BRUNEL FAMILY LEGACY

Box Tunnel is a railway tunnel between Bath and Chippenham in Wiltshire dug through Box Hill and is one of the most significant structures on the Great Western Railway Main Line. It was originally built for the Great Western Railway under the direction of the GWR's Engineer Isambard Kingdom Brunel. The tunnel is 1.83 miles (2.95 km) in length, straight, and descends on a 1 in 100 gradient from the east.

Geology

Proposed in the 1835 Great Western Railway Act, due to its length and the difficult underlying strata the construction of a tunnel through Box Hill was considered an impossible and dangerous engineering project. However, the project did have one advantage. The strata through which it would pass had already been proven to be tunnelable, the sequence being Great Oolite on top with Fuller's Earth, Inferior Oolite and Bridport Sand beneath.

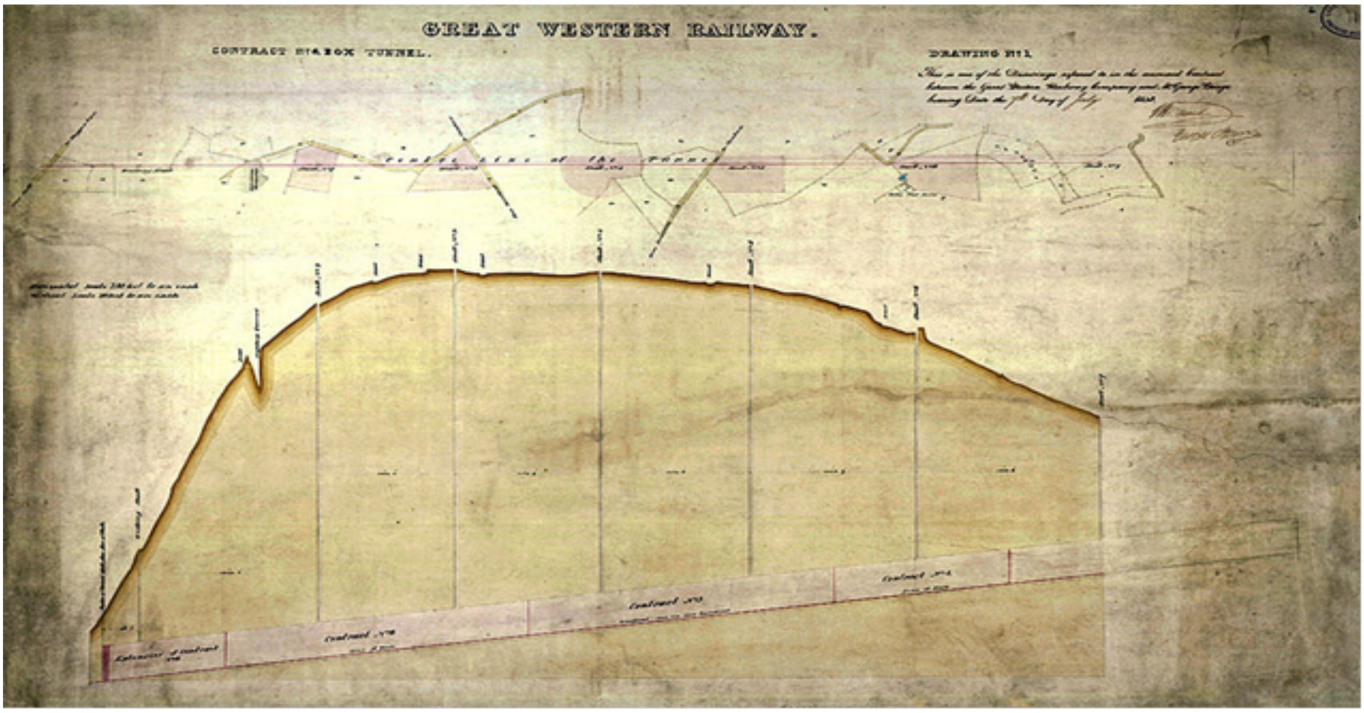
The Great Oolite limestone formed about 160 million years ago when the area was a shallow, warm sea. Ooliths form by strong currents moving tiny grains back and forth; calcium carbonate is precipitated around the grains in concentric rings until the Ooliths becomes too big for the currents to support. They fall to the seabed and over time are cemented by calcium carbonate to form the distinctive rock known as oolitic limestone, or locally as Bath Stone. Easily worked, this had been mined for construction purposes since Roman times, and particularly during the 17th and 18th century to build many of the buildings in Bath, extracted by the "room and pillar" method.

To assess the strata more accurately, between 1836 and 1837, Brunel sank eight shafts at intervals through the hill and along the projected alignment to establish the nature of the underlying rock.

Construction

The Great Western Railway selected two contractors from a tendering process. George Burge of Herne Bay was the major contractor responsible for 75% of overall tunnel length working from the west, who appointed Samuel Hansard Yockney as his engineer and manager. The locally based Lewis and Brewer were responsible for the remainder, starting from the east.

