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The Thames Tunnel by Marc Isambard Brunel – The world's first sub-aqueous tunnel

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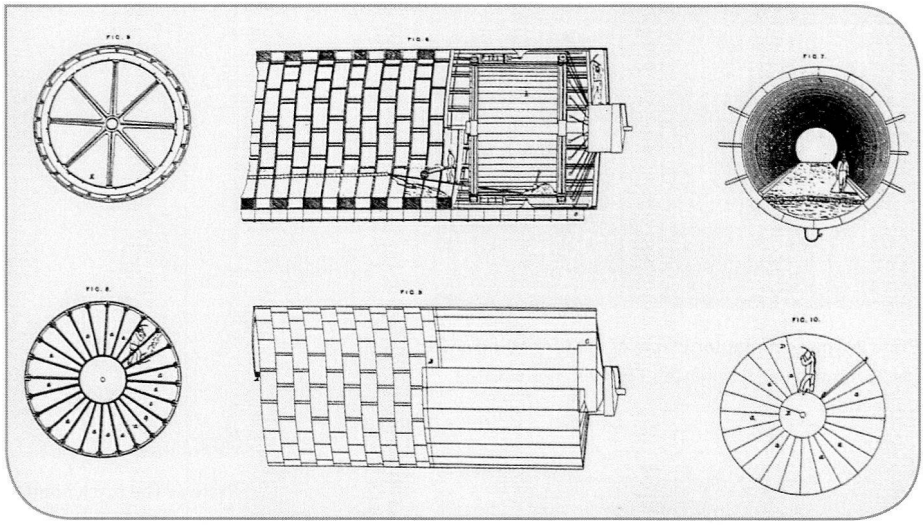

Plate 1: Detail from the Patent for a circular tunnel. UK Patent number 4204, January 1818. (Foto: Ironbridge Gorge Museum Trust)[1]

French-born civil engineer Marc Isambard Brunel built the world's first underwater tunnel in London and invented the tunnelling shield, providing a protected workspace for the labourers. The Thames Tunnel was constructed only a few metres below the bed of the river, so there were endless problems when the river broke in. Work began in 1825 with private funding, but after three years they ran out of money. An underwater fundraising banquet held in 1827 was not enough and work soon came to a complete stop. Six years later they started again, this time with a government loan and the tunnel finally opened in 1843. It is still in daily use today as part of London's Underground system.

Der in Frankreich geborene Ingenieur Marc Isambard Brunel baute in London den ersten Unterwasser-Tunnel der Welt und entwickelte dabei den Schildvortrieb, welcher den Arbeitern einen gesicherten Arbeitsbereich bot. Da der Thames Tunnel nur wenige Meter unter dem Flussbett gelegen war, kam es immer wieder zu Problemen mit eindringendem Flusswasser. Die Arbeiten am Tunnel wurden 1825 mit privaten Mitteln begonnen, welche jedoch nach drei Jahren erschöpft waren. Auch ein 1827 unter Wasser abgehaltenes Fundraising-Bankett konnte nicht genügend Mittel zur weiteren Finanzierung aufbringen und so kam das Projekt zu einem kompletten Stillstand. Erst sechs Jahre später konnten die Bauarbeiten wieder aufgenommen werden, diesmal finanziert durch eine Staatsanleihe. 1843 wurde der Tunnel eröffnet und wird heute, als Teil des Londoner U-Bahn-Systems, tagtäglich genutzt.

