FIRST QUARTER

For MATTER is the dust of the Earth, every atom of which is the life.

For MOTION is as the quantity of life direct, & that which hath not motion, is resistance …

For the EARTH which is an intelligence hath a voice and a propensity to speak in all her parts.

Christopher Smart, *Rejoice in the Lamb* (*Jubilate Agno*), 1759–63

‘The Leyden Experiment’

1 : EARTH, ELSTON & ELECTRICITY

On 12 December 1731, Erasmus Darwin was born at the Old Hall in Elston, about ten miles north-east of Nottingham, the sturdy seventh child of Robert and Elizabeth Darwin. His baptism was celebrated in style with a feast for the tenants and a special beer bottled in his honour – two unopened bottles, and the menu, survive. He grew up in a house noisy with children, beneath a steep-pitched roof with crumbling Elizabethan chimneys, shaded by trees and set amid flat fields of corn and cattle.

Darwin, Boulton and Wedgwood were all born in the heart of England, all descended from ‘yeomen’, small landowners and farmers. They came from different sides of the Midlands, where the counties curve around the Derbyshire Peak. And in the winter of 1739–40, when Darwin was eight, all across their region the earth froze. Snow fell on New Year’s Day and lay until March. Post-boys perched on coaches died of exposure in the cutting wind. In Birmingham steam from the forges clouded in ice-crystals around men’s heads; in Staffordshire the potters’ clay formed rigid crags; in Derby, women woke to find their breath frozen on the sheets. The trunks of ash trees split from top to toe; fish became slivers of steel and small birds fell dead from the trees, so that for three or four years their flocks were diminished. After the frost, ‘there came such a cold dry, stern, cutting & backward spring, as can hardly

be parallel'd'.[1] The harvest was poor and the price of grain spiralled; even the roots of the furze bushes, the fuel of the poor, froze in the iron ground. Many families suffered – Joseph Priestley's mother died this winter, after the birth of his youngest brother.

Darwin's family, however, was well padded against the long chill, warm by their great log fires. Erasmus was a youngest child, tagging after his elders, longing to make them take notice; large and big-boned, he seemed sunny, impetuous and confident, yet he stammered all his life. His older brother Robert had several random memories of him as a small boy – mostly of disasters.[2] He had a lock of white hair after a 'blow from a maid servant by accident' when he was five. He nearly drowned when they went fishing and his brothers stuck him in a sack with only his feet poking out, then twirled him round on the bank so that he walked straight into the river. He did once catch a hare with his brother John (celebrated in a 'fol-de-rol' song by the fourteen-year-old Robert),[3] but on the whole he disliked exercise and country sports. Instead he preferred poetry and experiments, although at school he and a friend, Lord George Cavendish, had a nasty scare with gunpowder. 'These things', decided Robert, 'made a deep impression & fixt habits of precaution on a bold temper.'

In the long holidays the Darwin boys hunted and fished, lazed and read. Their nearest town was Newark, where they could watch the laden barges on the Trent, carrying coal and lead, barley and malt, cheese and pots, to the wharves of Gainsborough and Hull. There was history here too, as well as commerce. Guarding one of the main crossings over the Trent, Newark had been a great Royalist stronghold, resisting Cromwell's army to the last despite plague and siege. Nearly a hundred years later, just as its ruined castle still loomed above the river so the Civil Wars still cast their shadow. Thousands of lives had been lost in the conflict and many families divided, and after the Restoration the tension continued, as Nonconformist ministers were ejected from their parishes, Presbyterian congregations were purged and Quakers were tried and imprisoned. Yet however strongly the Tory gentry and churchmen clung to their power, from Nottingham to Birmingham the Dissenters formed tight, independent communities and in the coming generations many became leaders of industry, banking and trade.

In the Old Hall at Elston there was no thought of trade: the sons of the gentry were destined for higher things. In the autumn of 1741 Erasmus joined his older brothers at school in Chesterfield, twenty miles north on the edge of the Pennines close to the Yorkshire border. Until this generation of the 1730s the Darwin family had not produced noticeable scholars. Their forebears were Lincolnshire landowners who held minor posts under James I and Charles I.[4] Robert, Erasmus's father, had given up his law practice at Lincoln's Inn when he married at the age of forty-two; his wife Elizabeth, a Lincolnshire girl, was twenty years his junior and they had seven children in as many years.

When Erasmus was born his father was nearly fifty, still working on his law even when no business came his way. In his son's memory, 'He was frugal, but not covetous; very tender to his children, but still kept them at an awful kind of distance.'[5] Two generations later, Charles Darwin mused on the portrait of this lawyerly great-grandfather and thought he looked, 'with his great wig and bands, like a dignified doctor of divinity'.[6] Charles also suggested rather hopefully that he might have had some taste for science since he was a member of the well-known Gentleman's Society of Spalding, in the south of Lincolnshire. Indeed Robert won a mention in the Royal Society's *Philosophical Transactions* as a 'Person of Curiosity' when he gave his fellow member William Stukeley an account of a skeleton 'impressed in Stone', a rare marvel, 'the like whereof has not been observed in this island, to my knowledge'.[7] Stukeley thought it was a prehistoric crocodile, but, as if with some uncanny premonition of the evolutionary interests of future Darwins, the bones found in the rectory garden across the road from the hall turned out to be the first fossil plesiosaur found in Britain.

Robert's own interests were more antiquarian than scientific. The Spalding Society had been founded in 1710, and was unusually distinguished, with close links to the London Society of Antiquaries and members including Isaac Newton and Sir Hans Sloane.[8] Their rules stated that the Chairman of the day should have the seat by the fire, and that there should be plenty of coffee, a pot of Bohea Tea, '12 clean pipes and an Ounce of Best Tobacco', a Latin Dictionary and Greek Lexicon, and a chamber pot. Robert Darwin was not one of the most intellectual members; Erasmus described him as 'a man of more sense than learning'.[9] By contrast, his wife Elizabeth was remembered as 'a very learned lady'. Full of spirit and humour, she lived to be ninety-five and 'to the last day of her life got up to feed the pigeons'.[10]

Erasmus's move to school meant parting from the hens, and from the leather-covered books in the Elston library. With its famous twisted spire, Chesterfield was a handsome, busy place, surrounded by high moors. In the old grammar school, in this town of wealthy tanners, shoemakers and iron-masters, he knuckled down to six years of solid classical education. What excitements there were — apart from the experiments with gunpowder — came from outside. In 1745, Chesterfield and Elston, like the rest of the nation, were caught up in the panic of the Jacobite invasion. Charles Edward Stewart, the Young Pretender, landed in the Hebrides in July and took Edinburgh virtually unopposed in September. With the Government at Westminster divided and ill-prepared the Jacobite army cut swiftly through northern England and reached Derby by December. Here, while Londoners fled from the expected attack, Charles dithered. Eventually he turned back, and his army straggled north through the winter storms to be butchered at Culloden in April 1746. The ten-year-old James Watt saw his father's workshop searched, amid rumours that Bonny Prince Charlie lay concealed at Greenock.

As the Jacobites marched south, the men of the Potteries buried their money and hid their cattle in the gorse. In Derby, the family of the painter Joseph Wright, like many others, fled as the Jacobites approached. But even when the threat was near, to young men it often seemed less important than immediate things: work, clothes, love. Although William Hutton – future historian of Birmingham – was then actually living in Derby, he treated the invasion merely as an interesting aside: 'The Rebellion broke out, which provided sufficient matter for inquiry and conversation.'[11] And for Birmingham lads like Boulton the blood of Culloden meant a night on the town, with 'Bonfires, Fireworks, giving great Quantities of Ale to the Populace, and Illumination of Windows throughout the whole Town'.[12] Yet for all the future Lunar men, as for so many of the coming generation, the Rebellion was a key point in the forging of a stout, Protestant, Hanoverian nationalism, whose patriotic rhetoric would ring loud in future projects.

For Darwin the waters of daily life soon closed over the '45. His school week was full of Greek and Latin translations and exercises. It was 'tedious and insipid', he declared off-handedly to his favourite sister Susannah, already celebrated in a boyish scribble:

My dearest Sue
Of lovely hue
No sugar can be sweeter;
You do as far
Excel Su-gar
As sugar does saltpetre.[13]

In February 1749 Sue wrote to him of family and friends, cramming her current diary neatly on to the back of her letter:

Thursday, call'd up to Prayers, by my Larum; spun till Eight, collected the Hens' Eggs; breakfasted on Oat Cake, and Balm Tea; then dress'd and spun till One, Pease Porrage, Pottatoes and Apple Pye; then turned over a few pages in Scriblerus; eat an Apple and got to my work … red in the Tatlar and at Ten withdrew to Prayers; slept sound …[14]

Sue also set her brother a puzzle for Lent. A 'learned Divine' had told her that hog's flesh was fish, and had been so 'ever since the Devil entered into them and they ran into the Sea': so could she eat the meat when the family pig was killed?

A fortnight later Erasmus scrawled his reply.[15] Of course he agreed, but the story of the Gadarene swine meant pork was a 'devillish sort of fish'. On the other hand, he himself had happily eaten 'roast beef, mutton, veal, goose, fowl, &c for what are all these? All flesh is grass!' He then burst into a mock invocation to Temperance, imagining all the 'Whimsical Tribe of Phisitians' cheated of their fees.

Without doctors, he thought men would still live to be a hundred; fever would be ‘banished from our Streets, limping Gout would fly the land … and death himself be slain’.

When Darwin became a physician himself, temperance would be his key prescription. But not at seventeen. And even in adulthood his restraint did not apply to food. To Susannah’s postscript, ‘Excuse hast, being very cold’, he responded, ‘Excuse Hast, supper being called, very Hungry.’ Food figured large, too, in a Pope-style Christmas verse letter to his schoolfriend Samuel Pegge:

> Thus spoke the dying Pigg, ‘Let all abroad
> The bright Black-pudding smoak upon his Board:
> While snaky Sausages their volumes roll,
> And hiss and spit before the burning coal’.[16]

*

Darwin enjoyed his verse. But although he never forsook his Muse, by now he had set his sights on a different career, as a doctor. Medicine was at the forefront of change, as *Chambers Cyclopedia* declared resoundingly:

> Medicine is become free of the tyranny of any sect, and is improved by sure discoveries in anatomy, chymistry, physics, botany, mechanics &c. See MECHANICS.[17]

This would suit Darwin. His brother Robert remembered how when young they often corresponded in verse, ‘viz in Enigmas and other trivial matters; & he has often told me, if it had not been for me, he shou’d never have been a Poet’.[18] Then he added:

> — he was also always fond of Mechanicks. I remember him when he was very young making an ingenious alarum for his watch; he used also to show little experiments in electricity with a rude apparatus he then invented with a bottle.

In Darwin’s youth an interest in natural philosophy was an accepted attribute in polite society, like a taste for art, or music, or collecting curiosities. The vogue had grown first in court circles after the founding of the Royal Society in 1660, with its emphasis on experiment and on making new discoveries public. Slowly the interest spread and by the 1720s scientific lecturers were gathering admiring crowds in London, and soon in the provinces. Such an interest could certainly be reconciled with poetry. Brought up on the collected volumes of the *Tatler* and *Spectator*, the Darwin children were familiar with Joseph Addison’s acclaim of Newton as ‘the Miracle of the Modern Age’.[19] The Newtonian view of the universe, the earth and the planets filled men, said Addison, ‘with a pleasing astonishment, to see so many worlds, hanging one above another, and sliding round their axles in such an amazing pomp and

solemnity', amid the 'wild fields of ether' extending to infinity.[20] When Newton died in 1727, four years before Darwin was born, he was mourned as a national hero, and Alexander Pope's famous couplet hailed him as Britain's gift from God:

> Nature and Nature's Laws lay hid in Night.
> GOD said *Let Newton be*! and all was Light.[21]

The language of Darwin's own *Botanic Garden*, written at the end of his life, still carries echoes of these raptures.

Yet was God a clockmaker or a chemist? Few people really grasped the mathematics or even read Newton's great *Principia* of 1687, although, said Voltaire, everybody talked about him. Most people probably turned to simplified primers, yet his *Opticks* of 1704, with its speculative 'Quaeries' at the end (to which Newton kept adding until 1717), set the agenda for experimental philosophy until the mid-century. And Newton's insistence on method — on inductive reasoning, drawing general conclusions from experiment and observation — became the universal lore, while his model of gravitational order was quickly transferred to all realms of life. Whig thinkers applied it neatly, for example, to the constitution, with monarch and ministers bound by 'natural' laws of attraction:

> What made the planets in such Order move,
> He said, was harmony and mutual Love.
> The Musick of his Spheres did represent
> That ancient Harmony of Government.[22]

But was the order as stable as this verse implied? Or was life a matter of perpetual flux, of shape-shifting, marvellously varied change and alteration, as Darwin came increasingly to think?

Children learned from the world around them just as much as from books. Some of Darwin's own early mechanical experiments — like the alarm for his fob watch or clock that Robert remembered — were probably inspired like this. Derby, twenty-five miles away, was renowned for the clock-making trade and for its many scientific interests. Lectures in natural philosophy were held here from the 1740s.[23] This was a vigorously commercial town, using the local metals and minerals in instrument-making, ironwork and gem-cutting — it was the home of John Flamsteed, first Astronomer Royal, and of George Sorocold, the brilliant designer of Sir Thomas Lombe's silk mill in 1718, the first great landmark of the industrial age. The designs were based on drawings smuggled home by Lombe's half-brother John from Italy (where he was said to have been poisoned by jealous Italian workmen), and all the machinery in the

mill was driven by a huge water-wheel, 23 feet in diameter. Sorocold was a friend of the steam pioneer Thomas Savery, and by 1731 the factory had its own 'fire-engine', housed in a huge block five storeys high, keeping warm air flowing to stop the silk filaments snapping.[24]

One of Darwin's future friends, John Whitehurst, the son of a watch-and clock-maker from Congleton, Cheshire, had moved to Derby in 1736 when he was twenty-three. He was already becoming known for his ingenious wind-vanes, barometers, pyrometers and especially for his clocks. And clocks had glamour. Britain was transfixed by the competition to find an accurate method of estimating longitude and in 1735, after seven years' work, John Harrison perfected the first of his famous chronometers.