Engineering drawing of the longitudinal cross-section of Box Tunnel



Construction began in December 1838, divided into six isolated sections. Access to each was via a 25-foot (7.6 m) diameter ventilation shaft, which ranged in depth from 70 feet (21 m) on the eastern end to 300 feet (91 m) towards the western end.

All men, construction equipment, materials and 247,000 cubic yards (189,000 m3) of extract had to go in and come out via the steam powered winches and was also the safety exit. The only lighting was via candlelight, which were consumed at the rate of one tonne per week, which was equalled by the weekly consumption of explosives. Due to the time period required to get men in and out of the workings, blasting occurred with the men inside the tunnel. This, plus the hazard of additional water influx above the calculated volumes, led to most of the deaths of navvies (railway construction workers) and the need for additional pumping and drainage to be installed during and after construction. The lives of about 100 workers were lost in making the tunnel.

These considerable restrictions led to a delay in the construction timetable of the tunnel, so that by August 1839 only 40% of the required works were completed. By summer 1840, the London Paddington to Faringdon Road was complete, as was the Bath to Bristol Temple Meads. In January 1841, Brunel agreed with Burge and Yockney to increase their workforce from 1,200 to 4,000 workers, resulting in the effective completion of the tunnel in April 1841. When the two ends of the tunnel were joined underground, there was found to be less than 2 inches (50 mm) of error in their alignment.

Opening

The tunnel opened to traffic on 30th June 1841 without ceremony. The navvies continued working on the tunnel's western portal near Box Wiltshire, during this period, which Brunel had designed in a grand classical style. The eastern portal, at Corsham has a more modest brick face with rusticated stone.

Brunel's birthday

There is a story which states that Brunel deliberately aligned the tunnel such that the rising sun is visible through it on 9 April each year, his birthday. This is not the case. Actual dates on which the sun has been seen to be visible from the western portal are 5 April 1992 and 5 September 1985; the time approximately 0634 hours on both occasions.

Angus Buchanan (2002) writes:

The alignment of the Box Tunnel has been the subject of serious discussion in the New Civil Engineer and elsewhere. I am grateful to my friend James Richard for making calculations which convinced me that the alignment on 9th April would permit the sun to be visible through the tunnel soon after dawn on a fine day.

On the other hand it has been asserted that it is impossible to guarantee the effect on a particular calendar day, because the angle at which the sun rises on a given date varies slightly with the cycle of leap years.

However, the sun subtends an angle of about half a degree, which is more than the year-to-year variation and more than the field of view through the tunnel, so it quite possibly seems to fill the tunnel every year. It is also asserted that Brunel failed to account for atmospheric refraction and the effect is visible a few days too early.

Buchanan concludes:

I have found no documentary evidence for the often-repeated story that Brunel aligned the Box Tunnel so that the rising sun shone through it on his birthday, even though careful examination shows that it could indeed do so, and it is certainly a good story.

It is tempting to think that with a suitable vantage point, the effect (if not Brunel's intentions) can easily be checked on 9 April. However, the appropriate point is in the middle of a high-speed railway line and is thus potentially very dangerous. Photographs of the effect have reportedly been taken with appropriate assistance from railway officials.

A mathematical exploration of the possibility of the phenomenon occurring on Brunel's birthday has been undertaken by C.P. Atkins. Atkins concludes that, taking atmospheric refraction into account, full illumination [of the tunnel profile] can occur on April 7 in three (non-Leap) years out of four, whereas in a Leap-Year this should occur on April 6. partial illumination is not possible on April 8, let alone the significant April 9th.

The author suggests that reports of the Sun shining through Box Tunnel on April 9, or even on April 15 and 16, as reported by the local head ganger suggests some reflection effect and is, in itself, worthy of further investigation. Ken Porter (Basildon Heritage) notes that what they all may have missed is Emma's Birthday on 05th April 1804 and the sun's alignment at that time and the story that Isambard actually had her birthday as his link.

Defence use

The East portal with the quarry entrance to the former CAD Monkton Farleigh clearly visible on the right.

The hill surrounding the tunnel had been extensively quarried from 1844, extracting Bath stone.

In the run-up towards World War II, there was a recognition of a need to provide secure storage for munitions across the UK. The proposal was to create three Central Ammunition Depots (CAD): one in the north Longtown Cumbria); one in the Midlands Nesscliffe, Shropshire); and one in the South of England.

In the 1930s, Monkton Farleigh quarry was renovated by the Royal engineers as one of the three major stockpiles. In November 1937 the GWR were contracted to build a 1,000 foot (300 m) long raised twin-loading platform at Shockerwick, with two sidings from the adjacent Bristol-London mainline branching off just outside the eastern entrance to Box Tunnel (at 51°24′19.31″N 2°17′22.94″W51.4053639°N 2.2897056°W.) 30 feet (9.1 m) below and at right angles to this point, the War Office had built a narrow-gauge wagon sorting yard.

