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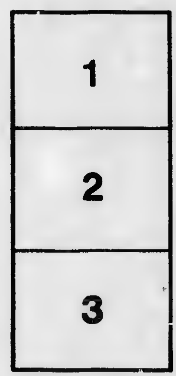


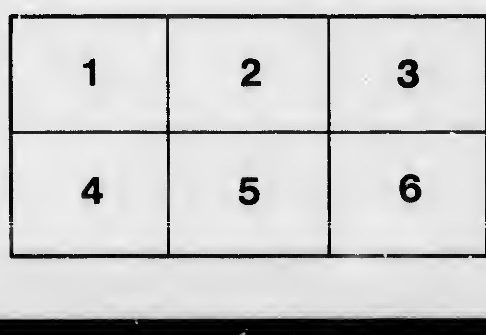

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**Canadian Society of Civil Engineers.**

INCORPORATED 1887.

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# THE DEVELOPMENT OF THE LOCOMOTIVE.

By T. T. Vernon Smith, M. Can. Soc. C.E.

*To be read on* 31*st January, or* 14*th February.*

A series of railway articles, by Mr. T. Curtis Clarke, have recently appeared, in a leading magazine, which have been decidedly interesting and deservedly popular, but they contain a number of statements which, designed to please American readers, are by no means correct in fact or generous to the engineers of other nationalities. Old country engineers have learned to regard railways and the locomotive, especially in its present form, as their undisputed invention and introduction, and although they are not so ungenerous as to claim every individual improvement, yet they consider that in this one department of engineering, the great bulk of the evolution of the present railway has been peculiarly British, and that Americans have not contributed a great deal towards the mechanical and scientific triumph that we now see. The first number of these papers is particularly guilty and ungracious in claiming for American inventors everything valuable and important that has been found out. "The modern railway," says Mr. Clarke, "was created by the Stephensons in 1830, when they built the locomotive Rocket. The development of the railway since is due to the development of the locomotive." "The earlier locomotives of this country modelled after the Rocket, weighed five or six tons, and could draw on a level about 40 tons. After the American improvements, which we shall describe, were made, our engines weighed 25 tons, and could draw on a level some sixty loaded cars, weighing 1,200 tons. The Stephenson type once fixed has remained unchanged (in Europe), except in detail, to the present day." "When we come to the United States we find an entirely different state of things. The key to the evolution of the American railway is the contempt for authority displayed by our engineers, and the untrammelled way in which they invented and applied whatever they thought would answer the best purpose, regardless of precedent." "When we began to build our railways in 1831, we followed English patterns for a short time, but our engineers soon saw that unless vital changes were made, our money would not hold out, and necessity truly became the mother of invention. The first and most far-seeing invention was that of the swivelling truck, which enables the engine to run round curves of almost any radius. This enabled us to build much less expensive lines than those of England, for we could avoid hills and other obstacles. The swivelling truck was first suggested by Horatio Allen for the South Carolina Railway in 1831, but the first practical use of it was made upon the Mohawk and Hudson Railroad in the same year. It is said to have been invented by John B. Jervis, Chief Engineer of that road. The next improvement was the equalizing beams or levers, by which the weight of the engine is always borne by three out of four or more driving wheels. The a double truck car precisely as we now see them, and what was more, it, had seats with reversible backs, as now universal in America, though they were never commonly used in England. This identical car was only used on the Liverpool and Manchester for a short time, and was subsequently sold to the Newcastle and North Shields, where numbers may still remember it as being occasionally used on the Sunday trains. The early history of railways begins altogether with the private unchartered roads of Great Britain, for although a railway company was chartered in the last century, and the first public railway that was actually constructed dates from the first year of the Nineteenth Century, all these early public roads were worked by horses, and contributed nothing of either scientific or mechanical interest until the Stockton and Darlington of 1825. During this quarter of a century, however, the private roads had solved most of the important mechanical questions upon which all the subsequent evolution of railways depends. Although Mr. Clarke sneers at the results of all the experiments and investigations prior to the era of the Rocket, there were but few important points in railway practice unsolved at the date of the Rainhill experiments, either in the construction of the railway or the locomotive. Since 1812 locomotives had been in constant daily use on a number of private railways, and these lines had been constructed and were being worked with just as rigid a regard to economy, and with as successful a record for economical work, as anything since discovered. The old Stockton and Darlington was laid out, not only with a strict regard to economy, but to make the best and most perfect road that could be obtained between its termini, and it remains to this day as complete and finished a line as can be produced, nor is there in existence, as far as the author knows, anything vastly in advance of the old Quakers road finished five years before there was a railway of any kind in America. Even the latest improvement introduced on the New York Central, for the advancement and recreation of their employees, might take a leaf with advantage, from the experience of the Stockton and Darlington 40 years since, on the management of the railway employees' reading, coffee and recreation rooms, which were first introduced and are still perhaps the most successfully managed on this good old railway.