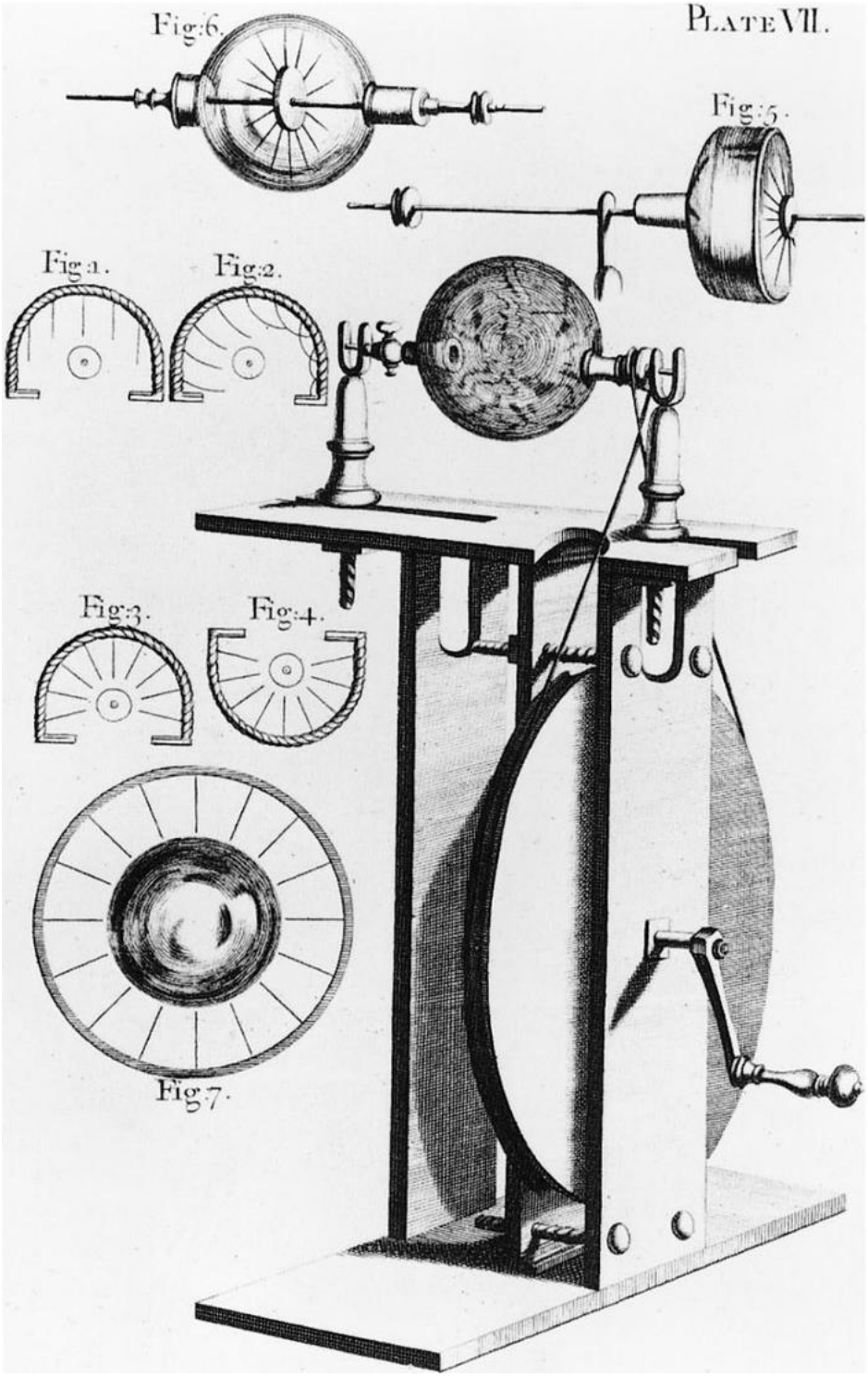
Mechanical wonders entranced many children. Just as Robert recalled Erasmus's fascination, so Richard Wright remembered how his brother Joseph, the future painter,

> being of an active mind, would frequently spend his vacant time from school in going to different shops to see the men work & when he returned home would imitate their works and compleat them in a masterly manner such as joiners goods, chests of drawers, clocks, spinning wheels, guns &c.[25]

A few years later Richard Lovell Edgeworth, a son of the Anglo-Irish gentry, fell under the same spell. His passion too began in childhood, when a Dublin acquaintance brought an electrical machine to treat his mother, who was partially paralysed after a stroke. Invited to his workshop, the seven-year-old Edgeworth was thrilled by the tools and machines and globes. In this Aladdin's cave, he wrote, the 'good natured philosopher' showed him 'a syphon, and the parts of a clock; he melted some metal for me in a crucible; he explained to me the bellows, and construction of an organ'. From that moment, Edgeworth was 'irrecoverably a mechanic'.[26]

But if clocks and globes and bellows were absorbing, then electricity, another feature of Darwin's childhood experiments, was even more magical. In the 1740s the educated public learned of new discoveries in the *Gentleman's Magazine* and flocked to the spark-filled demonstrations of the public lecturers, or 'electricians'. A generation before, in 1706, Francis Hauksbee, Newton's assistant and Curator of experiments at the Royal Society, had built a strange machine, with a great wheel which twirled a whirling ball of glass, rubbed to produce the 'electrical force': after some time the inside of the glass globe shone with a strange purple, blue-green glow, and lines of light crackled like lightning within it. It must have been extraordinary – thrilling and startling – to people who had never seen such a thing before.[27] From now on, discovery followed discovery. In the 1730s the British experiments of Stephen Gray on conduction and insulation, 'electric' and 'non-electric' bodies, attraction and repulsion, became widely known. In particular Gray had shown that electricity could be communicated from the rubbed glass tube, through a rod or a long wire, so that a charge could be carried for astoundingly long

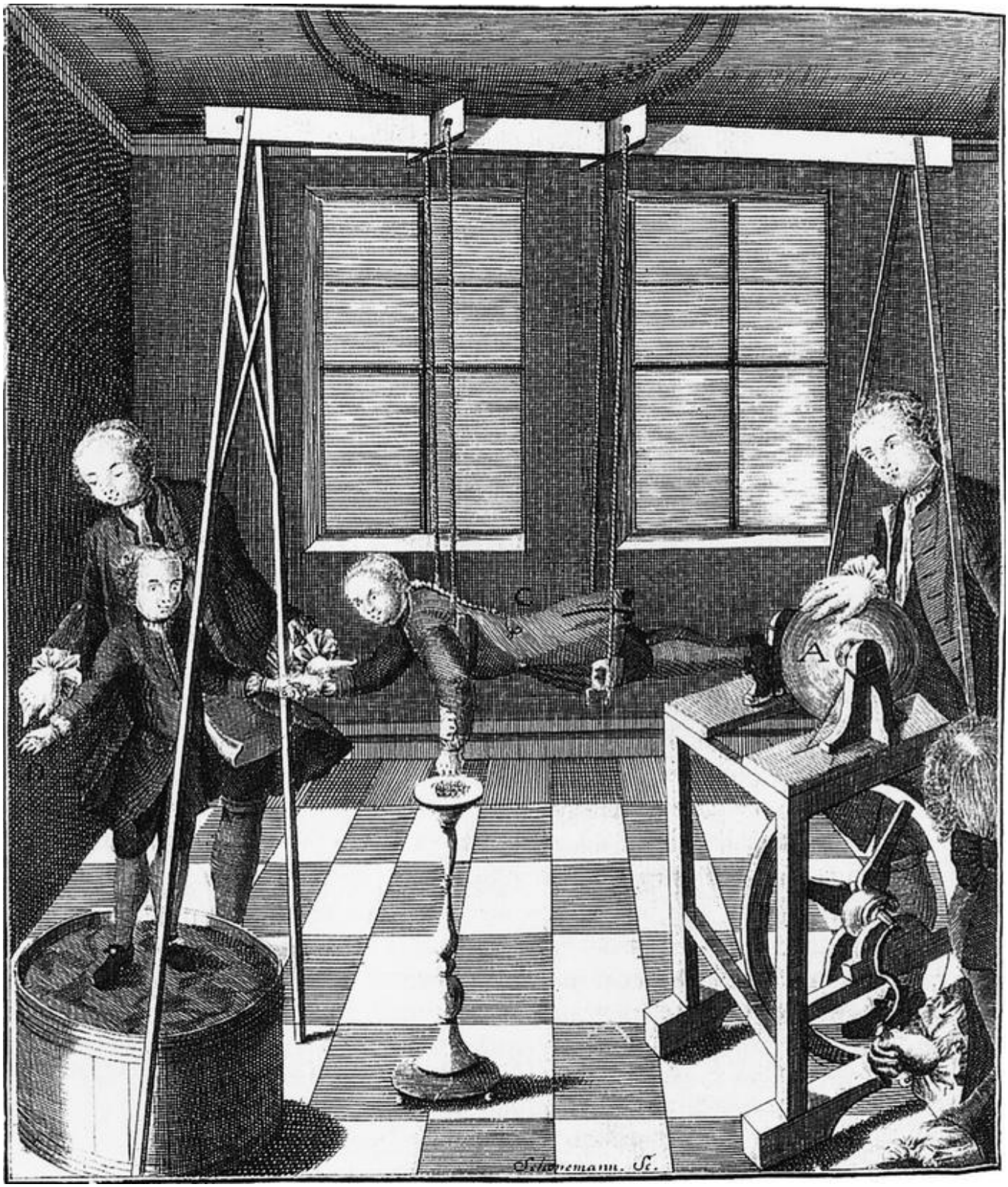
distances. Almost anything, it seemed, could either be a transmitter – silk, hair, glass and resin; or a receiver – ivory, metal and vegetables, 'soap bubbles, water, a map of the world, an umbrella'.[28] Most dramatically, the human body itself proved a spectacular conductor: in 1730, when Gray suspended a charity boy from a frame and touched him with his rubbed glass tube, the shivering leaves of metal placed on plates beneath shot upwards and clung to his body. From this point on, there were many famous public displays in Britain and on the Continent.



Hauksbee's electrical machine, from *Physico-Mechanical Experiments*, 1714

Soon the German professor G. M. Bose built a powerful machine whose massive wheel could generate static of a force unknown before. News came of one German demonstration in which a man kissed an electrified woman. 'Fire flashed from her lips in such abundance', wrote an English observer, Henry Baker, 'that they were both heartily frightened and also felt some Pain.'[29] Baker was sure that when the device reached London 'our own Country-Women will be found to have as much Fire in their Lips as well as in their Eyes as any of their Sex in *Germany*'. A report of Bose's fiery sparks reached Philadelphia in late 1745, and set Benjamin Franklin on the track of yet more electrical findings. It was held almost as irrefutable that electricity – like heat and light – was an 'imponderable', a physical but mysteriously weightless stream of minute bodies or corpuscles, shot out with great speed: a fluid, or 'effluvium'. And if it was a fluid, the real problem was how to catch it, hold it, make it portable. The German Hauksbee-type engines were massive and expensive. They were also phenomenally clumsy, with their huge wheels, and glass globes spun against the hand (if you were French), or against a leather pad (if you were British) – or against the foot, if you were a suspended German boy.

The breakthrough came by accident in 1746. Pieter van Musschenbroek, a Leyden professor, was trying to obtain 'electrical fire' from water electrified in a glass jar by a wire running into it from a conductor, which was a gun barrel hung from silk thread and charged by the rapidly spinning globe near by. The jar was carefully placed on an insulated stand, since once you had managed to lead the 'fluid' charge into any sort of container, it was thought that you had to insulate it as a precaution against it being 'leaked'. A lawyer friend of Musschenbroek, Andreas Cunaeus, tried to repeat the experiment at home: but instead of putting the jar on any base he simply held it in one hand and touched the electrified gun barrel with the other. With a world-shaking shock, he drew the charge straight into himself.[30] Cunaeus survived, but when the intrigued Musschenbroek repeated this he too found his hand 'struck with such force that my whole body quivered just like someone hit by lightning'.[31] He vowed never to attempt the experiment again. Others immediately tried the jar, issuing reports of nose-bleeds, paralysis and jolts that felt as if their arms and legs were being struck off. The little bottle upset all accepted theories; it condensed the weak electric static into a powerful shock: it could be carried from room to room, and it delivered its shocks until the charge was spent. Soon jars were ranged in a 'battery', piling up the power.



Abbé Nollet's experiment with the electrified boy, from *Recherches sur les causes particulières des phénomènes éléctriques*, 1749

At the same time, the electricians worked out that if one man held the jar and another the conductor, they would jump with shock when they touched. The eminently serious and influential Jean Antoine Nollet, lecturer and *Académicien*, who taught natural philosophy to the French royal family, entertained the

court by sending a charge through a set of guardsmen holding hands – and then topped this by placing several hundred Carthusian monks in a long line and electrifying the lot: they were said to give a 'sudden spring' when the contact was completed. Such fun apart, the simplicity of the Leyden jar meant that experiments were no longer the property of the royal and the rich. The jar was cheap, and easy to charge with a spinning globe or rubbed rod, and instrument-makers sold a range of devices, plus 'directions for gentlemen who have electrical machines, how to proceed in making their experiments'.[32] Everywhere, people tried electric shocks on themselves and their friends. (One man heard that the painter and experimenter Benjamin Wilson had made *all* his kitchen utensils 'into Leyden bottles. If so, I should not much care to dine with him.')[33]

The interest in electricity went beyond the thrill of experiment. Indeed, it aroused hot arguments on the propriety of demonstrating in public at all. Was it right to reveal these 'marvellous' effects to gaping crowds? Was electricity a material or divine emanation, 'the Soul of the World'? Were the demonstrations a manifestation of 'nature' or a new class of conjuring trick?[34] A controversy arose, dividing on party lines, with progressive-minded Whigs championing the demonstrators, and high-church Tories claiming it was blasphemy to expose God's secrets to an ignorant populace. Darwin sided with the first group. Leaving school and heading for Cambridge in October 1750, he was sure that asking questions could be nothing but good, and that the only way to find general 'truths' was from experiment. This might not be infallible, Newton had said, 'yet it is the best way of arguing which the nature of things admits of'.[35] It was the way that Darwin, for one, would argue throughout his life.

Notes – 1 **EARTH, ELSTON & ELECTRICITY**

1 *Weather Journals* 59.

2 Robert Darwin, 'old notebooks before I burnt them in 1800', DAR 227.5.12.

3 Darwin 6, and ED Commonplace Book.

4 Darwin 2. After the Civil Wars Erasmus's Royalist great-grandfather trained as a barrister and married t daughter of Commonwealth diplomat Erasmus Earle. Their eldest son married a Nottinghamshire heiress, Ann Waring, who inherited the manor of Elston.

5 ED to Thomas Okes [23?] November 1754.

6 Darwin 4. Portrait by Jonathan Richardson, 1717.

7 Darwin 4, *Phil. Trans.* April and May 1719.

8 See W. Moore, *The Gentlemen's Society at Spalding* (1851); D. M. Owen (ed.), *The Minute Books of th Spalding Gentleman's Society, 1712–1755*, Lincoln Record Society, 73 (Lincoln, 1981).

9 ED to Thomas Okes [23?] November 1754.

10 King-Hele 5. For portraits of Robert and Elizabeth Darwin see *Galton*, plate VII.

11 Hutton *Life* 29.

12 *Aris's Birmingham Gazette*, 17 April 1746.

13 ED to Susannah Darwin, March 1749, and UCL 578,34, *EDL* 4, n. 1.

14 Susannah Darwin to ED, 20 February 1749, DAR 227.3.1.

15 ED to Susannah Darwin, March 1749.

16 ED to Samuel Pegge, 28 December 1749.

17 Quoted in Porter *Beddoes* 24.

18 Darwin 6. A recent deposit by Christopher Darwin of over sixty notebooks in Cambridge University Lib contains numerous verse poems by Erasmus and his brothers, including ten of his 'Enigmas' and many juvenile poems.

19 *Spectator* IV 442.