This was attached by a 1.25mile (2.01 km) tunnel built by The Cementation Company, descending at a rate of 1:8.5 to the Central Ammunition Depot, housed in the former mine workings.

The whole logistics operation was designed to cope with a maximum of 1,000 tons of ammunition a day. Further, a Royal Air Force station was also established using one area of the tunnels, RAF Box. Due to the heavy Bristol Blitz, in 1940 Alfred McAlpine developed a fallback aircraft engine factory for the Bristol Aeroplane Company, which never went into production. BAC did however use the facility to accommodate the company's experimental department, which was working on a new engine for bombers and the Bristol Beaufighter.

CAD Monkton Farleigh closed at the end of hostilities, although was kept in an operational condition until the 1950s. The sidings were then cleared, and not used again until the mid-1980s when a museum opened for short period on the site. Portions of the Ammunition Depot were variously redeveloped to house the Central Government War Headquarters, RAF No1 Signal Unit, Controller Defence communication Network and the Corsham Computer Centre.

Today, only the Computer Centre remains, while the visible north end of the tunnel is sealed by a concrete and rubble installation. The former mine/CAD is used for secure commercial document storage.

The Brunel Family

Sir Marc Isambard Brunel FRS FRSE (25 April 1769 – 12 December 1849) was a French-born engineer who settled in England. He preferred the name Isambard but is generally known to history as Marc to avoid confusion with his more famous son Isambard Kingdom Brunel. His most famous achievement was the construction of the Thames Tunnel.

Early life in France

Brunel was the second son of Jean Charles Brunel and Marie Victoire Lefebvre. Jean Charles was a prosperous farmer in Hacqueville Normandy and Marc was born on the family farm. It was customary for the first son to inherit the farm and the second son to enter the priesthood. His father therefore started Marc on a classical education, but he showed no liking for Greek or Latin and instead showed himself proficient in drawing and mathematics. He was also very musical from an early age. At the age of eleven he was sent to a seminary in Rouen.

The superior of the seminary allowed him to learn carpentry, and he soon achieved the standards of a cabinetmaker. He also sketched ships in the local harbour. As he showed no desire to become a priest, his father sent him to stay with relatives in Rouen, where a family friend tutored him on naval matters. In 1786, as a result of this tuition, Marc became a naval cadet on a French frigate and during his service visited the West Indies several times. He made a quadrant for himself of brass and ivory and used it during his service.

During Brunel's service abroad, the French Revolution began, in 1789. In January 1792, Brunel's frigate paid off its crew, and Brunel returned to live with his relatives in Rouen.

He was a Royalist sympathiser, as were most inhabitants of Normandy. In January 1793, whilst visiting Paris during the trial of Louis XVI, Brunel unwisely publicly predicted the demise of Robespierre, one of the leaders of the Revolution.

He was lucky to get out of Paris with his life and returned to Rouen. However, it was evident that he would have to leave France. During his stay in Rouen, Brunel had met Sophia Kingdom, a young Englishwoman who was an orphan and was working as a governess. Unfortunately, he was forced to leave her behind when he fled to Le Harve and boarded the American ship Liberty, bound for New York.

America

Brunel arrived in New York on 6th September 1793, and he subsequently travelled to Philadelphia and Albany. He got involved in a scheme to link the Hudson River by canal with Lake Champlain and also submitted a design for the new Capitol building to be built in Washington. The judges were very impressed with the design, but it was not selected.

In 1796, after taking American citizenship, Brunel was appointed Chief Engineer of the City of New York. He designed various houses, docks, commercial buildings, an arsenal, and a cannon factory. No official records exist of the projects that he carried out in New York, as it seems likely that the documents were destroyed in the New York Draft Riots of 1863.

In 1798, during a dinner conversation, Brunel learnt of the difficulties that the Royal Navy had in obtaining the 100,000 pulley blocks that it required each year to fit out its ships. Each of these was being made by hand. Brunel quickly produced an outline design of a machine that would automate the production of pulley blocks. He decided to sail to England and put his invention before the Admiralty. He sailed for England on 7 February 1799 with a letter of introduction to the Navy Minister, and on 7th March his ship, the Halifax landed at Falmouth.

England

Whilst Brunel had been in America, Sophia Kingdom had remained in Rouen and during the Reign of Terror, she was arrested as an English spy and daily expected to be executed. She was only saved by the fall of Robespierre in June 1794. In April 1795 Sophia was able to leave France and travel to London.

When Brunel arrived from America he immediately travelled to London and contacted Sophia. They were married on 1st November 1799 at St. Andrew Holborn. In 1802 Sophia gave birth to their first child, a daughter, Sophie; in 1804 their second daughter Emma; and in 1806 their son Isambard Kingdom, who would become a great engineer.

During the summer of 1799 Brunel was introduced to Henry Maudslay, a talented engineer who had worked for Joseph Bramah and had recently started his own business. Maudslay made working models of the machines for making pulley blocks, and Brunel approached Samuel Bentham, the Inspector General of Naval Works.