From Woods' Treatise on Railways, the first edition of which was published in 1825, we learn that the date of the introduction of railways into the Newcastle district was between the years 1602 and 1649. These were of timber entirely. In 1738 cast iron rails were substituted for the wooden upper stringer, which was made of hardwood and took the wear of the wheels. In 1747 the Colebrookdale Company replaced their wooden rails with cast-iron, and iron wheels were introduced in 1753. Tramplates of the section used by Outram had been in use before his day, being first laid, it is supposed, on the Duke of Norfolk's railway near Sheffield in 1776, and the original shape was improved upon on the Surrey tramway, which has the honor of being the first public railway built under an Act of Parliament. This pioneer railway obtained its Act in 1801, extended from the Thames at Wandsworth, to Mersham and Reigate, being with branches 28 miles in length, and was subsequently sold to the Brighton Company and torn up. In 1793, Outram, from whom the tramway takes its name, laid down a number of tramways in Derbyshire, and introduced the stone blocks under the ends of the tramplates, which for a time displaced the former wooden sleepers, and were used by the Stephensons and others in all the early railways. The first edge railway, which is the parent of our present railway, was laid in 1801, for the conveyance of slate from Lord Penrhyn's quarries in North Wales, and within a few years all the Northumberland and Durham collieries adopted this improvement, and

1793, Outram, from whom the tramway takes its name, laid down a

question of adhesion, is proof sufficient that they were a success. To Stephenson's first engine in 1814, belongs the very great honor of being the machine that set at rest this vexed question of adhesion, whether the engine could propel itself on the rails to do any appreciable work without some other contrivance than depending upon its own weight. There was nothing in the engine itself that was widely different from Trevithick's or Blenkinsopp's engines, yet one had failed and the other had shunned the great question. He could give no reason for his faith, but he had made some experiments on friction, and he and his bosom friend, William Hutchinson, spent a very anxious night in a private trial of the engine before her public exhibition and trial on the following day, July 25th, 1814, when Lord Ravensworth, who had found the money to build the engine, the Brandlings and other leading coal owners were invited to be present. This engine settled this one important question, on which more than anything else the modern locomotive rests for its utility. The next year, 1815, and on the same railway the second great discovery was made almost by accident on a second of George Stephenson's engines. Hitherto the locomotive engines had exhausted their waste steam into the open air, and on a neighboring railway Mr. Blackett's engine had got the name of Puffing Billy, and frightened the horses and cattle for a mile away. In Stephenson's second engine the exhaust pipes were turned into the chimney, and a wonderfully enhanced effect in its steam-raising properties was at once found. Stephenson constructed a number of locomotives after this at Killingworth, each embodying some improvement over its predecessor, and that these engines were not so very much behind more modern examples is shown by the fact that one of them, built for the Kilmarnock and Troon Railway, in 1817, worked continuously until 1848, when she was broken up.

In 1822, George Stephenson's first railway for which he acted as engineer, the Hetton railway, was opened with six of his locomotives built at the Killingworth shops. This was a private railway belonging to the Hetton Colliery, but was far in advance of any previous road in its character and details. It had wrought iron rails, and for 20 years afterwards no important change was made either in the road or the locomotives which all remained very much as Stephenson left them, when he transferred his services as engineer from the Hetton Company to the Stockton and Darlington, which was a public railway constructed under an Act of Parliament, and the first important line that had been so constructed, for although 24 railways before the Stockton and Darlington had obtained charters and were most of them in operation, they were none of them equal in importance or character to the road now under construction by the Quaker coal proprietors of Darlington. On the 27th September, 1825, this railway was opened, was then and has been ever since a model road. It attracted an immense deal of public attention, and produced in fact a sort of a railway mania. Scores of Acts of incorporation were applied for, and of these 21 roads were completed within the next few years. So that 1825 is really the date from which British railway construction may be said to commence. Of the roads chartered in that year the Monkland and Kirkintilloch opened in 1827, the Canterbury and Whitstaple, and the Cromford and High Peak opened early in 1830, the Leicester and Swannington on which was a tunnel 1¼ miles long, and the Liverpool and Manchester, opened in September 1830, the Dundee and Newtyle, Bolton and Leigh and the Glasgow and Gainkirk all opened early in 1831, were all roads on which the work was of a superior character and all aided in the development of the modern railway. As all these roads were designed for locomotives, the question of supplying the necessary machinery for these were they with the accumulation of work, that only seven of the new engines were placed on the Liverpool and Manchester ready for the opening. Of these the Meteor, Comet, Dart and Arrow had 10 × 16 cylinders, the last named being the first engine that crossed Chat Moss and made the continuous run from Manchester to Liverpool. The other three engines, the Phœnix, North Star and Northumbrian, with 11 × 16 cylinders, were delivered just before the opening. On that occasion the Northumbrian was driven by George Stephenson himself, and after the accident to Mr. Husskison, took the dying statesman to his home, 15 miles in 25 minutes. All these engines were soon found to have grave defects, they were too small for the trains and at anything like speed they were rough and unsteady. A new design was now adopted with larger cylinders and longer bearing upon the road, and the worl s at Newcastle were pushed night and day to turn out locomotives fast enough. The Planet, Majestic, Mercury, and five others were got out early in the following year 1831, and ten others, all of the Planet class, were delivered at Liverpool before the end of the year or early in 1832. Other builders were now in the field, and Stephenson built but few engines for the Liverpool and Manchester after this. Amongst others, Bury's works started in Liverpool in 1831, and it was his class of locomotive and not Stephenson's that Norris, Baldwin and others in America principally took their ideas from.

