Engineers and inventors - overview

Initially, many of the engine erectors and engineers came from outside Cornwall and were originally agents or representatives of the pioneering Midlands foundries which had supplied the majority of the parts for the early beam engines. Such was the extent of their business relationships with Cornish mines that some settled in Cornwall for extended periods.

Josiah Hornblower came from the Midlands in the 1720s with his son Jonathon following him from Coalbrookdale in 1745. Four of Josiah's children were also to work as engine erectors for Boulton & Watt before setting up as engineers in their own right. John Wise came from Warwickshire in the 1740s. Of all these incomers the most important were the engineers and erectors sent to Cornwall by Mathew Boulton and James Watt in the later decades of the eighteenth century. William Murdoch was one, and he came to Cornwall as their chief engineer. But local engineers of distinction soon appeared. Richard Trevithick was the son of one of the mine captains at Dolcoath and was brother-in-law to Henry Harvey of Hayle. Arthur Woolf left Cornwall in 1785 to work for Joseph Bramah's engineering works in Pimlico (London) and subsequently worked as an engine erector and engineer until his return to Cornwall in 1811. There were many others, amongst whom were: William Sims, the self-taught son of an engine man, James Sims, John Hocking, Michael Loam, William West, the Michells, the Eustices, Samuel Grose, Billy Jenkin, the Tonkins, James Bullen and others on whose expertise rested the efficient running of Cornwall's mines. They became highly respected engineers.

The development of deep, hard-rock mining during the eighteenth century repeatedly threw up problems for which practical answers had to be found. Other people's ideas and skills were sometimes imported, whilst local mineral owners, merchants, miners and engineers, in an inherent empirical tradition, were constantly experimenting, improving and cumulatively innovating. In 1702 Robert Lydall of Truro developed an improved reverberatory tin furnace; in 1762 Sampson Swaine of Camborne developed a moorstone boiler which combined the production of steam with the reduction of low-grade copper ore to a partial smelt; in 1772 James Budge developed the tapered barrel whim; in 1805 John Taylor designed the mechanised copper ore crusher that became known as the Cornish Roll. These were first manufactured by Mount Foundry in Tavistock and first applied to ore-dressing at the important copper mines of Wheal Friendship (Mary Tavy) and Wheal Crowndale (adjacent to the Tavistock Canal); in 1812 Woolf's steam stamps were erected at the Carn Brea mines.

Whilst the best-known developments in mining technology lay in the field of steam engines, engineers from Cornwall and Devon were also responsible for numerous important improvements to boilers, mine pitwork, pumps, hydraulics, surveying equipment, and ore-dressing. In 1829 the Brunton Calciner was installed at Wheal Vor; in 1830 the first hydraulic jig was invented at Fowey Consols; in 1840 wire rope haulage was introduced at South Frances; in 1844 the Brunton Belt Concentrator

(a forerunner of the Frue Vanner) was installed at Devon Great Consols; in 1844 the Oxland process was developed for the removal of wolfram from tin ores; in 1856 the hydraulic classifier was invented by Isaac Richards; in 1860 Vincent invented the rag frame; in the 1870s Harveys of Hayle developed the pneumatic stamps; in 1880 Michell & Tregonning invented the barrel pulveriser (forerunner to the ball mill); in 1912 the James tin concentrating table was first manufactured by Holmans.

The nineteenth century also saw the emergence of a substantial gunpowder-making industry, the invention and manufacture of the safety fuse by William Bickford (whose company Bickford Smiths was to dominate world production for decades), the expansion of Perran Foundry and Harveys of Hayle into international suppliers of mining equipment, and the eventual emergence of Holmans of Camborne as world leaders in the field of rock drills and compressed air equipment. Murdoch lit his Redruth house with gas in 1792, Humphry Davy established himself as a pioneering British chemist, Goldsworthy Gurney ran a steam-driven coach from London to Bath in 1829 before turning his attention to lighthouses, Trevithick had trialled a steam carriage in 1801 and, in doing so, produced the world's first practical steam road vehicle and the forerunner of the steam train.

Thomas Newcomen (1664-1729) and the Atmospheric Beam Engine

The atmospheric engine invented by Devon-born Thomas Newcomen and installed at Dudley Colliery (West Midlands) in 1712 triggered changes in the Cornish mining industry that were to take it from an enterprise limited by what could be achieved using manpower, horse power and water power to a mechanised industry capable of large-scale and increasingly reliable production.