In April 1802 Bentham recommended the installation of Brunel's block-making machinery at Portsmouth Block Mills. Brunel's machine could be operated by unskilled workers, at ten times the previous rate of production. Altogether 45 machines were installed at Portsmouth, and by 1808 the plant was producing 130,000 blocks per year.

The Royal Navy needed about 100,000 pulley blocks of various sizes each year. They were used in a variety of ways including hoisting sales and handling guns. A 74 gun ship might use a thousand of various sizes.

Unfortunately for Brunel, the Admiralty vacillated over payment, despite that fact that Brunel had spent more than £2,000 of his own money on the project. In August 1808 they agreed to pay £1,000 on account, and two years later they consented to a payment of just over £17,000.

Brunel was a talented mechanical engineer, and did much to develop sawmill machinery, undertaking contracts for the British Government at Chatham and Woolwich dockyards, building on his experience at the Portsmouth Block Mills.

He built a sawmill at Battersea, London (burnt down in 1814 and rebuilt by 1816), which was designed to produce veneers, and he also designed sawmills for entrepreneurs. He also developed machinery for mass-producing soldiers' boots, but before this could reach full production, demand ceased due to the end of the Napoleonic Wars.

Brunel was made a Fellow of the Royal Society in 1814. In 1828, he was elected a foreign member of the Royal Swedish Academy of Sciences. In 1845 he was elected an Honorary Fellow of the Royal Society of Edinburgh.

Debtor's prison

Brunel several times became involved in unprofitable projects. As a consequence, by the beginning of 1821 he was deep in debt, and in May of that year he was tried and committed to the King's Bench Prison, a debtor's prison in Southwark. Prisoners in a debtor's prison were allowed to have their family with them, and Sophia accompanied him. Brunel spent 88 days incarcerated.

The new Kings Bench Prison consisted of 224 rooms with eight large state-rooms and a chapel. The prison did not operate in the way prisons do today and within the prison walls there were a coffee-house, two public houses, shops and stalls for meat and vegetables.

It was estimated 120 gallons of gin and eight butts of beer were drunk in a week. The grounds of the prison covered the whole of St George's Fields, an area with a circumference of approximately 3 miles, and known as "the rules". Prisoners who were able paid a sum of money to the keeper and in exchange were allowed their liberty anywhere within the "rules", even to take up a separate residence. Those with less money were able to purchase a "day pass". The system led to a Mr. W Smith writing in 1776 that "Many prisoners … occupy rooms, keep shops, enjoy places of profit, or live on the rent of their rooms a life of idleness, and being indulged with the use of a key go out where they please, and thereby convert a prison into an alms-house for their support."

As time passed with no prospect of gaining release, Brunel began to correspond with Alexander I of Russia about the possibility of moving with his family to St. Petersburg to work for the Tsar. As soon as it was learnt that Britain was likely to lose such an eminent engineer as Brunel, influential figures, such as the Duke of Wellington began to press for government intervention. The government granted £5,000 to clear Brunel's debts on condition that he abandon any plans to go to Russia. As a result, Brunel was released from prison in August.

Thames Tunnel

Richard Trevithick was engaged by the company to construct the tunnel. He used Cornish miners to work on the tunnel. In 1807 the tunnel encountered quicksand, and conditions became difficult and dangerous. Eventually the tunnel was abandoned after more than 1,000 feet had been completed, and expert opinion, led by William Jessop, was that such a tunnel was impracticable.

Inside the Thames Tunnel during construction, 1830.

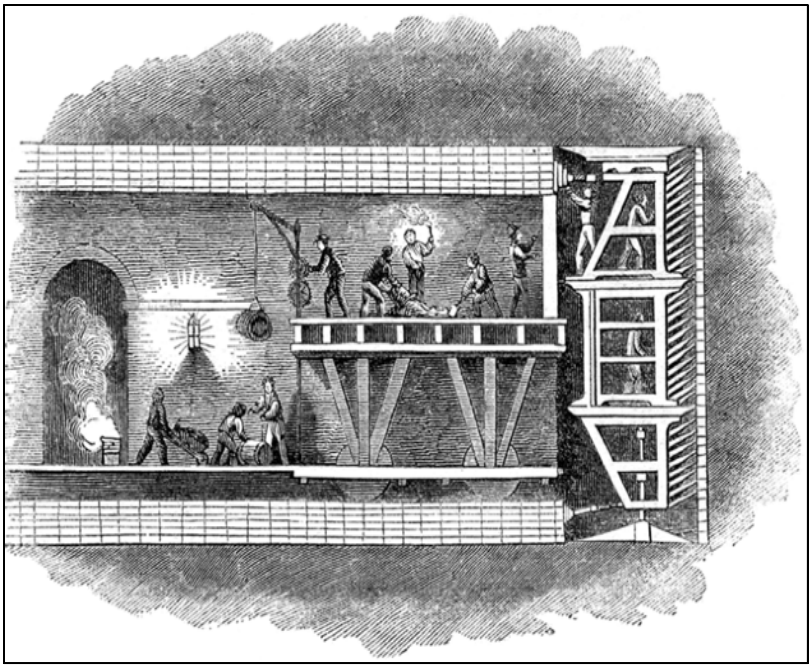
Brunel had already drawn up plans for a tunnel under the River Neva in Russia, but this scheme never came to fruition. In 1818 Brunel had patented a tunnelling shield. This was a reinforced shield of cast iron in which miners would work in separate compartments, digging at the tunnel-face. Periodically the shield would be driven forward by large jacks, and the tunnel surface behind it would be lined with brick. It is claimed that Brunel found the inspiration for his tunnelling shield from the shipworm, Teredo navalis, which has its head protected by a hard shell whilst it bores through ships' timbers.

