THE SOUTH DEVON ATMOSPHERIC RAILWAY - BRUNEL'S FOLLY?

A talk given to The West Dart History Group – Wednesday 6 March 2024

The extension of the Bristol to Exeter railway line to Plymouth was first considered at meetings held in 1835 arranged by Directors of what subsequently became the Plymouth, Devonport and Exeter Railway Company (PD&E). The following year Isambard Kingdom Brunel, engineer to the Great Western Railway (GWR) and to the Bristol and Exeter Railway (B&E), was commissioned to survey a route.

He proposed two routes for a double-track line both following the western shore of the Exe Estuary and passing inland of Dawlish and Teignmouth. Thereafter the proposals diverged, one through the South Hams via Torquay, Dartmouth, Kingsbridge and Modbury (the Lower Line), and the other skirting the southern edge of Dartmoor (the Upper Line). The Upper Line was Brunel's recommendation. For several years the routes were debated but little happened largely as a result of insufficient local capital.

In 1843 the PD&E accepted subscriptions from the GWR, the B&E and the Bristol and Gloucester Railway. A meeting was held and the route chosen was the Upper Line, Brunel being appointed sole Superintendent. Public meetings were held and in November the name was changed to the South Devon Railway (SDR). The 1843 route differed significantly from Brunel's 1836 proposal as he decided to take a 'sea wall' route to the seaward side of Dawlish and Teignmouth. There followed a period of negotiation, hearings and parliamentary debate until the SDR Act was finally passed on 4 July 1844.

Whilst planning the construction of the line, Brunel was considering the method of traction to be used. In the 1840s steam railway engines were still in the early days of development and issues such as speed, passenger comfort, tractive effort and cost were constant considerations.

Traditional rail haulage was done by a directly connected power source hauling the train, originally horses on the early industrial tramways and subsequently steam engines mounted on wheeled chassis. Another long-established form involved a remote stationary power source, such as a horse gin, water wheel or steam engine, pulling wagons for short distances using a rope or cable. Electricity is a more recent form of remote tractive power.

Atmospheric traction also relied on a remote power source. The principle involved evacuating air from one end of a pipe or tube containing either an object in the tube or an internal piston connected to an external object. The evacuation of air in front of the object created a vacuum causing it to be propelled forward by the atmospheric pressure behind it. We apply the same principle when drinking through straw or using a vacuum cleaner.

Experimentation on the atmospheric principle began in the C17 including ideas for moving items, and eventually people, from place to place. In recent memory the principle was employed by pipe and shuttle systems used to convey money and invoices between sales floors and accounts offices in large department stores.

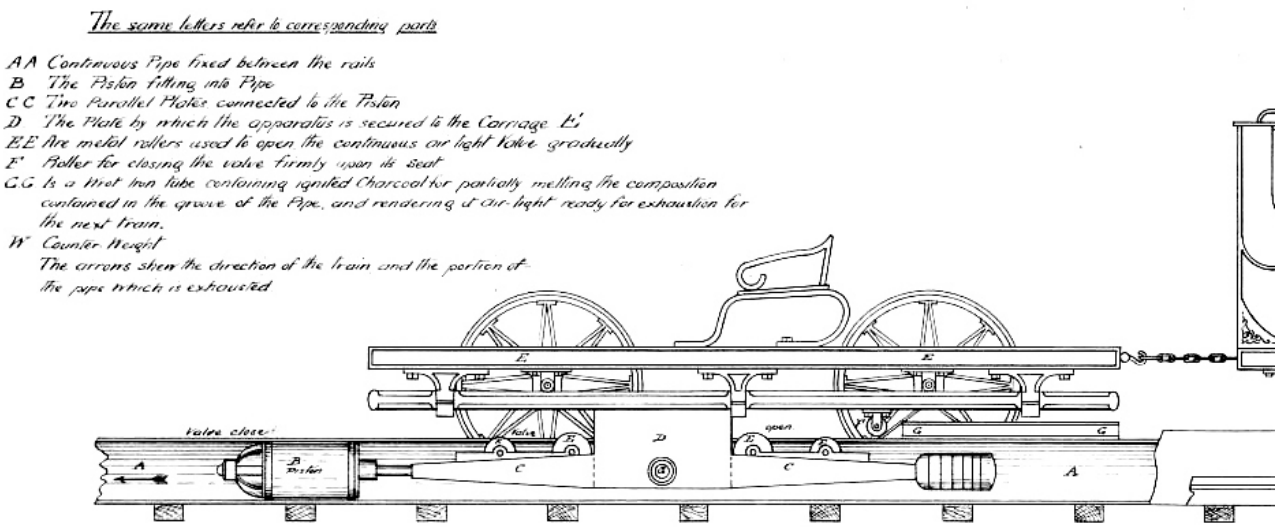
In 1799 George Medhurst took out a patent on the practical applications of compressed air. In 1810 he published a pamphlet on the conveyance of letters using the same method, and in 1812 proposed propelling passengers in a carriage within a tube and in 1827 published another pamphlet proposing three different compressed air configurations including a goods-carrying piston in a box pipe connected to a separate carriage through a slot.

