

CHAPTER 1

I.K. BRUNEL AND WILLIAM GRAVATT: THEIR TRAINING AND EARLY CAREERS

This chapter brings together evidence relating to the formative years and early careers of I.K. Brunel and William Gravatt, beginning with a review of their education and training up to August 1826 when Marc Brunel engaged Gravatt to assist his son in the Thames Tunnel. Their work together in the tunnel is examined next, and the chapter concludes with an investigation of their activities during the period from the shut-down of the tunnel in August 1828 through to the passage of the Great Western Railway Bill in August 1835.

According to the generally accepted version of events, Brunel's precocious talent for technical and mathematical subjects was enthusiastically encouraged by Marc. At the age of 14 he was sent to France for three years, where he studied at the College of Caen and the Lycée Henri Quatre in Paris in preparation for sitting the entrance examination of the prestigious École Polytechnique. When his attempt to gain entry to the Polytechnique was thwarted on the grounds of his nationality, he became a pupil of Louis Breguet.¹ Jean-Francois Belhoste of the École Pratique des Hautes Études, Paris, has recently challenged some aspects of this version of events.² He reviewed the evidence from a French perspective and has questioned the plausibility of Brunel having studied for a regulation-bound examination to enter the École Polytechnique only to discover at the last minute that there were conditions of nationality to be met. He has suggested that it is more likely that Brunel returned to England in consequence of Marc's embittered feelings towards the members of the Corps des Ponts et Chaussées, who were all graduates of the École Polytechnique and whom Marc had found to be obstructive in his attempts to renew his professional and business contacts in France in the early 1820s. Belhoste has pointed out that Brunel's so-called 'apprenticeship' with Breguet must have been very brief if all these events actually took place within just three years.³ He has also

¹ Anon, 'Isambard Kingdom Brunel' (obituary notice) Minutes Proceedings Institution of Civil Engineers Vol.19 (1860), p.169; Noble C.B., The Brunels: Father and Son (1938), pp.46-47; Rolt L.T.C., op.cit., pp.32-39.

² Belhoste J.-F., 'The French Connection' (unpublished paper given at the conference 'Works of Genius: I.K. Brunel's Engineering Achievements and Their Legacy,' organised jointly by English Heritage, Brunel200 and the University of Bath, 15 Sep 2006).

³ There is no mention of Breguet in the obituary notice devoted to Brunel that Eugène Flachet wrote for the Société des Ingénieurs Civils de France in 1859: Flachet E., Isambard Brunel, Robert Stephenson (Neuilly, 1859).

made an interesting observation on Brunel's 'conditioning' into the 'French turn of mind' by his father who, he said, inculcated in Brunel:

... the propensity to make theories about everything, to expect a great deal from mathematical calculations in order to deduce practical applications, and a hearty appetite for geometrical drawing.

Apparently Brunel spent some time after his return to England in 1822 at the works of the mechanical and civil engineer Bryan Donkin and with the firm of Maudslay, Son & Field; he also assisted his father in a variety of projects, ranging from suspension bridges to steam and 'gaz' engines, and culminating in the design of the tunnelling shield for the Thames Tunnel, Marc's most celebrated civil engineering undertaking.¹ Marc had patented a sub-aqueous tunnelling shield in 1818, which he said was inspired by his observing how a sea-worm, *teredo navilis*, bored its way through ships' timbers. His original design was for:

... forming a sub-aqueous tunnel of a circular form, by means of an immense iron 'worm,' having an auger head, and which was to bore its way through the ground by being slowly turned round, cast-iron segments being inserted behind it, as it advanced, which were to have been afterwards lined with brickwork, until the wall was of the requisite strength.

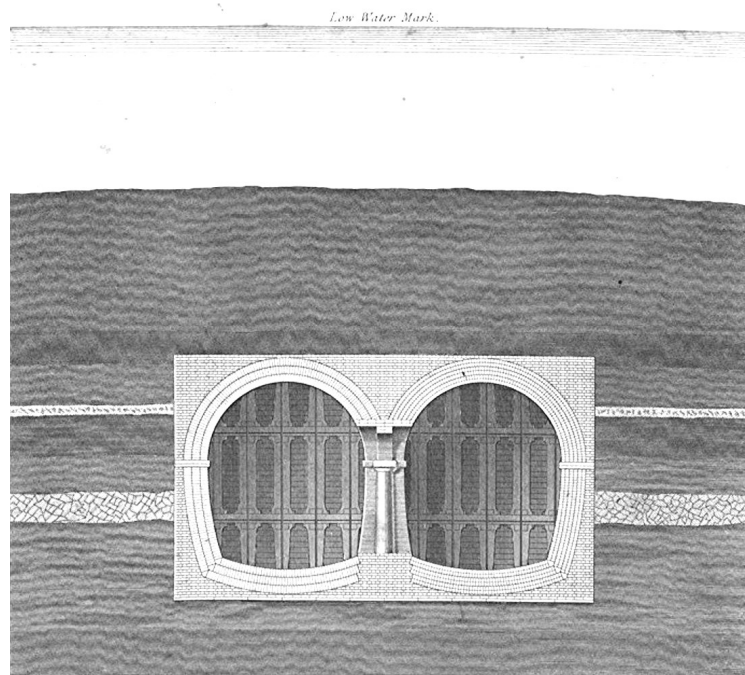
For the Thames Tunnel, he developed a rectangular form of shield which catered more effectively for a large cross-sectional area of tunnel than did the circular form; there were to be twin archways of irregular oval form, 14ft. wide and 15ft. 3ins. high., contained within a rectangular mass of brickwork 37ft. 6ins. wide and 22ft. 3ins. high. The shield itself consisted of twelve vertical cast-iron frames, side by side, each with three compartments, one above the other. Moveable cast-iron 'staves' protected the roof and sides, and horizontal timber boards supported the working face. Each board could be removed, the ground in front dug out and the board replaced. Each of the 36 frames could then be advanced separately by jacking against the brick tunnel lining behind it. The 1,200ft. long tunnel would be built between shafts at Rotherhithe and Wapping

¹ Anon, 'Isambard Kingdom Brunel' (obituary notice) Minutes Proceedings Institution of Civil Engineers Vol.19 (1860), p.169; Noble C.B., op.cit., pp.46-47; Rolt L.T.C., op.cit., pp.32-39. Angus Buchanan has quoted a letter from Brunel to Messrs. Maudslay & Field in 1853 in which Brunel referred to that firm:

... with which all my early recollections of engineering are so closely connected and in whose manufactory I probably acquired all my early knowledge of mechanics:

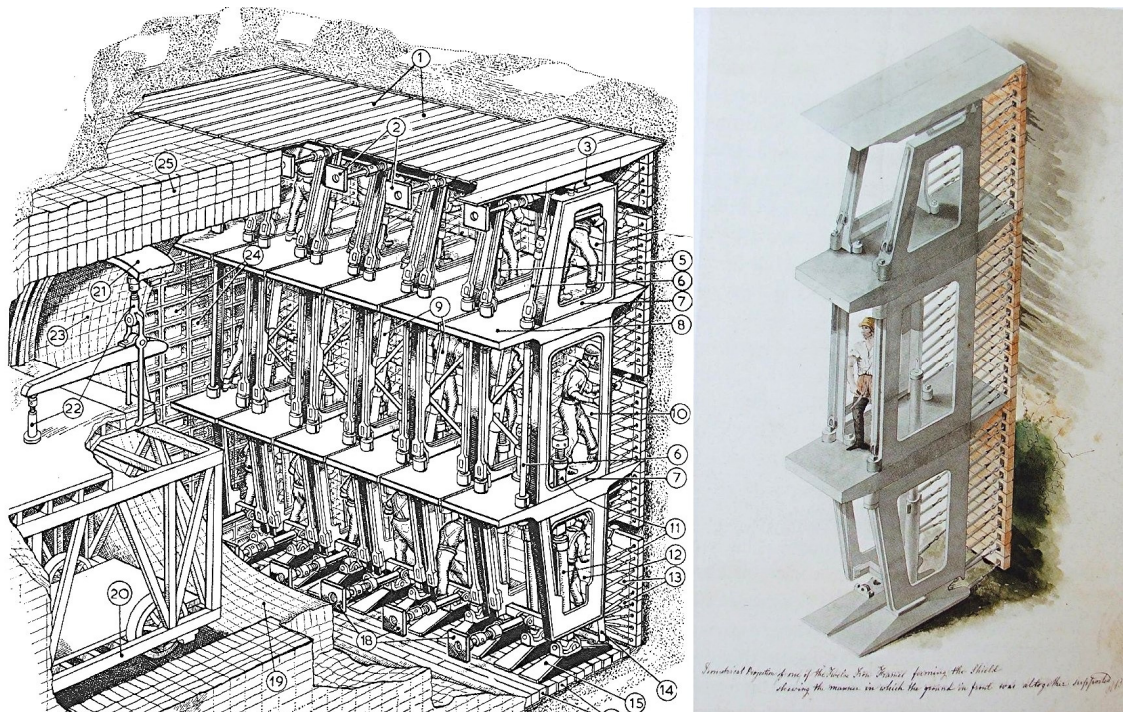
Buchanan R.A., Brunel: The Life and Times of Isambard Kingdom Brunel (2002), p.236.

Figure 1.1 Cross section of the Thames Tunnel



Source: Law H., A Memoir of the Several Operations and the Construction of the Thames Tunnel (1857), plate 1.

Figure 1.2 General view and detail of the Thames Tunnel shield



Sources: (left) Harding H., 'Tunnels,' in: Pugsley A. (ed.), The Works of Isambard Kingdom Brunel (1976), p.31; (right) unreferenced watercolour by Marc Brunel, reproduced in: Brindle S., Brunel: The Man Who Built the World (2005), p.59.

with, in places, only 16ft. or so of river silt between the top of the frames and the tidal Thames.¹

Marc and his son laid the first two bricks of the Rotherhithe shaft at the inauguration ceremony on 2 March 1825. Eight months later the shaft was ready to receive the tunnelling shield, and tunnelling commenced on 28 November.² Tunnelling commenced on 28 November 1825 with John Armstrong as Resident Engineer, assisted by Brunel, but by early August 1826 Armstrong, who was then in his early 50s, had broken down under the strain.³ Over the course of the next three months Marc engaged three more assistants: Richard Beamish, William Gravatt and Henry Riley.

Richard Beamish was born in 1798 in County Cork, the fourth son of William Beamish who was a partner in an extensive brewery concern in Cork. He was educated at Clifton and at the Royal Military Academy at Marlow and subsequently he served as an officer with the Coldstream Guards. His parents would not allow him to travel to the East as aide-de-camp to Sir Stamford Raffles, and later they prevented him from marrying. As a result he decided to become financially independent of them and he developed a passionate determination to better himself, principally, it seems, to make amends for his perceived 'dissipated' behaviour as a young guardsman. He learned to play the piano and cello, and studied music, languages and engineering. He arrived in London in February 1826, seeking to gain practical engineering experience; on 7 August Marc Brunel took him on as an unpaid 'volunteer' in the Thames Tunnel for a trial

¹ Law H., A Memoir of the Several Operations and the Construction of the Thames Tunnel (1857), pp.7-12; Beamish R., op.cit., pp.207-209; Brunel I., The Life of Isambard Kingdom Brunel, Civil Engineer (1870), pp.5-7; Harding H., 'Tunnels,' in: Pugsley A. (ed.), The Works of Isambard Kingdom Brunel (1976), pp.25-32; Smith D. (ed.), Civil Engineering Heritage: London and the Thames Valley (2001), pp.17-19. In 1877 Henry Law stated that, at low water, there was a 15ft. depth of water and 16ft. of 'ground' above the tunnel: Law H., in discussion of Redman J.B., 'The River Thames' Minutes Proceedings Institution of Civil Engineers Vol.49 (1877), p.131. Steven Brindle has reproduced a very informative series of Marc's sketches of various designs for the tunnel and the shield in: Brindle S., Brunel: The Man Who Built the World (2005), pp.99 -104.

² Rolt L.T.C., op.cit., pp.43, 46.