Brunel's invention provided the basis for subsequent tunnelling shields used to build the London Underground system and many other tunnels. Brunel was so convinced that he could use such a tunnelling shield to dig a tunnel under the Thames, that he wrote to every person of influence who might be interested. At last in February 1824 a meeting was held and 2,128 shares at £50 each were subscribed for. In June 1824 the Thames Tunnel Company was incorporated by royal assent. The tunnel was intended for horse-drawn traffic.

Work began in February 1825, by sinking a 50-foot (15m) diameter vertical shaft on the Rotherhithe bank. This was done by constructing a 50-foot (15m) diameter metal ring, upon which a circular brick tower was built. As the tower rose in height, its weight forced the ring into the ground, and at the same time workmen excavated the earth in the centre of the ring. This vertical shaft was completed in November 1825, and the tunnelling shield, which had been manufactured at Lambeth by Henry Maudslay's company, was then assembled at the bottom.

Diagram of the tunnelling shield used to construct the Thames Tunnel

Maudslay also supplied the steam powered pumps for the project. The shield was rectangular in cross section, and consisted of twelve frames, side by side, each of which could be moved forward independently of the others. Each frame contained three compartments, one above the other, each big enough for one man to excavate the tunnel face, and the whole frame accommodated 36 miners. When enough material had been removed from the tunnel face, the frame was moved forward by large jacks.



As the shield moved forward, bricklayers followed, lining the walls. The tunnel required over 7,500,000 bricks.

Problems

Marc Brunel assisted by his son, Isambard Kingdom Brunel now 18 years old. Brunel had planned the tunnel to pass no more than fourteen feet below the riverbed at its lowest point. This caused problems later. Another problem that hindered Brunel was that William Smith the chairman of the company, thought that the tunnelling shield was an unnecessary luxury, and that the tunnel could be made more cheaply by traditional methods. He wanted Brunel replaced as Chief Engineer and constantly tried to undermine his position. Fortunately, the shield quickly proved its worth. During the tunnelling both Brunel and his assistant engineer suffered ill health and for a while Isambard had to bear the whole burden of the work.

The composition of the Thames riverbed at Rotherhithe was often little more than waterlogged sediment and loose gravel, and although the extreme conditions proved the ingenuity of Brunel's tunnelling machine, the work was hard and hazardous.

For the workers the building of the tunnel was particularly unpleasant because the Thames at that time was still little better than an open sewer, so the tunnel was usually awash with foul-smelling, contaminated water. The tunnel was often in imminent danger of collapse due to the instability of the riverbed, yet the management decided to allow spectators to be lowered down to observe the diggings at a shilling a time. Two severe incidents of flooding halted work for long periods, killing several workers and badly injuring the younger Brunel.

There were several instances of flooding at the tunnel face due to its nearness to the bed of the river, and in May 1827 it was necessary to plug an enormous hole that appeared on the riverbed. Finally the resources of the Thames Tunnel Company were consumed, and despite efforts to raise more money, the tunnel was sealed up in August 1828. Brunel resigned from his position, frustrated by the continued opposition from the chairman.

He undertook various civil engineering projects, including helping his son, Isambard, with his design of the Clifton Suspension bridge.

The later incident, in 1828, killed the two most senior miners, Collins and Ball, and Brunel himself narrowly escaped death; a water break-in hurled him from a tunnelling platform, knocking him unconscious, and he was washed up to the other end of the tunnel by the surge. As the water rose, by luck he was carried up a service stairway, where he was plucked from almost certain death by an assistant moments before the surge receded. Brunel was seriously hurt (and never fully recovered from his injuries), and the event ended work on the tunnel for several years.

In March 1832 William Smith was deposed as chairman of the Thames Tunnel Company. He had been a thorn in Brunel's side throughout the project. In 1834 the government agreed a loan of £246,000 to the Thames Tunnel Company. The old 80-ton tunnelling shield was removed and replaced by a new improved 140-ton shield consisting of 9,000 parts that had to be fitted together underground.

Tunnelling was resumed but there were still instances of flooding in which the pumps were overwhelmed. Miners were affected by the constant influx of polluted water, and many fell ill. As the tunnel approached the Wapping shore, work began on sinking a vertical shaft similar to the Rotherhithe one. This began in 1840 and took thirteen months to complete.