In Brighton in 1826 John Vallance built a 150' long cast iron tube, 6' in diameter. Inside it, a carriage on a track was drawn forward by exhausting air from the pipe in front. This was the first ever atmospheric railway but sadly no investors were interested.

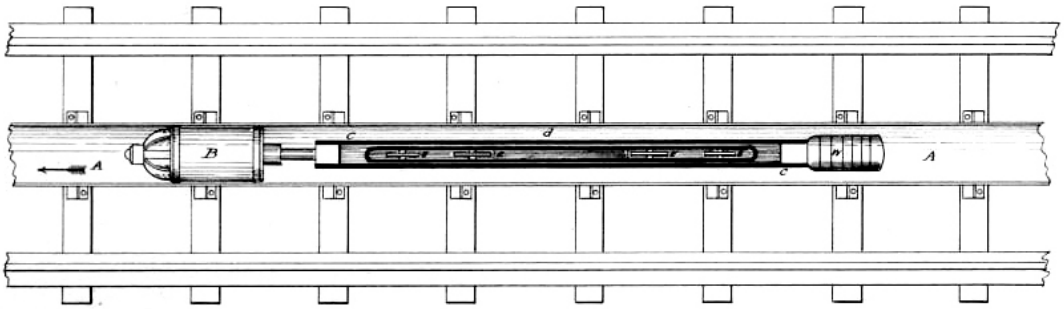
The idea of separating the vacuum tube from the carriage was revived by Henry Pinkus from 1834 including a proposal for a 10" pipe containing a piston connected to a locomotive by a metal tongue through a slot valve. His final design was very similar to the one that was finally adopted for commercial application. But like Vallance, Pinkus failed to attract enough investors.

The significant breakthrough came from the co-operation of Samuel Clegg, an engineer, and the brothers Jacob and Joseph Samuda who were prominent London shipbuilders. They filed a patent in 1838 for a complete atmospheric system, focussing particularly on a new valve system involving a hinged leather flap plated with iron. In 1841 Joseph Samuda published *A Treatise on the Adaptation of Atmospheric Pressure to the Purposes of Locomotion on Railways* explaining in detail the workings of the system

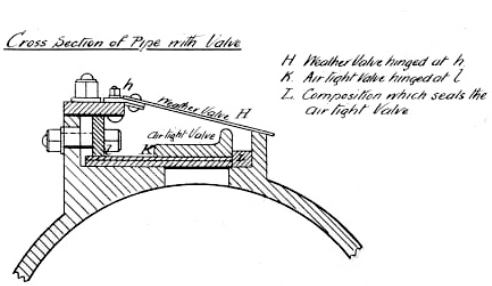
Technical drawings from the Samuda Treatise



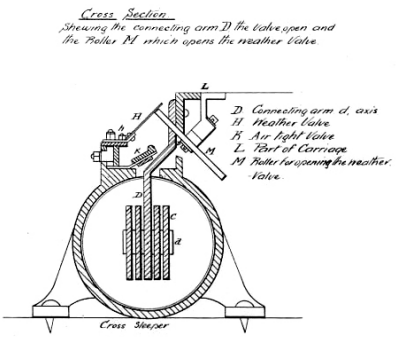
Elevation of Piston Carriage vertical cross-section of Piston