20 *Spectator* III 575. See Patricia Fara, *Isaac Newton: The Making of Genius* (2002).

21 Alexander Pope, 'Epitaph, Intended for Sir Isaac Newton', *Pope: Poetical Works*, edited by Herbert Dav (Oxford, 1966) 651.

22 J. T. Desaguliers, quoted in Daniels 38. See also *Newton Demands the Muse: Newton's Optics and the Eighteenth Century Poets* (Princeton, 1946) 37.

23 See Paul Elliott, 'The birth of public science in the English provinces: Natural Philosophy in Derby, *c*.1(1760', *Annals* 57 (January 2000) 61–100.

24 *Gentleman's Magazine*, 1732, see Craven 17.

25 Daniels 48.

26 Edgeworth *Memoirs* 26.

27 With thanks to Patricia Fara for describing this. For a concise, lively account of these early discoveries, her *An Entertainment for Angels: Electricity and Enlightenment* (2002).

28 Heilbron 247.

29 Henry Baker to Henry Miles, 29 April 1745, quoted in W. D. Hackman, *Electricity from Glass: The His of the Frictional Electrical Machine* (Alphen aan den Rijn, 1978) 105. See Darwin's version of this in *BG Ec. Veg.* I 349–56.

30 See Hackman, *Electricity from Glass*, 90–103, and Heilbron 309–23.

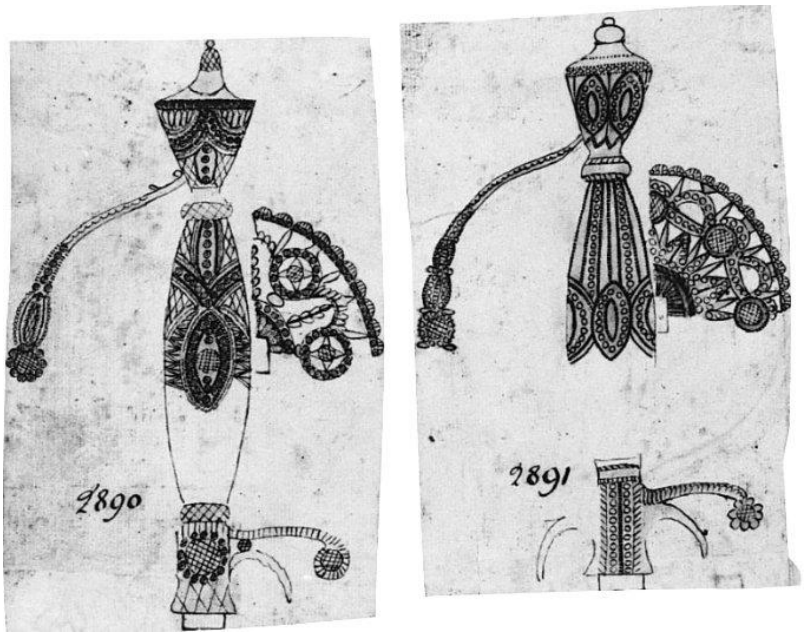
31 Musschenbroek to Reaumur, 20 January 1746, Heilbron 313–14.

32 John Neale, *Directions for Gentlemen who have Electrical Machines* (1747); quoted in Simon Schaffer, consuming flame: electrical showmen and Tory mystics in the world of goods', in John Brewer and Roy Porter (eds), *Consumption and the World of Goods* (1993) 491. See also Maurice Daumas, *Scientific Instruments of the 17th and 18th Centuries and their Makers* (1989).

33 W. Henly to J. Canton, n.d., Heilbron 317.

34 See Schaffer, ‘The consuming flame’, 497, and his ‘Natural Philosophy and Public Spectacle in the Eighteenth Century’, *Hist of Sci*, 21 (1983) 1–43.

35 Isaac Newton, *Opticks* (1704; 1952 edition) 404.



Sword-hilts, from Boulton & Fothergill pattern-book, 1760s

2 : TOYS

The rows over electricity made the spectacular public shows even more popular, in the provinces as well as in London. In early 1747 in Northampton you could see an electrical orrery, demonstrating the movements of the planets; in Birmingham, audiences were offered their own personal shocks from the Leyden jar.[1] And maybe, people thought, electricity was even the energy within us all. A little later Erasmus Darwin wrote to a student friend, Albert Reimarus, about a host of subjects, including wild speculations 'on the resemblance between the action of the human souls and that of electricity'.[2] Even a layman such as Matthew Boulton, scribbling comments on something he had read, wondered if electricity 'is that animal Spirit wch is secreted by the Brain & is the source of Motion and Sensation'.[3] A practical bloke, Boulton plumped soundly for material interpretations: however subtle electricity was, it had nothing to do with the soul: 'we know tis matter & there tis wrong to call it Spirit'.

Boulton briskly cast aside such 'Cymoras of each others Brain' which muffled truth. He shone with the contemporary confidence in observation. Thanks to recent work, he thought:

> we are much better enabled to say what Electy. is to know its uses & understand its Laws & propertys than the Philosophers of any preceding Age for we can both hear it see it smell it & feel it … We have it as much in our power as any of the other Elements we are acquainted with to experiment upon therefor let us consider it just as it appears to our senses.

For his part, he added, he loved electrical experiments ‘and should have a great pleasure in contributing my mite to the Science but am an absolute Sceptic in it’.

When Darwin was at university in 1755, Boulton, three years older, was making a note of the books he had bought to set up his study. His list was a model in miniature of the gentleman’s library, the kind of books that the Darwin children had grown up with. They included four collected volumes of the *Tatler* (with gilded spine) and eight of the *Spectator* (with frontispieces), English, Italian and French dictionaries and the complete works of Pope, Swift, Shakespeare and Locke. In the middle came more practical works such as ‘Clare’s Introduction to Book-keeping’. With touching pride and pleasure he was going at this full tilt, noting down everything, including ‘sett of Locks for my desk’ and ‘Hodgkins for making my desk and wood and brickwork’. He marked the prices neatly against every item apart from a little bunch at the foot which he had obviously had for some time:

I have on Electricity ye underneath Books: 3 Vols of Franklin’s containing in all 154pp, Freke (640), Benjamin Wilson’s treatise (242), Hoadly and Wilson, Simon Lovett, Benj. Martin (40), Lectures by M. l’Abbe Nollet (278), Gowin Knight on Attraction etc. (95).[4]

For Boulton, as for Darwin, these were the books that stirred his imagination – far more than the gilded *Tatler*, or the complete works of Pope.

*

When he made this list, Boulton was twenty-seven and had already worked in his father’s business for ten years. He had no manor house, Spalding Society or classical education behind him. His technical interest arose from his trade, while his curiosity and ambition made him determined to understand every advance, even if he could not exploit it directly – and especially if he could.

He was born on 3 September 1728 in the family house in Whitehalls Lane (now Steelhouse Lane) on the northern fringes of Birmingham and named Matthew after his father. This name had originally been given to the first-born son, who had died at the age of two in 1726. He was thus a double namesake, and although he had a brother, John, and two sisters, as he grew up it was he who carried his father’s hopes.

Boulton senior was a ‘toy-maker’, but his ‘toys’ were not for children – this was the general name for the wealth of small metal goods for which Birmingham was already famous. The makers provided luxury goods for the rich, but also wooed the lesser purchasers, whose spending power increased as the century rolled on, who could now afford new buttons and silver buckles, brass candlesticks and snuffers, a clock on the mantelpiece, an enamelled snuff-box in the pocket. Small traders and their wives left these prized objects in their wills, along with their new calicoes and silks and muslins. In the later

eighteenth century toy-making grew into a great trade, its wealth and variety summed up by the definition of 'Toy Makers', in *Sketchley's Birmingham Directory* of 1767:

> An infinite variety of Articles that come under this denomination are made here; and it would be endless to attempt to give a list of the whole, but for the information of Strangers we shall here observe that these Artists are divided into several branches as the Gold and Silver Toy Makers, who make Trinkets, Seals, Tweezer and Tooth Pick cases, Smelling Bottles, Snuff Boxes, and Filligree Work, such as Toilets, Tea Chests, Inkstands &c &c. The Tortoishell Toy maker, makes a beautiful variety of the above and other Articles; as does also the Steel; who make Cork screws, Buckles, Draw and other Boxes: Snuffers, Watch Chains, Stay Hooks, Sugar knippers &c. and almost all these are likewise made in various metals.[5]

Birmingham was the place for a man to make a fortune. Many men, said the bookseller William Hutton, came on foot and left in chariots. (Even in the 1970s a local saying held that 'Any fool can make money in Birmingham.') Boulton senior had come here from the cathedral town of Lichfield, fourteen miles to the north, and in 1724 he married Christiana Piers from Chester and settled down to build his trade and raise a family. It was a good move. In the 1720s the town was already booming. Perched on its sandstone bluff, the new church of St Philip (with a dome modestly modelled on St Paul's Cathedral) looked down over crowded streets to the fields beyond the river Rea. Forges and workshops clustered in low-lying areas around the alleys of Digbeth and Deritend, Well Street and Corn Cheaping, while the better-off citizens moved uphill to drier land and clearer air, building new, modern houses and squares.

The metal trades depended on the plentiful supplies of coal in South Staffordshire and Warwickshire. Iron, too, had been worked in the Midlands since Tudor times in small charcoal blast furnaces high on the hills. In 1709 the Quaker iron-master Abraham Darby began smelting iron with coke instead of charcoal at Coalbrookdale in Shropshire but until the wood for charcoal grew scarce, ironworking was slow to change. Years later, in the early 1770s, Joseph Wright would paint nostalgic scenes of the old forges: sparks flaring from a blacksmith's anvil; a forge in a barn with a great tilt-hammer, and the owner in his striped waistcoat, folding his arms and looking on. In another painting, though, the owner is now a smart gentleman industrialist and the gap between him and the workmen is far sharper.[6] Time is moving on.

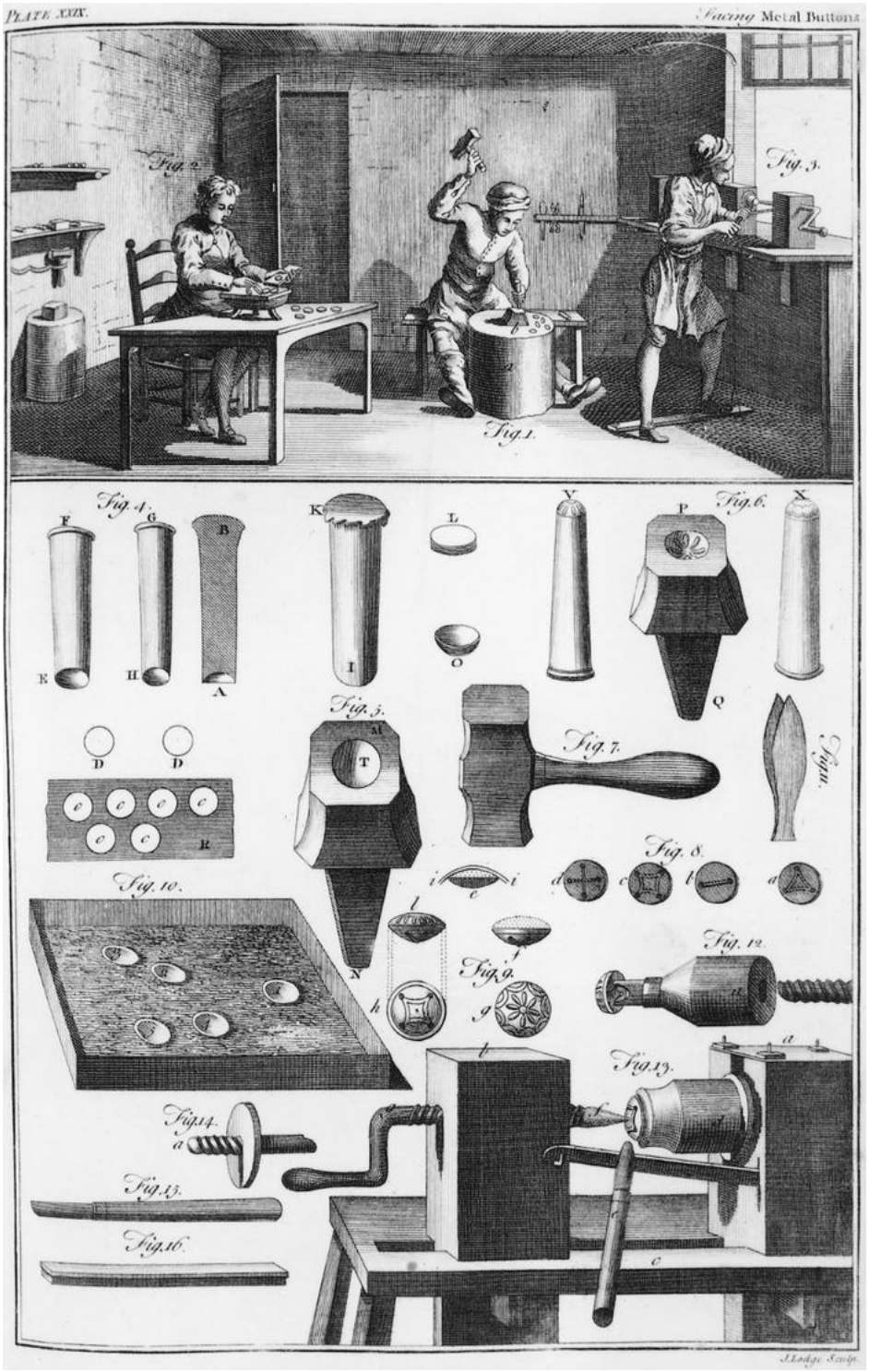
An Iron Forge, engraving by Richard Earlom, 1773, after the painting by Joseph Wright of Derby

The ironworkers of the hills were a fierce, separate community, but the metalworkers they supplied congregated in the small towns around the coalfields, specializing in nails or locks, scythes or buckles or guns. Birmingham had long rung with the sound of anvils; in 1538, John Leland had written of ‘many smithes in the towne that use to make knives and all mannour of cutting tooles, and many lorimers that make bittes, and a great many naylors, soe that a great part of the towne is maintained by smithes who have their iron and sea-cole out of Staffordshire’.[7] The red sandstone was good for grinding edges; the streams flowing down from the ridge turned the many water-wheels. After the Civil Wars came new trades – coining, minting and gun-making. Brass-working arrived and all the businesses were boosted by the boom in novelties and trinkets that followed the Restoration, and by protective legislation that banned the importation of buttons. In 1683 there were two hundred forges here. Six years later the French visitor Alexander Missen wrote that although he had seen fine swords, cane-heads, snuff-boxes and works of steel in Milan, they ‘can be had cheaper and better in Birmingham’.[8]

The copper and brass and steel were worked into thin sheets elsewhere, and brought into the town to be ‘hammered’ into goods, whose variety increased as new tools were introduced: stamps and dies, the turning lathe and the drawbench. Being far from the great rivers, the town’s workers concentrated on small, valuable items that could be carried cheaply across the land, especially buckles and buttons. The glittering buttons and delicate buckles, so fashionable for hats, shoes and knee breeches, could be made of iron, brass, copper or polished steel, cut into fine shapes, or covered with fabric, silver or gilding.