Marc Isambard Brunel (1769–1849) invented the tunnelling shield in 1818. He was born and educated in France as a naval officer and mechanical engineer, but in the age of the polymath he was also an accomplished inventor, artist and musician. He escaped the Revolution in 1793 and sailed to America where he worked as Chief Engineer to the port of New York, but six years later in 1799 he settled in England where he lived until his death.[2] Much of his career was involved with inventions used at the naval dockyards at Chatham east of London, especially the machinery that mass-produced ship's blocks in 1801 – the first production line of 45 machines that made standard parts and produced the 100 000 blocks needed each year at a fraction of the price.[3] He also invented the pendulum saw in 1805, the circular saw in 1808, and mass-produced boots and shoes for Wellington's army in 1810.[4]

The Tunnelling Shield

In 1818 Marc patented the world's first tunnelling shield[5] (Plate 1). He proposed two versions, a circular one which is the precursor of modern shields, providing a safe working area and a method of lining the tunnel with cast iron segments. However, it was the other one that was to be part of his life from 1825 until old age. It was to be for a 365 m two-carriageway road tunnel under the River Thames downstream of London Bridge in the busiest part of the port.[6] A tunnel in the middle of the port made a lot of sense and the idea was easy to sell to potential shareholders.

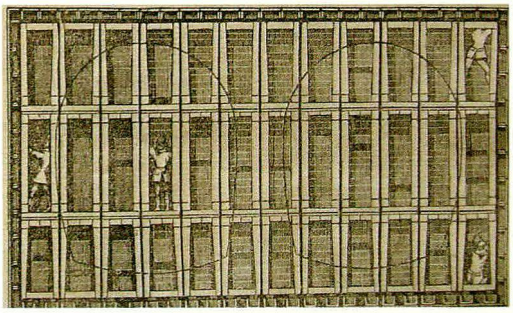

Plate 2: The rectangular frame of the tunnelling shield for 36 miners used under the Thames. (Foto: Elton Collection)[7]

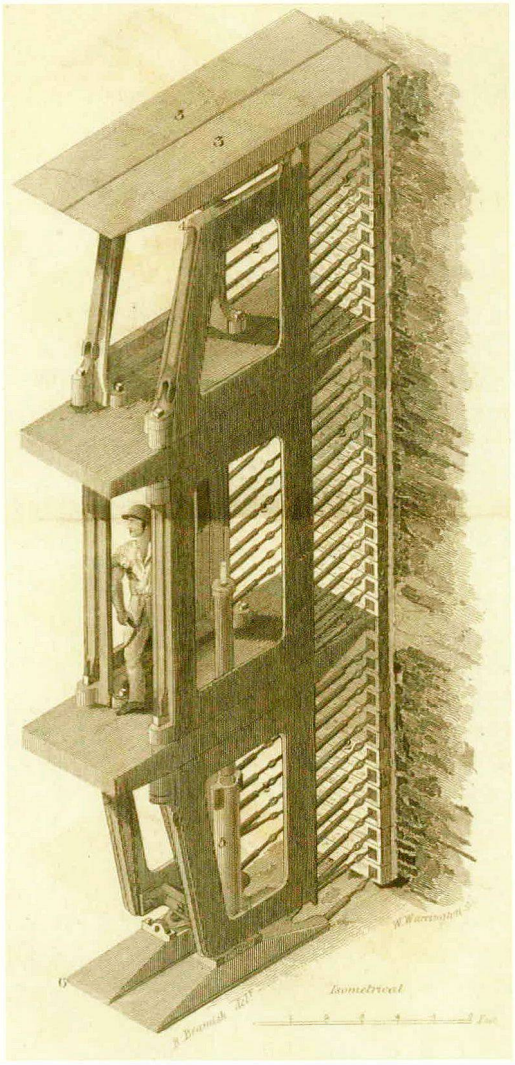

Plate 3: One of the cast iron frames of the tunnelling shield. With 12 frames side by side the working face was 12,5 m x 6,8 m, the others not shown. There were two 8-hour shifts a day with 36 miners working at a time.[8]