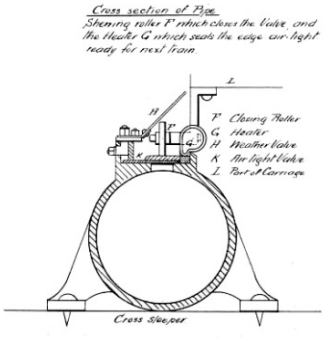
Plan of Piston and Valve Mechanism



Cross-section of Valve Mechanisms



Cross-section of opening mechanism



Cross-section of closing mechanism

In 1839 Samuda made an agreement with the West London Railway to build an atmospheric test track over a mile long, near Wormwood Scrubs, that was completed in 1840. It was this line that attracted the interest of Brunel, who was impressed by its potential. In 1843 he visited the trials of an atmospheric line near Dublin, the Kingstown and Dalkey Railway (KDR) that was using atmospheric equipment supplied by Samuda. In the following year he reported favourably to the SDR Board prompting a group of Directors to visit the KDR, which by then was fully operational. At their next meeting, they decided to adopt atmospheric working. Brunel's report stated that the atmospheric system would be cheaper in construction and working costs, though this was largely based on a change from double to single track. He claimed that the increased speed of the atmospheric trains would enable the same capacity to be carried. Other benefits he quoted were increased safety and greater passenger comfort.

A further advantage of the atmospheric system was that it answered the concern that the locomotives then available would not be powerful enough to haul longer trains up the extreme gradients of the 'South Devon Banks' on the line planned west of Newton Abbot – then known as Newton - and that the assistance of stationary engines would be required. The three steepest banks were at Dainton between Newton and Totnes, up to 1:36, and between Totnes and Plymouth, at Rattery up to 1:45 and Hemerdon at 1:42 for 2.5 miles. These are, respectively, still the 3rd, 7th and 4th steepest gradients on the British rail system.

Enthusiasts for steam railways often wait beside a line in anticipation of a special thundering past within a cloud of smoke and steam. Favourite places to do this in the South Hams are Dainton and Hemerdon Banks.

On 16 June 2013 the 'Royal Duchy' special from Bristol to Cornwall, comprised of 8 coaches, and hauled by 'Black 5' no.44932, tackled Dainton Bank. Despite being a member of one the most powerful locomotive classes designed by William Stanier for the LMS, and significantly stronger than the locomotives available in the 1840s, the engine barked and belched smoke, and suffered wheel-spin as she slogged up the final stretch of the 1:36 climb.

Brunel summarised his views thus:

I have no hesitation in taking upon myself the full and entire responsibility of recommending the adoption of the atmospheric system on the SDR, and recommending in consequence that the line and works should be constructed for a single line only.

Words he would come to regret.

The mid-1840s years marked the height of 'railway mania' when speculators competed to build lines that had dubious commercial justification. Added to this there was a burst of 'atmospheric

mania' with SDR Chairman, Thomas Gill, predicting an atmospheric line from Exeter to Land's End. GWR Chairman, Charles Russell, was not so enthusiastic and expressed 'very grave concerns' about the single line operation.

Work on the line from Exeter to Newton began in July 1844 with an army of 2000 navvies toiling on the required track beds, sea walls, viaducts and tunnels. The single-track line, built to Brunel's preferred Broad Gauge of 7' 0¼", progressed at an astonishing pace and on 30 May 1846 the first train, hauled by two steam engines, made the journey from Exeter to Teignmouth amidst great celebration. Its departure was a little delayed as there was confusion over whether it should leave at 12.10 Exeter time or London time, Exeter's public clocks being set 14 minutes behind those in London. The line progressed with a steam-hauled train to Newton on 31 December 1846, to Totnes on 20 July 1847 and to Plymouth Millbay on 2 April 1849.

