," said he, "is struck with



WYLAM ENGINE.

As may readily be imagined, the jets of steam from the piston, blowing off into the air at high pressure while the engine was in motion, caused considerable annoyance to horses passing along the Wylam road, at that time a public highway. The nuisance was felt to be almost intolerable, and a neighbouring gentleman threatened to have it put down. To diminish the noise as much as possible, Mr. Blackett gave orders that so soon as any horse, or vehicle drawn by horses, came in sight, the locomotive was to be stopped, and the frightful blast of the engine thus suspended until the passing animals had got out of sight. Much interruption was thus caused to the working of the railway; and it excited considerable dissatisfaction amongst the workmen. The following plan was adopted to abate the nuisance: a reservoir was provided immediately behind the chim-

surprise and astonishment on seeing a locomotive engine moving majestically along the road at the rate of four or five miles an hour, drawing along from ten to fourteen loaded

waggon, weighing about 21½ tons; and his surprise is increased on witnessing the extraordinary facility with which the engine is managed. This invention is a noble triumph of science."

ney (as shown in the preceding cut) into which the waste steam was thrown after it had performed its office in the cylinder; and from this reservoir, the steam gradually escaped into the atmosphere without noise. This arrangement was devised with the express object of preventing a blast in the chimney, the value of which, as we shall subsequently find, was not detected until George Stephenson, adopting it with a preconceived design and purpose, demonstrated its importance and value,—as being, in fact, the very life-breath of the locomotive engine.

While Mr. Blackett was thus experimenting and building locomotives at Wylam, George Stephenson was anxiously studying the same subject at Killingworth. He was no sooner appointed engine-wright of the collieries than his attention was directed to the means of more economically hauling the coal from the pits to the river side. We have seen that one of the first important improvements which he made, after being placed in charge of the colliery machinery, was to apply the surplus power of a pumping steam-engine fixed underground, for the purpose of drawing the coals out of the deeper workings of the Killingworth mines,—by which he succeeded in effecting a large reduction in the expenditure on manual and horse labour.

The coals, when brought above ground, had next to be laboriously dragged by means of horses to the shipping staiths on the Tyne, several miles distant. The adoption of a tramroad, it is true, had tended to facilitate their transit: nevertheless the haulage was both tedious and expensive. With the view of economising labour, Stephenson laid down inclined planes where the nature of the ground would admit of this expedient being adopted. Thus, a train of full waggons let down the incline by means of a rope running over wheels laid along the tramroad, the other end of which was attached to a train of empty waggons placed

at the bottom of the parallel road on the same incline, dragged them up by the simple power of gravity. But this applied only to a comparatively small part of the road. An economical method of working the coal trains, instead of by means of horses—the keep of which was at that time very costly in consequence of the high price of corn,—was still a great desideratum; and the best practical minds in the collieries were actively engaged in trying to solve the problem.

In the first place, Stephenson resolved to make himself thoroughly acquainted with what had already been done. Mr. Blackett's engines were working daily at Wylam, past the cottage where he had been born; and thither he frequently went¹ to inspect the improvements made by Mr. Blackett from time to time both in the locomotive and in the plateway along which it worked. Jonathan Foster informed us that, after one of these visits, Stephenson declared to him his conviction that a much more effective engine might be made, that should work more steadily and draw the load more effectively.

He had also the advantage, about the same time, of seeing one of Blenkinsop's Leeds engines, which was placed on the tramway leading from the collieries of Kenton and Coxlodge, on the 2nd of September, 1813. This locomotive drew sixteen chaldron waggons containing an aggregate weight of seventy tons, at the rate of about three miles an hour. George Stephenson and several of the Killingworth men were among the crowd

¹ At the Stephenson Memorial meeting at Newcastle-on-Tyne, 26th October, 1858, Mr. Hugh Taylor, Chairman of the Northern Coal-owners, gave the following account of one of such visits made by Stephenson to Wylam, in the company of Mr. Nicholas Wood and himself:—"It was, I think, in 1812, that Mr. Stephenson and Mr. Wood came to my house, then at Newburn, and after we had dined, we went and examined the locomotive then on Mr. Blackett's

waggon-way. At that early date it went by a sort of cog-wheel; there was also something of a chain to it. There was no idea that the machine would be sufficiently adhesive to the rails by the action of its own weight; but I remember a man going before—that was after the chain was abrogated—and scattering ashes on the rails, in order to give it adhesiveness, and two or three miles an hour was about the rate of progress."