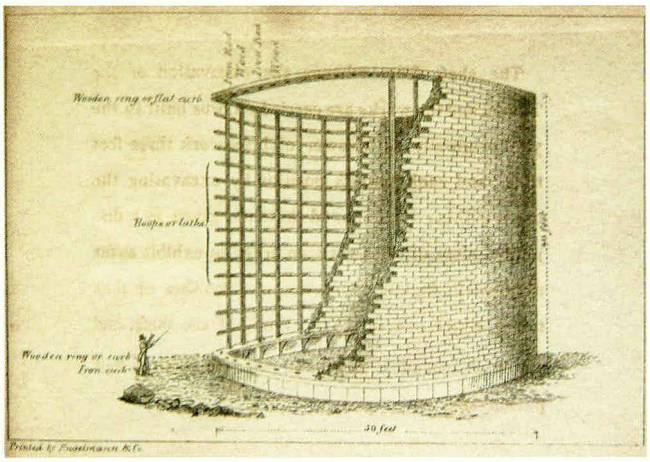

Plate 4: The brick shaft and its timber framing built on the south bank of the Thames, 1825. (Foto: Ironbridge Gorge Museum Trust)[9]

The conditions for tunnelling below the river bed were far from ideal, with layers of mud and gravel above a thin band of clay, and quicksand below it. Here a circular tunnel was out of the question because the intention had always been to allow horse-drawn carriages through the tunnel. The band of clay was too thin for a circle that would be big enough. Instead Marc Brunel designed a rectangular shield to provide a safe working area for 36 miners who could all excavate spoil at the same time[10] (Plate 2). Twelve cast iron frames provided a working platform, each allowing space for three miners standing one above the other (Plate 3). The working face was protected by a series of wooden boards about 11 cm high, each of which could be moved out of the way so the earth could be excavated a short way before being replaced. In this way the working face was continuously supported until the whole frame could be jacked forwards by about 23 cm. Behind the tunnelling frame a team of bricklayers constructed the two parallel tunnels using 16 750 bricks per meter, 71 million bricks in the whole project.[11]

Working Shafts

The intention was to sink a shaft on each shore and link them with a twin-bore road tunnel. On completion they would then add much wider 75 m diameter spiral descents in two more shafts so that horse-drawn vehicles could use the tunnel. Publicity began in 1824 with the printing of small illustrated booklets[12], which were used to persuade investors to buy shares because the tunnel was to be privately funded. They continued to be updated and reprinted almost every year. Site work began in March 1825 to build the world's first sub-aqueous tunnel. The circular access shaft at Rotherhithe on the southern bank was initially built above ground. It had an iron ring with a cutting edge on the bottom and a

shelf above it on which to build a circular brick wall (Plate 4). When the bricks had been built to a height of 13 m and nearly 1 m thick labourers began to excavate out the spoil in the centre and to the amazement of spectators the shaft began to sink of its own accord until it reached its final depth of 20 m below ground level (Plate 5). This phase took 6 months. Then the 12 frames of the cast iron shield were erected side by side and tunnelling out from the bottom of the shaft began in November 1825, but progress was slow due to the large amount of water that came in through the working face. Due to illness Marc was assisted by his 20-year old son Isambard who was appointed as resident engineer from late December 1826.

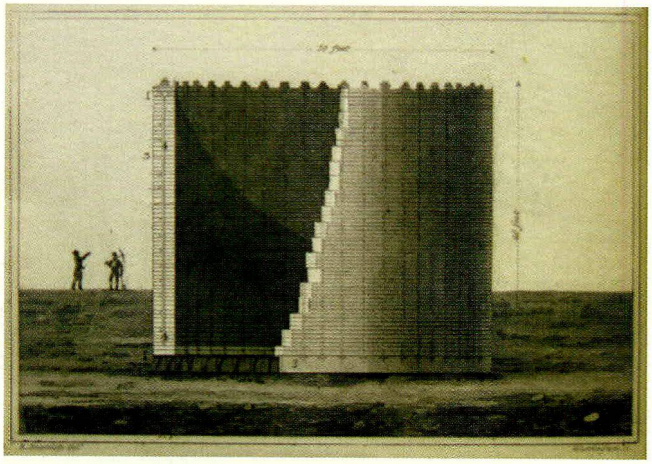

Plate 5: The shaft sank under its own weight as the earth was excavated out of the centre. (Foto: Elton Collection)[13]

