ISAMBARD'S GIFT

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Some years ago the BBC conducted a poll to determine the 100 greatest Britons. The surprising runner-up, beaten by Sir Winston Churchill, but well in front of Princess Diana, Charles Darwin and William Shakespeare, was the son of a French émigré, nineteenth-century engineering superstar, Isambard Kingdom Brunel.

Brunel was a driven man, a brilliant innovator who worked an eighteen-hour day; he devised the most radical and original engineering designs for his railways, bridges, tunnels and ships. But there is much evidence to suggest that he also had a well-developed sense of mischief and fun. He spent six weeks with a half-sovereign lodged in his windpipe, having accidentally inhaled it while doing conjuring tricks after dinner to amuse the children. He endured a tracheotomy (without anaesthetic) to admit a pair of forceps specially devised by Sir Benjamin Brodie in order to retrieve the coin, which was thought to be lodged deep in the right bronchus. The attempt was unsuccessful, but the coin finally dislodged itself and fell out the way it had come, with the help of gravity and a lot of coughing, when Brunel was inverted and strapped to 'an apparatus' designed either by himself or his father, Sir Marc Brunel.

A travelling companion, Charles MacFarlane, journeyed from Paris to London with the young Isambard and another friend in the cold winter of 1829. He described Brunel as a 'little, nimble, dark-complexioned man with a vast deal of ready, poignant wit'. They celebrated arrival in Dover with a slap-up meal at the Old Ship, and only had enough money left for the overnight coach to London. They were still laughing and joking when they arrived at Ludgate Hill at 6 am on a freezing cold morning. Sir George Burke, who was involved with Brunel in planning the railway to Bristol, lived opposite him in Parliament Street. Brunel fixed up a string across the road attached to a bell in Sir George's house so that he could wake him at 3 am ready to leave at 5 am to 'go into the country'. Burke commented that Brunel would:

> '...enter into the most boyish pranks and fun, without in the least distracting his attention to business ... I believe that a more joyous nature, combined with the highest intellectual faculties, was never created...'

Brunel's well-documented 'boyish pranks and fun' suggest that the following speculation may not be entirely without foundation.

Many of Brunel's engineering works are not only extant, but still in daily use. Of these, one of the best known is the Great Western Railway (GWR) running from London via Bristol to Cornwall. There are many notable works on the GWR, including the Wharncliffe viaduct at Hanwell and the elegant, shallow brick-arch bridge over the River Thames at Maidenhead; but the tunnel through the southern end of the Cotswolds at Box in Wiltshire must be that railway's most spectacular feature. At the time of its construction, Box Tunnel was the longest railway tunnel in the world, 1.8 miles in length, dead straight and falling from east to west with a gradient of 1:100. The tunnel opened on 30 June 1841, and the following year the *Salisbury and Wiltshire Gazette* of Saturday, 16 April 1842, reproduced a story from the *Devizes Gazette*: 'The Box Tunnel on Saturday last [9 April] presented a most splendid, though singular experience, the sun shining directly through it, and giving the walls a brilliancy, 'as though the whole tunnel had been gilt...' The story was repeated in a dozen other provincial newspapers between 18 and

30 April. Two years later, on Saturday 4 May 1844, the *Western Times* printed a long article on the completion of the 'Bristol and Exeter' railway; it quoted William Glennie, one of Brunel's assistants, who had been in overall charge of the construction of the Box Tunnel: 'Mr Glennie ... informs us that the sun shines through [Box] tunnel at rising, on April 9 and September 3.'

The story surfaced again in 1850; twenty-five newspapers repeated it this time. In 1856, the *Chelmsford Chronicle* revived the tale, this time saying that it happened on 1 May; again the story was repeated in many provincial newspapers culminating in the London *Morning Chronicle*, which reproduced it on 24 April 1856. In 1859, the Shropshire *Wellington Journal* again revived the story, reverting to 9 April as the date, and this time it was repeated in the *Daily Telegraph*.