A city of makers and traders, Birmingham almost seemed itself to be ‘in the making’, always looking forward. Many people claimed that part of the reason for its growth was its freedom from rules. It had no charter to shackle it, and no ancient craft guilds to block enterprise with strict apprenticeship and trading rules. The town had supported Cromwell in the Civil Wars and many Nonconformists settled here, especially after the 1660s, when the punitive laws of the Clarendon Code banned them from worshipping in the chartered towns.[9] The Test Acts of 1673 excluded Dissenters from public office, teaching and the universities, but after the Toleration Act of 1689 allowed some public worship, meeting houses and chapels sprang up in many streets. Strong-minded and determined, the Baptists, Presbyterians and Quakers infused the place with energy.

‘Freedom’ was built in to Birmingham’s self-image, and into Matthew Boulton’s. Its citizens boasted of its industry, its independence, its bustle and its power. There were no great ironworks or manufactories: this was chiefly a town of small independent masters, rarely employing more than twenty men and girls, with most of the work done by family or apprentices.[10] When William Hutton first came here as a runaway apprentice in 1740 he thought the people in the streets seemed more alert, more awake, than any he had seen. But, he wrote, ‘I could not avoid remarking that if the people of Birmingham did not suffer themselves to sleep in the street, they did not suffer others to sleep in their beds; for I was, each morning by three o’clock, saluted with a circle of hammers.’[11] In countless poems and broadsheets, Vulcan – not St Philip – is the patron of Birmingham, an artist and artificer, but also a thief, and a dangerous, powerful, pagan force.



Button-making, from Croker's *Complete Dictionary of the Arts and Sciences*, 1764–66

In Boulton's lifetime Birmingham would grow from a small craft town to a major manufacturing centre, its population doubling in each generation: from 15,000 in 1730 to 35,000 by 1760, reaching 70,000 by 1800.[12] And to those who watched it, the rise of Birmingham had a romance of its own. Writing his history of the town in 1785, Hutton drew breath as he reached the brink of the eighteenth century. So far, he wrote, his readers had seen the town in its infancy, growing slowly through the centuries,

‘comparatively small in her size, homely in her person, and coarse in her dress. Her ornaments wholly of iron, from her own forge’. But now:

> Her growth will be amazing, her expansion rapid, perhaps not to be paralleled in history. We shall see her rise in all the beauty of youth, of grace, of elegance, and attract the notice of the commercial world. She will add to her iron ornaments the lustre of every metal that the whole earth can produce, with all their illustrious race of compounds, heightened by fancy and garnished with jewels. She will draw from the fossil, and the vegetable kingdoms; press the ocean, for shell, skin and coral; she will tax the animal, for horn, bone and ivory, and she will decorate the whole with the touches of her pencil.[13]

In reality Birmingham was noisy, dirty and chaotic. Yet its exuberant individualism and inventiveness made it just as much ‘a City of the Enlightenment’ as Bath, or Edinburgh, or Bordeaux.

*

The Boultons’ business specialized in buckles, buying steel on credit from one of the big ironmongers who ran the trade. As he walked to school Matthew passed many workshops like his father’s, often with a casting shop and stamping house as well as the old workshop with its hearth and bellows. In slack times, the goods were piled in the back of the shop; when overseas trade was brisk there was a rush to fill orders before the boats sailed. Birmingham makers still rode out themselves, carrying their clean linen in their bag, and a pair of pistols in their holsters, to get orders and fix prices and deal with agents from London and elsewhere. Their goods reached across England to the Continent and the colonies. As early as 1720 English brassware was sent to Holland, France, Italy, Germany, Poland and Russia, and Birmingham toys even penetrated the illustrious court of France.

On the road, the hardwaremen might join up with Manchester manufacturers, Sheffield cutlers or Staffordshire potters, travelling together as protection against highwaymen, stopping at taverns and gradually building up a complex net of friendships, deals, shared knowledge. Within the town the links were closer still. The Boultons’ friends included the influential button-and hardware-maker Samuel Garbett and his partner John Roebuck, a pioneering industrial chemist, and the great printer John Baskerville. All three were important influences on Matt; all were independent-minded men, risk-takers pursuing their ends with dogged perseverance.

Garbett fought all his life for the interests of Birmingham to be represented in London. His partner Roebuck was the son of a Sheffield cutler, educated at the Dissenting Academy at Northampton and trained as a doctor in Edinburgh and Leyden. In Birmingham in the mid-1740s he worked on new methods of smelting and on producing the acids used in the trade. His laboratory became the town’s first refinery, recovering gold and silver from scrap, stripping them from the base metals that covered them

and Roebuck's stroke of genius was to make this on a large scale using great lead chambers. Vitriol (sulphuric acid, made with nitre and sulphur or iron pyrites) was central to this process. In 1746 he and Garbett opened a factory in Steelhouse Lane, and soon they started a bigger factory in Prestonpans, east of Edinburgh, where glassworks and salt-pans and potteries clustered along the Firth of Forth. Here the partners engaged in still more ventures, culminating in 1760 in Scotland's first major ironworks by the river Carron in Stirlingshire.

Garbett taught Boulton how to finance ambitious projects and manipulate patronage; Roebuck showed him that science could pay. His third mentor, Baskerville, demonstrated that art could be combined with experiment. He had allegedly been footman to a clergyman, employed to teach the parish boys to write, and came to Birmingham in the 1720s where he used his skill in calligraphy to design epitaphs on gravestones and to teach writing in a small school. In 1738, inheriting his father's estate, he taught himself japanning – covering metalware with layers of varnish, often decorated with pictures – and set up a workshop in Moor Street.[14] He was a good friend to Matt as he grew up, almost a second father. Caustic and witty, self-taught and obstinately independent, he was (like Boulton) also markedly 'fond of shew'. A short man, he 'delighted to adorn that figure with gold lace', and 'although constructed with the light timbers of a frigate, his movement was solemn as a ship of the line'.[15] Hutton's daughter Catherine remembered his 'cream-coloured horses, and his painted chariot, each pannel a picture, fresh from his own manufactory of japanned tea-boards'.[16] (He stuck in her memory too, 'by the token that he once took me up in his arms and kissed me'.) He succeeded without truckling to convention, living openly with his companion Sarah Eaves – whose husband had left her – braving disapproval and gossip. And he was equally disdainful of religious convention, pouring scorn on 'revelation' and shrugging off the barbs of 'the ignorant and bigoted', who were bamboozled into professing belief in 'absurd doctrines about which they have no more conception than a horse'.[17]

Matthew Boulton senior was altogether more conventional. As his toy-making prospered the family moved to Snow Hill, then a country lane running down through orchards on the north side of the city. The houses here were new, built around 1720, set back a little from the road with unusually large chimney stacks, which could allow metalwork to be done on the hearths.[18] About half a mile away a tree-lined lane led to the old manor of New Hall, the seat of the Colmore family, hidden behind iron gates at the end of an avenue of elms. New Hall's pools and trees, with their larks and cowslips, would soon be swallowed by houses, but in Boulton's childhood the parkland stretched from Snow Hill to Paradise Street, with views over open country all around.

Matt walked to school at the other side of the town, not to the grammar school, which had fallen into decline, but to an academy in Deritend run by the Reverend John Hausted, chaplain of the old St John's

Chapel. His route took him past the newly laid-out churchyard of St Philip and the fine houses in Temple Row, occupied by wealthy businessmen, lawyers and professionals. Then he could run down towards the steep, narrow High Street, scene of several fatal accidents when loaded wagons overturned on the tight corner. All around, the lanes and courts were packed with the workshops of jewellers and instrument-makers, glass-cutters and toy-makers. Markets were everywhere: butchers' stalls crammed one street, flowers and shrubs another; a double range of stalls clogged the Shambles; there was one market for cattle and another for pigs, sheep and horses. At the foot of the hill, corn and garden produce were sold in the Bull Ring in front of the old houses that ringed the parish church of St Martin's. 'Beds of earthenware lay in the middle of the footways,' remembered Hutton; while 'fruit fowls and butter were sold at the Old Cross; nay it is difficult to mention a place where they were not.'[19]

Several bookshops lay along this route. (Indeed when Matthew was seven, and still at dame school, Samuel Johnson was staying with his friend Edmund Hector at the house of Birmingham's leading bookseller, Mr Warren, struggling to translate Lobo's *Voyage to Abyssinia*, and making eyes at his future wife, Tetty Porter.) But learning was obscured by the glint of cash: the projecting eaves swung with shop signs, emblems and tavern posts. And on the low ground across the river, the road through Digbeth was lined with open forges, where sweating men and boys, and sometimes women, swung their hammers on the glowing iron bars. There were many distractions, from cock-fighting to bowling-greens. Spectacle abounded, such as the waxworks of the Royal Family which were on show in 1746, or the theatres in New Street and Moor Street where '*A tragedy called* "*Hamlet Prince of Denmark*"' played in 1747. There were scientific lectures, given by men such as Benjamin Martin or the Northampton engineer Thomas Yeoman, who promised the people of Birmingham that they would be 'agreeably entertained with a Variety of surprising Experiments in ELECTRICITY (that branch of Philosophy which engrosses so much Conversation everywhere, and is the Subject of so many learned debates)'.[20] And there were exhibitions of mechanical marvels such as the 'curious and unparallel'd Musical Clock' at the Wheatsheaf Inn, and a 'Grand, curious and splendid representation of the Temple of Apollo at Delphos, in Greece', displayed in a 'Machine' twelve feet high and nine wide, 'and not seen through any glass'.[21] The town and the workshop taught Boulton quite as much as the classroom. A smattering of classics stayed with him but by fifteen he had left school. At seventeen he had already developed the technique of inlaying steel buckles with enamel: these became so fashionable that they were 'exported in large quantities to France, from whence they were brought back to England and sold as the most recent productions of French ingenuity'.[22]

Matt Boulton was neat and dark and dapper, with curly brown hair, keen eyes and a broad grin. Frank and humorous, always with an eye to the main chance, he was a man on the make, like his town. But a

business needed capital, and if love and money went together, so much the better; and better still if it was all kept in the family. When it came to finding a wife, it was to his family that Boulton looked. Throughout his childhood he had visited Lichfield where his maternal grandmother Elizabeth lived until her death in 1746. He had a web of relations here, many belonging to the Babingtons and the Dyotts, powerful local families. One Royalist forebear is still commemorated in a plaque in Dam Street, where Lord Brooke, General of the parliamentary forces besieging the Cathedral Close in March 1643, died 'by a shot in the forehead from M. R. Dyott, a gentleman who had placed himself on the battlements of the great steeple to annoy the besiegers'.

Now it was Boulton's turn to lay siege. On 9 February 1749, at St Mary's Church in Lichfield, he married his distant cousin Mary, the daughter of Luke Robinson, a wealthy mercer with a farm at Whittington, three miles outside the city. In one move he cleverly reconnected himself to the lost, grand side of his family (his great-grandmother, and Mary's grandfather and mother were all Babingtons) and scooped a great deal of money. At ten, Mary had inherited a substantial estate from her godmother and an additional £3,000 on her father's death in 1750 – quite enough to buy a business or a small estate. After their marriage the couple lived briefly in Lichfield with her mother, before returning to Birmingham. When Matthew was twenty-one his father made him a partner. Flying on his own optimism and the security of Mary's fortune, he now set out to make his name.

Notes – 2 TOYS

1 For Midlands lectures, see Heilbron, and Musson and Robinson 381–2.

2 Darwin 17.

3 Notebook, MBP 290/2.

4 Ibid.

5 *Sketchley's Birmingham Directory*, 1767, 56.

6 *A Blacksmith's Shop* (1771), *An Iron Forge* (1772), *An Iron Forge viewed from without* (1773). See Dai 50–53, and *Wright of Derby* 101–4.

7 John Leland, *Itinerary* (1538), in Henry Hamilton, *The English Brass and Copper Industries to 1800* (19 122–3.

8 Alexander Missen, in Hutton *Life* xii. See Berg *Manufactures* 287–313, M. J. Wise (ed.), *Birmingham a its Regional Setting. A Scientific Survey* (Birmingham, 1950), and P. Hudson, *Regions and Industries* (Cambridge, 1989). Early works include S. Timmins (ed.), *The Resources, Products and Industrial History of Birmingham and the Midland Hardware District* (1866), and W. H. B. Court, *The Rise of the Midlands Industries 1600–1838* (1938).

9 The Clarendon Code included the Corporation Act (1661); the Act of Uniformity (1662); the Conventic Act (1664); the Five Mile Act (1665), banning Nonconformist ministers from living within five miles of their old parish, and the Test Acts (1673).

10 For a comparison of Birmingham and Sheffield, see Maxine Berg, 'Small Producer Capitalism in Eighte Century England', *Business History*, 35, I (1993) 17–39.

11 Hutton *History* 90–91.

12 See Carl Chinn, *Birmingham: The Great Working City* (Birmingham, 1994) and Eric Hopkins, *Birmingl The First Manufacturing Town in the World, 1760–1840* (1989).

13 Hutton *History* 55.

14 See William Bennett, *John Baskerville* (1937) and uncorrected galleys (BCA; MS 705/4).

15 William Hutton, *European Magazine*, November 1785; Pardoe 19.

16 Pardoe 20.

17 Will of John Baskerville, January 1773, Pardoe 126.

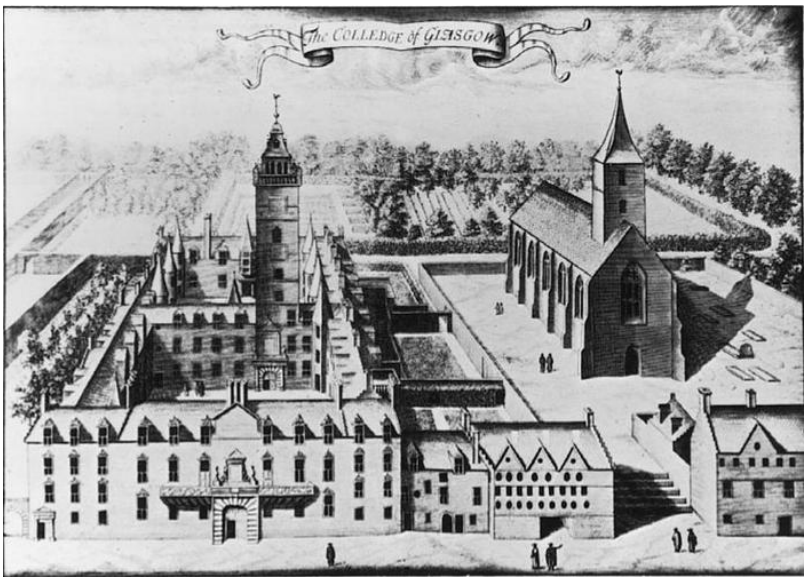
18 See Eric Robinson, 'Matthew Boulton's Birthplace and his home at Snow Hill: A problem in detection', *Transactions of the Birmingham Archaeological Association*, 1957, vol. 75, 88–89.