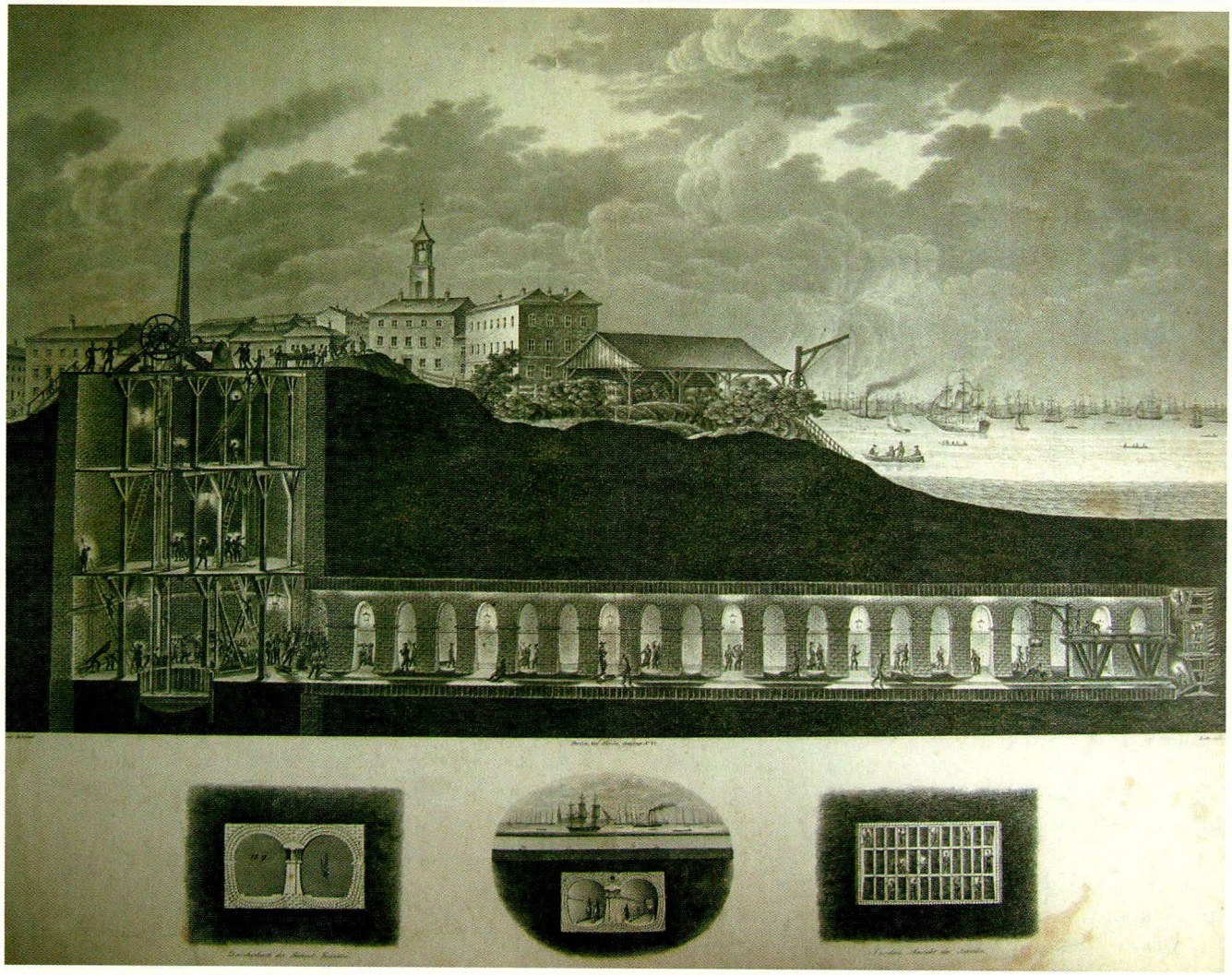

Plate 6: The shaft and tunnel under construction, 1827. (Foto: Elton Collection)[14]