³ Beamish R., op.cit., pp.211-230 passim; 'John Armstrong (1775-1854)', BDCE1, pp.20-21. Some writers have incorrectly named the Resident Engineer as William Armstrong: Rolt L.T.C., op.cit., p.47; Clements P., Marc Isambard Brunel (1970), p.103; Buchanan R.A., Brunel, p.23. Vaughan and Clifford have correctly named John Armstrong: Vaughan A., Brunel (1991), p.16; Clifford D., Isambard Kingdom Brunel (Reading, 2006), p.135.

period. He quickly impressed Marc by demonstrating 'much judgement in his exertions and zeal in his attendance'.¹

On 25 September Marc told the Directors that his son was now effectively acting as Resident Engineer as Armstrong was too ill to superintend the works and unlikely to recover.² As a consequence, there was no competent person to 'superintend the movement of the Shield upon which everything depends.' He had therefore engaged William Gravatt at a salary of £2 per week, expressly to

... devote his whole time to the Shield & Machinery & be considered responsible for the good order & security. The Gentleman whom I have appointed is an Engineer well known to Mr. Donkin & his partner Mr. Wilks & has hitherto been in their employment.³

Several Directors objected to Gravatt's appointment on financial grounds; however, Marc successfully countered their objections:

... no one being answerable for the good state of the Shield, the frames were always out of order, and great expence was incurred to keep it in a working condition.⁴

Gravatt was born just three months after Brunel, on 14 July 1806 at Gravesend, Kent, and baptised on 22 October at the parish church of SS. Peter & Paul, Milton-next-Gravesend.⁵ His father, also William, was then a Captain in the Royal Engineers and would later become Inspector of the Royal Military Academy at Woolwich.⁶ Gravatt's mother, Anne, was a daughter of General Hartcup.⁷ William and Anne Gravatt had at

¹ BUL DM 1306 I.1.iv, Marc Brunel's Journal, 5 Sep 1826; Beamish R., op.cit., p.230; Anon, 'Richard Beamish' (obituary notice) Minutes Proceedings Institution of Civil Engineers Vol.40 (1875), pp.246-247; 'Richard Beamish (1798-1873)', BDCE1, pp.46-47.

² Armstrong left London for Bristol on 28 September; ten days later Marc wrote to tell him that he should 'consider himself as discharged': BUL DM 1306 I.1.iv, Marc Brunel's Journal, 28 Sep, 6 Oct 1826.

³ Ibid, 25 Sep 1826; Marc Brunel to the Directors, 25 Sep 1826: BUL DM 1306 I.6.i. Without citing a reference, Clements has stated that Gravatt was taken on a week after Beamish, ie. about 14 Aug 1826: Clements P., op.cit., p.129.

⁴ BUL DM 1306 I.1.iv, Marc Brunel's Journal, 26 Sep 1826.

⁵ Obit, p.565; MAC P/252/1/2, parish register of SS. Peter & Paul, Milton-next-Gravesend, 22 Oct 1806.

⁶ William Gravatt senior (1771-1851) was appointed First Lieutenant in the Royal Engineers in 1793, Captain-Lieutenant in 1799, Captain 1802 and Colonel 1821: Royal Military Calendar Vol.3 (1820), p.333; London Gazette 21 Jul 1821; Cansick F.T., A Collection of Curious and Interesting Epitaphs, Copied from the Existing Monuments ... in the Churches and Churchyards of ... Friern Barnet (1875), p.206.

⁷ Died 1841: Cansick F.T., op.cit., p.206.

least six other children: Thomas Vaughan,¹ Thomas,² Elizabeth,³ George,⁴ Ann⁵ and Mary Catherine.⁶

In Gravatt's own words:

My father was an Engineer ... I showed a disposition to be an Engineer, and he encouraged it ... I was educated from infancy, almost, as a Civil Engineer ... I was in the habit of attending to prices [ie. estimating and costing] from quite a child ... if you call ten or twelve years old a child.⁷

According to Gravatt's ICE obituary, in 1822 Gravatt senior successfully applied to Bryan Donkin for an apprenticeship for his son who, he said, had been:

... brought up to know that he must trust to his own resources for advancement in life. Throwing as far as I can from me the partiality of a father, I must yet be permitted to say that his habits are particularly suited for the attainment of the duties of your noble profession since, to a good classical education he joins a knowledge of mathematics seldom attained at his years, including the practical parts of perspective, and the drawing of plans, elevations, and sections; he has also a most determined bias to whatever relates to machinery, which last I attribute to his having made the steam and other engines in [Woolwich] arsenal the objects of his contemplation.⁸

Donkin had joined the ICE in 1821 and regularly chaired ICE meetings; he had a large circle of distinguished acquaintances, not only in the field of engineering, but also scientists and mathematicians.⁹ Gravatt certainly met many of these during his apprenticeship and it is said he retained close friendships with some of them throughout

¹ Baptised 21 May 1804, buried 9 Sep 1804: MAC P/252/1/2, parish register of SS. Peter & Paul, Milton-next-Gravesend.

² Baptised 30 Jun 1805: *ibid.* He was killed at the storming of Khelat on 13 November 1839 while serving as a Lieutenant in the Queen's Royal Regiment of Infantry: Cansick F.T., *op.cit.*, p.206.

³ Died 29 Nov 1843, aged 31 years: Cansick F.T., *op.cit.*, p.206.

⁴ Born at Woolwich 13 Jul 1815. As a Lieutenant in the 28th Gloucester Foot Regiment he was Commandant of Moreton Bay penal settlement, Brisbane, for three months in 1839; he died at Khurachee, Scinde, on 29 Dec 1842: *ibid.*, p.206; Howard Gravatt, *pers. comm.*

⁵ '... eldest daughter of Colonel Gravatt,' married Captain Charles Henry Cobbe of the 60th Regiment, Bengal Native Infantry at Woolwich on 15 Oct 1835: The Times 17 Oct 1835.

⁶ TNA/PRO PROB 11/2142, will of William Gravatt senior, proved 7 Nov 1851.

⁷ TNA/PRO RAIL 1066/1718, evidence taken before the Lords Committee on the L&SR Bill, William Gravatt, 20 Jun 1834, pp.283, 288, 298.

⁸ Letter quoted in: Obit, p.565. However, in 1834 Gravatt reckoned he had been 'regularly apprenticed' 14 years before, ie. in 1820: TNA/PRO RAIL 1066/1718, evidence taken before the Lords Committee on the L&SR Bill, William Gravatt, 20 Jun 1834, p.288.

⁹ For biographical details of Bryan Donkin (1768-1855) see BDCE1, pp.188-189.

their lives.¹ It is possible that he also met Brunel, if the statement in Brunel's ICE obituary is correct in placing him at Donkin's works for some time during the period 1822-1824.²

As an apprentice Gravatt demonstrated an 'appreciation of delicate, mechanical manipulation, as well as an aptitude for mathematical investigation.'³ Indeed, Donkin must have considered that Gravatt satisfactorily served his apprenticeship as he was one of the three eminent ICE Members who proposed his election as an Associate of the ICE in 1826; Thomas Tredgold and Henry Robinson Palmer were the other sponsors. All three were key figures in the formation and development of the ICE.⁴ It is likely that Gravatt became known to Tredgold and Palmer through Donkin, although Gravatt's name does not appear among the 'Visitors' at ICE meetings before his election despite it being possible in the early years of the ICE for a pupil or apprentice to attend meetings as the guest of a Member. Gravatt was admitted on 7 March 1826, on 4 April he attended his first ICE meeting as an Associate to sign an undertaking to abide by the regulations, and he attended several meetings during the following two months.⁵ So, by the time Gravatt joined Brunel at the Thames Tunnel in September 1826 both were just twenty years old, appropriately trained and experienced, but Gravatt, as an Associate of the ICE, was the better qualified, on paper at least. In contrast to the well-ordered training regimen provided for Brunel and Gravatt, Beamish's self-taught approach was his own mature response to his perception of the opportunities he had squandered during his formative years, and it was embarked on in defiance of his parents' wishes. Though eight years older, in comparison to Brunel and Gravatt he was a novice.

¹ 'Fourteen years ago I was regularly apprenticed, and I saw Engineers there': TNA/PRO RAIL 1066/1718, evidence taken before the Lords Committee on the L&SR Bill, William Gravatt, 20 Jun 1834, p.288. Notable among his enduring friendships was the eminent instrument maker Edward Troughton, who presented Gravatt with a silver snuff box and a pair of callipers he had made with his own hands; Donkin himself gifted Gravatt his gold chronometer: Obit, p.565; Greg Smye-Rumsby, pers. comm. For biographical details of Edward Troughton (1753-1835) see BDCE1 pp.726-727.

² Anon, 'Isambard Kingdom Brunel' (obituary notice) Minutes Proceedings Institution of Civil Engineers Vol.19 (1860), p.169. Apparently based on this reference, Hay has written that Gravatt was a pupil at Donkin's works 'during the short time [Brunel] had also been there': Hay P., Brunel: His Achievements in the Transport Revolution (Reading, 1973), p.85.

³ Obit, p.565.

⁴ For biographical details of Henry Robinson Palmer (1795-1844) see BDCE1, pp.507-510; for Thomas Tredgold (1788-1829) see BDCE1, pp.716-722.

⁵ ICE undesignated, membership records, proposal certificate No.141, signed and approved 7 March 1826, where Gravatt's address was given as the Royal Arsenal, Woolwich; ICE undesignated, Minutes of Meetings, *passim*.

There are detailed records of the tunnel's construction in two principal secondary sources, one by Henry Law and the other by Richard Beamish. Law was a pupil of Marc's and was engaged on the tunnel after work was resumed in 1835.¹ His Memoir of the Several Operations and the Construction of the Thames Tunnel, first published in 1846, comprised an account of previous attempts to tunnel under the Thames and the proceedings leading to the incorporation of the Thames Tunnel Company, followed by an illustrated description of the shield and its use. It concluded with a record of construction progress on the tunnel up to the shut-down in August 1828, drawing on Marc's journals and reports. Beamish's biography of Marc Brunel, published in 1862, contains a graphic first-hand account of the dangers and hardships confronting all those involved in the tunnel works in 1826-1828. The main body of subsequent published literature dealing with the Thames Tunnel has been substantially based upon these two accounts and it is considered that the comprehensive coverage makes it unnecessary to reiterate the full history of the tunnel. Instead attention is focused on primary evidence relating to the working and personal relationships of Gravatt and his colleagues, with particular emphasis on recorded aspects of Gravatt's behaviour which appear to have had a significant bearing on their later associations. The principal primary sources are: Marc's diaries, journals and reports held at BUL and ICE; Brunel's journals and correspondence at BUL and TNA/PRO; and Beamish's diaries at ICE. Unsurprisingly, Beamish's diaries contain a more forthright account of events than does his biography of Marc Brunel which, like Law's Memoir, is essentially a deferential and non-critical tribute to both Brunels.

Gravatt, like Brunel, was invested with the authority to instantly dismiss workmen whose behaviour he found to be unsatisfactory or disruptive.² That the Directors' initial objections to Gravatt's appointment were for reasons unrelated to his youthfulness should not come as a surprise, as it was considered unexceptional at that

¹ 'Henry Law (1824-1900)', BDCE2, p.455.

² For example, on the evening of Saturday 4 November 1826 two workmen refused to go into the tunnel to start operations for moving the shield, feeling they were 'unfairly done by and was not meaning to do any more till something was done about it.' According to Gravatt:

Except in the critical situation we were now in I should have taken upon myself to discharge them instantly, but as I could not do that with safety to the works, I with some difficulty persuaded them to finish their job, which was at 7 o'clock on Sunday evening, they having performed their part as well as usual and to my satisfaction:

Gravatt to Marc Brunel, 6 Nov 1826: letter tipped in ICE TT/CE/1, Marc Brunel's Reports, emphasis as in the original.

period for engineers as young as Brunel and Gravatt to hold positions of such great responsibility.¹ The benefits of Gravatt's training and skill in mechanical matters were soon recognised by Marc:

We confidently rely on things being done better in future by having the principal part of the repairs done by our own men, under the Directions of Gravatt, whose activity cannot be exceeded ... What vigilance is required! Indeed, without competent persons, such too as can be depended upon, we should run great risks. Gravatt is quick and most vigilant.²

On 21 November 1826 Marc took on Henry Riley to assist Gravatt. He felt that Riley, who was aged about 24, would doubtless do well, 'he being brought up originally in the Engineering line connected with Canals.'³ Brunel was particularly struck by Riley's height: 'Mr Reilly – 6ft. high – came to try his hand at the Tunnel in the capacity of sub to Mr G – t.'⁴ Nothing else is known of Riley himself.