19 Hutton *History* 379.

20 *Aris's Birmingham Gazette*, 29 December 1746.

21 Dent 90–92.

22 JW Memorandum (1809) 1.



The Old College of Glasgow and Blackfriars Chapel

3 : SCOTLAND

Matthew Boulton's career seemed dictated by his family and the trades of his home. Far to the north, the same was true of James Watt, seven years younger, growing up among the planes and lathes and wood-shavings of his father's business at Greenock, where the salt air rang with the whistle of wind in rigging. By the mid-eighteenth century, Britain was on the verge of a boom and the captains of the ships on the Clyde were eager to share it. For three generations now, adding to the old exchange with northern Europe and the Mediterranean, colonial trade had been growing. Fierce navigation laws, passed almost a century before, required that all colonial goods be sent to Britain, in British ships, before being re-exported to Europe, while the colonists could buy only from the mother country. From the southern American seaboard and the West Indies came sugar and rum, tobacco and rice and mahogany; from New England and Newfoundland came timber and fish and furs. On the back of this trade, Greenock grew from a small fishing village into a busy port. The deep-bottomed boats could sail no further up the sandbank-filled estuary of the Clyde and the triangular trade that made Glasgow rich was based here. The ships left Scotland laden with local goods for the colonies – everything from cradles to coffins – returning with tobacco, which was then re-exported to Europe and exchanged for more goods and raw materials.

When Watt was born on 19 January 1736, his father was a substantial figure, a general merchant, builder, shipwright, carpenter and cabinetmaker, and part owner of several vessels. He made the first crane in Greenock for unloading the heavy, scented bales of tobacco, and into his workshop the captains brought their instruments for repair. This was the trade Watt set his heart on. Instrument-makers were

the unsung heroes of the scientific revolution. The sixteenth-century burst of exploration had fostered the mathematics of navigation and the improvement of astrolabes, quadrants and compasses, while on land surveying instruments were vital to map new territories.[1] Meanwhile the clock-and watchmakers were developing their craft, and the spectacle-makers and glass-grinders were working on new optical instruments, telescopes and microscopes. Yet the theoretical aspects of their work had little status: in Cambridge in the 1630s, 'Mathematicks … were scarce looked upon as Academical Studies, but rather mechanical, as the business of Traders, Seamen, Carpenters, Surveyors of Land, or the like.'[2]

The ground shifted in the late seventeenth century with the new fashion for demonstration and experiment. Mathematics achieved dignity, and Newton set a new tone with his title *The Mathematical Principles of Natural Philosophy*. Precision instruments now commanded more respect, especially after Newton's disciple Willem Jacob 'sGravesande developed a magnificent range of new instruments for his lectures in Leyden. Demand soared and in London a world-famous trade grew up. Meteorologists wanted barometers and thermometers, chemists more accurate balances, surgeons more delicate forceps, lecturers more spectacular models. Rich, aristocratic collectors requested orreries or armillary spheres, beautifully made, often in brass and silver, models of the solar system in which the planets rotated round the sun within a ring engraved with signs of the zodiac.

Watt knew all about the practical application of instruments: his grandfather, who had come west from Aberdeenshire to be a 'bailie' or agent for the local landowner, was described in the Burial Register as a 'teacher of navigation', while his uncle John, a lecturer in mathematics, astronomy and surveying, was responsible for the first survey of the Clyde in 1734.[3] Among the few possessions handed down to Watt were his uncle's notebooks, and two portraits, of Newton and of John Napier, the inventor of logarithms. He himself studied astronomy and botany, and pored over his father's copy of ' sGravesande's *Elements of Natural Philosophy*, translated by Desaguliers.

As a child James was constantly ill and the cosseting by his mother Agnes, who had already lost three children in infancy, might have helped to set him on his lifelong track of hypochondria. He stayed at home until he was ten or eleven, and when he did go to school he was miserable: only when he moved to the grammar school at thirteen did he begin to shine, especially in mathematics. The workshop was Watt' s retreat. His father gave him a workbench, tools and a small forge, where he made models and miniatures – tiny working cranes, pulleys and pumps, a barrel organ, a punch ladle hammered from a silver penny.[4] But in 1753, when he was seventeen, his secure Greenock home was struck a double blow: his mother died and his father's business suffered a series of losses, including a shipwreck. The

following year he left for Glasgow to pursue his own trade, listing the tools and clothes he took with him in a solemn round hand: his jack and chisels and files, his ribbed stockings and ruffled shirts, his holland night cap and tartan waistcoat, his leather apron and his hat with its crêpe mourning band.[5]

Until recently, Glasgow had been a small cathedral city surrounded by hills and woods and nursery gardens but by now the town was dominated by the legendary 'tobacco lords' with their scarlet cloaks and gold-topped canes. As well as the old linen-weaving industry, there was an iron foundry and a rolling mill, a fine printing press established by the Foulis brothers in 1741 and a pottery started by two Dutch brothers in 1748. In the columned arcades beneath the Trongate's tall buildings shoemakers, silversmiths and haberdashers ran their shops, while clubs such as the Hodge-Podge, the Accidental, the Grog, the Pig, the What-You-Please, met in the taverns. Life was lively, if hardly sophisticated. James Wolfe, stationed here in 1753, wrote home: 'We have plays, concerts and balls, public and private, with dinners and suppers of the most execrable food on earth, and wine that approaches to poison. The men drink till they are excessively drunk.'[6]

Watt stayed with relations of his mother, the family of George Muirhead, Professor of Humanity at the University. Passing through the first courtyard of the 'Old College', and under the sandstone arch of the tower, you reached College Green, a meadow stretching down to a brook where new houses for the professors were being built in a row facing the church. Scottish Calvinism could inspire bigotry but it also encouraged a self-sufficient, questioning approach, and learning was seen as the key to progress. Scotland had five universities to England's two, and was proud of its up-to-date, specialized courses.

Glasgow University was quietly progressive and determinedly practical. Its Political Economy Club linked merchants, gentry and academics, while its professors often gave public lectures and acted as consultants for patrons or for the 'Board of Trustees for Fisheries, Manufactures and Improvements in Scotland'. In 1757 Francis Home, the Professor of *Materia Medica*, published the pioneering *Principles of Agriculture and Vegetation*, while William Cullen, Professor of the Practice of Medicine since 1751, and an inspired chemist, advised on bleaching, salt-boiling and alkali-making.[7] A noted character, 'known everywhere by his strange pendulous lips, huge peruke, bigger hat, big coat-flaps sticking out and huge sand-glass to measure patient's pulses',[8] Cullen was an influential teacher whose network of students would spread his ideas throughout Britain.

Among the university men whom the young Watt met and impressed was Robert Dick, Professor of Natural Philosophy, who asked him to help set up a new batch of astronomical teaching instruments. By now, his move to Glasgow had begun to seem an error, since no one there was qualified to teach him instrument-making and the 'optician' he worked for knew less than he did. Instead, Dick persuaded him to go to London, promising that if Watt's father agreed he would provide him with introductions. It

seemed the only course. Preparing to leave Scotland for the first time, Watt sent his trunk ahead by sea from Leith and on 7 June 1755 he set off south with his friend John Marr, a naval instructor due to join his ship on the Thames. His father gave him two guineas, noting it carefully in his memorandum book, together with the carriage for the chest. For two weeks Watt and Marr journeyed slowly down the Great North Road, carrying their Bibles, refusing, like staunch men of the kirk, to travel on the sabbath, and tut-tutting at the ceremonies and the chattering of the clergy in York Cathedral. Finally, after crossing the Trent at Newark, near Erasmus Darwin's home, they reached London.

Many newcomers were daunted when they breasted Highgate Hill and gazed down across the smoke and the spires to the forest of masts on the Thames. Watt made his way into the maze, carrying Dick's letter of introduction to James Short, a highly regarded Scottish instrument-maker with a business on the Strand. But, unlike Birmingham, the capital was ruled by a rigid guild system and as Watt had served no formal apprenticeship, Short would not take him on, nor would the other makers. As he explained wretchedly to his father, instrument-makers were controlled by the Worshipful Company of Clock-makers, whose rules decreed that they must not employ any non-Londoners who were not already Freemen of the Company of Clock-makers, or apprenticed to one.[9] It took a month of despairing visits before he found a place with John Morgan, of Finch Lane, Cornhill.

Morgan was a master craftsman and a fine mathematician who had written a paper on the sand-glass and longitude, and had made a telescope for the King of Spain in 1752 which cost an astounding £1,200.[10] But his terms were hard: instead of receiving pay, Watt paid a fee of twenty guineas and promised full use of his services. It seemed worth it, since he hoped to pack into this single year a training that usually took four, and 'though he works chiefly in the brass way', he told his father, 'yet he can teach me most branches of the business, such as rules, scales, quadrants &c.'.[11] Watt learned fast. He moved swiftly from making rules and dividers to brass scales and quadrants and theodolites. Existing on eight shillings a week, he worked from early morning until nine in the evening, fitting in extra tasks at night until his hands shook from working. He pined for home and felt uneasy in the vast city. War with France broke out in 1756 and as he sweated in Finch Lane, lacking any official guild status, Watt was terrified of being press-ganged into the Navy, kidnapped by the East India Company for their army, or shipped off to West Indies plantations:

> They now press anybody they can get, landsmen as well as seamen, except it be in the liberties of the City, where they are obliged to carry them before my Lord Mayor first, and unless one be either a 'prentice or a creditable tradesman, there is scarce any getting off again. And if I was carried before my Lord Mayor, I durst not avow I wrought in the City, it being against their laws for any unfreeman to work, even as a journeyman within the Liberties.[12]

As the winter passed his spirits rose. In April he wrote, 'I think I shall be able to get my bread anywhere, as I am now able to work as well as most journeymen, though I am not so quick as many.'[13] Three months later, despite coughs and backache and exhaustion, he felt he had mastered the craft and could even 'make a brass sector with a French joint'.[14] In July his year was up. Back in Greenock he unpacked his materials and tools and his translation of Bion's *Construction and Use of Mathematical Instruments*.

Soon his training paid off. At the end of September, when Watt was in Glasgow on business, he sent a note to his father: 'wd have come down today but there is some instruments that are come from Jamaica that Dr Dick desired that I would help to unpack.'[15] The University had been debating for some time how to pay for an observatory, and the chance came with these astronomical instruments, bequeathed by a wealthy former student, Alexander Macfarlane, who had built his own observatory in Jamaica. Many had been damaged on the voyage and Watt was asked to repair them. He was given a fee of £5 and the use of a room near the Department of Natural Philosophy in the University.

The Macfarlane collection included many fine instruments and among the curious who came to Watt's room were Professor Joseph Black and the eighteen-year-old student John Robison. Robison remembered how he thought himself a 'pretty good proficient' in mathematics and mechanics and

> was rather mortifyd at finding Mr Watt so much my superior. But his own high relish for these things made him pleased with the Chat of any person who had the same tastes with himself … I loung'd much about him, and, I doubt not, was frequently teazing him. Thus our acquaintance began —[16]

He reminded Watt, too, how he had met Black in Watt's rooms:

> where you was rubbing up McFarlane's instruments. Dr Black used to come in, and, standing with his back to us, amuse himself with Bird's Quadrant, whistling softly to himself in a manner that thrilled me to the heart – I tryed to imitate him.

Watt, Black and Robison became lasting friends. In 1755 William Cullen had moved to Edinburgh and, at twenty-eight, Black succeeded to his old teacher's chair. He came from a very different milieu from Watt. His father was an Ulster wine merchant in Bordeaux, his brothers were Belfast manufacturers, and his friends included enlightened aristocrats such as Lord Kames. He was tall and fair-skinned, with large dark eyes, and in later life always dressed elegantly in black with silver-buckled shoes and carried a cane or green silk umbrella. With his learning went immense charm. 'The wildest boy respected Black,' wrote Lord Cockburn. 'No lad could be irreverent towards a man so pale, so gentle, so elegant and illustrious.'[17]

Joseph Black, from John Kay, *A Descriptive Catalogue of Original Portraits*, 1836

Black's Edinburgh MD dissertation had included the first of his historic discoveries, the isolation of 'fixed air' (carbon dioxide) from limestone. He realized that this gas – which could also be obtained by using acid on chalk, magnesia, soda and potash – was actually 'fixed in', part of their chemical make-up. He noticed, too, that it softened the harshness of caustic alkalis: when quicklime absorbed fixed air, for example, it became chalk. Robison later recalled the astounding new vistas revealed by the discovery

> that a cubic inch of marble consisted of about half its weight of pure lime and as much air as would fill a vessel holding six wine gallons … What could be more singular than to find so subtile a substance as air existing in the form of hard stone, and its presence accompanied by such a change in the properties of the stone?[18]

When Black took over Cullen's chair, he began to focus on heat, one of the great topics of chemistry in this century. The whisky distillers had asked him for advice on cost-cutting, and he set about investigating the heat involved in changes of state, starting with basic questions: exactly *how* did water absorb heat? Why doesn't ice melt straight away on a sunny day? He found that when ice is heated, its

temperature increases to freezing and stays there until all the ice has melted; similarly, if you boil water, its temperature stays the same until it has all evaporated – though in both cases you need to add heat to keep the process going. (In today's terms: 'The heat gives the water molecules enough extra kinetic energy to escape from the surface of the water.'[19]) To Black it seemed that heat – then thought of as a chemical substance itself – was actually combining with the ice or the water, and that a definite quantity was needed to make the transformation into melt-water or steam. This 'lost' or 'hidden' heat he called 'latent heat': a formula with great implications for the future.

Watt's vision broadened in the company of Black and Robison. He taught himself German to read Leupold's *Theatrum Machinarum* and Italian for other sources. Glasgow had several flourishing student societies and he joined the Anderston Club, a discussion club which included Black, Cullen, Adam Smith (who taught at Glasgow from 1751 to 1764), the radical lawyer John Millar and the argumentative John Anderson, 'Jolly Jack Phosphorus', now Professor of Natural Philosophy, who encouraged workmen and mechanics to attend his lectures without charge. 'Our conversations then,' Watt remembered, 'besides the usual subjects with young men, turned principally on literary topics, religions, belles-lettres, &c.; and to those conversations my mind owed its first bias towards such subjects, I never having attended a college, and being then but a mechanic.'[20]

That linking of science to philosophy and literature was typical of the ethos of contemporary Scotland. Only a few years before, the mountains had run with blood in the wake of the Jacobite uprising of 1745, and, as if desperate to put this behind them, the Protestant Scots of the cities and the Lowlands turned their backs on the Highlands and the past, and looked to the south and to the future: Scotland must take the lead in the modern age. By the mid-1750s journals, books and newspapers poured from the presses and discussion clubs such as those of Glasgow flourished across the country. And while some thinkers were investigating the physical world, others were subjecting the make-up of man and society to equally fierce scrutiny. In 1739 the philosopher David Hume, exhilaratingly bold, had described his *Treatise of Human Nature* as an attempt to bring experimental methods to bear on moral subjects and 'extend our conquests over all those sciences, which more intimately concern human life'.[21] To his distress, Hume's book 'fell dead born from the press' but over the next few years his *Essays* and *Political Discourses* built his reputation and since 1751 (looking more like 'the Idea of a Turtle-eating Alderman than of a refined Philosopher') he had been Keeper of the Advocates Library in Edinburgh, the national copyright library.[22]

Among Hume's friends was the thirty-year-old Adam Smith, currently working on the lectures that would be published as the *Theory of Moral Sentiments* in 1759. Smith too appealed to underlying laws of 'Nature': the idea that prices naturally 'gravitated' to certain levels and that regulation damaged

commerce, which could bring greater freedom and betterment to all. Both he and Hume set sensibility and the passions at the heart of their theories, and believed that self-interest and appetite drove economic and social growth.[23] The ideas of such men, the concerns of the Edinburgh clubs and the varied interests of Watt's circle in Glasgow would permeate the culture of the Lunar men. So much so, indeed, that at times it would seem as though Birmingham itself was an intellectual colony of Scotland.