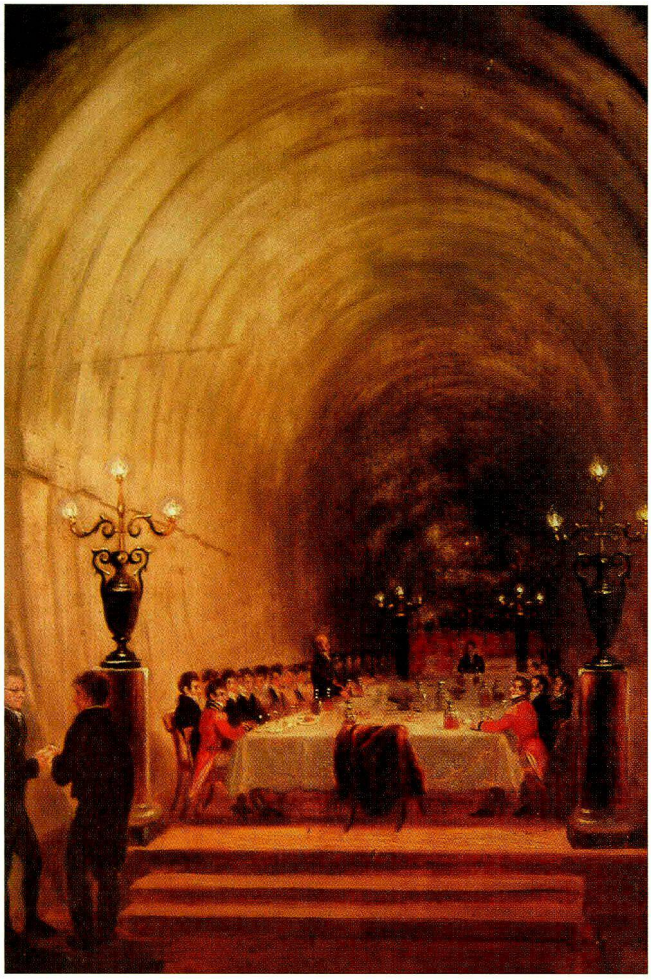

Plate 7: Gas-lit banquet in the tunnel, 1827. (Foto: Elton Collection)[15]

Plate 8: A peepshow souvenir of 1843. (Foto: Ironbridge Gorge Museum Trust)[16]

Sightseers and Underwater Banquets

Running out of money by March 1827, the owners charged sightseers to see the work in progress, much to the concern of the engineer. The tunnel reached 170 m by May 1827 (Plate 6) – almost half way – when the river broke in and flooded the works. Fortunately all the sightseers escaped unharmed, but it took four months to block the hole in the river bed and clear the mud out of the tunnel before work could continue. To gather publicity and more funds the young Brunel organised a gas-lit banquet for 50 guests inside the tunnel on 10th November 1827, recorded in a famous painting (Plate 7). The breach had been repaired and work had begun again just two weeks before the banquet, but two months later the Thames flooded in once more, this time killing six men, and in August 1828 tunnelling was stopped and the site closed down.

Six years passed before work started again in March 1835, but this time the cost was helped by a government loan. Marc was back as resident engineer because his son Isambard was working on other projects of his own, notably the Great Western Railway. The remaining half of the tunnel took another eight years to complete, during which time the Thames broke in on three further occasions.[17] It reached its full length in June 1840 on the far side of the river before the second shaft was sunk. The shareholders had never allowed tunnelling to be done from both sides at the same time, despite Brunel repeatedly requesting it. As a result stagnant air due to lack of ventilation had been a major problem and the noxious gases that seeped through from the open sewer of the river above their heads made working conditions for the miners almost impossible.