Such a circumstance as the rising sun shining through the length of the tunnel was remarkable indeed, but curiously, what none of the reports mentioned, was that 9 April was the birthday of Isambard Kingdom Brunel... That is until the publication of an engraving showing a GWR train emerging from the grand western portal of the Box Tunnel greeted by a number of fashionable ladies and gentlemen. Attached to the picture was the legend:

> 'It is a remarkable fact that annually on the morning of April 9th, the sun's rays penetrate through the great box tunnel of the Great Western Railway and on no other day in the year ... *The Daily Telegraph*, April 12th 1859. Even more remarkable is the fact that April 9th is the birthday of Brunel.'

Perhaps even more remarkable still, the *Daily Telegraph* of 12 April 1859 has no mention of Box Tunnel, the story having been run the previous day. The date of original publication of this picture is not known; it can have been no earlier than 12 April 1859 and appears to be the first time that the tunnel phenomenon was linked, in print, to Brunel's birthday. The picture was reproduced by Beckett without attribution, and all attempts to find the original have so far failed. Since Brunel died in September of 1859, there remains the intriguing possibility that it was published after his death, it being safe to publicize the story without embarrassing the great man. Thus was born the legend that continues to the present day, that Brunel deliberately aligned the tunnel, such that the rising sun shines right through it on his birthday.

Was it true? Brunel left no evidence to support the theory; the various biographies of him either do not mention it or are in disagreement. The detailed account mostly of his professional life, published by his son Isambard Brunel in 1870, makes no mention of the phenomenon. Neither does the biography written by his granddaughter, Lady Celia Noble, nor the classic work by Rolt. Vaughan claims that the sun does penetrate the tunnel, not on Brunel's birthday, but between 15 and 18 April, with a reported visual sighting on 15 April 1968. Buchanan claims that it does penetrate the tunnel on 9 April. In 1985, two accounts appeared presenting details of mathematical analyses of the problem. Atkins, in the *Journal of the British Astronomical Association*, and Barnes, in the *New Civil Engineer*, agreed that the phenomenon does occur, but two or three days earlier than Brunel's birthday, on 6 and 7 April. To further confuse matters, Barnes' piece included a colour photograph taken from the western portal on the 9 April 1982 clearly showing a red glow at the other end of the tunnel.

Such an annual display would be a very fitting memorial for a great engineer if it were true, and other architectural alignments with astronomical phenomena were known in Brunel's time. The most famous was at Stonehenge, where the midsummer sun was known to rise over the Heel Stone in line with the major axis of the monument. Furthermore, the activities of Belzoni in Egypt would have been well-known. Giovanni Battista Belzoni, one-time actor and pantomime strongman, was the first to excavate the temple at Abu Simbel, and he found the entrance to Khafre's pyramid at Giza. He published an account of his discoveries in English in 1820; 'lionised by London society', his book would certainly have come to the attention of Brunel's father, Marc Brunel, if not the young Isambard.

Belzoni discovered the original entrance to the pyramid on the north face of the structure. He proceeded to excavate a rectangular, straight passage more than 100 feet long sloping south at an angle of 26 degrees. He commented in his book:

> '...some consider them [the pyramids] built for astronomical purposes, but there is nothing in their construction to favour this ... the Egyptians did not fail to make their sides due north and south ... Their inclination too is such as to give light to the north side at the time of the solstice. But even all this does not prove ... that they were erected for astronomical purposes; though it is to be observed, that the Egyptians connected astronomy with their religious ceremonies, as we found various zodiacs, not only among the temples, but in their tombs also.'

Straight, inclined passages and aligned monuments may well have had resonances with Brunel, and he certainly used Egyptian motifs in his work. The piers of the Clifton Suspension Bridge and the Wharncliffe viaduct on the GWR, both show an Egyptian style taper and cornices, and the original design for the bridge had sphinxes on top of each pier; Lady Noble commented on Brunel's 'Egyptian influences' in her biography.