Indeed, some sources indicate that the first Newcomen engine on a metal mine may have been that installed in Cornwall, possibly at '…the Great Work…' mine (or Huel Vor = Wheal Vor) in Breage Parish, in or around 1710 (Rolt & Allen, 1997), though some authorities contend this. However, regardless of its true beginnings, the Newcomen engine was to be rapidly adopted across the coal mines of Britain and, to a more limited extent, in Cornwall over the coming decades.

The Newcomen engine introduced a radically new method of working. It also created the necessity for skilled workers who became known as engineers. Building upon centuries of mining experience, Cornwall was, over the next seven decades to 1790, poised to change from a region with a growing mining industry, to a fully industrialised economy which was amongst the earliest both in Britain, and the world. However for some time Newcomen engines proved to be something of a false hope for Cornish mine adventurers. Their inherent inefficiencies combined with the crippling burden of coal duty had initially made them far too expensive for all but the largest and most profitable mines to install. By 1727 only five Newcomen engines were working in Cornwall and by 1740 there were still only about 20. This slow adoption of steam power resulted from four factors: the high initial capital cost of constructing the engine; a duty on sea-borne coal (following petitions from Cornish mine adventurers this was finally abolished in 1741); the high cost of coal shipment from the coalfields of Bristol and south Wales and the added cost (often as much again) of mule carriage of landed coal from Cornish ports to the mines.

Added to this was the high consumption of coal necessary to keep the engines running continuously (a large engine might consume as much as 12 tons of coal per day - 80 mule loads - and worked at an incredibly low efficiency of 1 per cent). Even on the larger mines these running costs were often so high that the engines would be taken out of service after only a short period of use, to be replaced with the water-wheel pumps which had preceded them.

Nevertheless by the time of Newcomen's death in 1729, his engines were helping to drain mines in Hungary, Sweden, France, Germany, Belgium and Spain. One had even been delivered to the port of Vera Cruz in Mexico but had never made it to the silver mines for which it was intended. In 1753-55 Josiah Hornblower erected the first beam engine in North America in New Jersey.

Despite work by the Yorkshire engineer John Smeaton which resulted in the doubling of the efficiency of the Newcomen engine, it was increasingly seen as being too fuel-hungry for most Cornish mines.

In 1778 however there were still over 70 Newcomen engines at work when Pryce stated '…*Mr. Newcomen's invention of the fire engine enabled us to sink our mines to twice the depth we could formerly do by any other machinery.*' A depth of around 200m (below adit) approached the limit of the capability of these engines and, though they opened up important new ore-ground at such depths, technology remained at this level until the introduction of the Boulton & Watt engine into Cornwall in 1778.

Reference

Rolt, L.T.C. & Allen, J.S. (1997) *The Steam Engine of Thomas Newcomen*, Ashbourne: Landmark Publishing Ltd., p.44, 45

NB. In reaching their conclusion regarding the installation of the first Newcomen engine, Rolt and Allen cite the work of the nineteenth century geologist and industrialist Joseph Carne (1782-1858), that of the historian A.K. Hamilton Jenkin (*The Cornish Miner*), and the testimony of Davies Gilbert (1767-1839), as quoted in: Gilbert, D. (1838) *The Parochial History of Cornwall, founded on the manuscript histories of Mr. Hals and Mr. Tonkin; with additions and various appendices, by Davies Gilbert,* London: J.B. Nichols and Son.

Matthew Boulton (1728-1809) - industrialist

Intelligent, shrewd and intensely ambitious, Mathew Boulton succeeded in almost everything he turned his hand to. According to his eventual business partner James Watt, Boulton was an 'amiable and friendly character' and it would appear that he was liked and respected in the business world.

Matthew Boulton's background could not have been more removed from the world of mining. The son of an established toymaker specialising in buckles and buttons in Birmingham, he inherited his fathers business expanding it into the Soho Manufactory and added new products and methods of his own. The entrepreneur and innovator within drove Boulton to build up a business big enough to encompass the whole manufacturing and marketing process. Although the business proved to be a great success, attracting fame and many distinguished visitors, Boulton found his relaxation time in the company of scientists.

However Watts' steam engine was not Boulton's only business interest; his business pursuits were wide ranging but perhaps his greatest desire was to obtain government permission to produce English coins after the Royal Mint was thrown into chaos and ceased producing coinage in 1760. His passion and energy to succeed in this goal can be seen in the letters to Wilson, some of which also request huge amounts of copper from Cornwall to be shipped to Boulton's mint in Soho.

