GEORGE STEPHENSON AND 'THE ROCKET'

BY

COMMANDER M. MARTIN, R.N.

This article has nothing to do with some backroom boffin and the development of an inter-continental ballistic missile, but traces briefly the pattern of invention and experiment that led up to the construction, in 1829, of the famous locomotive.

The first ' railways ' were made for horse-drawn carts to run along while carrying coal from the pits of Northumberland and Durham to the loading staiths on the banks of the Tyne and the Wear, and the earliest known example was believed to have been built by one, Beaumont, who laid down wooden planks in a cart track in about 1630. By 1675 the use of these tracks was already extensive and one hundred years later, it is reported that, by use of a railroad ' one horse is enabled to draw fifty or sixty bushels of coals '—a load of about 25 cwts. Improvements continued and soon iron plates were nailed over the wooden rails to protect them and reduce friction. The earliest use of iron rails specially cast for the purpose is reputed to have occurred in 1738 at Whitehaven. These early rails were cast with a flange on them to keep the cart wheels on the track and it was not until 1789 that a Mr. William Jessop, who constructed a railway at Loughborough, developed the raised rail and put the flange on the waggon wheel thus producing the forerunner of the modern permanent way.

In those days, the transport of coal on the surface was a small problem compared with the difficulty of raising it to the surface and of removing the water that collected in the mine workings underground. It was in tackling these two problems by harnessing steam power for winding gear and water pumping that the north of England and Cornwall, both mining centres, became the cradle of British steam engineering. It was Newcomen who developed the Atmospheric Engine and thus first used steam power to pump water out of the mines ; and it was as an engineman, tending those wheezing, bumping and sighing contraptions of iron, wood and leather, that George Stephenson, the father of the locomotive, first learned the rudiments of mechanical engineering.

George Stephenson was born in Wylam, a mining village between Hexham and Newcastle in June, 1781, and since his father was the fireman of a pumping installation at a local mine, he was associated with machinery from his earliest days. By the time he was seventeen he had become an engineman at a new mine at Newburn with his father working under him as his fireman. It was about this time that he learned to read and write and, between the beginning of the century and 1815, Stephenson started making his name as an engineer. Common boiler pressures at this time were 5 lb ' on the inch ' and Stephenson was considered very advanced when he built a boiler to work at double that pressure.

With the rapid extension in the use of coal there were many devices employed to try to speed up its transport. Much was done by levelling the ' railways ' and by the use of self-acting inclines where the weight of loaded waggons was used to draw up a train of empty ones. Attempts were even made to harness the wind by rigging sails on the waggons. Savery, the inventor of the first working steam engine, was himself aware of the value of steam power for

traction purposes but, despite the progress of engineering in Great Britain, it was in Paris that the first steam locomotive was designed and built by Cugnot in 1763. Although powerful, the machine was extremely slow, having a speed of only two and a half miles per hour, and it could only run for fifteen minutes at a time, being somewhat under-boilered. A second machine, built in 1770, was more satisfactory but overturned one day in the streets of Paris and was finally locked up in the arsenal for safety's sake. Elsewhere other designers were busy—Oliver Evans built a steam carriage in America in 1772 and William Symington, in 1786, produced a working model steam carriage.

It fell to William Murdock, of Redruth, and his friend Richard Trevethick to make the next major steps towards the practical steam locomotive. Murdock first built a fine little model that scared the wits out of the local vicar one night when it ran away from its owner and the terrified parson believed the hissing, fiery little monster to be the devil himself. Trevethick, financed by a cousin, Andrew Vivian, constructed his first steam carriage in 1802. This machine, which was similar in appearance to a stage coach, mounted a double-acting, single-cylinder engine which drove the road wheels through spur gears. The steam cocks, forerunners of the slide valve, feed pump and bellows for forced draught were driven off the crank. This machine was taken to London and excited considerable interest when exhibited there. In 1803, Trevethick constructed his second locomotive which was used to haul waggons along a railway at Pen-y-Darran in South Wales. This machine had a cylindrical wrought iron boiler with internal furnace and flues and a horizontal single cylinder of eight inches diameter and four and a half foot stroke. The value of using the exhaust steam in aiding draught had not at this time been appreciated and although the exhaust of Trevethick's machine was passed up the chimney, this was done for silencing purposes. This machine was used at the steel works for some time and hauled a load of ten tons at about five miles per hour. It was, however, heavy and cumbersome and frequently broke up the railway lines so that after a while it was dismounted and used for pumping.