Simultaneous with the building of the Exeter to Newton line section of the SDR, contracts were being placed for the acquisition of machinery and materials for its adaptation to atmospheric running. The Clegg and Samuda system adopted required the laying of 4400 tons of the 13" pipes Brunel specified for the 20-mile route. At the end of 1844 they were ordered from George Hennet, contractor, shipowner and engineer, the man who also developed the Port of Teignmouth.

By the summer of 1845, 685 tons of 13" pipes had been delivered, but Brunel then decided he needed 15" pipes throughout, apart from 22" pipes for the banks, and had the 13" pipe order dumped in a field in Bristol. After an undoubtedly embarrassing Board Meeting, Brunel secured the new pipes and they were laid as far as the outskirts of Newton by August 1846. The leather valves were ordered from Joseph Samuda in February 1845, but fixing did not begin until late 1846 and had only reach Teignmouth by March 1847. The storage of the valves for so long caused a significant deterioration in the state of the leather.

One of the major construction requirements for the atmospheric system were engine houses each equipped with boilers and steam-driven pumping engines. Brunel planned eight for Exeter to Newton at approximately 3-mile intervals. Each engine house site comprised a tall pumping engine house, a smaller boiler house, a chimney and auxiliary buildings, built in the Italianate style with chimneys designed as campaniles. The first four were constructed of red sandstone and the others of grey limestone, with all having window surrounds of Bath stone and 'Italian Tile' roofing. Brunel never spared expense when commissioning elegant designs for his railway buildings.

In 1845-46 engine houses were built at Exeter, Countess Wear, Turf, Starcross, Dawlish, Teignmouth, Summer House (on the Teign Estuary) and Newton. Few images survive of the engine houses but we are fortunate that William Dawson (1790-1877), a land surveyor from Exeter, decided to paint panoramic watercolours of the route of the Atmospheric Railway as far as Totnes and many featured the engine houses.

The contracts for the steam engines and vacuum pumps were awarded in early 1845 to Boulton and Watt (3 pairs), G&J Rennie (3 pairs) and Maudslay (2 pairs). All were 40hp vertical engines producing 80hp in each engine house. All were completed by the end of 1845 but the engine houses were not. The boilers were delivered from May 1845 initially to Topsham Quay but were stock-piled because of the building delays.

There is little doubt that Brunel had been slow in bringing the essential elements of the Atmospheric Railway together. He excused the delays by saying that he wished to profit from the experiences of the only other atmospheric line in England, the London and Croydon Railway (L&CR) between New Cross and Croydon. Ironically the L&CR suffered an array of problems,

particularly after starting its public services on 16 January 1846. On 3 May 1847 the Board of the L&CR decided to end atmospheric operations in favour of steam haulage.

Supervised by Joseh Samuda, testing from Exeter southwards began in March 1847 and as more engine houses began to function, continued through to June when the Teignmouth engines were started. Undaunted by the abandonment of atmospheric working on the L&CR, Brunel and Samuda pressed on, still supported by the SDR Board. Brunel though was having doubts and expressed in an August report for shareholders that:

…the delays and difficulties…have been so wearying and incessant, that I have myself more than once repented having ever made the attempt.

He deleted the part about repentance before the report was printed. Wisely perhaps, as for a while the Atmospheric's fortunes improved. 'Ghost Service' trials each way between Exeter and Teignmouth were successful and the first public service ran on 13 September 1847. The engineers even allowed themselves a celebratory party in a house near Dawlish:

A very brilliant entertainment…a suite of three rooms was appointed to dancing, which was sustained with unwonted animation until long after daylight on Wednesday morning…the ices, confectionery, and wines were of the most recherché description…the decorations, lights, and furniture for the occasion were supplied by Mr Tapper of Dawlish, by whose taste the whole interior assumed the splendour of fairy magnificence.

Brunel was too busy to attend, but Mrs Brunel came alone along with invited local gentry,

The travelling public were very pleased with the fast, comfortable, and smoke and smut free service. In December the Summer House and Newton engine houses began working and on 15 February 1848 all steam locomotives were withdrawn leaving passenger and goods services between Exeter and Newton to be worked atmospherically. What could possibly go wrong?