As the invention of the truck is claimed almost universally for America, and as it has subsequently become a prominent feature in the American locomotive it may be as well to place on record a few facts, that at least go to prove that the Newcastle shops had something to do with the invention. Horatio Allen was sent to England by the Delaware and Hudson Canal Co., in the fall of 1828, to examine the English railways, and with instructions to order two or three locomotives.

He found Stephenson's works as stated above crowded with work and unable to take his order, so it was finally placed with Forster and Rastrick. The Stourbridge Line, the first of these, was delivered in May 1829, and was probably the first locomotive ever seen in America. It was intended that this engine should open the railway to the mines on the 4th of July, but the locomotive did not arrive till the 23rd, and was tried on the 1st of August. The engine, which was of the Killingworth type with two flues, was a perfect success, but the road, of hemlock longitudinals 8 × 10 and a strap rail, spiked down to cross sleepers, 10 feet apart, was too light to carry the weight, and the expense of altering it was deemed too much. So the engine was housed in a shanty for some years. The boiler was afterwards set to work at Carbondale, and the rest of the machinery was never used. The second engine was probably never set to work, at all events, as a locomotive. The first English engine that was actually worked in America was the Robert Fulton, built by Robert Stephenson & Co., and the drawings which accompanied it were dated July 4th, 1831. In the winter of 1832–3, this engine which was of the Planet class was altered, and fitted with a truck similar to the Experiment engine then on the Hudson and Mohawk Railway, under the direction of J. B. Jarvis, and re-christened the John Bull. It is this incident, I think, that has lead to an error, in attributing to Mr. Jarvis the invention of the truck. In looking over the old drawings in Stephenson's office, there is a difficulty in tracing the consecutive numbers, from the fact that in some cases the railway, or party ordering the engine, is put in place of the number on the drawings, some of the locomotives were built to numbers and some to names, but the presumption is that the numbers, where traceable, are consecutive. The Rocket as before stated was No. 19 and built in 1829. The engine for America referred to above has on the drawings "Stevens.

the John Bull. It is this incident, I think, that has lead to an error,

and during the following winter, the Stephenson engine John Bull was altered to be like the three truck engines that they already had.