The next important step came in 1811 when Matthew Murray, an engineer of Leeds, while assisting an inventor called Blenkinsop, first produced a twin cylinder engine driving cranks at right angles to one another thus getting over the top dead centre problem. Some of the inventions of that time, however, were extremely odd. A Mr. Brunton of Derbyshire, in 1813, patented ' a Mechanical Traveller to go upon legs like a horse '. This ingenious contrivance never got beyond the experimental stage for, at its very first trial, the driver, to make sure of a good start, overloaded the safety valve and the boiler burst killing a number of onlookers and injuring several more.

Meanwhile locomotives were being constructed at many places in England and, in 1813, George Stephenson built his first engine at Killingworth Colliery where he was employed at the time. One of the difficulties besetting the engine designer in those days was to find smiths and fitters with sufficient skill to manufacture the parts. Furthermore, the tools of the day were very crude and Stephenson's first engine was built by a colliery blacksmith at West Moor Mine workshops. The Blutcher, as this locomotive was called, had a wrought iron cylindrical boiler eight feet in length and thirty-four inches in diameter, with a twenty-inch flue tube passing through it. The engine had two vertical cylinders of eight-inch diameter and two feet stroke which were let into the top of the boiler. The pistons worked crossheads and cranks which transmitted the power to the four wheels through spur gears. An elementary form of feed heating was employed, and all the machinery was mounted upon an unsprung wooden frame. The Blutcher was placed in service on the 25th July, 1814, and on the same day drew eight carriages loaded with thirty tons up an incline

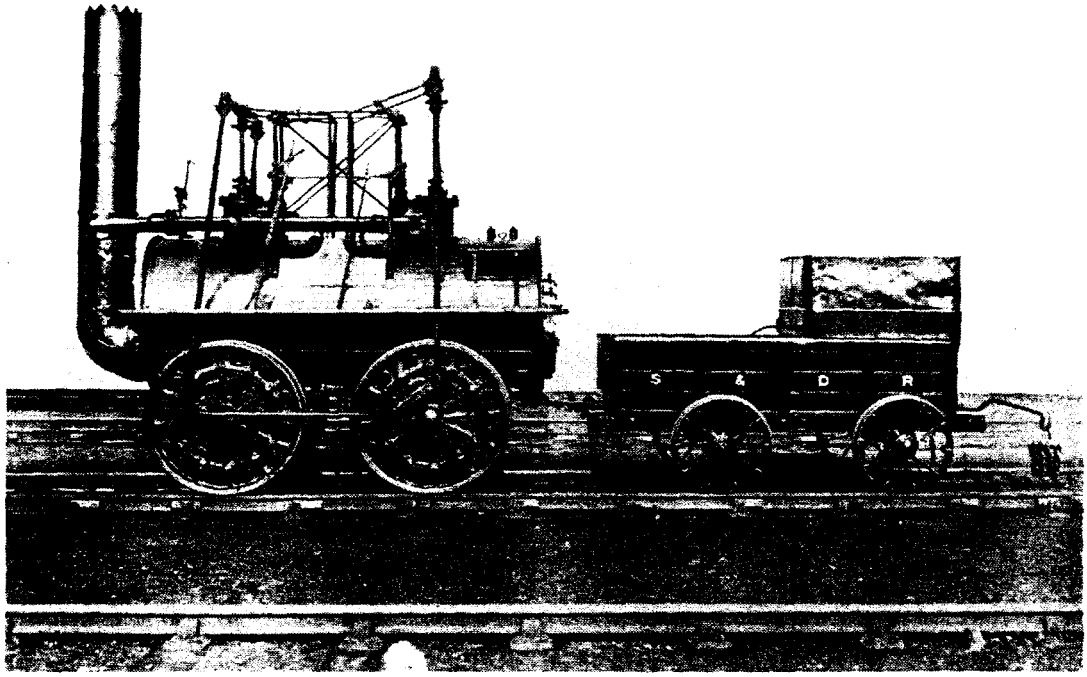
of one in four hundred and fifty at four miles per hour. Although an advance on earlier locomotives, the Blutcher suffered badly from rattles of the spur-gear drive to the wheels and, after a year's running, showed no financial saving over the horses normally employed for draught purposes. It was at this juncture that Stephenson hit upon the idea of using the exhaust to increase draught. As a result, the power of the Blutcher was more than doubled and a considerable improvement in economy resulted.