Notes – 3 SCOTLAND

1 For a survey see Gerard L'E. Turner, 'Scientific Instruments', in Pietro Corsi and Paul Weidling (eds), *Information Sources in the History of Science and Medicine* (1983) 243–58.

2 John Wallis, in Heilbron, 10; see her careful introductory survey.

3 For Thomas Watt, see Muirhead *Life* 4–9, Dickinson *Watt* 15; for Watt's uncle John, see Jacob 100–105

4 George Williamson, *Memorials of the Lineage, Early Life, Education and Development of the Genius of James Watt* (1856), quoted in Dickinson *Watt* 19.

5 JWP 4/161.

6 In Harry Grey Graham, *The Social Life of Scotland in the Eighteenth Century* (Edinburgh, 1901) 142.

7 See Jane Rendall, *Origins of the Scottish Enlightenment* (1978) 17, and A. L. Brown and Michael Moss, *University of Glasgow: 1451–2001* (Edinburgh, 2001).

8 Chambers, *Traditions of Edinburgh*, I 105; see also John Thomson, *An Account of the Life, Lectures and Writings of William Cullen, M.D.*, 2 vols (Edinburgh, 1859).

9 JW to James Watt senior, 1 July 1755, JWP 6/46.

10 'The improvement of the Sand glass for the True Measuring of Time in order to find Longitude'; G. L'E Turner, *Scientific Instruments*, XIV 19.

11 JW to James Watt senior, 21 July 1755, JWP 6/46.

12 JW to James Watt senior, 31 March 1756, JWP 6/46; Muirhead *Life* 39.

13 JW to James Watt senior, 20 April 1756, JWP 6/46.

14 JWP April 1756, 19 June 1756, JWP 6/46.

15 JW to James Watt senior, 2 October 1756, JWP 4/11.2.

16 'Robison's Narrative' (1796); Robinson and Musson 24.

17 Henry Cockburn, *Memorials of his Time* (1910 edn), 46. For Black, see R. G. W. Anderson, 'Joseph Bla in D. Daiches et al. (eds), *A Hotbed of Genius* (Edinburgh, 1986), and A. D. C. Simpson (ed.), *Joseph Black, 1728–1799* (Edinburgh, 1982).

18 Introduction to Black's *Lectures* (1803), in James Sambrook, *The Eighteenth Century* (1986) 15.

19 Adam Hart-Davis, 'James Watt and the Lunaticks of Birmingham', *Science*, 6 April 2001, 56.

20 Smiles 33.

21 David Hume, *A Treatise of Human Nature*, edited by Ernest Rhys, 2 vols (1911) 5.

22 Lord Charlemont, quoted in Alistair Smart, *Allan Ramsay, 1713–1784* (Edinburgh, 1992).

23 See Christopher Lawrence, 'The Nervous System and Society in the Scottish Enlightenment', in Barry Barnes and Steven Shapin (eds), *Natural Order: Historical Studies of Scientific Culture* (1979).

‘I cure all’; the Doctor, from a contemporary broadsheet of professions and trades

4 : THE DOCTOR’S BAG

In these early years the lives of the Lunar men crossed like cotton threaded between pins on a map. By 1753 Erasmus Darwin was in Edinburgh, encountering many of the same men whom James Watt knew in Glasgow. Darwin, like Watt, loved machines, while Watt said he might have become a surgeon if he had not been so squeamish, as an interest in the body’s mechanism was natural to an engineer.

When he left school in 1750 Darwin went with his brother John to St John’s College, Cambridge. Although he won a scholarship of £16 per annum these were lean years, and he would tell his second wife that if she cut the heel out of a stocking he could put a new one in ‘without missing a stitch’.[1] Still, he learned more than darning at Cambridge. He enjoyed his classics and won a name as a poet in 1751 with a flowery elegy on the death of Frederick, Prince of Wales. Ever keen on short cuts, he learned shorthand, making 170 pages of lecture notes, under headings such as ‘the fossil and animal kingdoms’ and ‘waters, earths, metals stones; insects, fish, birds, quadruped and man’.[2] He also made a careful longhand copy of manuscripts on physic and on the pulse which had been left at the college by a former

teacher, the great physician William Heberden. Fellow students borrowed this eagerly, scrawling their ironic comments on the cover: 'Damn you Darwin you have spelt a thousand words wrong, you son of a whore.'[3]

Cambridge, however, offered little at the cutting edge of medical knowledge. For that he had to go elsewhere. In early 1753 he took lodgings in London so that he could go to the anatomy lectures of William Hunter and Noah Thomas's two alluring-sounding courses at St Thomas's Hospital on salivation (the mercury and 'sweating' cure for venereal disease) and on 'acrimonious' and 'narcotic' poisons. Thomas was a good teacher but Hunter was the star, and the steeply raked benches in his class were a crush of broadcloth coats, powdered wigs, gold-topped canes. The seventh child of a farmer from East Kilbride, and one of Cullen's brilliant protégés, he had opened his anatomy school in Covent Garden in 1746. He ran courses six days a week, using a breathtaking collection of models and specimens.[4] He and his brother John eventually became the most distinguished surgeons of their day.

Later that year Darwin rode north, with his eldest brother Robert as his travelling companion, to finish his studies in Edinburgh, 'the hotbed of genius'. The Luckenbooths, where Erasmus lodged, 'at Miss Ogston's in Goldielocks Land', was a row of massive sixteenth-century buildings facing St Giles Church. All classes bumped here on the narrow common stair: sweeps and messenger boys in the cellars; merchants on the ground floor; a countess or a judge on the first; shopkeepers, dancing masters and clerks above; and artisans in the attics. Student lodgings were low-ceilinged, stuffy and cold. Oliver Goldsmith, who arrived the winter before as a medical student from Ireland, wrote mournfully, 'I have hardly any society but a Folio book a skeleton my cat and my meagre landlady.'[5]

Darwin however found plenty of society. There were cheap taverns such as Johnnie Davie's, known for its ale and its toasted ham, herring and whiting; and there were assemblies and dances, societies and drinking clubs. Among the many friendships he made here, one in particular, with James Keir, would last a lifetime; a decade later Keir would move south, to become a central figure in Lunar life, 'the wit, the man of the world, the finished gentleman who gave life and animation to the party'.[6] Four years Darwin's junior, Keir too was a youngest child, the last of eighteen. He came from a well-connected family and after his father died when he was eight his education was supervised by his uncles, the Linds, one of whom was Lord Provost and MP for Edinburgh, the other Sheriff of the County. Tall and broad-shouldered, Keir was invariably good humoured, with a gravity that could suddenly crack to reveal unexpected wit and feeling. He was amused by Darwin's jovial extravagance and remembered how he stood out among the students with his poetry, his wit, his Cambridge ways and classical background. Yet, like any student, Erasmus drank, pursued women (always his weakness) and staggered home down the dark streets before dawn. Typically, he left one bizarre, semi-scientific memory: discussing

phosphorescence, he noted that the Edinburgh folk often threw their fish heads in the streets, and 'I have on a dark night easily seen the hour by holding one of them to my watch.' [7]

Edinburgh had its grander intellectual side, as well as the folk who threw fish heads. 'Here I stand, at what is called the cross of Edinburgh,' wrote one ecstatic visitor, 'and within a few minutes take fifty men of genius by the hand.'[8] Among the gowned lawyers and black-suited elders who strode through the city streets, the university men were a conspicuous group. The Scottish universities were open to Dissenters (unlike Oxford and Cambridge) and the Town Council had long ago seen that the sale of learning was a way to enrich its city. Under the brilliant mathematician Colin Maclaurin Edinburgh had become a hub of Newtonian mathematics and astronomy, and other schools flourished too, including the medical school, founded in 1726.[9] Darwin's courses included medical practice, theory and chemistry (which he and Keir studied with the well-known teacher Andrew Plummer), and clinical medicine, a very modern subject which was taught at a special ward opened at the Royal Infirmary in 1740.[10] Here the professor, John Rutherford, impressed on his students the importance of observation, noting all the signs of the patient's face – the reddened eyes, sore gums, pale skin. But diagnosis was a matter of deduction: the examinations rarely went further and looking at the rest of the body, let alone touching it, was out of the question.

This limitation was typical and indeed the progressive ideas of the Edinburgh medical school were constantly held back by the crudeness of contemporary medicine itself. In surgery, there was no anaesthetic and operations were often performed at lightning speed. As for the *materia medica* – the doctor's bag of remedies – the ingredients listed in the university's *Pharmacopoeia* contained spider's webs, Spanish flies, pigeon's blood, hoofs of elks, eggs of ants, spawn of frogs, dung of horse, pig and peacock, human skulls and mummies.[11] Until the forward-looking Cullen revised the *Pharmacopoeia* in the next decade, students still had to learn elaborate concoctions simmered in everything from Rhenish wine to treacle.

Yet if the cures were medieval the theories were firmly post-Newtonian. It was in Edinburgh that Darwin and many others first grappled with the new ideas of the body, of perception and human understanding that would mark enlightened British thought with its distinctive blend of belief both in reason and in 'sensibility'. The first Edinburgh professors had all been taught in Leyden by the powerful Hermann Boerhaave, who had applied Newtonian physics to the body, explaining health and sickness in terms of forces, weights and hydrostatic pressures; health was a matter of achieving equilibrium, balancing the pressures of internal fluids. In this teaching, a doctor does indeed sound more like an engineer, as Watt saw, or even a plumber. Keir put it well, years later, when he thought back to the narrow Boerhaavian system,

… in which man was considered as an hydraulic machine, whose pipes were filled with fluids capable of chemical fermentation, while the pipes themselves were liable to stoppages or obstructions (to which obstructions and fermentations all diseases were imputed).[12]

How did Darwin, Keir wondered, manage to put this behind him and move on 'to the more enlarged consideration of man as a *living being*, which affects the phenomena of health and disease more than his merely mechanical and chemical properties'? In fact, as Keir acknowledged, even when they were students some Edinburgh teachers were beginning to 'throw off the Boerhaavian yoke'. Influenced by the Swiss physiologist Albrecht von Haller, critics were focusing less on the vascular and more on the nervous system, looking at irritability, sensibility, excitability and reflexes.[13] On the Continent, anatomy and physiology were already blending into one science, 'living anatomy', and in Edinburgh, one of the most notable proponents of this was Cullen, who also fostered an interest in fevers, epidemics and nosology – the classification of disease. From now on, Edinburgh-trained doctors would be at the forefront in the new, radical linking of health and the environment.[14]

But if the body was not in the end 'a machine that winds its own springs', as the French theorist La Mettrie put it in his *L'homme machine* of 1748, where did the life-giving force come from? Was the 'soul' a God-given facility, separate from the body, as the animists and religious dualists held? Was it a natural function of the nervous system as the 'vitalist' camp believed? Or an unconscious but active entity controlling the body, as another Edinburgh professor, Robert Whytt, declared?[15]

Darwin was fiercely interested in such arguments. Everything he learned at Edinburgh concentrated his mind on the physical and the material. Inevitably he rejected conventional religion, with its mystical Trinity, its promise of salvation and store of miracles. He himself was what one might call a Deist, developing his ideas with his close friend, Albert Reimarus, son of a noted Dutch Deist philosopher. He was still ready to accept the notion of some controlling force – a First Cause, a Being of Beings or 'Ens Entium' – but he refused to believe that this remote God had much to do with everyday life. When his father died in November 1754 he wrote to an old Cambridge friend:

> That there exists a superior ENS ENTIUM, which formed these wonderful creatures, is mathematical demonstration. That he influences things by a particular providence, is not so evident. The probability, according to my notion, is against it, since general laws seem sufficient for that end.[16]

General laws were quite enough to 'roll this planet round the sun'. And as to life after death, no one could know: 'The light of Nature affords us not a single argument for a future state; this is the only one – that it is possible with God; since he who made us out of nothing can surely recreate us.'

*

In June 1755, a few months after he penned these thoughts, there came a parting of the ways. In a long Latin letter, Keir broke the news that he was leaving Edinburgh without graduating; burning to see foreign lands, he would join the Army. In the same month, Darwin took his Bachelor of Medicine in Cambridge and the following summer, after another year in Edinburgh, he presented his thesis. At twenty-four he could call himself Dr Darwin.

His entry into the world of work was markedly unsteady. He dawdled through the high-summer months at Elston until the corn was cut. Then at last he set off for Nottingham, where he took lodgings with an upholsterer and declared his practice open. It seemed a good choice as the town was busy and prosperous (and he could easily slip off to the races), but Darwin had no connections here and no introductions. The autumn wore on and still no paying patients came. To make matters worse, he became embroiled in a row with a London surgeon over an operation for a young Nottingham worker, which Darwin – who never charged his poor patients – had assumed would be free, but was not.[17]

Nottingham was a financial disaster. Darwin's sole case seems to have been the treatment of an infection after a stabbing in a brawl between two shoemakers. He prescribed medicines with alarming enthusiasm (a lasting habit) but, after rallying briefly, the unhappy cobbler expired: 'Convulsions of the muscles of the Face. Death. Dissection.'[18] Not until the post-mortem did Darwin realize that the man's stomach had been pierced. But how could he tell? he lamented. There was no vomiting, and 'what evidence had we, except the pulse'? Dead patients are not a good advertisement. In November, a month before his twenty-fifth birthday, Darwin moved on to Lichfield.

*

Lichfield, 'the mother of the Midlands', was the most important of an arc of old Midland towns flanking the woods and heaths of the Birmingham plateau. The cathedral stood on a long sandstone ridge to the north of the town, its three spires reflected in the series of shallow pools that divided the close from the borough, with its Guildhall and market square, parish church and fine houses of russet-coloured brick. Between city and close ran a muddy causeway. Lichfield was an important staging post on the London–Holyhead route but more important to Darwin it was the heart of a web of county families, and the cultural centre of the region. Darwin – soon comfortably ensconced with his sister Susannah as housekeeper – found that Lichfield also had a good cathedral lending library, several printers and booksellers and a strong intellectual tradition. Addison had been the son of a Lichfield Dean; David Garrick, whose brother Peter still lived near the cathedral, was now blazing across the London stage;

Samuel Johnson, whose *Dictionary* was published in 1755, was the son of a town bookseller. 'Sir,' Johnson told Boswell in 1776, 'we are a city of philosophers; we work with our heads, and make the boobies of Birmingham work for us with their hands.'[19]

This time Darwin brought the vital introductions, one to a local dowager, Lady Gresley, the other to the Reverend Thomas Seward, Canon Residentiary of the Cathedral (a fellow graduate of St John's). Since the bishop lived elsewhere, Seward lived in the Bishop's Palace and Darwin immediately found himself part of his circle. The Canon, like Darwin, had poetic pretensions and had contributed to Dodsley's *Miscellany* in 1746, including a poem on 'The Female Right to Literature', written in the persona of 'A young Lady'. He undoubtedly had in mind his own daughter Anna, a prodigy who could recite Milton at the age of three and was now writing poetry herself, with her father's encouragement.