On 24 March 1841 Brunel was knighted by the young Queen Victoria. This was at the suggestion of Prince Albert who had shown keen interest in the progress of the tunnel. The tunnel opened on the Wapping side of the river on 1 August 1842. On 7 November 1842 Brunel suffered a stroke that paralysed his right side for a time. The Thames Tunnel finally officially opened on 25th March 1843 and Brunel, despite ill health, took part in the opening ceremony. Within 15 weeks of opening, 1,000,000 people visited the tunnel. On 26th July 1843 Queen Victoria and Prince Albert visited. Although intended for horse-drawn traffic, the tunnel remained pedestrian only.

After the completion of the Thames Tunnel, his greatest achievement, Brunel was in poor health. He never again accepted major commissions, although he did help his son, Isambard, on various projects. He was proud of his son's achievements and was present at the launch of the SS Great Britain in Bristol on 19thJuly 1843.

In 1865 the East London Railway Company purchased the Thames Tunnel for £200,000 and four years later the first trains passed through it. Subsequently the tunnel became part of the London Underground system, and remains in use today, as part of the East London Line of London Overground.

SS Great Britain

In 1845 Brunel suffered another, more severe stroke and was almost totally paralysed on his right side. On 12 December 1849, Brunel died at the age of 80, and his remains were interred in Kensal Green Cemetery in London. His wife, Sophia, was subsequently interred in the same plot, followed by their son, Isambard, just ten years later.

The Brunel links to the Basildon Borough.

Sophia Brunel (1802 Soho – 17th Jan 1878) Eldest daughter of Marc and Sophia Brunel who married Benjamin Hawes (19 March 1797 Westminster – 15 May 1862 Westminster) on 11th October 1820 at St. Lukes Chelsea. He was elected MP for Lambeth on 12 December 1832.

George Harrison (1800 – 1875).
George Harrison (Born 16 May 1800 Feering (Essex) – died 14 Mar 1875 Bideford Devon) was Curate at Langdon Hills from 14 March 1833 at a Stipend of £80 plus the Rectory. On 26th July 1834 he also became Curate at Vange on a Stipend of £70 still residing in the Rectory at Langdon Hills as indicated on the 1841 Census. He was educated at Catherine Hall Cambridge obtaining a Bachelor of Arts Degree.

Emma Joan Brunel (1804 St. James Park Westminster – 25th October 1883).
George Harrison married Emma Joan Brunel at St. Mary's Church Rotherhithe Surrey on 31 October 1836. He was a widower. Emma Joan Brunel was the daughter of Sir Marc Brunel and sister of Isambard Kingdom Brunel. Their son John Harrison was Baptised in the Parish of New Brentford on 06th March 1844.

The Will of her death was proved at Bodmin by Isambard Brunel son of Isambard Kingdom Brunel Barrister at Law of Lincoln's Inn Fields, the Nephew of Emma.

Isambard Kingdom Brunel (09 April 1806 – 15 September 1859 London)
The third child of Marc and Sophia Brunel who became one of Britain's most famous Engineer's and as previously mentioned, in recent times was voted second only to Sir Winston Churchill as the most famous Britain.

Though Brunel's projects were not always successful, they often contained innovative solutions to long-standing engineering problems. During his short career, Brunel achieved many engineering "firsts", including assisting in the building of the first tunnel under a navigable river and development of SS Great Britain, the first propeller-driven ocean-going iron ship, which was at the time also the largest ship ever built. Brunel suffered several years of ill health, with kidney problems, before succumbing to a stroke at the age of 53. Brunel was said to smoke up to 40 cigars a day and to sleep as few as four hours each night.

Early life

Isambard Kingdom Brunel was born in Portsmouth, Hampshire, on 9th April 1806. At 14 he was sent to France to be educated at the Lycée Henri-Quatre in Paris and the University of Caen in Normandy. Brunel rose to prominence when, aged 20, he was appointed chief assistant engineer of his father's greatest achievement, the Thames Tunnel, which runs beneath the river between Rotherhithe and Wapping.

Brunel established his design offices at 17–18 Duke Street, London, and he lived with his family in the rooms above. R.P. Brereton, who became his chief assistant in 1845, was in charge of the office in Brunel's absence, and also took direct responsibility for major projects such as the Royal Albert Bridge as Brunel's health declined. On 5th July 1836, Brunel married Mary Elizabeth Horsley (10th December 1813 – 03rd April 1881), the eldest daughter of composer and organist William Horsley, who came from an accomplished musical and artistic family.

The initial group of locomotives ordered by Brunel to his own specifications proved unsatisfactory, apart from the North Star locomotive, and 20-year-old Daniel Gooch (later Sir Daniel) was appointed as Superintendent of Locomotives. Brunel and Gooch chose to locate their locomotive works at the village of Swindon, at the point where the gradual ascent from London turned into the steeper descent to the Avon valley at Bath.