Assuming that Brunel was inspired by Stonehenge and Belzoni's discoveries in Egypt, was he capable of the astronomical calculations necessary? In fact the problem is fairly straightforward and simply the inverse of navigation at sea. A ship's officer, in order to determine his position on the Earth's surface, would measure the elevation (angular height above the horizon) of an astronomical object. This could be the moon or a star or planet but was frequently the sun. Knowing the local time from a chronometer and the tabulated positions from an almanac, and after applying corrections for atmospheric refraction and various geometric factors, the ship's position could be determined to within a few hundred yards. By reversing the calculation, it was a simple matter to determine the direction of the sun from a particular point on the Earth's surface at any given time. And Isambard had someone trustworthy quite near at hand to teach him how to do it; his father, Marc Brunel, had been a lieutenant in the French Navy on board the corvette *Le Maréchal de Castries* for some years, and had constructed his own Hadley's Quadrant which he used for navigation.

The most straightforward way to find out if the rising sun does shine through the Box Tunnel on 9 April, is to stand at the western portal on that day and observe what happens, but this is fraught with difficulty. The most obvious problem being that anyone doing so would be arrested by the authorities for dangerous trespass if they had not already been struck by one of the high-speed trains which run at that time of the morning (around 5:30 am). Visibility through the tunnel could be obscured, either by diesel exhaust fumes from the trains, or trees on the embankment at the eastern end. Then there is the British weather; how likely is early April to provide skies clear enough all the way to the horizon to observe the sunrise? Finally there is the problem of the Gregorian calendar and the leap-years. The azimuthal or compass bearing of the rising sun on any given date drifts south by around half a degree over a four year cycle to be reset by the leap-year, except that the reset slightly overcompensates, causing the *average* position to then drift north by a little more than half a degree over a period of 100 years. This drift is itself reset every 400 years as determined by the Gregorian cycle of century leap years (1800 was not a leap year, 1900 was not a leap year, 2000 was a leap year). Thus the rising sun, itself half a degree in diameter as seen from Earth, will vary in position on a particular date by as much as that diameter from year to year. It would also be difficult in a practical experiment to be sure that any observed sunlight was not a reflection from the tunnel walls or the rails.

With the advent of advanced computer programmes designed to run on PCs, it is not difficult to calculate the position of the sun at Box, and display the results in an accessible manner. This enables the previously reported calculations to be verified or otherwise, but also allows investigation of the variation, year on year, of the illumination due to the calendar. New calculations would also allow for detailed analysis of the situation pertaining at the time that Brunel designed the tunnel. Atkins used current (1985) published tables of the sun's position commenting that they would 'also have obtained 150 years ago when the tunnel was first built', which is not entirely true; the long-term effect of the leap-year drift has to be properly taken into account. Barnes' calculations were also based on current tables, although he did calculate an offset factor for the 1830s, showing that penetration could not have taken place on 9 April. Both authors mention the effect of atmospheric refraction, but neither seriously considers the

possibility that had Brunel intended to align the tunnel with the sun, he might have neglected the effects of refraction which make the sun appear higher in the sky than it really is.

The requirements of navigation at sea meant that tables of the sun's position in the celestial sphere were readily available in Brunel's time, and had been for many decades; since the British Navy used them for navigation, the accuracy of these tables was beyond dispute. Calculating the position of the sun as seen from Earth involved a simple computation based on the latitude and longitude of the observer's position. However the very significant correction due to the refraction of the atmosphere alters the results considerably. Because the density of the atmosphere varies with height, light passing through it is bent, the amount of bending increasing close to the horizon. It is this effect that makes the moon or sun appear to be slightly squashed when very low in the sky. In navigation, proper account of refraction, which is only zero when the object is directly overhead, had to be taken, and correction tables were included in the Nautical Almanac. The tables were based on measurement, and the correction factor varied according to both temperature and atmospheric pressure. There was, therefore, an intrinsic uncertainty in the corrected altitude due to weather conditions, and the magnitude of the correction increased substantially close to the horizon.

Tables of refraction were included in the Nautical Almanac up to the year 1833. Thereafter, the committee of the Council of the Astronomical Society, who had been asked by the Lords Commissioners of the Admiralty to improve the almanac, decided that the tables should be excluded and transferred to another work, presumably because they were unchanging year on year. This seems a curious decision, since consideration of refraction was essential in observational navigation and the tables, together with an explanation and examples of their use, took up just three pages out of three hundred in the 1833 almanac.