of spectators that day ; and after examining the engine and observing its performances, he remarked to his companions, that "he thought he could make a better engine than that, to go upon legs." Probably he had heard of the invention of Brunton, whose patent had by this time been published, and proved the subject of much curious speculation in the colliery districts. Certain it is, that, shortly after the inspection of the Coxlodge engine, he contemplated the construction of a new locomotive, which was to surpass all that had preceded it. He observed that those engines which had been constructed up to this time, however ingenious in their arrangements, were in a great measure practical failures. Mr. Blackett's was as yet both clumsy and expensive. Chapman's had been removed from the Heaton tramway in 1812, and was regarded as a total failure. And the Blenkinsop engine at Coxlodge was found very unsteady and costly in its working ; besides, it pulled the rails to pieces, the entire strain being upon the rack-rail on one side of the road. The boiler, however, having shortly blown up, there was an end of that engine ; and the colliery owners did not feel encouraged to try any further experiment.

An efficient and economical working locomotive engine, therefore, still remained to be invented ; and to accomplish this object Stephenson now applied himself. Profiting by what his predecessors had done, warned by their failures and encouraged by their partial successes, he commenced his labours. There was still wanting the man who should accomplish for the locomotive what James Watt had done for the steam-engine, and combine in a complete form the best points in the separate plans of others, embodying with them such original inventions and adaptations of his own as to entitle him to the merit of inventing the working locomotive, as James Watt is to be regarded as the inventor of the working condensing engine. This was the great

work upon which George Stephenson now entered, though probably without any adequate idea of the ultimate importance of his labours to society and civilisation.

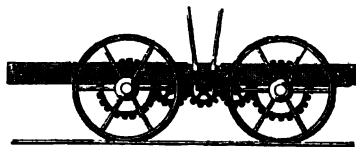
He proceeded to bring the subject of constructing a "Travelling Engine," as he then denominated the locomotive, under the notice of the lessees of the Killingworth Colliery, in the year 1813. Lord Ravensworth, the principal partner, had already formed a very favourable opinion of the new colliery engine-wright from the improvements which he had effected in the colliery engines, both above and below ground; and, after considering the matter, and hearing Stephenson's explanations, he authorised him to proceed with the construction of a locomotive,—though his lordship was by some called a fool for advancing money for such a purpose. "The first locomotive that I made," said Stephenson, many years after,¹ when speaking of his early career at a public meeting in Newcastle, "was at Killingworth Colliery, and with Lord Ravensworth's money. Yes, Lord Ravensworth and partners were the first to entrust me, thirty-two years since, with money to make a locomotive engine. I said to my friends, there was no limit to the speed of such an engine, if the works could be made to stand."

Our engine-wright had, however, many obstacles to encounter before he could get fairly to work with the erection of his locomotive. His chief difficulty was in finding workmen sufficiently skilled in mechanics and in the use of tools, to follow his instructions and embody his designs in a practical shape. The tools then in use about the collieries were rude and clumsy; and there were no such facilities as now exist for turning out machinery of an entirely new character. Stephenson was under the necessity of working with such men and

¹ Speech at the opening of the Newcastle and Darlington Railway, June 18, 1844.

tools as were at his command; and he had in a great measure to train and instruct the workmen himself. The engine was built in the workshops at the West Moor, the leading mechanic being John Thirlwall, the colliery blacksmith, an excellent workman in his way, though quite new to the work now entrusted to him.

In this first locomotive constructed at Killingworth, Stephenson to some extent followed the plan of Blenkinsop's engine. The wrought-iron boiler was cylindrical, eight feet in length and thirty-four inches in diameter, with an internal flue-tube twenty inches wide passing through it. The engine had two vertical cylinders of eight inches diameter and two feet stroke let into the boiler, which worked the propelling gear with cross-heads and connecting-rods. The power of the two cylinders was combined by means of spurwheels, which communicated the motive power to the wheels supporting the engine on the rail, instead of, as in Blenkinsop's engine, to cogwheels which acted on the cogged rail independent of the four supporting wheels. The engine thus worked upon what is termed the second motion. The chimney was of wrought iron, round which was a chamber extending back to the feed-pumps, for the purpose of heating the water previous to its injection into the boiler. The engine had no springs, and was mounted on a wooden frame supported on four wheels. In order to neutralise as much as possible the jolts and shocks which such an engine would necessarily encounter from the obstacles and inequalities of the then very imperfect plateway, the water-barrel which served for a tender was fixed to the end of a lever and weighted, the other end of the lever being connected with the frame of the locomotive carriage. By this means the weight of the two was more equally distributed, though the con-



THE SPUR-GEAR.

trivance did not by any means compensate for the total absence of springs.