Through the Autumn of 1847 and the early months of 1848, the Atmospheric ran well with no more delays and faults than were suffered by steam traction. But being a controversial innovation there were always detractors looking for problems, and the press, especially *Woolmer's Exeter and Plymouth Gazette*, were often keen to highlight failures.

There were, however, inherent flaws in the system that not only reduced efficiency, but in turn increased cost and reduced the confidence of customers and shareholders. Brunel had omitted the protective weather flap from Samuda's original designs, believing it to be an unnecessary additional cost. Consequently, the leather seals dried out in hot weather and froze in the winter, causing air leakage and water ingress. Air leakage meant that pumping engines had to work harder to attain an adequate vacuum, making operations more costly. Sometimes the leather was stripped away and trains were delayed or cancelled.

Starting and stopping was also an issue. Trains sometimes stopped short of or overshot platforms and passengers had to dismount and walk along the track. Goods wagons and carriages could not be shunted at stations, except by hand, trains could not reverse, and points and rail crossings were technically not possible. With increased traffic these problems were likely to increase.

Another factor increasing cost was that although stations had telegraphs using Cooke and Wheatcroft equipment, the engine houses did not. Workers did not know exactly when to steam up to create the vacuum for an approaching train. Consequently, they pumped for long enough to allow for late departures, often twice as long than would otherwise have been necessary, thus doubling the cost of fuel.

From 1846 Brunel seemed reluctant to plan for the extension of the Atmospheric beyond Newton despite requests from the Board. During 1846-47 steam engines, of a more powerful 68hp horizontal design, were ordered and Brunel was prompted to plan the next series of engine houses at Dainton, Totnes, Rattery, Wrangaton and Ivybridge as well as one at Torquay. Construction of Dainton, Totnes and Torquay began in the summer of 1847. Dainton received its engines in 1848, though they were never started. A few pieces of machinery reached Totnes, but Torquay remained a shell, and the buildings at Rattery were never finished. Also in 1848, the laying of 22" pipes from Newton to Totnes was completed, the larger diameter used to cope with Dainton Bank.

But ominous clouds were gathering. George Hudson, the so-called 'Railway King', a director of the shareholding Midland Railway, which had taken over the B&GR, had in August 1847, requested a halt to expenditure on the Atmospheric west of Totnes, apart from work on pipes on Rattery and Hemerdon Banks to assist conventional locomotives. A year later the Board instructed Brunel to sell off surplus steam engines that had been purchased.

Precise details of the tumultuous events of 1848 are difficult to discover. All Brunel's records of the period have been lost, though newspaper reports are available. During that year Brunel showed increased indifference to the fate of the Atmospheric, telling the Board in February that he was *refraining from offering any observations* on the six months of practical experience that had been gained because of the lack of telegraph communications with the engine houses. The responsibility for this delay was surely Brunel's and it took another 6 months to be remedied.

Board members were increasingly concerned that the Atmospheric would never be cost-effective. The anti-atmospheric press took every opportunity to report and exaggerate financial or technical issues. The summer of 1848 was particularly warm and dry and problems with the leather valves increased. Not only did sections of dry leather begin to tear away, but rusting iron, including the fixing rivets, began to corrupt and loosen the leather. This was exacerbated by the salt air between Starcross and Teignmouth.

Between May and August 1848 meetings were held of the Board and an appointed Atmospheric Committee in which debate took place between the pro- and anti-atmospherics. Both sides selected evidence to support its case, especially with regard to profitability. Brunel, who had already demonstrated equivocation over the future of the Atmospheric, proposed that continuation should only be considered if Samuda agreed to renew and service the valves at his own expense and based on Brunel's specification. As it was unlikely that Samuda would agree, Brunel had effectively moved to the anti-atmospheric camp.

On the 28 August Brunel told an Atmospheric Committee meeting that he doubted that Samuda would succeed in installing a successful valve, further weakening the resolve of the pro-atmospheric group. Brunel presented a written report to the Board stating:

The cost of construction has far exceeded our expectations, and the difficulty of working a system so totally different from that to which everybody—traveller as well as workmen—is accustomed, have (sic) proved too great; and therefore, although, no doubt, after some further trial, great reductions may be made in the cost of working the portion now laid, I cannot anticipate the possibility of any inducement to continue the system beyond Newton.