The following analysis has been undertaken using effectively the same data that Brunel had available to him. The ephemeris (celestial position) of the sun has been computed for convenience using *SkyMap Lite*, which was itself checked against the ephemerides in the 1830s almanacs, and found to be correct to within a fraction of a second of arc. The refraction tables in the 1833 Nautical Almanac were used, and the latitude and longitude of the western portal of Box Tunnel were taken from the Ordnance Survey, Sheet ST 86/96. The tunnel was built between 1836 and 1841, before a high resolution ordnance survey of the area had been completed. However the position of the tunnel entrance could have been easily computed in the same way, and with better accuracy, as if it had been at sea.

The figure shows the far portal of Box Tunnel as it would have been observed by a person of Brunel's stature standing at the western entrance looking east shortly after sunrise on 9 April. The position of the sun close to the tunnel is shown for the years 1831-1834, superimposed on to the same chart. The dotted line shows the track of the rising sun during the year of 'closest approach', 1831, although during the years 1835, 1839, 1843 etc., the sun would have been in a similar position. The effect of the leap-year cycle is clearly visible (fig. 1).

Since the positions of the sun and tunnel do not overlap, the disappointing conclusion is that the sun does *not* shine through the Box Tunnel on the morning of Isambard Kingdom Brunel's birthday. But the fact that it very nearly does, makes clear what gave rise to the legend, and it is entirely likely that such a close coincidence could well cause reflections from the walls or rails making it seem as if the sun and tunnel really were lined up. But this is not the end of the story.

Did Brunel intend an alignment, but fail to take account of refraction? The correction for refraction is the least certain part of the calculation; it is subject to the vagaries of the weather and is at its greatest extent near the horizon. Calculation shows that in 1834, and every four years, the *true* sun, the sun that would be hypothetically visible if the atmosphere was absent, really does penetrate the tunnel on Brunel's birthday, to the extent of about 25%. But if Brunel did intend an alignment, particularly if he had his father's assistance in the calculations, it seems highly unlikely that he would have made such an elementary error as ignoring refraction, even if the tables had been excluded