"My anxiety for Cornwall hath caused me to neglect my own business and my own interest. It hath induced me to put my self to a considerable expence in makeing new Machines and Experiments to perfection the art of Coining etc. And when I had secured all the important points then Cornwall comes forward (as if jealous of me) with a precipitate proposal to furnish the pieces ready for Coinage at 11 pence per pound or to furnish 3000 Ton of Coin in 20 Months which is next to impossible when it is considered that the whole of ye apparatus is yet to make." [Ref: AD1583/2/47]

"*By way of shortening what I have to say to you I send you inclosed a Copy of a Letter I wrote this day to the Deputy Gov [erno]r in London . I have reason to believe means will be taken to force ye E. J. Co[mpany] to export more copper and that a Coinage will take place. If to which you will take obvious means to push Sales you may stand on your own Legs otherwise you had better try to agree w[i]th Anglesey. But you must consider well all the future consequences as well as ye present. It is a great and deep stake. Anglesey hath ye advantage of Cornwall, inasmuch that A[nglesey] knows all that is said and done in Cornwall whereas C[ornwall] knows little of what Ang[lesey] is doing and intends doing you will see in my letter to ye D[epu]ty Gov[erno]r that I advise 3 things and without they are attended to you had better sell to Anglesey all your Copper which will undoubtedly for ever estable the Trade in the hands of ye A[nglesey] Co[mpany]."* [Ref: AD1583/2/50].

As demonstrated in the extracts above, Boulton's style of writing was quite unique. The language which he used was old fashioned even for the time and he often used shorthand and abbreviations. For example he substituted the chemical symbol for copper instead of writing the word and also instead of Water. However, perhaps what is most striking about his letters is that when he writes these on a more personal basis to business partners about the business, he writes in the third person.

Endorsed: "Mr Boulton July 26 1797'

'.Addressed to: " Mr Thomas Wilson, Truro, Cornwall , V[ia] Gloscester".

"To Your self alone [these previous four words being underlined].

Soho July 26 - 1797.

Dear Sir,

I have this mom[en]t rec[ei]vd yours of ye 23[r]d and assure you the last letter of B&W: was as painful for me to write it as it could be for you to read: but I find I am now only one fourth of a Man, & consequently have no comptroling power. - It is a maxim in Chymistry that when two Substances are put together the Compound is neither one or the other but is, what is called a tersium quid.

Thus if ye substance B is combined w[i]th W it makes a third substance of another nature; such was the nature of the letter I copyed, & sent you. -

Be assured you have a friend and advocate in me who wishes to live in harmony with his connections but who will never desert his old friends, & under that Idea I hope you will tranquilise your mind.

I shall lay your letter of ye 23[r]d In[stan]t before B&W but as I write this from my own feelings I must for the sake of peace request you will burn it for I cannot change my nature. -

Do the best you can to settle w[i]th B&W: relying also upon me as a mitigator, and as more at a pinch [these previous six words being underlined]. - I intended writing to you before but every day brings forth perpetual & unavoidable business, which has prevented me from telling you that I enter into the spirit & meaning of your former letter respecting your Son W[illia]m whom I shall render as happy as the nature of circumstances will admitt & shall not in any respect depress his spirits but on the Contrary keep them up & make him happy. -

If you think Mr Townend would let his money lye in your hands on condition he had the addition of my Security I would not scruple to give it, although contrary to my article of partnership, for I cannot see you in difficulties without partaking of them my self. -

Although I think highly of your son Toms prudence yet you must not let him see this Letter [these previous seven words being underlined] as it may so come round so as to endanger my peace. God bless you be of good Cheer. I am,

D[ea]r Sir Your sincere friend M Boulton" [AD1583/9/93]

In the late 1790s both Boulton and Watts' sons became more actively involved in the business meaning that the fathers could take more of a back seat. However, they lacked the drive and imagination of their fathers and the business steadily went into

decline. Although his health continued to fail Matthew Boulton continued to work on other projects up until his death. He died on the 18th August 1809 at the grand age of 80.

James Watt (1736-1819) and the Separate Condenser

James Watt patented the separate condenser in 1769 and in doing so created a steam engine which was considerably more economic in operation. Not only were the new engines far more powerful than the old Newcomen type but also their consumption of fuel was less than a third of the atmospheric engines.