Open at last

The Thames Tunnel finally opened in March 1843, and even with 99 steps down and up again on the other side 1800 000 pedestrians walked through in the first nine months. But only pedestrians, because the carriage approaches had not

been built for lack of money. Commemorative pamphlets, souvenirs, gin in moulded stoneware bottles, and medallions were produced and sold in the underwater arcades (Plate 8). The tunnel had cost £ 486 250 (SFr one million) but by 1843 London's docks had been greatly enlarged further downstream, taking away much of the original need for the tunnel. Twelve men had died during its construction, or one for every 30,5 m. Without the higher tolls from carriages the tunnel could never hope to repay the shareholders, and in 1865 the tunnel was bought by the East London Railway Company for less than half its original cost.[18] By December 1869 they built approach tunnels at each end and were running their steam trains under the river. It is still in use today as part of London's Underground railway system between Rotherhithe and Wapping, though much of the brickwork was covered in concrete in 1995-8. Of international significance in tunnelling history, it has been recognised as an International Landmark Site by the American Society of Civil Engineers.

At only 365 m long this tunnel is dwarfed by later ones, but it was the world's first sub-aqueous tunnel, precursor of the Eurotunnel and the starting point for the tunnelling shield with its protected space for the workforce. Tunnel labourers around the world owe a debt of gratitude to Marc Isambard Brunel.

Unless otherwise stated, all illustrations and publications are from the collections of the Ironbridge Gorge Museum Trust, Coalbrookdale, England, and in particular from the Elton Collection.

[1] Patent drawing of 1818, reproduced from Bagust, H. 2006. The Greater Genius. Hersham: Ian Allen.

[2] Clements, P. 2006. Marc Isambard Brunel. Chichester: Phillimore. Revised 2nd edition, first published in 1970.

[3] UK Patent 2478, 10 February 1801: Ships' Blocks.

[4] UK Patents 2844, 7 May 1805 (Saws for machinery and timber sawing), 3116, 14 March 1808 (Circular saws) and 3369, 2 August 1810 (Boots and Shoes).

[5] UK Patent 4204, 20 January 1818: Forming Drifts and Tunnels Underground.

[6] Fundraising pamphlet, 1825 showing a plan of the location. Elton Collection, AE185.2549.

[7] Detail from an 1835 broadsheet which announces the (incomplete) Tunnel is open again to sightseers from 9 in the morning till dusk. The River flooded the works twice more in 1837 which put a stop to this form of fundraising. Elton Collection, AE185.620

[8] Engraving of one frame of the tunnelling shield, from An Explanation of the Works of the Tunnel Under the Thames January 1836. Elton Collection AE185.2551.

[9] From Sketches and Memoranda of the Works for the Tunnel under the Thames, 1827, published and sold at the Tunnel works. Elton Collection AE185.2549.

[10] Op cit, Bagust, H. 2006.

[11] Op cit, Clements, P 2006.

[12] The earliest booklet is dated 1824, the latest 1845. There are examples in the Elton Collection in English and Danish, with other publications in French and German.

[13] From a Explanation of the Works of the Tunnel under the Thames, 1837. Elton Collection AE185.2552.

[14] Lithograph published in Berlin by Trautmann after Bönisch, 1827. Elton Collection, AE185.610.

[15] The banquet was held on 10th November 1827 illuminated by acetylene gas, with music played by the Coldstream Guards. Oil on panel attributed to George Jones, Elton Collection, AE185.157.

[16] Op cit, Clements, P. 2006.

[17] Folding paper peepshow, 1843. There is a view through each of the two parallel tunnels and also a view at river level. Ironbridge Gorge Museum Trust, IGMT.1979.1065.

[18] Jones, R. 2006. Isambard Kingdon Brunel. Horncastle: Mortons