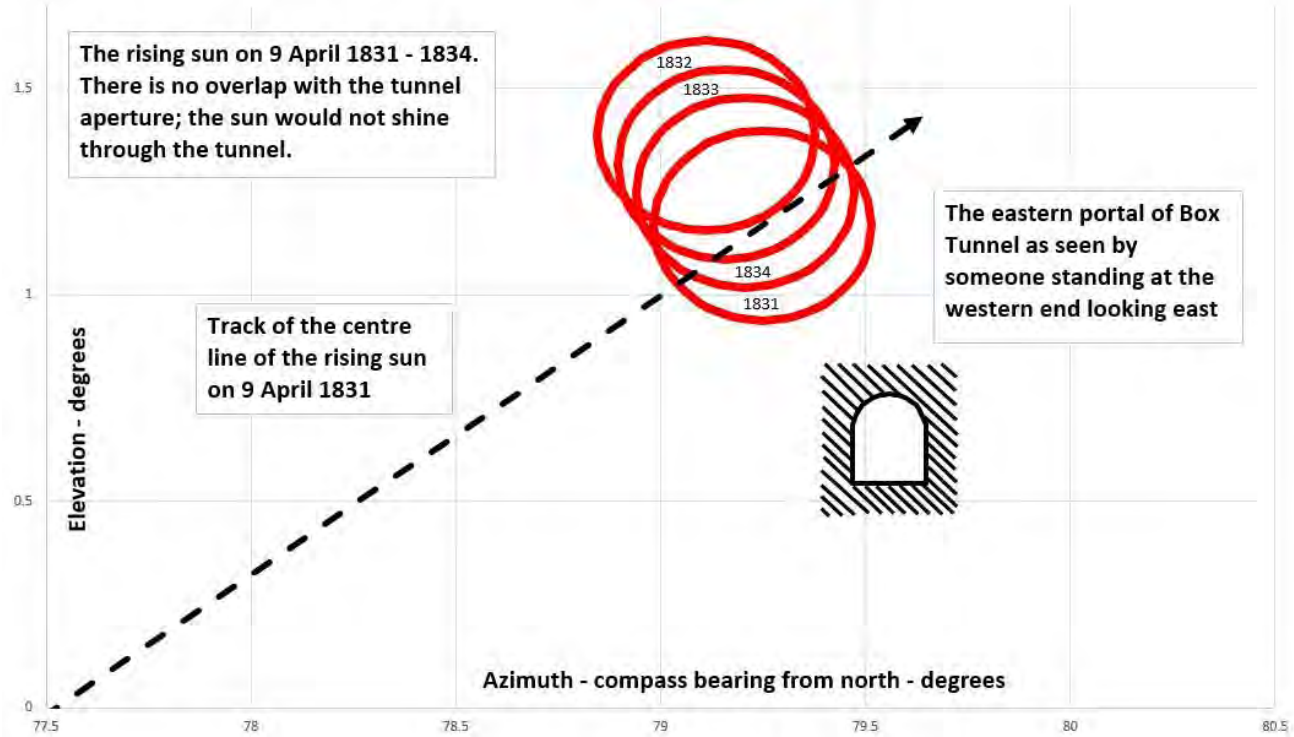

Fig. 1 - Sunrise at Box Tunnel in the 1830s on Brunel's birthday.

from the current Nautical Almanac… It remains possible that he did make a mistake of some sort, but he was responsible for some of the most radical bridge designs using materials and structures thought by many people to be dangerously close to failure. The most meticulous, precision calculations in design were needed, and none of his bridges ever failed catastrophically; this suggests that Brunel did not make mistakes in his mathematical analyses.

The newspapers had picked up the idea of an alignment the year after the tunnel was opened. If the story was true, Brunel might well have faced some very uncomfortable questioning from the directors of the GWR on his commitment to controlling costs; he was notorious for failing to work to budget. Work on the GWR continued until 1852 when it was extended finally to Penzance; Brunel could easily have found himself out of a job and ridiculed in the press. As it was, any astronomer or navigator worth his salt could show that the story was false.

One is very reluctant to leave such a fascinating idea with a sense of failure; a possibility so close and yet so far from providing a spectacular annual display of Brunel's hubris, if not his sense of fun. Further analysis shows that the sun does penetrate the tunnel, either fully or partially, on the 6, 7 and 8 April, and again on 5, 6 and 7 September. Is it possible that Brunel really did intend an alignment, but for an event other than his birthday? Perhaps a significant date in his family? It seemed to be an intriguing possibility, and a list of the birthdays and dates of marriage of his family was eagerly scrutinized. There was even the possibility that it could have been a secret gift to his one-time long-standing girlfriend, Ellen Hulme. Work started on the tunnel in 1836, so the precise position had to have been established by that date. None of the birthdays fitted; not Brunel's parents and wife, the dates of their marriages (his was in 1836), the birthday of his spirited sister, Sophia Macnamara Brunel, known as 'Brunel in skirts', or her marriage to Benjamin, later Sir Benjamin Hawes. The mysterious Ellen Hulme, with whom Brunel was supposed to have had an early, long-term romantic connection, was born in November, so she was no good either.

But Brunel had another sister, Emma Joan Brunel, 'she had inherited her mother's serenity, but was less robust than Sophia, her lively, bright-eyed sister'. Lady Noble was dismissive of her:

> 'His [Marc Brunel's] second daughter, Emma, seems to be one of those dim and rather ailing creatures who are so often referred to in their family as 'poor'. "Poor Emma" suffered from nervous headaches ... she married a curate and died young.'

Lady Noble named the curate 'Frank Harrison', and said that Emma had gone to live with him at 'Longdon near Tewksbury'. This information was repeated by Harold Bagust (and elsewhere) in his 2006 biography of Isambard's father, Marc; Marc, he said, had related that his daughter Emma was of little assistance: 'Subject as she is to headaches which suddenly come on her, she is incapable of any kind of exertion in such circumstances.' Emma's date of birth appears nowhere in the published literature, and Lady Noble seems to have dismissed her as being of no consequence.