After Brunel's death the decision was taken that standard gauge should be used for all railways in the country. Despite the Great Western's claim of proof that its broad gauge was the better (disputed by at least one Brunel historian), the decision was made to use Stephenson's standard gauge, mainly because this had already covered a far greater amount of the country. However, by May 1892 when the broad gauge was abolished the Great Western had already been re-laid as dual gauge (both broad and standard) and so the transition was a relatively painless one. The present Paddington station was designed by Brunel and opened in 1854. Examples of his designs for smaller stations on the Great Western and associated lines which survive in good condition include Mortimer, Charlbury and Bridgend (all Italianate) and Culham (Tudorbethan). Surviving examples of wooden train sheds in his style are at Frome and Kingswear.

Brunel's "atmospheric caper"

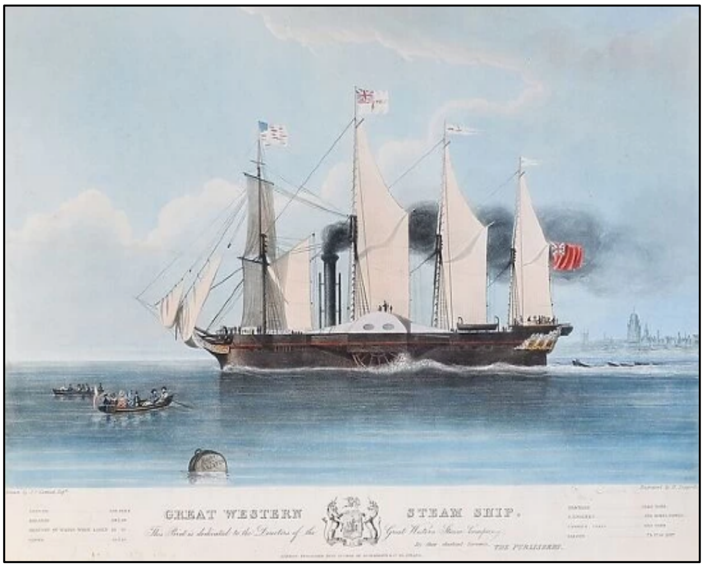
Though ultimately unsuccessful, another of Brunel's interesting use of technical innovations was the atmospheric railway, the extension of the GWR southward from Exeter towards Plymouth, technically the South Devon Railway (SDR), though supported by the GWR. Instead of using locomotives, the trains were moved by Clegg and Samuda's patented system of atmospheric (vacuum) traction, whereby stationary pumps sucked air from the tunnel.

The section from Exeter to Newton (now Newton Abbot) was completed on this principle, with pumping stations with distinctive square chimneys spaced every two miles, and trains ran at approximately 20 miles per hour (30 km/h). Fifteen-inch (381 mm) pipes were used on the level portions, and 22-inch (559 mm) pipes were intended for the steeper gradients.

The technology required the use of leather flaps to seal the vacuum pipes. The leather had to be kept supple by the use of tallow, and tallow is attractive to rats. The result was inevitable the flaps were eaten, and vacuum operation lasted less than a year, from 1847 (experimental services began in September; operationally from February 1848) to 10 September 1848. The accounts of the SDR for 1848 suggest that atmospheric traction cost 3s. 1d (three shillings and one penny) per mile compared to 1s 4d/mile for conventional steam power.

A number of South Devon Railway engine houses still stand, including that at Starcross, on the estuary of the River Exe, which is a striking landmark and a reminder of the atmospheric railway, also commemorated as the name of the village pub. A section of the pipe without the leather covers, is preserved at the Didcot Railway Centre.

Transatlantic shipping
Even before the Great Western Railway was opened, Brunel was moving on to his next project: transatlantic shipping. He used his prestige to convince his railway company employers to build the Great Western, at the time by far the largest steamship in the world. She first sailed in 1837.



She was 236 ft (72 m) long, built of wood, and powered by sail and paddlewheels. Her first return trip to New York City took just 29 days, compared to two months for an average sailing ship. In total, 74 crossings to New York were made. The Great Britain followed in 1843; much larger at 322 ft (98 m) long, she was the first iron-hulled, propeller-driven ship to cross the Atlantic Ocean.

There are many references in books that in 1838 Isambard Kingdom Brunel was seriously hurt in an accident aboard the SS Great Western off Canvey Island and was brought ashore to the island. Whether his stay was brief, or a bit longer is in dispute.

Quoting local historian and writer Robert Hallmann…..In 1837 the first of Isambard Kingdom Brunel's three steamships was launched in Bristol, a paddle steamer built of oak and iron, with a tall funnel and four sail masts for auxiliary power. It was by far the longest ship in the world at the time. (Reports vary from 212 to 236 ft in length.) Engines and boilers were fitted in Lambeth and speed trials carried out on the Thames.