Brunel's journal entries for the remainder of 1826 give an impression of a sociable, but respectful, team working under arduous conditions. For instance, on 11 December Brunel found Marc at the tunnel discussing with Gravatt, Beamish and Riley various methods for strengthening the frame components, which ended 'by approving Gravatt's, with reserving the power of adding a very good bracket proposed by Reilly.' The following day Beamish was writing reports for the next Directors' meeting while Brunel and Gravatt were giving directions for fitting up their 'apartments' – the rudimentary cabin down in the tunnel that they were to share, quickly nicknamed 'Tunnel Cottage.' Four days later two of the Directors brought them a couple of bottles of sherry, 'to christen the room'; Brunel recorded that he went to bed feeling unwell, 'I think perhaps affected a little by the wine and the heat of the room.'⁵

Shortly before Christmas 1826 Marc set out his proposals for improving the 'division of labour' of the superintending staff:

I propose to place my son immediately under myself as 2d Engineer, & give him an official character & station in the Company's establishment ...

¹ As another example of youthful responsibility, (Sir) John Fowler gave parliamentary evidence in 1838 before he was 21, and was Resident Engineer on the Stockton and Hartlepool Railway before he was 23: 'Sir John Fowler 1817-1898),' BDCE2, pp.302-309 passim.

² BUL DM 1306 I.1.iv, Marc Brunel's Journal, 15,18 Oct 1826, emphasis as in the original.

³ Marc Brunel to the Directors, 28 Nov, 5 Dec 1826: BUL DM 1306 I.6.i, pp.104, 106; same to same, 28 Nov, 5 Dec 1826: ICE TT/CE/1, pp.52, 53.

⁴ BUL DM 1306 I.3.i, Brunel's Journal, 21 Nov 1826.

⁵ Ibid, 11-16 Dec 1826.

Under him I propose placing Mr. Gravatt as 1st Assistant & Mr. Riley as 2d Assistant.

Brunel was to receive a salary of £200 per year; Gravatt and Riley were each to receive £100 per year, with free lodging and £5 per year for coal. Despite having the same salaries, it is likely that Gravatt's position as '1st Assistant' signified seniority over Riley.¹ Beamish was not mentioned in the staffing proposals as Marc considered him still to be a 'volunteer' on trial. Pressing for early endorsement of the re-structuring arrangements, Marc told the Directors on 2 January 1827 that he considered it vital that Brunel should be formally appointed as Resident Engineer as soon as possible: 'It is however a satisfaction & relief to me to find him so ably assisted by Mr. Gravatt.'² The Directors approved the staffing proposals the following day.³

By then Riley's flagging performance was becoming a source of critical observation by Brunel, who noted on 5 January that Beamish, presumably having worked long beyond his allotted hours, was 'still in the Frames – a lesson to R,' adding, 'Gravatt often says no soldier like volunteers, c'est tout naturel,' clearly in reference to Beamish's industrious, yet 'amateur,' status.⁴ The following week Riley overslept by an hour, which earned him another disparaging mention in Brunel's diary.⁵ These lapses were doubtless symptomatic of Riley's failing health as by the end of January he was dangerously ill.⁶ With the burden of work now falling more heavily on the rest of the team Marc recorded his concerns about their poor time-management:

Gravatt & Isambard might save themselves much trouble by dividing their attendance, but they are always together when one might be in bed.

¹ Marc Brunel to the Directors, 22 Dec 1826: BUL DM 1306 I.6.i, pp.110-111; same to same, 22 Dec 1826: ICE TT/CE/1, p.54. Marc added:

Since Mr. Gravatt's appointment one source of expense in the employment of Maudslay's men has been removed, he being able to direct all the operations of the smiths & engineers.

Henry Maudslay, mechanical engineer and partner in the firm of Maudslay, Sons & Field, supplied the first tunnelling shield and a steam engine for the tunnel; for biographical details see 'Henry Maudslay (1771-1831),' BDCE1, pp.435-437.

² Marc Brunel to the Directors, 2 Jan 1827: BUL DM 1306 I.6.i, p.112-113; same to same, 2 Jan: ICE TT/CE/1, p.55.

³ BUL DM 1306 I.4, Marc Brunel's 'General Remarks,' p.101.

⁴ BUL DM 1306 I.3.i, Brunel's Journal, 5 Jan 1827. Marc's journal entry for that day has a virtually identical reference to Riley, 'Mr Beamish still in the Frames – a lesson it should be for Riley,' implying that he supplemented his own journal with entries from Brunel's: BUL DM 1306 I.1.iv, Marc Brunel's Journal, 5 Jan 1827.

⁵ BUL DM 1306 I.3.i, Brunel's Journal, 11 Jan 1827.

⁶ BUL DM 1306 I.1.iv, Marc Brunel's Journal, 31 Jan 1827. Brunel sent for Riley's brother the following day: BUL DM 1306 I.3.i, Brunel's Journal, 1 Feb 1827.

Three days later he observed, 'It would not however be so bad if Isambard and Gravatt were to time their attendance better.'¹ Riley died on 8 February, 'from the hard service incident to our operation.'² On 13 February Brunel and Gravatt attended his funeral at the Dissenters burial ground at Bunhill Fields, after which Brunel recorded in his journal:

Thus ended poor Riley's connection with us and the Tunnel. He certainly was an amiable young man and intelligent but no energy of character and certainly not fit for our work nor likely to have become so.³

Evidently Beamish had satisfactorily stood in for Riley, as his appointment as Riley's replacement in mid-March was backdated to 1 January on Marc's recommendation:

... on every occasion [Beamish] acquitted himself with so much judgment, zeal & perseverance, that we considered every thing safe when he was on duty. Mr Beamish is therefore a valuable assistant & the best I can recommend for the situation.⁴

Beamish soon found reason to criticise Gravatt's excessively 'hands-on' style of management during an ominous incident that the tunnel workforce afterwards characterised as 'an irruption repelled.' On 12 May there was a tremendous 'run' of loose material into the frames as the tide rose. Brunel directed the operations to secure the frames and prevent a major inundation. Gravatt superintended work in one of the frames and, according to Beamish, he actually laboured with the workmen to clear the excavated material away, a course of action which Beamish considered 'should always be avoided as much as possible.' As a result the men delayed the work on Beamish's shift, 'being huffed with Mr. G.' Likewise, Gravatt's habitual failure to delegate, and a consequential tendency to meddle, caused Beamish himself to react with circumspection; two days after this incident, Gravatt and Brunel went into the works on Beamish's shift and, according to Beamish, 'Mr. G. being disposed to direct the operations, I retired.'⁵

The ground conditions deteriorated rapidly and the first great inundation of the tunnel occurred on 18 May 1827. All the workmen managed to escape except for one of

¹ BUL DM 1306 I.1.iv, Marc Brunel's Journal, 31 Jan, 2 Feb 1827.

² Marc Brunel to the Directors, 13 Mar 1827: BUL DM 1306 I.6.i; Beamish R., op.cit., p.239. Law recorded 9 February as Riley's date of death: Law H., op.cit., p.68.

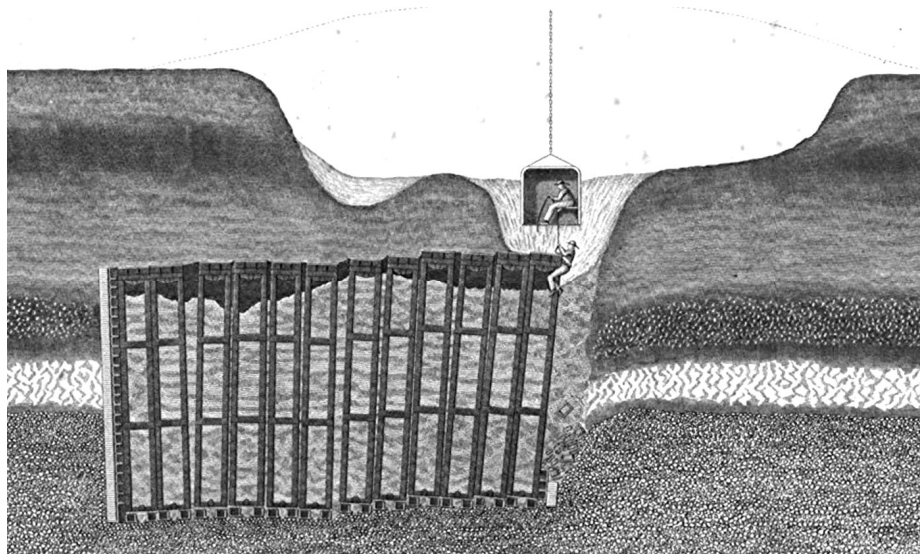
³ BUL DM 1306 I.3.i, Brunel's Journal, 13 Feb 1827; TNA/PRO RG 4/3997, Bunhill Fields Burial Ground, City Road, Burials, 13 Feb 1827.

⁴ Marc Brunel to the Directors, 12 Mar 1827: ICE TT/CE/1, p.57; same to same, 13 Mar 1827: BUL DM 1306 I.6.i.

⁵ ICE 1827BEADAD, Beamish's Diary, 12,14 May 1827.

the supervisors, who was seen to be struggling in the water. With great presence of mind, Brunel and Gravatt rescued him at considerable risk to themselves. A diving-bell hired from the West India Dock Company enabled Marc and the assistants to inspect the condition of the breach in the river bed and the exposed shield and to plan remedial action. The breach was sealed by throwing bags of clay into the depression above it and on 25 June Brunel and Beamish were able to punt through the tunnel as far as the shield. Two days later a boat capsized while carrying Brunel and Gravatt into the tunnel with two Directors and three other men. Brunel and Gravatt rescued the Directors and two of the others. When it was discovered that the fifth man was still missing, Brunel and Gravatt dived several times to reach him, but he was taken out dead.¹ Beamish's eyewitness reports of the two incidents were a vital factor in the Royal Humane Society deciding to award each of them an 'Honorary Medallion,' presented on 17 April 1828.² It took until the end of September 1827 to clear the tunnel of water and debris and to restore the shield to working order.³

Figure 1.3 'Inspecting the breach and the shield by means of the diving bell'



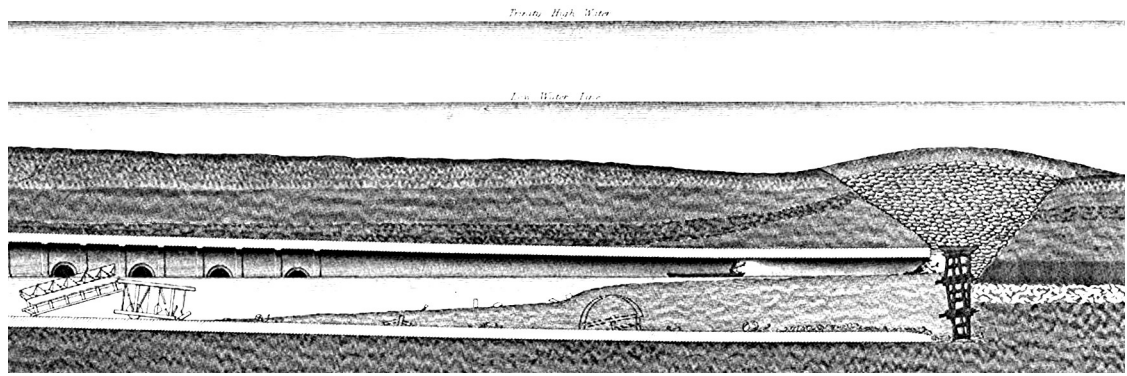
Source: Law H., A Memoir of the Several Operations and the Construction of the Thames Tunnel (1857), plate 16.

¹ Beamish R., op.cit., pp.243-254; Law H., op.cit., pp.74-81.

² LMA 4517/A/06/01/6, Royal Humane Society, Annual Report, 1828, pp.35-37; The Times 12,16 Apr 1828. The two Directors, R.H. Marten and R.P. Harris, presented Gravatt with a gold ring as a memento of his 'humane, prompt, and efficient help in rescuing them from a perilous situation': Obit, p.566. Beamish accepted a medal on behalf of Brunel who was recuperating from the severe injuries he had received during the second great inundation in January 1828: ICE 1828BEADAD, Beamish's Diary, 17 Apr 1828.

³ Law H., op.cit., p.93

Figure 1.4 'The state of the east arch and the river bed in June 1827'



Source: Law H., A Memoir of the Several Operations and the Construction of the Thames Tunnel (1857), plate 16.