Investigation shows that Emma did not die young; her husband was actually *George* Harrison, a Cambridge graduate, and he was curate of *Langden* Hills, near Basildon in Essex. They were married in October 1833 at St Mary, Rotherhithe. In 1842, Harrison became vicar of New Brentford, where, in 1844, Emma gave birth to a son, John Harrison. In 1853 George became rector of Sutcombe in Devon. He died in 1875, and Emma died in 1883 at Bude; she was eighty years old and there is a marble plaque recording them both, including her famous family connection, in the church at Sutcombe.

A search was made for Emma's birth details in the Portsmouth area, where Isambard was born, and in London where Sophia's birth was registered at St Anne, Soho. After considerable effort nothing was found, although the census returns were revealing. On 3 March 1851, Emma's age was given as 47; on 7 April 1861, it was 58; on 2 April 1861, it was 67, and on 3 April 1881 it was 77. If her age was correctly rendered, this meant that her date of birth lay between 3 and 7 April 1803, and the sun shines through the Box Tunnel on 6 and 7 April… Did Brunel deliberately align the Box Tunnel with the rising sun on the birthday of his favourite sister, 'Poor Emma'? Was it a special, secret gift known only to the two of them?

It gets better. As this article was being prepared, a discussion regarding the merits of various internet-based genealogical resources led to one final search for Emma's birth - and an image of the original register of St Margaret, Westminster, was found online. On 3 June 1803, the baptism of Emma Joan Brunel, daughter of Mark Isambard by Sophia was recorded. The register also noted the date of birth; it was 6 April 1803... (fig. 2).