At a continuation of the Board Meeting the next day, Lord Courtenay proposed that atmospheric operation should be terminated on 9 September unless Samuda agreed to make the improvements and undertake to work the line at a defined cost per train mile. Later the same day at a meeting of shareholders, the Board presented Brunel's report and proposed that Brunel's recommendation, about extending atmospheric working, be enacted. No voice was raised

against the proposal. There was, however, loud and protracted cheering when someone proclaimed that:

The idea of continuing such a system one moment longer appears to almost border on insanity

and when Samuda was declared to be:

,,,as wild a visionary as ever existed.

The Board met again on 6 September and rejected new proposals from Samuda, resolving that locomotive working would commence on Sunday 10 September. The Atmospheric staff were given their notice and coal supplies to the engine houses were cancelled. The last atmospheric train was an up goods that arrived at Exeter at 12.30am. At 4.15am the down mail left Exeter under its own power as have all trains since.

The enterprise had cost the SDR nearly £450,000 - £57,000,000 at today's values. Over the next few years about 20% of the losses were recouped. Land was disposed of, the pipes went for scrap, the piston cars converted to carriages and the pumping engines and boilers sold off. It was more problematic to find a new use for the engine houses, with *Woolmer's Exeter and Plymouth Gazette* suggesting they should become asylums for the shareholders. But as the materials were relatively new, Countess Wear, Turf, Teignmouth, Summer House and Dainton were soon sold for their stone, followed later by Dawlish and Newton. Exeter was converted to a gas house and strengthened to support a large water tank on its roof. Torquay, Starcross and a much altered-Totnes survive along with a part of Rattery, converted into a cottage, and the reservoirs at Turf and Rattery.

Was the South Devon Atmospheric Railway Brunel's Folly? Brunel could be judged guilty of trying to manage too many projects at one time. He was heavily involved with the expansion of the GWR network and building the largest passenger ships in the world. Perhaps the SDR did not command enough of his attention. He overlooked vital details and delayed decisions on important matters such as the engine house telegraph system and the durability of the leather valve, failing to recognise the importance of the weather flap to protect it. Overarching all other issues was cost, a factor rarely uppermost in Brunel's mind. Frequently, regardless of expense, he changed specifications if the end result was better.

In Brunel's defence, the widely held view of the time was that the atmospheric principle offered great advantages regarding cost, speed, power and comfort. It was inevitable that it would attract bold visionaries and entrepreneurs such as Brunel and Samuda, though those of a more conservative outlook, such as Brunel's great rival and friend Robert Stevenson, were always sceptical and refused to contemplate its adoption.

Many factors were beyond his control, such as the volatility of shareholders, local vested interests, the incessant criticism of the sceptics and opponents, and the changing mood of the country. The launch of the SDR Atmospheric Railway was at the height of Railway Mania, but the bubble burst in 1847 just when the SDR required further investment to capitalise on the success it had already achieved. Simultaneously, hauled lines proliferated - 6,220 miles were authorised between 1844 and 1846 - and much more powerful locomotives became available. At this time the popular press was always ready to lampoon the visionary ideas of inventors, scientist and engineers. But the Atmospheric Railway did work and ultimately delivered the speed and comfort promised. It was even demonstrating that running costs would become competitive.

In 1848 Brunel had recommended that it was in the best interests of the company and its shareholders that the atmospheric project be discontinued. That was a courageous thing to do for a man who had truly believed in it and devoted so much time and energy to it.

Fortunately for Brunel's reputation, he had built amazing railway lines such as the GWR from London to Bristol, with engineering firsts such as the Thames Bridge at Maidenhead and Box Tunnel, and would go on to create many more. It was inevitable that, given his enthusiastic and optimistic personality, he would misjudge the viability some of his visionary ideas. So perhaps we can call Brunel's Atmospheric Railway not a folly but a great idea for which time ran out.

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