Despite his readiness to acknowledge Gravatt's courage under pressure during this period, Beamish also noted the disruptive effects of Gravatt's behaviour on what was rapidly becoming an uneasy relationship. In one particular instance, during July 1827 he recorded how he attempted to brief Gravatt as they changed shifts:

... but I fear there was not sufficient in the communication to engage [Gravatt's] attention, as he did not stay to hear me out – this I lament – not that my acts could for a moment hope to receive consideration; but from the circumstance that without a knowledge of what has been performed & what intended by both parties the work can not proceed with the same wished for facility.¹

Less than three weeks later Gravatt reported to Beamish that there was a serious 'run' of loose material into one of the frames though, according to Beamish, 'at the same time [Gravatt] appeared to think but little of it – don't understand.'² Brunel was more forthright in his journal entry concerning the same incident: 'Gravatt on duty. At Breakfast he reported that there had been a great deal of running silt and mud at [frame] No. 6'; then, in French:

... but he never writes a report of these things so that I am always obliged to make my own examination – he avoids describing the details as though he feared losing respect – and at the same time he never listens to my orders or Beamish's reports.³

By the end of the year the diving-bell was needed by the Dock Company and the only other method of obtaining information about the bed profile and condition over the

¹ ICE 1827BEADAD, Beamish's Diary, 4 Jul 1827.

² Ibid, 21 Jul 1827.

³ BUL DM 1306 I.3.ii, Brunel's Journal, 21 Jul 1827.

tunnel as the shield moved forward again was by taking soundings at every tide.¹ According to Henry Law, even though the soundings were less reliable than a visual inspection they did at least establish that the river bed above and ahead of the shield had been so disturbed as to afford very little protection:

In this critical situation [Marc Brunel] felt that the entire safety of the works consisted in keeping in good order the covering over the shield, and immediately filling up with gravel any depressions or soft places which might be caused in the bed of the river, by the continual runs of ground which took place in the frames ... Under these circumstances nothing remained but to advance with extreme caution until the shield could be brought into the undisturbed ground.²

On 1 January 1828 Beamish noted in his diary that loose clay, gravel and rock that was then being dumped into the depression instead of bagged clay, in an attempt to speed up progress, reappeared through the face of the shield as it moved forward:

I regret that [Brunel] does not consider it a fit time for throwing in bags. What protection can ground offer which permits the very stuff we throw in to again make its appearance and that within a few hours?³

In his biography of Marc, Beamish's account of the inundation that occurred ten days later included a similar passage:

Unfortunately, the resident engineer did not deem it necessary to employ those means which had already proved successful, and to fill up the depressions in the bed of the river.⁴

In the event, Beamish's concerns about Brunel's imprudence were justified. Brunel was at the shield on the morning of 12 January, having been on duty since 10a.m. the previous day due to Gravatt's absence through illness. Beamish arrived at 6a.m. to take over from Brunel but was detained on the surface, issuing refreshment vouchers to the gang coming off the night shift. While he was engaged in this an overwhelming torrent broke into the tunnel, killing six workmen and seriously injuring Brunel.⁵ A long and detailed article describing the events of 12 January, published in The Times on Monday 14 January but said to be 'From a Sunday Paper,' appears to have been written by

¹ In December 1827 the Director R.H. Marten brought to Brunel's notice the forthcoming sale by public auction of 'a diving bell with crane and the usual appurtenances ... It occurs to me that this may go cheap and be worthy of attention for tunnel use': R.H. Marten to Brunel, 20 Dec 1827: TNA/PRO RAIL 1008/80. Evidently it was not purchased by the TTC.

² Law H., op.cit., pp.100-101.

³ ICE 1828BEADAD, Beamish's Diary, 1 Jan 1828.

⁴ Beamish R., op.cit., p.259.

⁵ ICE 1828BEADAD, Beamish's Diary, 12 Jan 1828; Beamish R., op.cit., p.261.

Beamish, or at least based on his eye-witness account. For example, there is a strong suggestion of Beamish's hand in an observation on the consequences of not using bagged clay:

The present spot of excavation is many feet beyond the recent spot of irruption [ie. in May 1827]; and it is much to be regretted that the precautionary measures adopted in that instance were not continued. Had the bags of clay been thrown a few feet further, so as to afford an additional substance of earth, the accident might have been averted.¹

Beamish's account of the events published in his biography of Marc 34 years later, when both Brunels were dead, was even more condemnatory; he placed a large portion of the responsibility for the disaster on the younger Brunel: firstly for discontinuing the tried-and-tested method of sealing the river bed with bagged clay, and secondly for starting operations in the shield when the tide, and the consequent risk, was at its highest:

In the earnest desire to make progress, some of the precautions which experience had shown to be so important were unfortunately omitted; and [Brunel], judging, with youthful confidence, that a more rapid rate of progress would also be more safe, and calculating upon the tried skill, courage, and physical power of some of the men coming on in the morning shift ... ventured at high water, or when the tide was still rising, to open the ground.

Beamish laid no blame for the disaster on the workmen in either his diary or his biography of Marc. By contrast, a letter to The Times of 17 January, signed 'J.B.' but otherwise unidentified, attempted to shift at least some of the responsibility from the 'engineer' and 'superiors' onto the workmen:

I have frequently had opportunities of observing ... that workmen in processes attended with risk, do not sufficiently avail themselves of the securities provided by an engineer for their safety; and notwithstanding admonitions are daily and hourly bestowed to beware of danger, and to proceed with care and attention, still chances like the present will occur [ie. at the Thames Tunnel], from disregarding the suggestions of their superiors ... Consternation and a want of energy generally assail a miner, when proceeding rapidly or slovenly with his work, should any danger suddenly present itself; and unless his faculties are quite alive to detect the fluid at the moment it attempts to break in, which the apertures in the shield would very well enable even a feeble person to control, painful to relate, such moment of security is allowed to escape, and in rushes the torrent.

¹ The Times 14 Jan 1828.

The letter went on to promote the case for speedily restarting and completing the tunnel.¹ These may be merely the sentiments of an impartial individual, but they could conceivably have been part of a damage-limitation exercise mounted by Marc and/or the Directors.

Brunel himself recorded his recollections of the inundation in his private diary 14 weeks after the event, while he was still recuperating. He showed little remorse in his account, and by today's standards he appears extraordinarily egocentric and insensitive:

When the danger is over, it is rather amusing than otherwise – while it existed I can't say the feeling was at all uncomfortable ... While exertions could still be made and hope remained of stopping the ground it was an excitement which has always been a luxury to me ... While standing there the effect was – grand – the roar of the rushing water in a confined passage, and by its velocity rushing past the opening was grand, very grand. I cannot compare it to anything, cannon can do nothing to it. At last it came bursting through the opening. I was then obliged to be off – but up to that moment, as far as my sensations were concerned, and distinct from the idea of the loss of six poor fellows whose death I could not then foresee, kept there. The sight and the whole affair was well worth the risk and I would willingly pay my share, £50 about, of the expenses of such a 'spectacle.'²

With Brunel laid up and Beamish incapacitated through sickness and injury, it was left to Marc Brunel and Gravatt to assess the damage during the days immediately following the inundation. The Docks diving-bell was quickly loaded onto a barge and moored over the end of the tunnel, enabling Gravatt, and occasionally Marc, to inspect the river bed and supervise the laying of bagged clay. Beamish acknowledged with 'very best thanks' Gravatt's offer to perform all the arduous duties, as he himself was able to do little more than carry out clerical work and visit the workmen's widows and Brunel.³ However, it is likely that Gravatt's offer was not merely a benevolent act but also a symptom of an increasing possessiveness.⁴ Then, without warning, and to Gravatt's great shock and distress, on 19 January Marc directed that 'Mr. Beamish be the person to act in

¹ The Times 17 Jan 1828.

² Quoted in: Rolt L.T.C., op.cit., p.60.

³ ICE 1828BEADAD, Beamish's Diary, 12-16 Jan 1828.

⁴ For example, on 18 January Beamish spent some time on the barge but he left when, it seems, Gravatt's behaviour signalled that he was not welcome on board:

Mr. G. however being disposed to continue his superintendence and directions whilst heaving the bags, I came ashore to see after supplies:
ibid, 18 Jan 1828.

the absence of Isambard as Resident Engineer, referred all the accounts &c. to him.¹ According to Gravatt, writing five weeks after the event, Marc told him:

Oh, Gravatt, for the sake of subordination, you must consider Mr. Beamish in place of my son as Resident Engineer; give him all the papers you have, and the letters ... Tell Mr. What-is-his-name the clerk, in the office, that he must apply to Mr. Beamish for all things; that there may be no mistake.²

Gravatt's chagrin was immediately evident; Marc recorded in his diary, 'Gravatt went immediately to Town on some frivolous pretence! Singular enough.'³ The purpose of his journey was to complain about the situation to Brunel's brother-in-law and close friend, Benjamin Hawes, who relayed his grievances to Marc. Significantly, Gravatt slept on board the barge for the next three nights, no doubt to avoid Beamish.⁴ Subsequently Marc told Gravatt he was sorry he had mistaken his meaning, 'which was only that Mr. Beamish should attend to the money concerns.' This placated Gravatt for a few days, until he happened to read in what he referred to as Beamish's 'journal':

Mr. Brunel directed that I should be the organ of his wishes during the absence of his son – God give me strength to fulfill &c.⁵

This entry does not appear in Beamish's diary that is held in the ICE archive or in his biography of Marc; indeed, there is no mention at all, in either case, of Marc's momentous order. However, it is evident from other entries in his diary that Beamish kept a separate record of events, his 'Journal Particular,' which has not been found.⁶

The strained relationship between Gravatt and Beamish worsened further when Gravatt transferred to the class of 'Ordinary Members' of the ICE on 19 February.⁷

¹ ICE TT/BD/1828, Marc Brunel's Diary, 19 Jan 1828.

² Gravatt to Brunel, 25 Feb 1828: TNA/PRO RAIL 1008/75.

³ ICE TT/BD/1828, Marc Brunel's Diary, 19 Jan 1828.

⁴ ICE 1828BEADAD, Beamish's Diary, 19-21 Jan 1828.

⁵ Gravatt to Brunel, 25 Feb 1828: TNA/PRO RAIL 1008/75.

⁶ For example, having recorded that he accompanied Benjamin Hawes to the annual dinner of the Company of Tallow Chandlers in July 1827 Beamish added 'vide journal particular': ICE 1827BEADAD, Beamish's Diary, 25 Jul 1827.

⁷ ICE undesignated, membership records, 19 Feb 1828. Gravatt's transfer was proposed by Joshua Field, George Smart and William Cubitt. Field was a partner in the firm of Maudslay, Son & Field, so would have known Gravatt because of the firm's involvement with the tunnel work. Like H.R. Palmer, he was a founder and stalwart of the ICE during the formative years. No direct evidence has been found to explain how Smart and Cubitt could have come to know Gravatt well enough to support his application. Smart, an engineer and timber merchant, had business connections with Palmer, so may have met Gravatt via Palmer. Cubitt moved from East Anglia to set up a civil engineering consultancy in London in 1826; he may have come to know Gravatt by attending ICE

Neither Brunel nor Beamish was a member of any class of the ICE at that time, and Gravatt's indignation at the perceived lack of respect paid to his superior qualifications was the source of yet more antagonism between him and his colleagues. Marc had cause to record his exasperation with Gravatt's unmannerly behaviour when Gravatt unexpectedly left the site the day before his ICE transfer, 'merely to take a lesson on the flute.' As a result Marc was obliged to ask Beamish to go down in the bell: 'It is quite inexcusable in Gravatt to have been absent, the tide passed without his coming.'¹

A week later Gravatt set out his grievances in a letter to Brunel. He quoted the words Marc had spoken to him five weeks earlier, and he offered to resign from a situation 'which I could not in honour hold; that of assistant to an Amateur engineer, of 12 months standing.' He asked Brunel to meet him, 'so that although no longer your Deputy Assistant Engineer, I may yet shake hands.'² Brunel wrote back immediately in an attempt to mollify him, admitting frankly that he had expected and feared that Gravatt would write to him in this manner. He told Gravatt he had foreseen that Marc would want to put Beamish in charge of 'the finance and domestic arrangements ... [because] he is more capable of that sort of management.' He also told him he realised that Gravatt would misunderstand Marc's meaning and that Beamish would, no doubt unintentionally, appear to possess more authority than Marc had meant him to have. He understood Gravatt's temperament well enough to know he would feel 'slighted':

Your pride (which entre nous is your great fault) would breed jealousy [and] would cause you to see every thing in the worst light – unfortunately that same pride prevents your seeking openly explanations of what might appear to you just cause of complaint – the consequence of all this is evident.