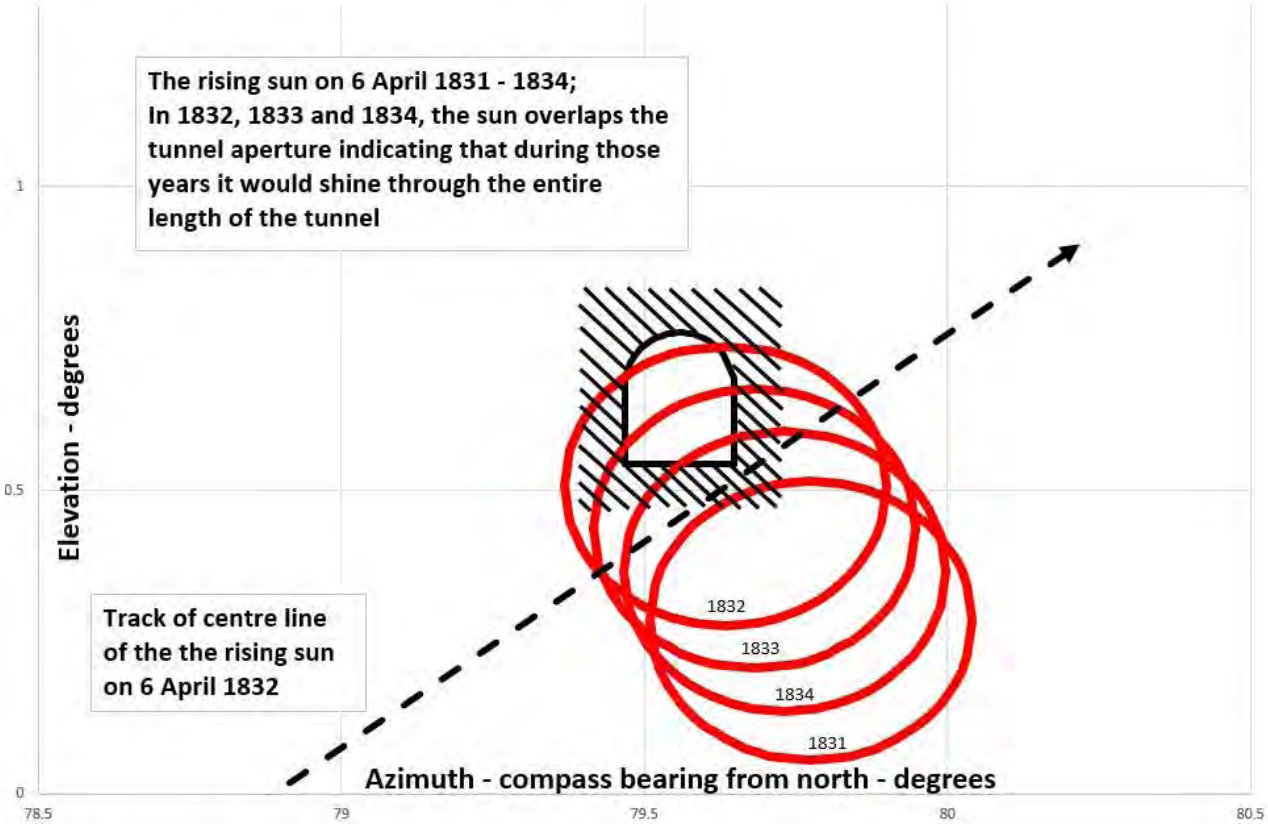

Fig. 2 - Sunrise at Box Tunnel in the 1830s on the birthday of Emma Joan Brunel.

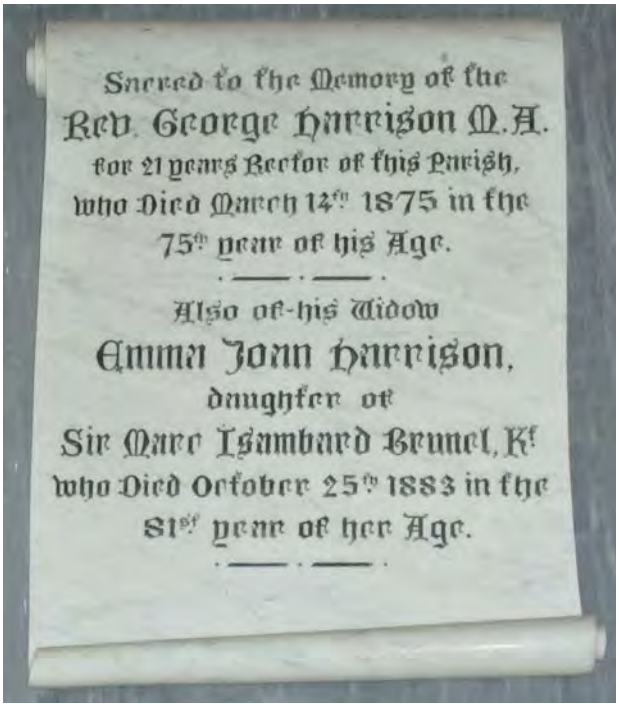

Fig. 3 - Memorial in Sutcombe Church to George Harrison and Emma Joan Harrison née Brunel.

It can now be stated with some confidence that on three years out of four in the leap-year cycle in the 1830s, the morning sunrise, weather permitting, on 6 April, the birthday of Emma Joan Brunel, shone right through the great Box Tunnel on the Great Western Railway. Whether Isambard intended this or it was just a happy accident will be subject to endless speculation - unless an intrepid Brunel scholar someday uncovers a previously unknown letter or document from Brunel either proving or disproving the fact. It remains, however, a perfect afterword to the whole affair of Brunel and his tunnel.

After all the press reports, claims and counter-claims, mathematical analyses, sightings and Lady Noble's efforts to write Isambard's sister out of the Brunel story, indeed out of history, it turns out that it is the birthday of the 'inadequate', mild-mannered 'poor' Emma, wife of an obscure clergyman, the least exalted member of the Brunel clan, that is forever commemorated by the spectacular alignment of the sun with one of the most enduring symbols of nineteenth-century railway engineering.

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Notes

Solar penetration of the inner chamber of the temple at Abu Simbel is supposed to happen on two days in the year, but this fact was almost certainly unknown in Brunel's time.

Because of the slow drift in position due to the leap years, the years 2012 and 2013 show 100% penetration of the tunnel on Emma Joan Brunel's birthday, with partial illumination in 2014 and 2015. This pattern will be repeated every four years for a long time to come.

I am most grateful to Matthew Payne, Keeper of the Muniments, Westminster Abbey, for checking the original baptismal register of St Margaret's, Westminster for the birth details of Emma Joan Brunel.

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