Besides the sixteen engines built by Stephenson, sent out to America in these early years of American railroads, Bury sent an engine out to America in 1831, and others in 1832 and 1833, and the first engines built by Norris between 1833 and 1837 were in these details almost exact copies of Bury's arrangement. Baldwin's first engine in 1832 was a copy of the first Stephenson engine sent out to the United States, similar to the Liverpool and Manchester Planet class, although Baldwin subsequently adopted the Bury boiler and inside frame, and Stephenson's truck, and from this combination has been developed the present American type, precisely as in England the Stephenson and Bury types, amalgamated and improved, have developed the bulk of the present locomotive forms. Bury from a very early day was Stephenson's principal opponent in the locomotive design, and from 1836 to 1848, it was a moot question which was the better engine. The differences were broadly marked and irreconcileable. Stephenson's standard engine had an outside frame with six wheels, and after 1842 with a long boiler and all the wheels under the barrel of the boiler. Bury's engines had only four wheels with an inside frame. Stephenson's fire box was square in plan, Bury's semicircular. Stephenson's frame was of oak, the sides sandwiched between iron plates, and latterly a single iron plate with the horn plates for the axle cut out of the solid. Bury's was a built frame inside the wheels very similar to the American frame of to-day, which in fact has been evolved and improved from his type. The cylinders of Stephenson's engines were fastened, in fact rivetted, into the smoke-box. Bury's were carried as in the modern engines by the frameplates, the one was a massive heavy-looking design, fit only for a first class railway, fastened and bolted together as if built to last forever. Bury's engines, with their light skeleton frames and all their machinery in sight, looked unsubstantial and temporary beside the other, but proved in practice more accessible for repairs and renewals, and better adapted for rough usage. In 1837, the London and Birmingham Railway was opened with 90 of Bury's engines, and Bury himself became the locomotive superintendent, although Robert Stephenson was the chief engineer of the railway. Of the two types of engines of that day, probably Bury's engine up to 13 inches in diameter was the better machine, but when heavier locomotives were required, the Stephenson type had the advantage. Bury's frame inside the wheels and the cylinders bolted to the frame was, however, undoubtedly the best arrangement, and both in England and America this is now almost universal.

Mr. Clarke claims for American engineers the invention of two things, which he seems to think the important improvements that have revolutionized the locomotive and made it the success it is. The truck is before referred to, and that it is an improvement in ordinary work is undoubted. At the same time it must be borne in mind that it has not been universally adopted, and of the locomotives that have recently done such marvellous work between London and Edinburgh, undoubtedly the best locomotive performance that ever has been done, the truck was not adopted on the engines that did the best running, whilst the one that did the worst happened to be a truck-engine. Comparatively few of the European engines have the American truck, and on some lines, like the North Western, Midland, and Great Western, with 6000 locomotives on the three lines, it has never been adopted. The equalizing lever on long engines of American construction is, no doubt, essential, and either it or the Austrian contrivance of bell crank attachment to the springs with a link between them, the latter, a lighter and perhaps better arrangement, is an excellent relief on rough roads;