Interestingly, in the draft of this letter Brunel had originally written, 'I knew the faults of your character,' suggesting that he considered Gravatt to have a number of character faults. He went on:

meetings. For biographical details of Joshua Field (1786-1863) see BDCE 1, p.226; for George Smart (d.1834) see BDCE 1, p.618; for (Sir) William Cubitt (1785-1861) see BDCE 1, pp.160-163.

¹ ICE TT/BD/1828, Marc Brunel's Diary, 18 Feb 1828. Beamish noted in his diary:

Mr. Brunel down 10½ [i.e. 10.30]. Anxious for the Bell to go down. Mr. G. gone to Town while he should be down in Bell ... Waited till 12 low water and Mr. G. not having returned I descended with Collier and Chaplain:

ICE 1828BEADAD, Beamish's Diary, 18 Feb 1828.

² Gravatt to Brunel, 25 Feb 1828: TNA/PRO RAIL 1008/75, emphasis as in the original.

Did you ... ask my father whether he means this or that? No, you hoard up his very words The remembering at this lapse of time (for I should hope you did not write it) my father's very words and mistakes of wording implies a wish to construe it according to your feelings, and not according to my fathers probable meaning.

He felt Gravatt had also misconstrued Beamish's journal entry:

... in which you know he writes (wrongly I think) his feelings of the moment – You see a sentence which ... may be read to mean what you say – This gives you in your opinion just cause to re-indulge in those feelings which were only dormant – you keep it all to yourself and now you say you must resign a situation which you do not hold, viz. assistant to Beamish – Who makes the soundings? Who is most seen directing the operations on the river? Who is exclusively employed in the bell? Who has made the borings and the report upon them to my father? I think the answers to these questions will not place Beamish at the head of the engineering department.¹

An indignant Gravatt responded with yet more complaints. In his opinion Brunel's view that Beamish was more capable of managing the accounts, a task which Gravatt felt required no great intelligence, could be construed to imply 'stupidity ... when a person is incapable of attending to it.' Then, in the case of the so-called 'domestic arrangements' Beamish had:

... interpreted them in the fondest sense; for taking great interest in the affairs of the Tunnel, he has set them all down in a family circle, round his own friends, keeping the door carefully shut lest my coming in should give them cold.

Gravatt conjectured that the Directors must think he had committed some great fault, inasmuch as all questions relating to the Tunnel were first asked of Beamish, who also wrote and signed the reports during Brunel's absence. Beamish's journal had been 'let out sundry times for the amusement of tea coteries,' so the entry claiming 'Mr. Brunel made him the Organ, etc. and God to help him' would be common knowledge. Gravatt asked what effect it would have on his future prospects:

... if people should believe ... that I (after 6 years study and practical experience) was found upon trial to be fit only to act as deputy to a gentleman who, sick of dissipation, had turned an engineer twelve calendar months?

It was merely a desire to protect his reputation, and not angry feelings against Beamish for whom he had 'only a true lawful professional regard,' that had influenced his

¹ Brunel to Gravatt, 25 Feb 1828: TNA/PRO RAIL 1008/75.

conduct, 'in a situation which forbids me to consult my father from respect to his feelings, or Mr. Donkin from the slightest feeling of delicacy.'¹

Brunel wrote back asking him either to say he felt he was mistaken in his apprehension, or to confirm his resignation.² During the next seven weeks Brunel sent three chasing letters to Gravatt. The first was an appeal to Gravatt's sense of loyalty:

Do not think that I am pressing you hard, I do not wish to hurry you but it is absolutely necessary that such matters should always be clearly set at rest and at the time, not only to prevent unpleasant feelings afterwards but because such sentiments are quite incompatible with that degree of confidence so necessary to our own comfort and to what we ought to consider above all, the interests of the Company for which we are now employed and whose interest certainly depends wholly under the guidance of my father upon the aspiration and zeal of all engaged.³

In the second and third chasers Brunel expressed his irritation at Gravatt's apparent tardiness or, more likely, reluctance to reply.⁴ During those seven weeks Gravatt again antagonised Marc when he contradicted him in front of the Works Committee during a site meeting on 22 March, to Marc's 'extra-ordinary surprise' and acute embarrassment. Not satisfied with the explanation that Gravatt gave at the next Committee meeting, Marc directed Beamish to send in an account of the state of the works every morning 'independent of Mr. Gravatt.'⁵ Not only was Marc's dissatisfaction with Gravatt's behaviour becoming apparent, but on 25 March Beamish himself candidly recorded for the first time his astonishment at some of Gravatt's actions, after Gravatt ordered several barge-loads of gravel to be tipped into the river over the tunnel, which was not only unnecessary but also detrimental.⁶ Gravatt was able to boat through the flooded tunnel as

¹ Gravatt to Brunel, 25 Feb 1828: TNA/PRO RAIL 1008/75, emphasis as in the original.

² Brunel to Gravatt, dated 'Feb 2d' but, from the context, almost certainly drafted 2 March 1828: *ibid.*

³ Same to same, 12 Mar 1828: *ibid.*

⁴ Same to same, 1, 22 Apr 1828: *ibid.*

⁵ ICE TT/BD/1828, Marc Brunel's Diary, 22-26 Mar 1828. Beamish noted in his diary:

Mr. Brunel down. It appears the Directors were not altogether satisfied with Mr. G's explanations touching certain questions put to him the last Committee day at the Tunnel:

ICE 1828BEADAD, Beamish's Diary, 27 Mar 1828.

⁶ Mr. G. it appears had had two more Barge loads over at low water – rather wild, throwing when there is no depression ... Returned at 5½ pm. Another barge of gravel had been thrown in by Mr. G.'s directions and more ordered!! Took soundings at HW [high water] 8 pm. Found the mound in all its accumulating magnitude. While standing in the Lodge, an order came from Mr. G. – Williams to have men ready by LW [low water] 4 am. to throw more gravel!!! This order not a little astonished me,

far as the frames on 12 April, and immediately intimidated Beamish by his possessiveness:

Finding Mr. Gravatt disposed to continue the Superintendence and always fearful of contradicting orders, of which a prospect appeared, I came ashore.¹

In contrast to his soured association with Gravatt, Beamish had struck up a cordial working and social relationship with 'Mr. Hammond,' whose name appears first in Brunel's journal on 11 January 1828 and then frequently in Beamish's diary from early February. Hammond was evidently working as a novice 'volunteer' at the tunnel, much as Beamish himself had done, and Brunel and Beamish found him to be a capable, enthusiastic and reliable learner and one to whom they could confidently entrust relatively important technical and supervisory tasks. And, moreover, Hammond and his sisters were able musicians whose soirées delighted the cello-playing Beamish.² This was almost certainly John Wallis Hammond, who was possibly Brunel's first pupil and who later became his Resident Engineer for the eastern end of the GWR.³

On 22 April, while Beamish was in Ireland for the funeral of his father, Gravatt returned all the letters he had received from Brunel, together with a covering note telling Brunel that he now had no hesitation in saying he had written the aggrieved letters under a mistake, and that he had been satisfied with his situation:

... ever since I found that Mr. Beamish's assertion 'Mr. Brunel was pleased to appoint me the organ of his wishes, during the absence of his son' was a bombastic Iricism,⁴ an Iricism that has been attended with such pain to my feelings, that I consider it but little removed from a direct falsehood, especially as he is in the habit of now and then lending his journal to other persons.⁵

Brunel immediately returned the letter to Gravatt with a request to delete 'a most personal observation upon one whom I very much esteem,' and to substitute merely the

as Mr. G. could not be altogether aware of the soundings, and I then considered it time to make some remark:

ICE 1828BEADAD, Beamish's Diary, 25 Mar 1828.

¹ Ibid, 12, 13 Apr 1828.

² BUL DM 1306 I.3.ii, Brunel's Journal, 11 Jan – 19 May 1828 passim; ICE 1828BEADAD, Beamish's Diary, 8 Feb – 9 Jul 1828 passim.

³ 'John Wallis Hammond (c.1800-1847), ' BDCE2, p.360.

⁴ Irregular form of 'Irishism'; ie. an Irish peculiarity, especially of expression (OED). Presumably used by Gravatt in pejorative reference to Beamish's ancestry.

⁵ Gravatt to Brunel, 22 Apr 1828: TNA/PRO RAIL 1008/75, emphasis as in the original. Brunel noted in his journal: 'Received a note from Gravatt ... received also a packet of my notes to him': BUL DM 1306 I.3.ii, Brunel's Journal, 22 Apr 1828.

expression of his satisfaction with his situation 'ever since that mistake was explained.'¹
Eventually, in a letter which he took in person to Brunel on 7 May, Gravatt conceded:

The letters to which you refer were written in confidence, and the intention therein expressed of resigning on account of Mr. Beamish having been appointed to superintend these works in the absence of [Marc Brunel] and yourself can no longer exist, since that appointment, it has been showed, never existed but in my mind.²

In contrast to the formal 'Yours truly' with which Brunel customarily ended his letters to Gravatt, on 26 April Brunel wrote Beamish a letter of condolence and support on behalf of himself and Marc, which he closed with an expression of affectionate anticipation of Beamish's return:

You will then find one who from all the high esteem and attachment he feels for you has shared, altho' only in imagination, all your sorrows and who feels the more strongly by your absence that he is and will remain,
Your sincere friend
I. Brunel³

Beamish returned from Ireland on 13 May and immediately visited the tunnel to inspect the frames, which were accessible now that the debris had been cleared. He ordered some remedial works to be started and the following day, having entrusted the repairs to the foremen, in whom he had 'entire confidence,' he called to see Brunel. In obvious reference to Gravatt's negligence, Beamish recorded in his diary that he and Brunel agreed that 'we ought to consider ourselves most fortunate in having had no further settlement when so little pains had been taken to prevent it'. Gravatt's priority at that time was to get the pumps working efficiently, and merely to board up the frames. Later that day, while Gravatt and Beamish were arguing as to the priorities, Marc arrived and sided with Beamish, who recorded the incident in his diary, under the heading 'Mr. Gravatt's want of common consideration':

Could not avoid asking Mr. Gravatt if he purposed to drown us. He answered that Mr. Brunel wished the pump to be finished that evening. Observed that the Frames were of infinitely more importance. Fortunately Mr. Brunel arrived and determined the question ... It is very distressing to have things in so uncertain a state – Mr. G's views and mine being so different upon points of the most serious importance to the work. He considers the Frames 'sufficiently safe' in which opinion I can in no way agree.⁴

¹ Brunel to Gravatt, 5 May 1828: TNA/PRO RAIL 1008/75.

² Gravatt to Brunel, 7 May 1828: *ibid.* Brunel noted in his journal: 'Mr. Gravatt came up – Letter to me': BUL DM 1306 I.3.ii, Brunel's Journal, 7 May 1828.

³ Brunel to Beamish, 26 Apr 1828, pasted into: ICE 1828BEADAD, Beamish's Diary.

⁴ ICE 1828BEADAD, Beamish's Diary, 13,14 May 1828, emphasis as in the original.

Marc invited Beamish to tea that evening, when Gravatt's actions and behaviour were discussed; Marc noted in his diary his own feelings about Gravatt:

From Mr. Beamish's report in which I concur, it is evident that Gravatt has not seen into things properly, and has not of course reported the true state of the frames. Adverse as he always is to follow any directions from others, he represents things just as it suits his purpose in order that his own ways may be thought the best. I have told him repeatedly to trust the Foremen and leave the execution of his orders to them, that he might not waste his strength; but it is to no purpose to advise him, he finds so many reasons to convince himself that he is right and he never gives any chance of success to any thing that emanates from others.¹

The following day he noted with a hint of cynicism, 'Gravatt rather unwell, he is gone to Woolwich – but he has not been in the frames!'²

Marc granted Gravatt leave of absence from 22 May to 9 June, and Beamish recorded that Gravatt was excited by the prospect of touring the North Country. Gravatt called in to the tunnel works just before he left for his trip and surprised Beamish by not asking a single question about what operations were planned during his absence.³ Nothing was heard from him until his return on 9 June, which again surprised Beamish:

Strange that so little interest should be felt for so noble and novel a work, the more after having been engaged with its superintendence so long – however ...⁴

Gravatt had visited Birmingham, Liverpool, Manchester and Chester, among other places, and Brunel recorded that he looked very well on his return.⁵ The purpose of his trip was not stated but it seems probable that he was visiting engineering works in progress, not only to study their construction but also with a view to future employment as it was becoming clear that the Company could not raise sufficient funds through subscriptions to keep the work going.⁶ The relationship between Gravatt and Beamish

¹ ICE 1828BEADAD, Beamish's Diary, 14 May 1828; ICE TT/BD/1828, Marc Brunel's Diary, 15 May 1828, emphasis as in the original.