In a region without its own coal, the invention was a breakthrough of immeasurable consequence. Boulton & Watt's first engine in Cornwall was at the Chacewater Mine (later part of Wheal Busy, Chacewater) in 1778. Over the next four years 40 per cent of the Boulton & Watt engines built were destined for Cornish mines.

What later became Consolidated Mines in Gwennap operated seven Newcomen engines in 1779 to keep the mine workings drained but had to cease working due to the crippling cost of firing them. The mines were subsequently acquired by another group of adventurers who erected five Boulton & Watt engines in 1780. These operated at a full third of the pumping cost in coal.

By 1783, 21 of the new engines were at work in Cornwall with only one Newcomen engine still operating. By 1790 the number of Boulton & Watt engines in Cornwall had increased to 45 and by 1800 mines were able to attain depths of around 300m below adit. The era of the Newcomen engine was over. James Watt and Matthew Boulton were not slow to recognise that Cornwall in particular stood to benefit enormously from these clearly more efficient engines.

Protected by the Parliamentary extension to Watt's patent from 1775, Boulton & Watt could profit from a market in engines that they controlled and encouraged. The company also invested in a number of Cornish mines to encourage the adoption of their engines. Under the terms of their licensing agreement with the owners, mines could only use this new technology under an arrangement which returned to Boulton & Watt one third of the saving in coal gained by using their engine rather than an atmospheric type of equivalent power; an equation which was prone to dispute and interpretation.

The separate condenser patent was strictly enforced, as Hornblower and Winwood were to discover in the 1790s (in relation to their compound engines). Edward Bull Junior, with his inverted engine termed it '…*a manifest piracy*...' Watt continued to improve his engine designs, adding the steam jacket concept in 1778; an improved rotative winding engine in 1781 (the first Cornish whim engine was erected three years later); the idea of expansive steam in 1782; the double acting engine and, in 1784, the parallel motion, which kept the piston rod aligned with the beam and cylinder.

By the last years of the century, however, the Cornish mines' market was becoming far less important to Boulton & Watt than the developing factories of the

Midlands and North of England. Nevertheless their engines had laid the foundation for the most significant phase in Cornish mining.

CORNISH MINING WORLD HERITAGE

Our mining culture shaped your world

United Nations Educational, Scientific and Cultural Organization

Cornwall and West Devon Mining Landscape
inscribed on the World Heritage List in 2006

Richard Trevithick (1771-1833) and the Cornish Engine

Richard Trevithick of Camborne is Cornwall's most famous engineer. He is accredited with the first practical application of high-pressure steam and a series of historic steam related innovations.

The end of the Watt Patent in 1800 ushered in an era of experimentation with alternative engine designs that flourished during the first three decades of the nineteenth century. James Watt had a long established distrust of high-pressure steam and recognised the potential both for wear and tear due to harder working, and for catastrophic explosions in poorly-maintained boilers and engines. Trevithick, by contrast, recognised it as the way ahead; the key to the development of much faster, more powerful, and portable engines.

Trevithick, along with Arthur Woolf and others, was to make the high-pressure engine a practical reality and over the coming decades engineers in Cornwall vied with each other to create the most efficient designs. *Lean's Engine Reporter*, published from 1811 in Cornwall, recorded the relative performance of engines per unit of coal. It helped to promote competition amongst engineers and mine owners to develop more efficient and powerful engines.

The Cornish engine was to be adopted not only by Cornish and overseas mines but, from 1837, by the new waterworks being constructed to service Britain's rapidly-growing towns and cities. Cornwall and west Devon foundries expanded to meet the growing demand. They benefited from being in close contact with their market and rapidly became leaders in engine-building technology, supply, and the erection on site wherever in the world the topography and depth of workings required them.

Trevithick's first high-pressure engine was erected at Stray Park (latterly a section of Dolcoath Mine) in 1800 and incorporated a series of radical improvements. It worked perfectly from the beginning, clearly implying that the engine had been under development for some time. Trevithick's influence on mine engines was considerable, particularly following the introduction of his high-pressure 'Cornish' boiler which allowed safe, high working pressures. An important legacy however lay in the potential for small, powerful, self-contained engines, particularly in the field of self-propelled transport.

Trevithick's work laid the foundation for the development of the steam locomotive, the steam ship, the portable engine, the traction engine and the steam car and lorry, for many of which he built prototypes. The development of efficient high-pressure steam engines with multi-tube boilers effectively freed industry and communications from the limitations of water power, horse power and wind power. Equally significant, the more economical use of fuel meant freedom of location. It was now possible to take and use steam power anywhere.