the worst happened to be a truck-engine. Comparatively few of the

not be able to compete with canals for economical transport, and as much of this as possible was a water level to be some day as he expected transformed into a canal. Of the 34 miles, 29¾ were a dead level. Five inclines, of which four were within the first four miles, carried the road 984 feet vertically in 3306 yards, and four inclines at the West end lowered it again 739 feet in 2112 yards. Two twelve mile levels were to be worked by locomotives. "There are few curves," says Mr. Clarke, "of less than 1,000 feet radius on European railways, whilst the swivelling truck enabled us (Americans) to build much less expensive lines than those of England, for we could now avoid hills and other obstacles at will." The curves on the High Peak were all of 132 feet radius, the rails were cast to that curve, and it was an immense saving to have them all uniform, and the rails to the exact radius. The locomotives were not truck engines, they were four wheel engines, and the wheels only, 3 feet 6 inches centres were closer together than the wheels of a truck usually are, and as close, in fact, as they could be placed. Round these curves between 43 and 44 degrees of curvature; these engines, with the device of running on the flanges on the outside guard rail, ran easily enough, and the locomotives, though small, on this beautifully laid road, heavy rails and broken stone ballast, could handle a very respectable train, as much as could be brought up the inclines at two hauls. Mr. Clarke further says: "The climbing capabilities of a locomotive upon smooth rails were not known until in 1852, Mr. Latrobe tried a temporary gradient of 10 per cent. This daring feat has never been equalled." Now this statement is somewhat rash. The question of gradients and adhesion was about as exhaustively gone into on a score of private railways in England as it could be before the experiments on the Cromford and High Peak, made in the interest of the Mont Cenis railway, conclusively settled the maximum gradient that it would be safe to use across the Alps previous to the opening of the Mont Cenis tunnel. With ordinary locomotives a 10 per cent. rise is not practicable, on a very fine day, the Cromford and High Peak engines with a very ingenious sanding arrangement could go up the Hindlow plane of 1 in 13. On a wet day they could not; but the Fell engines, which were tried on this road preparatory to their being sent to France, could go up any plane, (and the steepest, the Upper Goyt, was a little better than 1 in 7,) and take one or two waggons behind her. The author is not aware, and is much surprised thereat, that the principle of the Fell engine has ever been tried in America on some of the temporary roads, the switchbacks that Mr. Clarke seems to think are peculiarly an American invention. From the experiments on this road, they are perfectly reliable up to gradients of 1 in 12, and will take their own weight behind them up such a grade. The one in use on the Cromford and High Peak weighed a little over 13 long tons, say 30,000 lbs., and she could take easily 4 cars, each weighing with their load 15,000 lbs. or 60,000 lbs., together double her own weight, up the Whaley plane, averaging 1 in 13, or a rise of 406 feet in the mile. Mr. Clarke can scarcely have known of these engines, which worked for three years the continental traffic between France and the East of Europe, or he would not have made some of the statements in this Magazine article. Another great mistake made in connection with English and European practice is the general idea of Mr. Clarke and others in America that everything there is stationary and unchanged, and that the time of evolution and improvement has long since set in Europe, to be found now only in America. Says Mr. Clarke: "The Stephenson type of engine once fixed has remained unchanged in Europe, except in detail, to the present day. European locomotives have increased in weight and power, and in perfection of material and workmanship, but the general features are those of the locomotives built by the great firm to build much less expensive lines than those of England, for we could avoid hills and other obstacles. The swivelling truck was first suggested by Horatio Allen for the South Carolina Railway in 1831, but the first practical use of it was made upon the Mohawk and Hudson Railroad in the same year. It is said to have been invented by John B. Jervis, Chief Engineer of that road. The next improvement was the equalizing beams or levers, by which the weight of the engine is always borne by three out of four or more driving wheels. The original imported English locomotives could not be kept on the rails of rough tracks." "Another American invention is the switch-back, by which the length of line required to ease the gradient is obtained by running backwards and forwards in a zigzag course, instead of going straight up the mountain. This device was first used amongst the hills of Pennsylvania over 40 years ago, to lower cars down into the Nesquehoning Valley." Now this is sufficient to shew the general style of claiming everything that has led up to the present development of railways for American engineers only. Excepting to the Stephenson's, not one particle of credit is hinted at as belonging to anyone else. Touching however the American invention of the switch-back, Mr. Curtis Clarke's claim of 40 years' use in Pennsylvania is not sufficient. In Tom Moore's Epicurean, written in 1800, a good 40 years before that again, is a capital description of the switchback, and by it the pretty priestess of the Egyptian temple saves the life of her lover. Tom Moore wrote some of his finest poetry, including Lalla Rookh and the Epicurean, in the heart of the lead mining district of Derbyshire, where the "switch-back" has been in use for a century, as a means of bringing the materials to the smelting works in the valleys. At Asheton's Smith's slate quarries, 20 or 30 of these, benched into the mountain side, may be seen one above the other, bringing down the slates over 2,000 feet vertically in as many feet horizontally measured directly up the mountain. All that American engineers invented in this contrivance was the name, and as for some of the other claims that are inferentially supposed to have evolved the American locomotive and railway from the primitive rudeness of the English original, it may prove that the improvements rest upon an equally poor foundation.

In comparing English and American practice, especially in the earlier days of railways, one great source of confusion and mistake, made by American authors, arises from the fact that in England there have always been two distinct classes of railway, one chartered by Act of Parliament the affairs canvassed and discussed every half year, and all their peculiarities and inventions thoroughly ventilated by the papers and in other ways, whilst the others are strictly private, their proceedings, experiments and practice utterly unknown to the public, and but seldom finding their way into the public press. Yet these "private" railways preceded the public lines by years; until quite recently even their mileage was in excess of the public lines, and almost every important invention that has led to the result of the modern locomotive, and the existing railway was invented, tested and developed on the private railways of Great Britain, and many of the most important of them years before there was a mile of railway in America. The double trucked car for instance, which in Mr. Clarke's paper is claimed as the invention of Ross Winans, was in use for carrying timber and long stuff before there was a road in America at all; and the passenger car out of which Mr. Husskicson descended to meet his death, on the memorable day that preceded the opening of the Liverpool and Manchester railway, was