² ICE TT/BD/1828, Marc Brunel's Diary, 16 May 1828.

³ ICE 1828BEADAD, Beamish's Diary, 17,20 May 1828. Brunel gave Gravatt a route for his journey: BUL DM 1306 I.3.iii, Brunel's Journal, 18,19 May 1828.

⁴ ICE 1828BEADAD, Beamish's Diary, 4 Jun 1828.

⁵ Ibid, 9 Jun 1828; BUL DM 1306 I.3.iii, Brunel's Journal, 10 Jun 1828.

⁶ For example, work had recently started on the construction of Grosvenor Bridge at Chester which, at 200ft. span, would be the longest masonry arch bridge in the world: Hartley J.B., 'An Account of the New or Grosvenor Bridge over the River Dee at Chester' Minutes Proceedings Institution of Civil Engineers Vol.1 (1836), pp.207-214. Just over two years before Gravatt visited Chester, Marc Brunel himself had been consulted about the practicability of constructing the bridge in rubble masonry; he also

was still strained; five days after Gravatt's return Beamish recorded, 'I do not like to interfere when Mr. G. is on duty unless particularly ordered.'¹ During the next two months Beamish noted in his diary at least a dozen occasions when he disagreed with Gravatt's orders to the men, or when Gravatt failed to carry out Brunel's instructions. By contrast, Beamish and Brunel were evidently very chummy by now – playing billiards, smoking together and visiting exhibitions.² However, by early August 1828 Gravatt and Beamish had been given notice that their services were no longer required, and on 14 August Beamish returned to Ireland.³

Rolt has described the five apparently lean years that followed the closure of the Thames Tunnel as Brunel's 'years of frustration.'⁴ A high point during this period was his election as FRS on 10 June 1830.⁵ Professionally, he certainly busied himself, but it seems that most of the projects with which he was involved were abandoned or postponed; Mike Chrimes has identified a mere handful of projects for which he was able to claim payment (Table 1.1).⁶ As will be seen later Gravatt assisted in, or at any rate contrived to play a role in, at least three of the projects: Clifton Suspension Bridge, the Kensington Observatory and the GWR.

Gravatt had often visited Woolwich to see his family during the Thames Tunnel works and it is likely that he settled there immediately after the tunnel closure.⁷ Through 1829 and the early part of 1830 he regularly attended 'Ordinary Meetings' of the ICE,

prepared an estimate for constructing it in brickwork, which was to be presented by Brunel to the Commissioners of the Chester Dee Bridges: Ruddock T., Arch Bridges and Their Builders (Cambridge, 1979), pp.186-188; Woodward G., 'The Brunels and the Grosvenor Bridge, Chester' Transactions Newcomen Society Vol.69, No.1 (1997-1998), pp.129-143.

¹ ICE 1828BEADAD, Beamish's Diary, 14 Jun 1828.

² Ibid, 11 Jun – 25 Jul 1828 passim. Beamish, but apparently not Gravatt, went on board the Dublin steamer Thames on 12 July to see Brunel off as he sailed for Plymouth at the start of a short holiday: ibid, 12 Jul 1828.

³ BUL DM 1306 I.3.iii, Brunel's Journal, 14 Aug 1828; Marc Brunel to the Directors, 19 Aug 1828: ICE TT/CE/1, p.103; same to same, 19 Aug 1828: BUL DM 1306 I.6.i, p.265; Anon, 'Richard Beamish' (obituary notice) Minutes Proceedings Institution of Civil Engineers Vol.40 (1875), p.249.

⁴ Rolt L.T.C., op.cit., pp.62-77.

⁵ RSL undesignated, membership records.

⁶ Chrimes M.M., 'Castles in the Air' to the Bristol Railway: How Did Isambard Kingdom Brunel Make his Living, 1828-1833?' Newsletter of the Panel for Historical Engineering Works No.109 (March 2006), pp.1-2.

⁷ ICE 1828BEADAD, Beamish's Diary, passim; for example, Beamish noted that Gravatt spent his twenty-first birthday with his family at Woolwich. Gravatt's address in the ICE membership records for 1830 is given as 'Royal Arsenal, Woolwich': ICE undesignated, membership records, list of members, Jan 1830.

Table 1.1 Projects with which Brunel was involved, 1828-1833

Gaz Engine	1828-1833	Experiments
Thames Tunnel	1828-1831	
Tollesbury Siphon	1830-1831	£19 4s. in fees
Clifton Bridge	1830-1831	
Essay on Draft	1830	
Kensington Observatory	1830-1832	£1,700
Cuvette	1830	
Bristol, Birmingham Railway	1830	
Seville Suspension Bridge	1831	£15,000 estimate
Sunderland Docks	1831-	£395 in fees
Woolwich Dockyard	1831-1832	
Shield Railway	1832	Evidence
Bristol Docks	1832-	
Irish Post Office Committee	1832	Evidence
Chingford Bridge	1832	£347
Bristol Railway (GWR)	1833-	

Source: Chrimes M.M., 'Castles in the Air' to the Bristol Railway: How Did Isambard Kingdom Brunel Make his Living, 1828-1833?' Newsletter of the Panel for Historical Engineering Works No.109 (March 2006), p.2.

which at that period were generally held weekly during the first half of the year.¹ Notably he was at the meetings on 13 and 27 January 1829 when Brunel and Beamish were proposed and duly admitted as Associate Member² and Corresponding Member³ respectively; Gravatt was one of Beamish's sponsors. He was also present at the meeting on 3 February 1829 when Brunel attended as an Associate for the first time, and again the following week when Brunel was formally introduced to the President of the ICE, Thomas Telford.⁴ No satisfactory explanation has been found as to why Brunel should

¹ ICE undesignated, Minutes of Meetings, 13 Jan 1829 – 2 Mar 1830 passim.

² ICE undesignated, membership records, candidate's circular No.196, 13 Jan 1829; ICE undesignated, Minutes of Meetings, 13,27 Jan 1829. Brunel's application was supported by Bryan Donkin, H.R. Palmer and Joshua Field. Skempton is incorrect in stating that Brunel was admitted as an Associate in 1824: BDCE1 p.xxxiii.

³ ICE undesignated, membership records, candidate's circular No.197, 13 Jan 1829; ICE undesignated, Minutes of Meetings, 13,27 Jan 1829. Beamish's application was supported by Gravatt, Joshua Field and Peter Barlow (1776-1862). His address was given as Cork. At that time 'Corresponding Members' were those Members 'who practice but cannot generally attend [meetings]': ICE undesignated, Minutes of Annual General Meeting, 20 Jan 1829.

⁴ ICE undesignated, Minutes of Meetings, 3,10 Feb 1829. On 10 February 1829 Brunel recorded that he 'went to the Engineers, paid my fee': BUL DM 1306 I.3.iii, Brunel's Journal, 10 Feb 1829.

have waited until now to join the ICE, and then only as an Associate: he did not transfer to full Membership until 1837.¹

At an ICE meeting in May 1829 Gravatt presented an account of 'Several sections through the Plastic Clay Formation, in the vicinity of London,' which was later published as a paper in the ICE Transactions in 1836.² There is nothing to suggest that he supervised or had any other role in the drilling of the boreholes, wells and drift-shafts on which his descriptions of the geological sections were based. It is most likely that the data was collected during the Thames Tunnel construction:

... the 'Plastic Clay Formation' was 'the old, unsatisfactory, pre-1854 term for the Woolwich & Reading Beds plus the Thanet Sand,' through which the tunnel was driven.³

During 1829 and 1830 he occasionally attended meetings of the Royal Society and the Society of Arts with Brunel, and from time to time they dined together with mutual colleagues.⁴ At one of these dinners on 5 September 1829 Gravatt announced that he had applied for the post of Engineer to the East London Waterworks; Brunel provided him with a testimonial, but the application was apparently unsuccessful.⁵

Apart from the Waterworks application no evidence has been found relating to Gravatt's career activities during these two years. However, he was occupied for part of

¹ Anon, 'Isambard Kingdom Brunel' (obituary notice) Minutes Proceedings Institution of Civil Engineers Vol.19 (1860), p.172. Marc had been an active Member since 1823:

... constantly attending all the meetings, giving accounts of the progress of his works, bringing forward subjects, taking part in the discussions ... and aiding in the advancement of the Society by every means in his power:

Anon, 'Sir Marc Isambart [*sic*] Brunel' (obituary notice) Minutes Proceedings Institution of Civil Engineers Vol.10 (1851), p.81.

² ICE undesignated, Minutes of Meeting, 26 May 1829; Gravatt W., 'Some Account of Several Sections Through the Plastic Clay Formation in the Vicinity of London' Transactions Institution of Civil Engineers Vol.1 (1836), pp.151-153.

³ Skempton A.W. & Chrimes M.M., 'Thames Tunnel: Geology, Site Investigation and Geotechnical Problems' Geotechnique Vol.44, No.2 (1994), p.203. The one dated reference is to boring operations for water at Tring Hill which were 'discontinued in Nov. 1827.' On 6 April 1828 Beamish recorded that he received at the tunnel specimens from a boring made 'through ground very similar to ours' at Hendon,' suggesting that Gravatt collected at least some of the data while working on the Thames Tunnel: ICE 1827BEADAD, Beamish's Diary, 6 Apr 1827.

⁴ BUL DM 1306 I.3.iii, Brunel's Journal, 12,24 Feb, 31 Mar, 1 Apr, 6 Aug, 5 Sep 1829; BUL DM 1306 II.3.1, Brunel's Private Diary, 3 May, 19,25 Aug, 5 Oct 1830; RSA AD/MA/100/12/75, Society of Arts Minutes, 24 Feb 1829.

⁵ BUL DM 1306 I.3.iii, Brunel's Journal, 5,14,18 Sep 1829. The post of 'Resident Engineer and General Superintendent of the out-door department of this undertaking' was advertised in August 1829: notice inviting applications, dated 20 Aug 1829: The Times 22 Aug 1829.

the time in developing an improved surveying level and staff. He called his level the 'Dumpy' level on account of its relatively short, squat shape; by taking advantage of the recent advances in the manufacture of object lenses, he produced a lighter, more compact and robust instrument than those generally in use for land surveying. The pre-eminent instrument-makers Troughton & Simms made the first Dumpy level for him and later produced them in considerable numbers when its unmatched suitability for civil engineering applications became apparent. Gravatt's 'Account of his improvements in spirit levels' later earned him one of the three silver Telford Medals awarded by the ICE in 1835.¹ He is said to have also invented a small, portable surveying instrument that he called a 'nadir,' which he used in conjunction with a box-sextant to take trial levels of railway lines without the assistance of a staff-holder.²

The earliest evidence of Gravatt having been employed professionally relates to his engagement in early 1831 by the Grand Junction Canal Company to prepare a survey and estimate in opposition to the London & Birmingham Railway Bill, possibly on the recommendation of Bryan Donkin who had recently valued the GJC's premises and machinery. In April 1831 Gravatt was paid £213 2s. for 'surveying proposed line of Rail Road from London to Birmingham,' but the exact period of his engagement is not known although it is unlikely to have been during March as he attended all four Ordinary Meetings at the ICE in London that month.³ The GJC subsequently engaged him to inspect the tunnels at Braunston and Blisworth during the annual stoppage in June 1831,

¹ Obit, pp.568-569; ICE undesignated, Minutes of Conversations Vol.3, No.186, 26 May 1835, 'Gravatt's Level', p.7; ICE undesignated, Council Minutes, 13 Jun 1835; Simms F.W., A Treatise on the Principles and Practice of Levelling (1837), pp.15-16; Bruff P., A Treatise on Engineering Field-Work (1838), p.137; Gravatt W., in discussion of Bray W.B., 'On Measuring Distances by the Telescope' Minutes Proceedings Institution Civil Engineers Vol.21 (1862), p.38; Stanley W.F., Surveying and Levelling Instruments (1890), quoted in Bennett J.A., The Divided Circle: A History of Instruments for Astronomy, Navigation and Surveying (Oxford, 1987), p.201; McConnell A., Instrument Makers to the World: A History of Cooke, Troughton & Simms (York, 1992), p.28. Gravatt also improved the levelling staff to such a degree that, according to Bourns:

... with this new staff, the surveyor is to a great degree independent of his assistant; so much so, that any steady labouring man may be employed in that capacity [ie. as staff-holder]:

Bourns C., The Principles and Practice of Land, Engineering, Trigonometrical, Subterraneous, and Marine Surveying (1843), p.209.