The wheels of the locomotive were all smooth, Stephenson having satisfied himself by experiment that the adhesion between the wheels of a loaded engine and the rail would be sufficient for the purpose of traction. Robert Stephenson informed us that his father caused a number of workmen to mount upon the wheels of a waggon moderately loaded, and throw their entire weight upon the spokes on one side, when he found that the waggon could thus be easily propelled forward without the wheels slipping. This, together with other experiments, satisfied him, as it had already satisfied Mr. Hedley, of the expediency of adopting smooth wheels on his engine, and it was so made accordingly.

The engine was, after much labour and anxiety, and frequent alterations of parts, at length brought to completion, having been about ten months in hand. It was placed upon the Killingworth Railway on the 25th of July, 1814; and its powers were tried on the same day. On an ascending gradient of 1 in 450, the engine succeeded in drawing after it eight loaded carriages of thirty tons' weight at about four miles an hour; and for some time after it continued regularly at work.

Although a considerable advance upon previous locomotives, "Blutcher" (as the engine was popularly called) was nevertheless a somewhat cumbrous and clumsy machine. The parts were huddled together. The boiler constituted the principal feature; and, being the foundation of the other parts, it was made to do duty not only as a generator of steam, but also as a basis for the fixings of the machinery and for the bearings of the wheels and axles. The want of springs was seriously felt; and the progress of the engine was a succession of jolts, causing considerable derangement to the machinery. The mode of communicating the motive power to the wheels by means of the spur-gear also caused frequent

jerks, each cylinder alternately propelling or becoming propelled by the other, as the pressure of the one upon the wheels became greater or less than the pressure of the other; and, when the teeth of the cog-wheels became at all worn, a rattling noise was produced during the travelling of the engine.

As the principal test of the success of the locomotive was its economy as compared with horse power, careful calculations were made with the view of ascertaining this important point. The result was, that it was found the working of the engine was at first barely economical; and at the end of the year the steam power and the horse power were ascertained to be as nearly as possible upon a par in point of cost.

We give the remainder of the history of George Stephenson's efforts to produce an economical working locomotive in the words of his son Robert, as communicated to the author in 1856, for the purposes of his father's 'Life.'

"A few months of experience and careful observation upon the operation of this (his first) engine convinced my father that the complication arising out of the action of the two cylinders being combined by spur-wheels would prevent their coming into practical application. He then directed his attention to an entire change in the construction and mechanical arrangements, and in the following year took out a patent, dated February 28th, 1815, for an engine which combined in a remarkable degree the essential requisites of an economical locomotive,—that is to say, few parts, simplicity in their action, and great simplicity in the mode by which power was communicated to the wheels supporting the engine.

"This second engine consisted as before of two vertical cylinders, which communicated directly with each pair of the four wheels that supported the engine by a cross-head and a pair of connecting-rods; but in attempting to establish a direct communication between the cylinders and the wheels that rolled upon the rails, considerable difficulties presented themselves. The ordinary joints could not be employed to unite the engine, which was a rigid mass, with the wheels rolling upon the irre-

gular surface of the rails; for it was evident that the two rails of the line of railway could not always be maintained at the same level with respect to each other—that one wheel at the end of the axle might be depressed into a part of the line which had subsided, whilst the other would be elevated. In such a position of the axle and wheels it was clear that a rigid communication between the cross-head and the wheels was impracticable. Hence it became necessary to form a joint at the top of the piston-rod where it united with the cross-head; so as to permit the cross-head always to preserve complete parallelism with the axle of the wheels with which it was in communication.

“In order to obtain the flexibility combined with direct action which was essential for ensuring power and avoiding needless friction and jars from irregularities in the rail, my father employed the “ball and socket” joint for effecting a union between the ends of the cross-heads where they united with the connecting-rods, and between the end of the connecting-rods where they were united with the crank-pins attached to each driving-wheel. By this arrangement the parallelism between the cross-head and the axle was at all times maintained, it being permitted to take place without producing jar or friction upon any part of the machine.

“The next important point was to combine each pair of wheels by some simple mechanism, instead of the cog-wheels which had formerly been used. My father began by inserting each axle into two cranks at right angles to each other, with rods communicating horizontally between them. An engine was made on this plan, and answered extremely well. But at that period (1815) the mechanical skill of the country was not equal to the task of forging cranked axles of the soundness and strength necessary to stand the jars incident to locomotive work; so my father was compelled to fall back upon a substitute which, though less simple and less efficient, was within the mechanical capabilities of the workmen of that day, either for construction or repair. He adopted a chain which rolled over indented wheels placed on the centre of each axle, and so arranged that the two pairs of wheels were effectually coupled and made to keep pace with each other. But these chains after a few years' use became stretched, and then the engines were liable to irregularity in their working, especially in changing from working back to forward again. Nevertheless,