1793, Outram, from whom the tramway takes its name, laid down a number of tramways in Derbyshire, and introduced the stone blocks under the ends of the tramplates, which for a time displaced the former wooden sleepers, and were used by the Stephensons and others in all the early railways. The first edge railway, which is the parent of our present railway, was laid in 1801, for the conveyance of slate from Lord Penrhyn's quarries in North Wales, and within a few years all the Northumberland and Durham collieries adopted this improvement, and the railway superseded the tramway for ever. In 1789, Mr. Jessup constructed the public railway at Loughborough with cast iron rails of much the same pattern as those now used, and put flanged cast iron wheels on the carriages. The normal difference between a tramway and a railway, as then understood, was that on the latter the flange that guided the waggon on the track was cast upon the tramplate, whilst on the edge railway, as it was then called, the flange was upon the wheel. The advantage that the tramway undoubtedly possessed was that the plain faced wheel could be used off the plates, might run over planks or hard ground, or into a quarry, where there would be no necessity for laying down a plate. Sectionmen on the English railways, especially in the old mining districts, are still called "plate layers," a memento of their original employment. In 1805 a great improvement was made when the Walbottle Colliery introduced malleable iron rails, although these were expensive and were only made in two feet lengths. In 1808 Mr. Thompson put down wrought iron rails of an improved section at Tindale Fell near Carlisle, and from that date this class of road became common round the Newcastle collieries. The next important improvement was made in 1820, when the Bedlington Iron Works took up Birkenshaw's patent, and produced a wrought iron rail 15 feet long, with a deepened flange between each sleeper to strengthen the unsupported portion of the rail. These fish-bellied rails were common till long after the Liverpool and Manchester, ~~on which they were exclusively~~ used, was in successful operation. This was the most important improvement yet introduced, and linked the old waggon way to the modern railway. The roads, therefore, upon which Blackett and Blenkinsopp and Stephenson first introduced locomotives were not widely different from those to which we are now accustomed.

The first practical locomotive was undoubtedly Trevithick's, which was placed upon the Merthyr tramway in 1803. There was nothing in this engine to prevent its being as great a success as Blenkensopp's or Stephenson's a few years later, but it failed, from the road being too weak to carry it, and from want of adhesion. The wheels slipped round without propelling the machine, precisely as in the same district two of Sharpe's finest engines afterwards failed, and for the same reason the old shape of the tramplates held the mud and water, and were always excessively dirty. Had Trevithick's engine been tried on a railway instead of a tramway, we should never have heard of that bug-bear, want of adhesion that frightened all the early engineers. To obviate this supposed difficulty, Mr. Blenkinsopp of the Middleton Colliery, near Leeds in 1811, took up one side of his railway, and substituted for the rails that had been formerly used others with large cogs cast upon the outward edge. These cogs were six inches from centre to centre, so that there were six of them upon each three feet length of rail. His engines were modelled after Trevithick's, and in August, 1812, commenced regular working, and the fact that they did all the work on the railway for five or six years, and long after Stephenson's engines had settled the