² Obit, p.569n.

³ TNA/PRO RAIL 830/4, Board Minutes, 10 Dec 1830; TNA/PRO RAIL 830/67, Cash Book, 12 Apr 1831; ICE undesignated, Minutes of Meetings, 8,15,22,29 Mar 1831; TNA/PRO RAIL 1066/1718, evidence taken before the Lords Committee on the L&SR Bill, William Gravatt, 21 Jun 1834, p.283.

when three Board members accompanied him through the tunnels and ordered that his recommended works be carried out immediately.¹ Just three months earlier, on 16 March, Brunel had been formally appointed to design the Clifton Suspension Bridge, and by early July he was at work on the siting of the towers. Gravatt arrived in Clifton on 29 July and spent about a week there assisting Brunel in setting out a base-line for establishing the tower centre points by triangulation.² No other evidence has been found that points to Gravatt having been involved in the Clifton Bridge project before or after this episode. Having completed the setting out, Brunel returned to London on 7 August before making a short trip to Gloucester. On 21 August, after visiting Gloucester Cathedral he went on to see Telford's bridge on the Severn at Over, which had been substantially completed in 1828. He noted that it 'settles and cracks most awfully ... The bridge doesn't appear used at all,' and he sketched the positions and extent of the cracks and deformations.³

On 27 September 1831 Beamish married Theodosia Mary Heise, the daughter and heiress of Lt. Col. Augustus Heise.⁴ Brunel met the couple in London three days later and showed them around the Thames Tunnel. The three of them inspected the new London Bridge by boat on 1 October, just two months after the King had performed its opening ceremony. Brunel recorded in his diary that it was evident that the masonry courses in the river elevations of the bridge piers sloped several inches from one end to the other, adding;

Surely this is not a settlement. I hope sincerely – most sincerely – it may not be. Everything was done (at least according to received notions) to ensure the soundness of foundations and it would be most disturbing to [Sir John] Rennie to see such an unforeseen defect in the most splendid bridge in the world – a source of constant anxiety altho' probably no serious derangement will take place.

In the light of the notorious settlement problems at Over Bridge, Rennie was no doubt vexed that Thomas Telford was one of the three eminent engineers who were at that time preparing reports on the condition and stability of the new London Bridge for the

¹ TNA/PRO RAIL 830/5, Board Minutes, 12 Apr, 13, 18 Jun 1831; TNA/PRO RAIL 1066/1718, evidence taken before the Lords Committee on the L&SR Bill, William Gravatt, 21 Jun 1834, p.286. In January 1832 Gravatt was paid £78 2s. for 'Services surveying &c Blisworth and Braunston Tunnels': TNA/PRO RAIL 830/67, Cash Book, 5 Jan 1832.

² BUL DM 1306 II.3.1, Brunel's Private Diary, 29, 31 Jul, 7 Aug 1831.

³ Ibid, 21 Aug 1831.

⁴ The Annual Register 1831, p.208; Montgomery-Massingberd H. (ed.), Burke's Irish Family Records (1976), p.95.

Corporation of London, whose attention had been drawn to the distortion in early September. Telford, James Walker and William Tierney Clark concluded that the principal cause was indeed settlement, compounded to a small degree by setting-out errors.¹ It seems probable that Brunel was motivated by the publicity surrounding the London Bridge investigation to see the evidence for himself on 1 October in the company of an old friend who shared his inquisitive propensity for technical matters. He added an insightful afterthought to his diary note of their inspection:

Well, the day is not far distant when a good bed of clay will not be pricked to pieces with piles unless in some cases perhaps sheet piling.

Four days later he recorded that, after he and the Beamishes had breakfasted together, 'Beamish came up to me & we went over bridge affairs.' Regrettably the topics of their discussion were not stated but it would be fair to assume that they included Beamish's current engineering role as Engineer of Cork and surrounding counties.²

On 13 December 1831 Brunel went to the Navy Office at Woolwich to discuss proposals for a new dry-dock in the dockyard, and while he was there he called on Gravatt and arranged to tour the Arsenal with him the next day; following the tour they dined at Gravatt's father's house on Woolwich Common.³ Brunel's diary contains the cryptic entry for 15 December: 'Went to Gravatt's – explained to him what I wanted.' He

¹ BUL DM 1306 II.3.1, Brunel's Private Diary, 30 Sep, 1 Oct 1831; The Times 7 Sep 1831; Telford T. et al., Reports Presented to the Corporation of London Relative to the Stability of the New London Bridge (1832). Rennie himself made light of the settlement and, in his response to the reports, noted that Telford's Over Bridge was the only instance of a major bridge where settlement had prevented, and still prevented, the bridge from being opened to traffic: Rennie J., Report on the Subject of Messrs. Telford and Walker's Reports (1832). The cause of the London Bridge settlement was a controversial issue for many years, and the debate was revived in the late 1960s/early 1970s when Rennie's bridge was demolished; for examples: Davy C., 'Report on the Present State of the New London Bridge, 27 February 1832' Mechanics' Magazine Vol.16 (1832), pp.450-453; printed minutes of evidence taken before the Select Committee on Thames Conservancy, S.W. Leach, 4 May 1863, p.53; Rennie J. in discussion of McAlpine W.J., 'The Supporting Power of Piles' Minutes Proceedings Institution of Civil Engineers Vol.27 (1868), p.300; Brown C.D., 'London Bridge: Planning, Design and Supervision' Proceedings Institution of Civil Engineers Vol.54 Issue 1 (1973), pp.25-28; Nash J.K.T.L. in discussion of Brown C.D., 'London Bridge: Planning, Design and Supervision' Proceedings Institution of Civil Engineers Vol.54 Issue 4 (1973), pp.726-732.

² BUL DM 1306 II.3.1, Brunel's Private Diary, 1,5 Oct 1831.

³ Ibid, 13,14 Dec 1831. In December 1829 Gravatt's father, as Inspector of the Royal Military Academy, had been granted permission to move into the house on the Common: Secretary to the Board of Ordnance to unknown recipient, 16 Dec 1829: RMA WO 150/3, correspondence of the Secretary to the Board of Ordnance.

followed this up by sending Gravatt a note on 20 December. Neither the subject of the note nor Gravatt's response was recorded but Brunel was prompted to record in his diary: '... my first impulse to answer it in person – but prudence gained the day.' That evening Brunel agreed with Benjamin Hawes how Gravatt should be answered: '... the great point being not to interfere in our present arrangements with Sir James.'¹ The unspecified topic was clearly related to a dispute between Brunel and Sir James South over alleged faults in the design and construction of the observatory at Kensington that Brunel had recently completed for South.² However, Gravatt's role in the matter has not been determined. To add to Brunel's disappointment and frustrations at that time, on 17 December he learned that an attempt launched 14 months earlier to raise sufficient funds to revive the Thames Tunnel project had been abandoned; he confided in his diary:

Tunnel is now I think dead ... This is the first time I have felt able to cry, at least for these 10 years – some further attempts may be made – but it will never be finished now in my father's lifetime I fear – However, nil desperandum has always been my motto – we may succeed yet – perseverantia.³

Gravatt was elected FRS on 2 February 1832. He had been proposed by six eminent Fellows: Marc Brunel, Edward Troughton, Peter Barlow, Samuel Christie, Charles Pasley and Augustus Frazer.⁴ Barlow, Christie and Pasley were all involved in the education of Royal Engineers, and so would doubtless be known to Gravatt via his father; Frazer was an artillery officer who had trained at the Royal Military Academy at Woolwich.⁵ That Marc Brunel should now consider that Gravatt's credentials were appropriate for 'a Gentleman well versed in various branches of natural knowledge, mathematics and mechanics' says much about Gravatt's enhanced reputation at that time. Gravatt's ICE obituary quotes a pertinent anecdote of Augustus De Morgan, Professor of Mathematics at London University, whom Gravatt regularly met at Royal Society meetings at this period; apparently, Gravatt subscribed to a charity of De Morgan's

¹ BUL DM 1306 II.3.1, Brunel's Private Diary, 15,20,21 Dec 1831; emphasis as in the original.

² Rolt L.T.C., *op.cit.*, pp.71-72.

³ BUL DM 1306 II.3.1, Brunel's Private Diary, 17 Dec 1831; emphasis as in the original.

⁴ RSL undesignated, membership records.

⁵ Barlow was at the Royal Military Academy from 1801-1847, for much of that time as Professor of Mathematics: 'Peter Barlow (1776-1862),' BDCE1 pp.39-41. Samuel Hunter Christie (1784-1865) was also Professor of Mathematics at the Royal Military Academy. In 1812 Charles Pasley founded the Royal Engineer Establishment, a school for junior officers at Chatham, and was its Director for many years: '(Sir) Charles Pasley (1780-1861),' BDCE1 pp.512-514.

choice in appreciation of the benefit he had derived from the latter's work on differential calculus. De Morgan said Gravatt was:

... very curious about questions of principles in mathematics ... certainly, a mathematician of the higher branches ... A person who could have any right to the feeling [of benefit derived] from so extensive a work on the higher mathematics as my Differential Calculus, must either have been a person who could flatter himself he understood that he did – a very unlikely thing in so clear-headed a person – or must have had a true understanding of the contents. And this is the impression I derived from other conversations.¹

Gravatt gave evidence before the Commons Committee on the first L&BR Bill during May 1832. Regrettably this did not survive the destruction of the Palace of Westminster in 1834, and it is not known who employed him to give evidence. However, he later stated that he had been 'paid by the Opponents, and therefore I imagined it was to find fault', so presumably he was representing the GJC and their allies. Also, he agreed that he had been questioned at length about his knowledge of bridge building and he admitted that:

I had not then built a bridge upon my own account, not a bridge for which I was the responsible person myself, but I understood bridge-building.²

In consequence of Donkin's 'very favorable recommendation,' Gravatt was engaged on 23 June 1832 to assist, and soon after to replace, Thomas Bradley, the elderly Engineer to the Calder & Hebble Navigation Company.³ This appointment provided him with opportunities to enhance his general engineering expertise, not only in managing day-to-day routine maintenance works but also in observing the practical effects of hydraulic operations.⁴ By October 1832 he had been elected to the Council of the recently formed Halifax Literary & Philosophical Society, where his technical and

¹ Obit, p.566, which also stated that Gravatt became a Fellow of the Royal Astronomical Society in 1832; however, membership records of the RAS show his election to FRAS as being on 12 April 1843: RAS undesignated, membership records. De Morgan (1806-1871) never became FRS, but he was elected FRAS in 1828 and held various offices including Secretary and Vice-President: <http://www.oxforddnb.com/view/article/7470>, accessed 7 Oct 2009.

² TNA/PRO RAIL 1066/1718, evidence taken before the Lords Committee on the L&SR Bill, William Gravatt, 20 Jun 1834, p.291.

³ TNA/PRO RAIL 815/8, Calder & Hebble Navigation Co. Committee Minutes, 2,23 Jun 1832. For biographical details of Thomas Bradley (1753-1833) see BDCE1, p.69.

⁴ Gravatt was later able to cite his experience on the C&HN in support of statements he made about the effectiveness of the method of flashing locks to scour river shoals: TPA HC/CL/PB/2/5/14, evidence taken before the Commons Committee on the Parrett Navigation Bill (further powers), William Gravatt, 15 Mar 1839, pp.123-124.

mathematical talents were much appreciated.¹ He designed a new building in Harrison Road, Halifax, to house a lecture room and museum for the Society, which was eventually completed in 1834.² 'Mr. Waterhouse,' who is said to have contributed some of the technical information on which Gravatt's ICE obituary was based, was almost certainly John Waterhouse (1806-1879), the long-standing President of the HLPS with whom Gravatt retained a close friendship over many years; in which case it was probably Waterhouse who also contributed the 'warts-and-all,' yet essentially sympathetic, character appraisal.³

In February 1833 Gravatt produced plans and specifications for two new timber bridges for the C&HN – one near Brighthouse and the other above Cooper Bridge – and for rebuilding a masonry bridge at Horbury.⁴ Tenders for the timber bridges were immediately advertised but during the tender period a sub-committee discussed some unspecified 'difficulties' regarding the workmen and expressed the opinion that:

Mr. Gravatt's talents, tho' unquestionably of a superior order, are not such as are best calculated for the situation of the Company's Engineer, and that they therefore recommend to the general Committee to allow Mr. Gravatt a year's salary from the time at which he entered upon his office and to provide themselves with a person of more experience in the management of workmen in this part of the country.⁵

The following week, on 23 March, the Committee resolved to continue Gravatt's employment only until the anniversary of his engagement, so that he could supervise construction of the two timber bridges; construction of the stone bridge was postponed.