In February, 1815, Stephenson and Dodds took out a patent for an extremely simple locomotive. It was, like its predecessor, a two cylinder machine but with the crossheads connected direct to each pair of driving wheels by rods. In order to allow for relative movement between the crosshead and axles, for the railways of those days were anything but smooth, ball and socket joints were employed.

It was at this time that Stephenson turned his attention towards improving the railway tracks and, in 1816, a Newcastle ironfounder called Losh joined with him in taking out a patent for a new pattern of rail. This was a cast iron rail three feet nine inches long and cut away to form a scarph or half lap joint at its ends where it was supported. The two adjacent rails were held in line by a round bottomed chair and the scarph on the top gave a flush joint over which the waggon wheels ran easily and smoothly. Other innovations of the day included the increased use of wrought iron, and, since spring manufacture was in its infancy, a method of supporting the boiler and engine by means of cylinders and pistons, the former supplied with steam at boiler pressure and the ends of the latter bearing upon the axles so that much of the weight of the machinery was supported by steam. Stephenson's next undertaking was the construction of the eight-mile long railway from Hetton Colliery to the River Wear near Sunderland. This railway employed mixed motive power : self-acting, where full coal waggons pulled up empty ones on a double-tracked incline, two powered inclines with fixed engines of sixty horse-power and two locomotives each capable of hauling a load of about sixty tons at five miles per hour. It was the experience gained in constructing this railway that resulted in Stephenson being appointed engineer of the Stockton and Darlington Railway.

The Stockton and Darlington Railway was projected in 1817 by Edward Pease, and Royal Assent was obtained for it in 1821. As originally projected the use of locomotives was not envisaged and the promoters hoped to recover their capital after the railroad was completed by having it incorporated in the national system of highways. However, Stephenson's enthusiam was infectious and after a visit to Killingworth to see that railway and its locomotive, the directors changed their minds. Construction started in May, 1822, and the line was designed to employ both fixed engines and locomotives carrying principally coal and merchandise. Most of the profits were expected to accrue from the local carriage of goods and what turned out to be the two biggest money-spinners, coal transport to the Wear and passenger traffic between the towns, had not been envisaged. Concurrently with the surveying and construction of the railway, Stephenson started his locomotive works at Newcastle, the three initial shareholders being Stephenson, who put in £1,000, and Pease and Richardson who each contributed £500.

One of the major technical problems that confronted the directors was the choice of material for the rails. It says much for Stephenson's integrity that he advised against cast iron rails although he was a shareholder in a factory making them and stood to gain considerably if they were used. He advocated the use of wrought iron rails because of their toughness and shock resistant



'LOCOMOTION, NO. 1' OF THE STOCKTON AND DARLINGTON RAILWAY
(This photograph is reproduced by the courtesy of the Curator of Historical Relics, British Transport Commission.)

qualities but, since at £12 per ton they were double the price of cast iron, the directors decided to buy only half the total requirement of wrought iron. The rails employed weighed twenty-eight pounds per three foot rail and had a top flange of two and half inch width and three-quarters of an inch thickness. They were of the fish-bellied type—two inches deep at the ends and three and a quarter inches deep at the middle. The gauge of the Stockton and Darlington Railway was virtually settled by precedent at four feet eight and a half inches, the standard gauge of today, because that was the usual width between the wheels of the waggons commonly in use for coal carrying.

Fixed engines were used at some places on the line, but three locomotives were built by Stephenson at his engine works in Newcastle. No. 1 engine, the Locomotion, which was a development of earlier machines, weighed about eight tons and could achieve a speed of about sixteen miles per hour, but was normally employed hauling heavy loads at about five or six miles per hour. That historic machine now stands preserved on Darlington main line station. The line was formally opened on 27th September, 1825, and a local reporter remarked 'The signal being given, the engine started off with this immense train of carriages (thirty-six assorted sizes and types) and such was its velocity that in some places the speed was frequently twelve miles an hour. The arrival at Stockton excited a deep interest and admiration.' Nevertheless, the principal haulage continued to be performed by horses for some years despite the 'deep interest and admiration'.