the Canterbury and Whitstaple, and the Cromford and High Peak opened early in 1830, the Leicester and Swannington on which was a tunnel 1¼ miles long, and the Liverpool and Manchester, opened in September 1830, the Dundee and Newtyle, Bolton and Leigh and the Glasgow and Gainkirk all opened early in 1831, were all roads on which the work was of a superior character and all aided in the development of the modern railway. As all these roads were designed for locomotives, the question of supplying the necessary machinery for these railways was pressing, and so in 1824 the great locomotive works of Stephenson were commenced, the parties finding the money for the Stockton and Darlington being the original proprietors. Nos. 1, 2 and 3 at the Forth works Newcastle, turned out early in 1825, were the same numbers on the Stockton and Darlington, and No. 1 the old "Locomotion" is the engine that now stands on a pedestal in front of the railway station at Darlington. Amongst the first engines built at Newcastle were locomotives for the Wylam, Bedlington, and Clarence private railways, the Stanhope and Tyne, Glasgow and Garnkirk, Dundee and Newtyle, and Canterbury and Whitstaple Railways. In 1828 the first engine with inside horizontal cylinders, the "Twin Sisters," was built for a Lancashire Colliery line at the Newcastle works. This marked a great improvement in the locomotive, which though departed from in the Rocket, built the next year for the Liverpool and Manchester experiments, was readopted on all the other engines for that line, and subsequently became in the Planet class the standard Stephenson locomotive. The Rocket was No. 19 at the Stephenson works, and the important improvement that she introduced was the multitubular boiler, the original suggestion for which was made by Mr. Booth, secretary of the Liverpool and Manchester, though the same idea had previously been patented in France, but the Rocket was undoubtedly the first engine built on that principle. This engine, constructed expressly to compete for the premium offered by the Liverpool and Manchester Railway, was finished early in 1829, and on her completion was taken to Killingworth, and there tried on the same railway that had witnessed so many of the early triumphs of the locomotive. But Mr. Clarke is entirely wrong when he speaks of the Rocket as being the type of a class. She was totally unlike, in arrangement and details, any other engine either previously or subsequently built, and the works at Newcastle completely revolutionized all their ideas before the second engine was produced for the Liverpool and Manchester. The faults of the Rocket were apparent from the first day. The glory of being the prize winner in the first locomotive contest was tarnished the next year by her being the engine that killed Husskison, the member for Liverpool, and one of the warmest supporters of the railway. She was not long employed on the Liverpool and Manchester. She was too light for the work, and in 1831, was sold to Mr. Thompson of Kirkhouse near Carlisle, where she once ran at the rate of nearly fifty miles an hour, with the news of the successful winner of the Carlisle election. Subsequently bought by the Government for the Kensington Museum, she now commands attention as having largely contributed to the success of the railway system, and the evolution of the locomotive. After the decision at Rainhill, the Newcastle shops were busy with the engines for the Liverpool and Manchester, and for the other lines that opened about the same time. The type of engine selected was an inside horizontal cylinder engine, with a heavy outside frame, with outside bearings on the axle, and so pressed the John Bull. It is this incident, I think, that has lead to an error, in attributing to Mr. Jarvis the invention of the truck. In looking over the old drawings in Stephenson's office, there is a difficulty in tracing the consecutive numbers, from the fact that in some cases the railway, or party ordering the engine, is put in place of the number on the drawings, some of the locomotives were built to numbers and some to names, but the presumption is that the numbers, where traceable, are consecutive. The Rocket as before stated was No. 19 and built in 1829. The engine for America referred to above has on the drawings "Stevens, New York," built in 1831. In the same year No. 31 for the Stanhope and Tyne, No. 36 for the Liecester and Swannington, the first 6 wheel connected engine, and No. 37, a similar engine sent to the Liverpool and Manchester, are so marked. The next number still in 1831 is No. 42, ordered by the Saratoga and Schenectady Railway, an engine with 9 × 14 cylinders, 1 pair of 4′, 5″ driving wheels, and a truck with 4 wheels 2′, 8″ diameter. In the same year but without a number is an engine for the Hudson and Mohawk with 10 × 14 cylinders, with 4 coupled wheels 4′, 0″ diameter. In 1832, No. 52 is simply marked United States, a Planet engine with a single pair of drivers 5′, 0″ diameter. No. 61 and Brother Jonathan in the same year were truck engines built for the Hudson and Mohawk, and so was No. 75 for the Saratoga and Schenectady, all three 10 × 16 engines, with 4 truck wheels 2′, 8″ in diameter. In 1833, three engines were built for the Newcastle and Frenchtown Railway of the Comet class with 4 coupled wheels. They were named the Delaware, Maryland and Pennsylvania, and have no shop number marked on the drawings. The same year three engines appear to have been built for the Charleston and Columbia, the W. Aitken, the Edgefield and No. 99, and in 1834, three bogy or truck engines Nos. 104, 106, were built for "Pennsylvania," so that from the meagre records left, there are in these four years, the working drawings of sixteen locomotives built by Robert Stephenson & Co., for the United States, of which seven were truck engines. There were other engines built by Stephenson for the States, but the drawing office records do not show their numbers, as the Planet and Comet classes, the first with single drivers and the other coupled, were sent out without comment when similar engines to these were wanted. For instance, two were shipped to the Bangor and Oldtown Railway in Maine about 1836, bu there is no number or other record of these than the fact that they were shipped. The Hudson and Mohawk Railway was opened September, 1831; and some time after, but probably before the end of the year, a locomotive called the De Witt Clinton, built at West Point Foundry, was put upon the line, being the second locomotive built in America, the first having been put on the South Carolina Railway in 1830 and exploding the next year. Both these were four wheel engines. In Appleton's Encyclopædia we are told that in August, 1832, an engine called the Experiment was placed on the Hudson and Mohawk with four swivelling wheels, built by Adam Hall of the West Point Foundry. Now putting all these stories together. it seems that in 1831, Stephenson's No. 42 was put upon the Schenectady road, the first locomotive with the four wheel truck, and at the same time Stephenson sent an engine of the Planet class to the Hudson and Mohawk, which was subsequently two years after called the John Bull. In 1832, Stephenson sent two engines to the Hudson and Mohawk and another to the Schenectady line all with the truck. In August of that year the West Point Foundry put on their Experiment, probably a copy of the Stephenson engines, the worst happened to be a truck-engine. Comparatively few of the European engines have the American truck, and on some lines, like the North Western, Midland, and Great Western, with 6000 locomotives on the three lines, it has never been adopted. The equalizing lever on long engines of American construction is no doubt, essential, and either it or the Austrian contrivance of bell crank attachment to the springs with a link between them, the latter, a lighter and perhaps better arrangement, is an excellent relief on rough roads; but this contrivance, although perfectly well known in Europe, is not deemed of any great importance where the railways are in good condition, it is by no means essential, nor is it as a rule adopted on some of the leading railways where the best designs are taken regardless of expense. It is absurd to mark these as important developments of the locomotive, comparable to the blast pipe on Stephenson's Killingworth engines, the Booth multitubular boiler, the link motion which regulates at will the expansion of the steam, and the power of the engine as it passes over the ever varying gradients of the roadway, or the French invention of the injector which supplies the boiler with water, irrespective of the engine being in motion. If the universal adoption of an improvement is to be the guage of its value in the evolution of the locomotive, the Glasgow and Garnkirk locomotive, the St. Rollox which was the first on which the guage glass to see the height of water in the boiler, or the Leicester and Swannington Comet, where the familiar whistle was first used, ought certainly to be immortalized, and rank far higher than the two inventions specially claimed, and which outside of America are not found except on a small minority of locomotives.