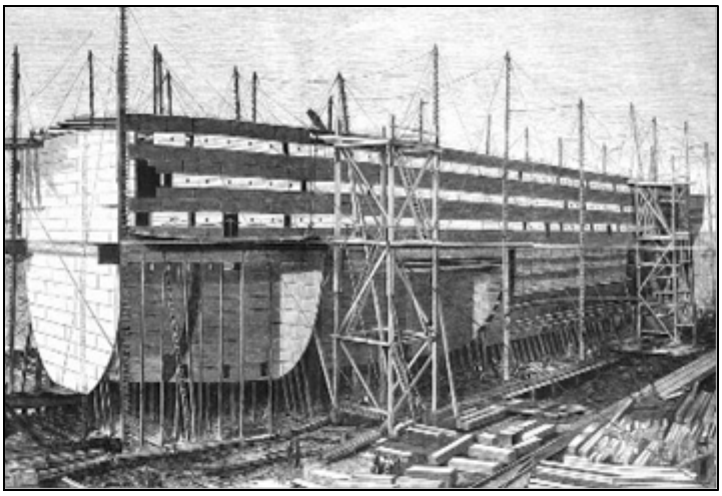
On 31st March 1838, while on its way back from London to Bristol, the ship caught fire off Canvey Island and was 'beached' on a sandbank to fight the emergency. While trying to help, the great engineer fell some 18-20 ft off a ladder. Seriously hurt, he was taken ashore, apparently to Canvey, where he recuperated for some three weeks.

'Isambard was taken ashore to Canvey Island where he was put to bed, seriously hurt. Even then he would not let go of his responsibilities and within hours of the incident he was writing directions to Claxton' (Captain Christopher Claxton, his naval assistant).

Ship-building successes, Brunel turned to a third ship in 1852, even larger than both of her predecessors, and intended for voyages to India and Australia. The Great Eastern (originally dubbed Leviathan) was cutting-edge technology for her time: almost 700 ft (213 m) long, fitted out with the most luxurious appointments and capable of carrying over 4,000 passengers.

She was designed to be able to cruise under her own power non-stop from London to Sydney and back since engineers of the time were under the misapprehension that Australia had no coal reserves, and she remained the largest ship built until the turn of the century. Like many of Brunel's ambitious projects, the ship soon ran over budget and behind schedule in the face of a series of momentous technical problems.

The ship has been portrayed as a white elephant, but it can be argued that in this case Brunel's failure was principally one of economics — his ships were simply years ahead of their time. His vision and engineering innovations made the building of large-scale, screw-driven, all-metal steamships a practical reality, but the prevailing economic and industrial conditions meant that it would be several decades before transoceanic steamship travel emerged as a viable industry.



Though a failure at her original purpose of passenger travel, she eventually found a role as an oceanic telegraph cable-layer, and the Great Eastern remains one of the most important vessels in the history of shipbuilding — the Trans-Atlantic cable had been laid, which meant that Europe and America now had a telecommunications link.

Crimean war

During 1854, Britain entered into the Crimean War, an old Turkish Barrack building became the British Army hospital in Scutari (modern-day Üsküdar in Istanbul). With injured men suffering from a variety of illnesses including cholera, dysentery, typhoid and malaria purely from hospital conditions, Florence Nightingale sent a plea to The Times for the government to produce a solution.

Brunel was already working on building the SS Great Eastern amongst other projects but accepted the task in February 1855 of designing and building the War Office requirement of a temporary, pre-fabricated hospital that could be shipped to the Crimea and erected. In five months he had designed, built and shipped the pre-fabricated wood and canvas buildings that were erected, near Scutari Hospital where Nightingale was based in the malaria free area of Renkioi.

His designs incorporated the necessity of hygiene, providing access to sanitation, ventilation, drainage and even rudimentary temperature controls. They were feted as a great success, some sources stating that of the 1,300 (approximate) patients treated in the Renkioi temporary hospital, there were only 50 deaths. In the Scutari hospital it replaced, deaths were said to be as many as 10 times this number.

Nightingale herself referred to them as "those magnificent huts." Brunel not only designed the buildings but gave advice as to the location of placing.

The art of using pre-fabricated modules to build hospitals has been carried forward into the present day, with hospitals such as the Bristol Royal Infirmary being created in this manner.

Illnesses and death of Brunel

In 1843, while performing a conjuring trick for the amusement of his children, Brunel accidentally inhaled a half-sovereign coin, which became lodged in his windpipe. A special pair of forceps failed to remove it, as did a machine devised by Brunel himself to shake it loose.

Eventually, at the suggestion of Sir Marc, Brunel was strapped to a board and turned upside-down, and the coin was jerked free. He convalesced by visiting Teignmouth and enjoyed the area so much that he purchased an estate at Watcombe in Torquay, Devon. Here he designed Brunel Manor and its gardens to be his retirement home. Unfortunately he never saw the house or gardens finished, as he died before it was completed.

Brunel suffered a stroke in 1859, just before the Great Eastern made her first voyage to New York. He died ten days later at the age of 53 and was buried, like his father, in Kensal Green Cemetery in London. He left behind his wife Mary and three children: Isambard Brunel Junior (1837–1902), Henri Marc Brunel (1842–1903) and Florence Mary Brunel (c.1847–1876). Henri Marc enjoyed some success as a civil engineer.

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