It was in 1821 that the Liverpool and Manchester Railway was first projected as a tramway for horse-drawn waggons. An early prospectus, however, produced in 1824, called for a double line of railway between the two cities. In 1825, much opposition developed from the owners of the canal systems

roundabout and there were many bitter wrangles before the Parliamentary Bill was finally passed. Meanwhile, protracted arguments took place as to the form of traction to be employed. At one time it was nearly decided to employ some twenty stationary engines to draw the trains. Atmospheric engines and other far-fetched methods were also proposed but largely through Stephenson's perseverance the directors finally agreed to offer a prize of £500 to the designer of the best locomotive at a competition to be held on 1st October, 1829.

The conditions laid down were :—

' 1. The engine must effectually consume its own smoke.

' 2. The engine, if of six tons weight, must be able to draw after it, day by day, twenty tons weight (including the tender and water tank) at ten miles an hour with a pressure of steam on the boiler not exceeding fifty pounds to the square inch.

' 3. The boiler must have two safety valves, neither of which must be fastened down, and one of them be completely out of control of the engineman.

' 4. The engine and boiler must be supported on springs, and rest on six wheels, the height of the whole not exceeding fifteen feet to the top of the chimney.

' 5. The engine, with water must not weigh more than six tons ; but an engine of less weight would be preferred on its drawing a proportionate load behind it ; if only four and a half tons then it might be put upon only four wheels. The Company to be at liberty to test the boiler, etc., by a pressure of one hundred and fifty pounds to the square inch.

' 6. A mercurial gauge must be fixed to the machine, showing steam pressure above forty-five pounds to the square inch.

' 7. The engine must be delivered complete and ready for trial, at the Liverpool end of the railway, not later than 1st October, 1829.

' 8. The price of the engine must not exceed £550.'

It was to satisfy these conditions and to win the five hundred pound prize that George Stephenson and his son Robert, by now working in the Engine Works at Newcastle, set to work to design and construct the Rocket. The principal problem facing them was to improve the rate of raising steam by increasing the heating surface. The boiler of the Rocket was of the cylindrical type and, to give the necessary heating surface, there were twenty-five copper fire-tubes of three-inch diameter carrying the gases from the fire-box to the smoke-box. Initially, these tubes were fitted with brass screwed ends to fit into the end plates, but this design leaked badly and watertightness was finally achieved by passing the tubes through the plates and brazing them in place. The boiler was six feet long and three feet four inches in diameter, and the upper half was used as a steam drum. The fire-box, surrounded by water, was three feet high and two feet wide. The exhaust steam was led to the lower end of the chimney and the nozzles there produced a vacuum of three inches of water. The piston rods from the two cylinders mounted on either side of the boiler near the fire-box drove cranks on the front pair of wheels through connecting rods. The tender held a water barrel for feed water at the rear and coal was stowed at the front. The weight of the engine with water at working level was four and a half tons. Trials on the old Killingworth Railway were completely successful and the Rocket was despatched to Rainhill, near Liverpool, in time for the competition.

There were four other locomotives entered, but one, the Cyclopod, worked by a horse in a frame, was disqualified. The others were the Novelty, entered by Messrs. Braithwaite and Ericsson, the Sanspareil, entered by Mr. Hackworth and Mr. Burstall's Perseverance. The Rocket was the first of the engines to be ready for the competition and on 6th October, while still waiting for the other machines to be prepared, Stephenson gave a demonstration run of some twelve miles up and down the test track. Trials continued until the 14th and during this period there were so many breakdowns among the other locomotives that the Rocket emerged as a clear winner. Her successful run was carried out on the 8th when steam was raised from cold to 50 pounds in fifty-three minutes, and the engine, drawing about thirteen tons, ran some sixty miles in two sessions at an average speed of fifteen miles per hour. A maximum speed of twenty-nine miles per hour was recorded and the engine comfortably fulfilled all the conditions of the competition.

It was as a result of the competition that the locomotive became firmly established as the tractive power for the railways of the world. The Rocket may thus be considered as the forerunner of the modern steam locomotive and Stephenson as the father of that great branch of mechanical engineering.