I have often seen & heard the Safety valves lifted by hand in lieu of the whistle

But Mr. Clarke goes further, he claims that in consequence of these two inventions,—the truck and the equalizing level, American engineers were able to build cheaper and more efficient roads than any previously existing, that they could use sharper curves and steeper gradients than could be worked on British lines, and construct railways economically where the old country engineers could only make them at an enormous expense. Now to refute these statements let us take some facts. One of the numerous railways which obtained its charter in 1825, and was partly opened in 1828, before there was a railway at all in America, was the Cromford and High Peak. It was a line 34 miles long with rails 63 pounds to the yard on stone sleepers, and all the machinery was the best and most perfect of its kind. It had to cross the Peak of Derbyshire, the back-bone of England, and over some of the roughest country and the finest scenery that even still is the delight of tourists. It connected the Canal system of the East coast from London and Hull with the extension of the Duke of Bridgewater's canal from Manchester and Liverpool, which had been completed to the foot of the High Peak, and it was intended and fitted for a heavy freight traffic, irrespective of passengers. There was necessarily a deal of heavy work, and one tunnel near Buxton 580 yards long was unavoidable. Yet it was finished, without its machinery, for about £4,000 per mile, and with its seventeen incline engines and three locomotives, with all the incline fixtures for less than £6,000. It was Outram's idea that railways would lish and European practice is the general idea of Mr. Clarke and others in America that everything there is stationary and unchanged, and that the time of evolution and improvement has long since set in Europe, to be found now only in America. Says Mr. Clarke: "The Stephenson type of engine once fixed has remained unchanged in Europe, except in detail, to the present day. European locomotives have increased in weight and power, and in perfection of material and workmanship, but the general features are those of the locomotives built by the great firm of George Stephenson & Son before 1840." So far from this being the case, the standard engine of the Stephenson works, Robert Stephenson & Co., not George Stephenson & Son, from 1837 to 1842, has been entirely abandoned since 1844, and although other builders continued that excellent type for a number of years, and perhaps occasionally do so still, Stephenson entirely gave it up after their patent of 1842 came into use, and that style again has since been entirely abandoned. The Stephenson's after 1831 never had a monopoly of a locomotive type. As before mentioned, Bury's engines always formed a separate type, so did the Allan engine, or Crewe engine of 1840, still the type of the Northern division of the North Western, of the Caledonian, and some of the French railways. As far as the locomotive of different countries is concerned, the fixidity of type, the absence of change, the slavish following of precedent is to be seen now more in America than any where. You travel from New Orleans to Montreal, from New York to the Pacific, and you see nothing but the one type of locomotive unchanged for forty years, the American 8 wheel, 4 coupled driver, truck engine, with inside frame and outside cylinders, with its Swedish iron laggings, and its monotonous uniformity. In England, on the contrary, the complaint justly made by a recent writer, that the type of locomotives varies on every railway, is unfortunately but too true, and the most casual observer cannot but notice it. The dull red colored machine, with its two coupled driving wheels and single leading wheel, heavy outside frame entirely covering up the inside cylinders and machinery, which takes you in 4½ hours from Liverpool to London on the Midland, is essentially different in design and arrangement from the bright green outside cylinder engine with its one huge driver, 8 feet 6 inches in diameter, of the Great Northern, or the North Western compound, with its bright central polished cylinder cover, and its double machinery, each part working its separate uncoupled driving wheel. These three locomotives are as distinctly different from each other as any one of them is from the old Rocket, yet all running between the same termini, and keenly competing for the same traffic. It is difficult to trace any resemblance between the Mediterranean engine of the great French company or the Lombardo Venetian, or the Belgian, yet all are in a constant state of alteration and struggle for improvement, and each developing and evolving its own type of ideas, and improving its own specific class of machine, although that improvement often, nay always, leads to a further divergence from the common original and from each other. The standard locomotive of the future has yet to be designed.