Anna Seward was nearly fourteen when Darwin arrived. Much later, after his death, when her youthful fondness for him had long soured, she recalled her first impressions. What did he look like? He was tall, 'his form athletic, and inclined to corpulence; his limbs too heavy for exact proportion'. His pock-marked face lit up in company, but his features were heavy and his stooping shoulders and full-bottomed doctor's wig made him look twice his age. Yet he swept all before him:

> Florid health, and the earnest of good humour, a sunny smile, on entering a room, and on first accosting his friends, rendered, in his youth, that exterior agreeable, to which beauty and symmetry had not been propitious. He stammered extremely; but whatever he said, whether gravely or in jest, was always worth waiting for, though the inevitable impression it made might not always be pleasant to individual self-love.[20]

So – he could be charming but he could also be arrogant, capable of wounding irony, and always revenging opposition, 'by sarcasm of very keen edge'.

Most Lichfield people took kindly to this large, loud, generous, big-souled man, and within a few weeks – by sheer luck – he also made his name as a physician, when he cured a well-connected Staffordshire man, whose own doctor had prophesied a speedy death. Thanks to Darwin's 'reverse and entirely novel course of treatment' (its details still a mystery) the patient recovered, later to flourish as a local magistrate. At the end of the year, Darwin happily noted down his fees, adding up to £18 7s 6d for the seven weeks since his arrival.[21] As the Lichfield matrons totted up his rising income, he began to seem quite a catch. Darwin, however, eluded their nets and fell in love as impulsively as he did everything. Across the Close from the Sewards lived the widowed solicitor Charles Howard, a schoolfriend of Samuel Johnson and now Proctor in the Ecclesiastical Court, an affable, efficient man with a son Charles and a seventeen-year-old daughter Mary, known as Polly. Darwin was soon

showering her with verse, giving her a copy of Dodsley's *Miscellany* embellished with a long poem of his own packed with hints of 'chequer'd Passions', 'serious Pains' and 'soft-eddying Pleasures'.[22] By late 1757 they were engaged.

On Christmas Eve, staying with friends in an old manor house, Darwin poured his whimsical passion into a letter, pretending he had found a dusty old recipe book, full of receipts for piecrust and tarts – and 'To make Love'. This, he thought, he must send to Miss Howard next post.[23] Another recipe was: 'To make a good Wife'. 'Pshaw,' Darwin continued, 'an acquaintance of mine, a young Lady of Lichfield, knows how to make this Dish better than any other Person in the World, and she has promised to treat me with it sometime.' And thus 'in a Pett', he said, he threw down the book. So he rattled on. But with the wedding imminent, he suddenly panicked. He would be home in five days, but could Mr Howard order a licence now? Then they could have the ceremony discreetly next morning at eight o'clock, 'as the Voice of Fame makes such quick Dispatch with any News in so small a Place as Lichfield'.

> Matrimony, my dear Girl, is undoubtedly a serious affair (if any Thing be such), because it is an affair for Life. But, as we have deliberately determin'd do not let us be *frighted* about this Change of Life; or, however, not let any breathing Creature perceive that we have either Fears or Pleasures upon this Occasion.[24]

Whatever the pre-wedding nerves, on the morning of 30 December 1757, Mary and Erasmus were married in St Mary's Church. Soon they moved into an old half-timbered house at the western end of the Close, the lease being taken by Darwin's patron, the formidable Lady Gresley ('Greasly', as Darwin ungratefully called her: 'Lady Blackwig' to others[25]). On 3 September 1758, eight months after the wedding, their first son was born, named Charles after Mary's father and brother. That summer Mary stayed with old Mrs Darwin in Elston, and Erasmus wrote to his 'dear Pollakin' of deaths and of a hearse rattling past the door, of gossip and love affairs, of his queer-coloured rabbits and bantam hen.[26]

Next year, the pattern was the same. He was altering the house to suit their status, turning it entirely around. The old house looked east into the Close but Darwin added a new front facing west across the road towards open fields. The new Georgian façade had fine Venetian-style windows, letting in the afternoon sun. Across the yard were stables and outhouses – space both for children and experiments. Between the new front and the road ran a deep dell, overgrown with briars, the remains of the old semicircular moat around the Close. Across this, Anna Seward remembered, Darwin 'flung a broad bridge of shallow steps with chinese paling, descending from his hall-door to the pavement'.[27] He cleared the bottom to 'lawny smoothness', made a terrace, and planted lilac and roses.

Darwin’s house in Lichfield, drawn by Rosemary Thomas

Anna was keeping a sharp eye on her new neighbours. She was immensely fond of Mary, and Darwin was still her ‘poetic preceptor’. All her critical knowledge, she said, came from him, although a tactless burst of enthusiasm when he declared her verses better than her father’s had led to the jealous Canon’s disapproval. Her father withdrew his support, for fear, thought Walter Scott, of producing ‘that dreaded phenomenon, a learned lady’.[28] From now on, Anna’s writing was done in secret: in public she confined herself to music and sewing. From this point too, as she watched Mary wearied by childbirth before she was twenty, her admiration of Darwin faltered. But Darwin himself was untouched by doubt. Each year he worked out his earnings – ‘The Profits of my Business’ – and each year they rose: £192 in 1757; £305 in 1758; £460 in 1759; £544 in 1760.

There were some mad moments in this steady career. One, recorded with possible exaggeration by Anna forty years later, was a midsummer outing on the Trent. The day was hot and sultry and, according to the story, his party had a picnic and lashings of wine, promoting ‘a high state of vinous exhilaration’.

Without warning he leapt into the river, clambered up the bank and strode coolly across the meadows towards Nottingham. A dripping river-god, he was found standing on a tub holding forth to the crowd – without a trace of a stammer – on the virtues of industry and fresh air.[29] On the whole, he steered clear of such public displays. Occasionally he did try more serious lectures, even venturing into anatomy, a subject that crystallized all the superstitions that fuelled distrust of science: at Tyburn relatives would cling to the feet of hanged men to prevent them being carried to the surgeon's hall. Executions were rare around Lichfield, but he was ready when one came, as this advertisement suggests:

> October 23rd, 1762 – the body of the malefactor, who is order'd to be executed at Lichfield on Monday the 25th instant, will be afterwards conveyed to the House of Dr Darwin, who will begin a Course of Anatomical Lectures, at four o'clock on Tuesday evening, and continue them every Day as long as the Body can be preserved; and shall be glad to be favoured with the Company of any who profess Medicine or surgery, or whom the Love of Science may induce.[30]

The love of science attracted unlikely folk – in 1768 two clergymen friends asked if he could mount another show.

Looking at Darwin as a young man, one gets the feeling that the fires were damped down, that concern for his reputation stifled his smouldering originality. Yet wherever he went, his lodgings were cluttered with tubes and wires and chemicals. The dearth of patients in Nottingham in 1756 had at least given him time to play. He made friends among clock-makers, passed on scandal about plagiarisms in John Hill's new *British Herbal* and wrote to Albert Reimarus in a tangle of English and bad Latin about the soul, about Egyptian mummies, about using spring rims on coach wheels as shock absorbers, about Benjamin Franklin and electricity. Franklin had now been working on this, among many other things, for ten years, and was best known for his work on lightning and 'pointed conductors'. Trying to understand how clouds charge themselves with lightning, he had suggested that the 'fire' was collected from the friction of salt and water in the ocean, held on the surface of clouds and discharged as a shock when the cloud met a mountain, a steeple, a tree, a ship's mast.[31] Then in May 1752, in the small village of Marly, French electricians had proved that lightning could indeed be drawn safely from the clouds by a metal rod and 'grounded'. From Poland to Portugal, church towers sprouted their new conductors.

All this intrigued Darwin, and the debates about electricity inspired his first scientific paper, which was published in the Royal Society's *Transactions* in early 1757, a few months before his marriage.[32] In this he set out to demolish a recently proposed theory that vapours, like clouds, rise and stay up because they are electrically charged. Instead Darwin argued that solar heat, cooling and expansion were enough to explain the behaviour of clouds and described an ingenious experiment to prove it.

And around this time he did meet someone who shared his interests: Matthew Boulton. The Robinsons, Mary Boulton's family, were among Darwin's patients and the two men were also admirers of John Baskerville, by now an innovative printer, to whose beautiful edition of *Virgil* they both subscribed, and friends of John Michell, an inspired natural philosopher and astronomer, whom Darwin had known in Cambridge and Boulton entertained in Birmingham.[33] But the chief bond between them was the love of invention and experiment. Very quickly they realized how they could complement each other: Darwin the university-educated theorist, Boulton the man with the technical know-how. Equally outspoken, energetic and ebullient, they were two sides of a coin. The first Lunar link had been forged.

Notes – 4 THE DOCTOR'S BAG

1 Darwin 12.

2 Darwin learned from the *Brachygraphy* of Thomas Gurney; his notes were on lectures by Dr George Ba at King's College: Wellcome WMS 2043; see King-Hele 13–14.

3 King-Hele 15.

4 See Roy Porter, 'Medical lecturing in Georgian London', *BJHS*, 28 (March 1995), 91–100, and W. F. Bynum and Roy Porter (eds), *William Hunter and the Eighteenth-Century Medical World* (Cambridge, 1985), Porter, *The Greatest Benefit to Mankind* (1997) 245–305.

5 *The Collected Letters of Oliver Goldsmith*, edited by Katharine C. Balderston (Cambridge, 1928) 3.

6 *SchimmelPenninck* 37.

7 *Phytologia* 208; King-Hele 18.

8 Quoted in D. Daiches et al. (eds), *A Hotbed of Genius* (Edinburgh, 1986) 1.

9 See Christopher Lawrence, 'Ornate physicians and learned artisans: Edinburgh medical men, 1726–177(Bynum and Porter, 153–76; and R. G. W. Anderson and A. D. C. Simpson (eds), *The Early Years of the Edinburgh Medical School* (Edinburgh, 1976).

10 See Guenter B. Risse, *Hospital Life in Enlightenment Scotland. Care and Teaching at the Royal Infirma Edinburgh* (Cambridge, 1986).

11 *Pharmacopoeia Edinburgensis; or New Edinburgh Dispensatory*, 4th edn (1744).

12 JK to Robert Darwin, 1802; King-Hele 17.

13 The Leyden-trained Haller published his physiological textbook, *Primae lineae physiologiae*, in 1747, followed by *Elementa physiologiae corporis humani* (8 vols, 1757–66).

14 For Cullen's ideas and impact, see Golinski 11–40.

15 Robert Whytt, *On the Vital and Other Involuntary Motions of Animals* (1751); discussed in Klonk 18; P *The Greatest Benefit*, 251.

16 ED to Thomas Okes, [23?] November 1754.

17 ED to Albert Reimarus, 9 September 1756, Darwin 18.

18 DAR 227: 1.4; King-Hele 20.

19 Boswell *Johnson* II 464.

20 Seward 2–3. For an interesting discussion of Seward, see the chapter in Brewer, 'Queen Muse of Britain 573–612.

21 ED Commonplace Book.

22 DAR 227: 1.14; King-Hele 29.

23 ED to MH, 24 December 1757.

24 Ibid.

25 King-Hele 32, 34.

26 ED to MD, 18 May 1758, DAR 227: 1.16.

27 Seward 15.

28 Seward *Poetical Works* vii.

29 Seward 65–8.

30 *Aris's Birmingham Gazette*, 25 October 1762.

31 Heilbron 342.

32 The paper was read on 5 May and published in *Phil. Trans.* I (1757) 250–54.

33 Seward 16. A tutor at Queen's College, Michell had lectured on Hebrew, Greek, arithmetic, geometry a philosophy.

Creamware shapes from a Wedgwood catalogue

5 : POTS

In a sketch map of Burslem in Staffordshire drawn in 1750 a broad straggle of houses runs along the top of the hill, with the church in the valley below.[1] The shops of a cobbler, a barber and a couple of butchers are dotted amid clusters of potworks and inns: the Turk's Head, the Jolly Potters, the Court House, the Bear. Between the potteries lie triangles of common land and lanes twisting outwards to meadows and crofts. A maypole is raised on the village green and on a hill named 'The Jenkins' a windmill turns. It seems a rural spot, yet the landscape was more like the moon than the English countryside, gouged with pits and humped with mounds of drying clay and towering shard-rucks of spoiled pots. And on every side great bottle-shaped kilns curved and smoked against the sky.

Wedgwoods had been potters here since the early seventeenth century, and in 1758, while Darwin was building his practice and Boulton his business, the young Josiah Wedgwood was planning to start his first pottery. Much later, looking back at the notebook he kept in early 1759, he wrote, 'I saw the field was spacious, and the soil so good as to promise an ample recompense to any one who should labour diligently in cultivation.'[2]

The agricultural image was apt. Throughout the eighteenth century the land still dictated most people's lives. Great estates, such as that owned by Lord Gower at Trentham on the edge of the Potteries, straddled the Midland counties, and if such men owned great reserves of coal, or timber, or stone they had no snobbery about making money from them. The rich soils gave farmers a fat living and the unenclosed woodlands and heaths supported smallholders and commoners. The earth also fed the region's industry: the deposits of iron ore and lead, the limestone and flint of the hills, the brown and yellow clays of the Potteries. There were many Midland trades. In the late sixteenth century the glass-makers came, often immigrants from France, settling around the Potteries and in the Stour valley west of Birmingham. A century later, there was brewing in Burton-on-Trent; silk-weaving and ribbon-making

near Coventry; framework knitting around Nottingham. From Cheshire rock salt was sent downriver to the Mersey where the flow of the tide dissolved it into brine in great lead cisterns, clouding the horizon with briny smoke.

One of the oldest of the local crafts was pottery. For two hundred years, in a handful of small towns and villages dotted along the low hills of North Staffordshire, potters had been making marbled and mottled ware from local clay, selling butterpots and pitchers and patterned plates. There were six villages in this cluster, running from north to south – Tunstall, Burslem, Hanley, Stoke, Longton and Fenton – bafflingly known later as the 'Five Towns' and now united in the rambling Stoke-on-Trent.