¹ WYA Misc 49/7/1, HLPS Minutes, 1 Oct 1832; WYA Misc 49/14, HLPS Transaction Book, 5 Oct 1832. Gravatt occasionally chaired monthly meetings, and in February 1833 he presented a well-received paper, 'On the Diving Bell': WYA Misc 49/7/1, HLPS Minutes, *passim*; WYA Misc 49/14, HLPS Transaction Book, *passim*; Halifax Guardian 9 Feb 1833.

² WYA Misc 49/7/1, HLPS Minutes book, 15 Oct 1832, 13 Jun, 28 Oct 1833; WYA Misc 49/14, HLPS Transaction Book, 4 Nov 1833; Halifax Guardian 9 Nov 1833, 17 May 1834; WYA P/020 R 5081, HLPS Annual Report, 1834; Crabtree J., Concise History of Halifax (Halifax, 1836), pp.352-353; Pevsner N., The Buildings of England: Yorkshire, The West Riding (2nd edition 1967, reprinted 1993), p.233. The building is still extant and is now used as office accommodation; on a tablet affixed to the foundation stone Gravatt was described as 'Architect': WYL undesignated, brass rubbing.

³ Obit, p.569n. Gravatt bequeathed several of his cherished personal items to 'my dear friend John Waterhouse of Wellhead, Halifax': Greg Smye-Rumsby, *pers.comm.*

⁴ TNA/PRO RAIL 815/8, Committee Minutes, 8 Feb 1833.

⁵ Halifax Guardian 9 Feb 1833; TNA/PRO RAIL 815/8, Committee Minutes, 15 Mar 1833. No indications of the nature of these 'difficulties' have been found in either the C&HN records or contemporary local newspapers.

Having expressed their regret at terminating his employment they stressed that the only reason for it was their wish to have 'a person of more local knowledge.' Advertisements appeared in the next edition of the Halifax Guardian for:

... an Engineer of good practical knowledge and experience in the repairs of canal and river navigation and in the management and supervision of workmen in this part of the country.¹

Gravatt is said to have demonstrated much ingenuity and innovation in his designs for the timber bridges, 'the arches of which were remarkable for their stability and cheapness.'² Their construction was sufficiently complete by July 1833 for him to certify the outstanding accounts and he was thenceforward replaced as Engineer to the C&HN by William Bull.³ Coincidentally, a fortnight before the C&HN sub-committee recommended that Gravatt should be replaced, Brunel's fortunes had changed dramatically for the better when he was appointed Engineer to the 'Bristol Railway.' By July 1833, when Bull took over from Gravatt on the C&HN, Brunel had completed his preliminary survey of the railway and was ready to address a public meeting in Bristol to solicit support, before taking the proposals to London where he was appointed Engineer to the newly-named 'Great Western Railway' on 27 August 1833; the parliamentary plans were deposited on 30 November 1833.⁴

Direct evidence of Gravatt's movements and activities in the period following his dismissal from the C&HN in July 1833 is sparse; however, the printed minutes of his examination before the Lords Committee on the London & Southampton Railway Bill, augmented by entries in two office diaries that Brunel kept during 1834, throw some light on his activities.⁵ Gravatt told the Lords Committee on the L&SR on 21 June 1834 that he had spent some time studying the construction and operation of railways in the North of England and that his early knowledge was founded on his 'observations':

¹ TNA/PRO RAIL 815/8, Committee Minutes, 23 Mar 1833; Halifax Guardian 30 Mar 1833.

² Obit, pp.567-568. The road deck of each bridge was said to be laid on two laminated timber arched 'girders' of about 103ft. span and 3ft. 9ins. rise. The girders were pre-compressed in consequence of the arrangement of the joints and the sequence of assembling them; regrettably, the method whereby this was achieved was not explained.

³ TNA/PRO RAIL 815/8. Committee Minutes, 5 Jul 1833. This episode is summarised in: Hadfield E.C.R., NE England, p.199. For biographical details of William Bull (fl.1824-1846) see BDCE1, pp.98-99.

⁴ Rolt L.T.C., *op.cit.*, pp.99-104; Clifford D., *op.cit.*, pp.27-31; Vaughan A., Brunel (2006), pp.21-22, 29-36.

⁵ TNA/PRO RAIL 1066/1718, evidence taken before the Lords Committee on the L&SR Bill, William Gravatt, 21 Jun 1834, pp.283-306; BUL DD 1834/1 and BUL DD 1834/2, Brunel's Office Diaries.

I have attended a good deal to railways; I have been continually upon the Manchester and Liverpool, and I know the Leeds and Selby. He had been on the latter 'whole days ... seeing what the workmen were doing.' When he was questioned about the comparative excavating capabilities of 'common field labourers' and 'navigators' or 'excavators' in relation to engineering projects, his response reflected his own experience as an 'excavator' during this period:

[The labourers] might be employed, but I do not think they would with Profit. The Navigators are very strong Men, and they have had Practice, which is a great Thing in excavating. I have been an Excavator myself, and I have worked with my own Hands as an Excavator, and I know what they can do. I know the Advantage of Practice.

He had subsequently made speculative surveys and calculations for projected railway schemes: 'I did it as an amateur, and I did it preparatory to being employed'. His estimates for the cost of tunnelling on the L&SR were based on his own 'considerable experience in tunnels,' and he cited as an example the 'Leeds & Selby tunnel' whose Engineer, James Walker, he named as one of those who had employed him to make 'calculations.' However, he then corrected himself, 'No, no; I cannot say that I have been employed by him,' thus implying that he had worked as an 'amateur' on the Leeds & Selby line. According to his ICE obituary, he was engaged by H.R. Palmer in 'examining the country for the original scheme of the London and Dover Railway,'¹ and in June 1834 Gravatt himself named Palmer, Donkin and Brunel as other engineers who had employed him. He said that he had speculatively 'examined' the L&SR line out as far as Kingston and had subsequently been employed to oppose the L&SR Bill by James St. George Burke, the GWR's Parliamentary Agent. As a result, in May 1834 he was examined by the Commons Committee on the L&SR Bill, but he claimed he was unaware of Burke's connection with the GWR when Burke engaged him. Regrettably, the records of the Commons proceedings were destroyed in the 1834 fire, but under examination on 21 June 1834 by the Lords Committee on the L&SR Bill he said he had been employed by Brunel 'for some time ... in making Calculations for the Great Western Railway.' Despite repeated questioning, he adamantly denied that he had been employed by Brunel himself to oppose the L&SR Bill; he was employed by Brunel merely to make calculations.² Entries in Brunel's office diaries confirm that Gravatt was indeed engaged in GWR matters during March 1834 at least. Appendix 2 of this study

¹ Obit, p.568.

² TNA/PRO RAIL 1066/1718, evidence taken before the Lords Committee on the L&SR Bill, William Gravatt, 21 Jun 1834, pp.283-306.

explores the evidence relating to Gravatt's involvement in the GWR at this period, concluding that it seems most likely that any calculations Gravatt carried out before July 1834 involved the railway alignment and the preparation of estimates, rather than detailed structural design. He does not appear to have assisted in the GWR survey itself.

Following the rejection of the first GWR Bill in July 1834 a coordinated campaign was launched in support of a new Bill which included a 'probable' branch line from Merthyr to Cardiff. In the first of his diaries referred to above, Brunel recorded two visits he made to Merthyr during August 1834 on behalf of the GWR to discuss the proposals with the Welsh interests – principally ironmasters who already knew him through their involvement in projects such as the Clifton Suspension Bridge. Eventually on 7 October he was instructed by the promoters of the Merthyr and Cardiff Railway to proceed with a survey. He spent two or three days in Merthyr and the surrounding district with George Frere who, with John Hammond and others, had been assisting with the GWR survey and to whom Brunel had now apparently entrusted the supervision of the M&CR survey.¹ Lady Charlotte Guest, wife of Sir John Guest, the MP for Merthyr and ironmaster of Dowlais Iron Works, recorded that on 12 October:

Mr. Brunel, of the Thames Tunnel, accompanied by Mr. Frere, came here in the evening. They are to make a survey of a railroad from Merthyr to Cardiff, and Merthyr [Lady Charlotte's pet name for her husband] got up soon after six this morning, in order that he might have a very early meeting with them on the subject.²

Brunel and Frere were back in Merthyr on 19 October to get the survey properly under way; Brunel returned to Bristol on 23 October, leaving Frere at Cardiff. He paid a short visit to the area again from 1 to 3 November, issuing instructions and meeting the promoters. He noted that he went over parts of the line with Frere and also with Gravatt who, it appears, then stayed on in Wales to assist Frere. Brunel's next visit to the area was from 6 to 12 November, when he noted he was 'engaged ... on lines,' presumably in reference to selecting the parliamentary lines for the main line and branches. Following his return to London, he recorded that on 16 November he had been 'engaged on sections & laying down lines – sending directions to Frere, Gravatt, Johnson &c.' He made two more short visits, from 21 to 24 November and from 29 November to 2 December.³ The

¹ BUL DD 1834/1, Brunel's Office Diary, 7,8,21-25 Aug, 7,11-15 Oct. 1834.

² Bessborough, E.P. (ed.), Lady Charlotte Guest: Extracts from her Journal 1833-1852 (1950), pp.35-36, emphasis as in the original.

³ BUL DD 1834/1, Brunel's Office Diary, 18-24 Oct, 1-30 Nov passim, 1,2 Dec 1834.

parliamentary plans and books of reference for the M&CR were deposited on 30 November 1834, the day following the deposition of those for the GWR.¹

Although Gravatt's ICE obituary states that Brunel engaged him 'to survey a line of railway from Cardiff to Merthyr Tydfil and Dowlais,' the majority of payments relating to the survey were entered in Brunel's diary as having been made to or through Frere, the one significant exception being a payment by Brunel himself of £50 to 'W.G. on M&C' on 17 December. It is almost certain that it was Frere who supervised the survey, with assistance from Gravatt; unfortunately, the Engineer and Surveyor are not named on the deposited plans or books of reference.² Frere was then aged 27, six months younger than Gravatt. The Frere family was then living at Bitton, near Bristol, but George's father, Edward, had been a partner in the Clydach ironworks and it was there that George had been born.³ The family's connections with the ironmasters may have helped to secure his employment by Brunel on the GWR and M&CR surveys, although it seems that one of the Frere family, possibly George, was already known well enough by Brunel to have spent a companionable evening with Brunel, Gravatt and other colleagues as early as August 1830.⁴

No evidence has been found relating to Gravatt's professional activities during the period between his work on the M&CR survey in November 1834 and the passage of the GWR Act in August 1835. He attended most of the ICE meetings held during 1835, including the meeting on 13 January at which he seconded the unsuccessful nomination of Bryan Donkin for President. At a meeting on 26 May he presented a paper detailing his improvements of the level and staff, for which he was awarded a Silver Telford Medal on 13 June at the inaugural presentation of these prestigious awards.⁵

¹ GRO Q/D/P/52, 'Plan of a Proposed Railway from Merthyr Tydfil to Cardiff with Branches,' 30 Nov 1834. For a comprehensive account of the historical and contextual background of the M&CR during this period see: Jones S.K., Brunel in South Wales: Vol.1, In Trevithick's Tracks (Stroud, 2005), pp.94-99.

² BUL DD 1834/2, Brunel's Office Diary, 24 Oct, 9,24 Nov, 12,17 Dec 1834; Obit, p.570.

³ James B.Ll. 'The Making of a Scholar Ironmaster: An Introduction to the Life of G.T. Clark' in James B.Ll. (ed.), G.T. Clark: Scholar Ironmaster in the Victorian Age (Cardiff, 1998), p.8; 'George Edward Frere (1807-1887),' BDCE2, pp.318-319.

⁴ On 19 August 1830 Brunel noted in his diary that he had spent that evening with 'Frere, Somerville, Gravatt and W.H.': BUL DM 1306 II.3.1, Brunel's Private Diary, 19 Aug 1830. Somerville and 'W.H.' have not been identified.

⁵ ICE undesignated, Minutes of Meetings, 6 Jan – 2 Jun 1835 passim; ICE undesignated, Minutes of Conversations, Vol.3, No.186, 26 May 1835, 'Gravatt's Level'; ICE undesignated, Council Minutes, 13 Jun 1835. Gravatt's nomination for an award was proposed by H.R. Palmer and seconded by Brunel.