Ceramics had always been a mix of science, design and skill, and every good potter was in a sense an experimental chemist, trying out new mixes and glazes, alert to the impact of temperatures and the plasticity of clay. Years of trials had preceded the great breakthrough in Dresden in 1708, when the formula for porcelain was discovered, a secret held in China for a thousand years. The Royal Saxon Porcelain Company at Meissen spurred rival royal factories across Europe but porcelain from the East was still a treasure and the tons of blue-and-white ware ballasting the ships of the East India Company were never enough. The same ships brought new luxuries – tea, coffee and chocolate – which in turn increased demand for fine teacups and pots. (Both pottery and porcelain alike soon became loosely known as 'china'.) To meet the fashion, Dutch potters, particularly at Delft, had long ago begun decorating their tin-glazed pottery in the much admired blue-and-white designs, and soon English workshops followed suit. Then in 1745 the first English soft-paste porcelain (whose ingredients were more like those for glass) was made at Chelsea, and then in Bow and Derby, Staffordshire and Worcester. But only in Bristol and Plymouth was the true 'Chinese' hard-paste porcelain made, after the discovery of kaolin, the vital ingredient, in Cornwall.

Sensing the wealth to be made, a new kind of entrepreneur moved in. Apothecaries and doctors with chemical knowledge, or jewellers and goldsmiths with skills in design and modelling and a feel for the luxury trades, set up partnership with potters.[3] But fortunes did not come easily: there were huge technical and financial problems in producing both sorts of porcelain, soft and hard, and the losses in firing were tremendous. Factories foundered and bankruptcies multiplied. Yet the fashion inspired a search for something similar but cheaper and less risky, a fine white earthenware to suit 'polite' tables. There were basically two kinds of pottery. The first was earthenware, which could be made from local clay and fired at quite low temperatures (around 1000 °C), but which remained porous and easily breakable, and had to be glazed a second time before it could hold water. The other type was stoneware, in which the clay was mixed with flint and fired at a far higher heat, so that the ingredients vitrified and it became glassy and non-porous, a great advance.

Wedgwood cherished the history of his trade, the way Staffordshire potters had learned, stage by stage.[4] Each step forward gave potters a competitive edge, and they held their secrets tight. Folktale stories of chance or cunning often cloaked industrial espionage. The story of salt-glazing is typical: although the Dutch had long used soda for glazing (a technique known since the Greeks), in the mid-seventeenth century Burslem men still used the old powdered lead-glaze melted in charcoal 'hearths' high on the moors. And then in 1680, so they said, a happy 'accident' occurred: a servant on a farm near Burslem was making a saltley for curing pork; it boiled over, tumbling down the sides of the pot, and when it cooled it left a clear, glassy glaze: the farmer told his neighbour, a potter, and soon salt was arriving from Cheshire by the ton. In fact salt-glazing had spread slowly from Europe to London and the North. Its advantage was that only a single firing was needed, although the heat had to be intense.

New kilns were built, wide and high, able to hold a mass of ware packed into saggars, the rough clay boxes that protected the pots against uneven heat and flame and toxic fumes. Standing on scaffolding on the outside, 'firemen' emptied sacks of salt into holes high in the kilns and as the fumes circulated in the great vertical flues a glassy silicate formed on the pots, giving them a lasting sheen. Each Saturday morning a heavy white cloud hung over the countryside round Burslem, so thick 'as to cause persons often to run into each other, travellers to mistake the road; and strangers have mentioned it as extremely disagreeable and not unlike the smoke of Etna or Vesuvious'.[5]

Burslem also produced red and black earthenware. In the late seventeenth century the Dutch potter J. P. Elers settled here, working a newly discovered seam to imitate fashionable red teapots of Oriental porcelain. (So secretive was he, people said, that he laid underground pipes to detect the sound of strangers' footsteps and employed an idiot to turn his wheel.) Elers also made a strong 'Egyptian black', the precursor of Wedgwood's blackware, and other local potters often blackened their wares with 'car' found in the drainage from the coalmines, full of heavy iron oxide. The trade moved on. In the 1720s some potworks began using blue and white 'ball clay' from Dorset and Devon to make a fine white earthenware, while others made salt-glazed white stoneware, using ground flint. Then around 1740 a new process was developed, in which earthenware was fired to 'biscuit', then glazed and refired to produce a lustrous 'creamware'. With this new body – the basis of Wedgwood's later ware – the Staffordshire potters could finally attack the fashionable markets.

Josiah had to learn all the stages of his craft, beginning with the long preparation before the clay even reached the wheel. Once dug, it was weathered in piles in the fields and yards for two or three years to make it more plastic. Then it was mixed with water, traditionally in a huge, shallow outdoor pit called a sun kiln, but more often now in great 'slip-houses' which gave protection from the weather. Men with poles and paddles mixed or 'blunged' the cloudy liquid so that gravel and pebbles and heavy grains sank

to the bottom. Then it was sieved and poured into heaps to dry, building up layer by layer until it could be cut into blocks and stored in a damp shelter.[6] Finally the clay was 'wedged', pounded and kneaded like bread to get rid of any air pockets which might make it fracture in the kiln. Only then was it fit for the wheel.

Most of Wedgwood's close family were involved in this trade. Two of his uncles, Thomas and 'Long John' – one an expert thrower, and the other the best 'fireman' in the district – were leading makers of salt-glazed stoneware and by the early 1740s had made a fortune, building the first house in Burslem to be roofed with slates, a square-cut three-storey building standing out on the hillside, simply known as 'The Big House'. Both seemed confirmed bachelors, and their relations were staggered and amused when first John married, at the age of fifty-three (and had six children), and then Thomas took the plunge at sixty-two. 'A VOICE this moment breaks in upon me with – NEWS, NEWS, NEWS,' wrote Wedgwood in the middle of a letter to his friend Thomas Bentley, '& what do you think it is? why truly, the Marriage writeings are making between my Unckle Thomas, and my Cousin Molly, both of venerable memory, this may serve as *a Choice drop of Comfort to Old maids & Batchelors*.'[7]

Another uncle, Richard, left the district to become a cheese-factor in Cheshire, growing wealthy enough to act as a private banker. Meanwhile, Josiah's father, a maker of 'moulded ware', inherited the Churchyard Works which had belonged to his grandfather and father before him. Josiah, baptized on 12 July 1730 in the church next door, was the youngest of thirteen children, of whom seven survived. At six, he joined his older brothers and sisters at a school in nearby Newcastle-under-Lyme run by Thomas Blunt, an ascetic man with some classical knowledge, interested in mathematics and chemistry. Anecdotes selected (or invented) with hindsight stress Josiah's dexterity and eye for design, such as his schoolmates' memories of how he borrowed his sisters' scissors to 'cut out the most surprising things' like 'an army at combat, a fleet at sea, a house and a garden, or a whole pot-work, and the shape of the ware made in it'.[8]

For three years Josiah walked to school, seven miles a day there and back, and cut out his paper armies. Then in June 1739, when he was nine, his father died. In a hasty last-minute will Thomas left the works to his eldest son, another Thomas, and £20 each to his six younger children: Margaret, John, Aaron, Richard, Catherine and Josiah. But this was wishful thinking. Old Thomas Wedgwood had been a good potter but a bad businessman, and his last small legacy was not paid until the 1770s, by Josiah himself.

It was said (though it is hard to prove) that on his father's death Josiah began straight away in the family pottery where he and his brother Richard, three years his senior, 'sat at work at the respective corners of a small room'.[9] Old stories also claimed that when he was almost twelve the smallpox struck

and that he was severely ill, the infection penetrating his joints, particularly his right knee, leaving him with a marked limp. Certainly he bore the marks of smallpox into middle age, as did Erasmus Darwin, whose face was pitted with 'the traces of a severe smallpox'.[10]

On 11 November 1744, a year before the Jacobite army passed near the Potteries, Wedgwood was bound for five years as apprentice to his eldest brother. Thomas contracted to teach him 'the Art, Mistery, Occupation or Imployment of Throweing and Handleing', a sign that he was marked down to be a master-potter, and to provide him with board and lodging and clothing, 'Linen and Woollen and all other Necessaries, both in Sickness and in health'.[11] In return he agreed to serve Thomas faithfully, not divulge his 'secrits' or embezzle his goods. And, as was standard, the Indenture dictated his leisure: 'at Cards Dice or any unlawful Games he shall not Play, Taverns or Ale Houses he shall not haunt or frequent, Fornication he shall not Commit – Matrimony he shall not Contract.'

The Churchyard Works, Burslem

The potter's wheel was usually turned by kicking a treadle, and perhaps because of the pain in his knee at fifteen he abandoned hopes of becoming a thrower and turned instead to moulding, design and experiment. He was already deeply interested in chemistry, at least judging by one notebook, annotated

in later years by his secretary Alexander Chisholm as ‘Experiments done before 1750’.[12] This shows that he was reading widely, copying down experiments he had come across, relating not just to pottery but also glass and metalwork and other fields. When his apprenticeship ended in 1749, he worked for his brother for three years and then left to make his own way: perhaps the Churchyard Works was too small to support two partners, or the household was disrupted when Thomas remarried – his first wife had died in 1750. Whatever the reason, Wedgwood now joined Harrison & Alders, a minor pottery in Stoke.

Josiah was too clever and too ambitious to stay with Harrison & Alders for long. In 1754, aged only twenty-four, he obtained a partnership at Fenton Vivian near Stoke, with Thomas Whieldon, eleven years his senior and a pivotal figure in pottery history. Whieldon had begun modestly by making ceramic bases for snuff-boxes for the Birmingham metal trade but was soon employing several journeymen and apprentices (one of whom, in the late 1740s, was Josiah Spode), and now owned a second factory as well as Fenton Hall and its flint mill.[13] Many of the innovations credited to Wedgwood, such as the division of labour, with men employed on different tasks – throwing, turning, handling, decorating, mixing slip – were started by Whieldon. He was the first man in the neighbourhood to rent accommodation to his workers, as Wedgwood did later, and he paid his men well, sometimes adding a shirt or a pair of shoes to make up small bills, all neatly entered in his account books: ‘I am to give him a old pr. stockins, or somthing.’[14] Better still, he was a great pioneer, keen on all technical advances and a leading maker of creamware.

Each year, thousands of crates of pottery were sent down the river Weaver to Liverpool, or the Trent to Hull. Dealers in the Strand and shops across the country advertised their stock, as Mrs Ley did in Birmingham:

> … a choice selection of Staffordshire ware, viz., white cased stone plates and dishes both round and oval, carved sauce boats of various sorts and sizes, Dutch pudding cups, mellons, scalloped shell-shaped flummery and artichoke cups, custard cups, and all other curiosities that are made.[15]

Advertisements for Whieldon’s wares appeared as far away as Boston, New York and Philadelphia.[16] Orders poured in for square sugar boxes and curvaceous ewers, tea-caddies with birds and fruit, dishes with scalloped edges, fat striped teapots and punch-pots and tall pear-shaped coffee-pots. Many were mottled wares with beautiful, semi-transparent coloured glazes; others were a deep, buttery cream, crusted with reliefs of flowers, painted with Oriental scenes or enamelled with pastoral vignettes.

Wedgwood had already won a name for new glazes and designs, and Whieldon encouraged him with a partnership agreement that let him pursue his research without divulging his methods.[17] He worked on new glazes, yellow and green. He experimented with tortoiseshell and marbled ware, where the cream

body was dusted with crystals of metallic oxides such as copper, iron or manganese, which dissolved during the firing to leave streaks of blue, brown and green. He tried new forms of 'Agate', where red, yellow and white clays were wedged together or mixed in the surface slip, and by the time he left, he wrote, 'I had already made an imitation Agate which was esteemed beautiful, and made a considerable improvement.'[18] In early 1759 he began to keep notes of these trials and much later he added a note explaining that 'this suite of experiments' was begun at Fenton Hall:

> … for the improvement of our manufacture of earthenware, which at that time stood in great need of it, the demand for our good decreasing daily, and the trade universally complained of as being bad and in a declining condition.

There follows the first of nearly five thousand carefully recorded trials, carried out over the next thirty-five years.

Although a slump had followed the poor harvests of the early 1750s and the war with France, it was not sales that worried Wedgwood so much as staleness. The low price of white stoneware, he wrote, meant that potters could not pay attention to 'Elegance of Form'; the country was tired of tortoiseshell and even his fine agate fell victim to the weariness with variegated colours. He had to find something new. He was learning all the time and one of his mentors was Warner Edwards, a Shelton potter known for his chemical knowledge, whose 'secret partner' was a local Nonconformist minister. Similarly, Wedgwood apparently took lessons from the Reverend William Willet, the Unitarian minister at Newcastle-under-Lyme, 'a man of great mechanical ingenuity' who married Josiah's youngest sister Catherine in 1754.[19] (Wedgwood's maternal grandfather had himself been a Dissenting minister and this connection would be a central thread all his life.)

He was becoming restless at Whieldon's and only needed a push to make him move on. In 1756 he might have hoped for something from his rich, eccentric aunt Katherine Wedgwood Egerton; heiress to a large property and further enriched by three marriages, Katherine could neither read nor write but she was an extremely shrewd businesswoman. Yet she bequeathed her considerable estate, right down to the featherbed she was lying in, to Josiah's older brother Thomas, apart from small individual legacies, including £10 to Josiah himself. That £10, however small, was one spur to independence. The other was his cousin Sarah – daughter of Richard Wedgwood, his Cheshire merchant uncle. At twenty-two Sally (as Wedgwood always called her) was not beautiful, but striking, tall and slim, with pale skin, reddish hair and grey-green eyes. They had known each other since childhood but she was better educated and far wealthier, and her father was wary, supposedly telling Josiah that he would not consent until he could match Sarah's dowry of £4,000, 'guinea for guinea'.[20]

Wedgwood set out to do this. At the end of 1758 he arranged to employ his cousin Thomas, who was four years his junior and had worked in a porcelain factory at Worcester. On May Day, when Thomas's contract began, Wedgwood rented the Ivy House Works in Burslem from his uncle John of The Big House. When he reached thirty in 1760, he was employing fifteen men and boys and already laying claim to being a master-potter.

Much of his ware used the rich green and yellow glazes he had developed at Whieldon's, now applied to his popular 'greengrocery' in the shape of cauliflowers and pineapples, artichokes and melons. He also made plain creamware, some of which was painted locally or sent to be enamelled by the firm of Rhodes in Leeds. And in the early 1760s he took a more significant step, arranging for his pots to be decorated by the new transfer printing. In this revolutionary process, the craftsmen took prints from engraved copper plates, made on paper or on sheets of glue using ceramic colour, and pressed them on to the glaze. The origins of the technique are disputed but it seems to have been developed at Bow and Chelsea and was taken up by Sadler and Green in Liverpool in the mid-1750s for use on tiles.[21] From 1761 Wedgwood was placing orders here, and from now on he and other potters brought British tables and dressers to vivid life, with flowers and sentimental love scenes, landscapes and exotic birds, monarchs and heroes and emblems.[22]

Earthenware teapot cast in the form of a cauliflower, with green glaze

It was on one of his trips to Liverpool in 1762 that Wedgwood met the man who would become his closest friend and partner. On his way, Wedgwood was forced off the road by a carriage near the Mersey

bridge at Warrington and injured his weak leg in the accident. He was taken to the Golden Lion in Liverpool, where he was treated by the surgeon Matthew Turner, a keen experimental chemist. Soon Turner introduced him to a local friend, Thomas Bentley, a general merchant in the town. Bentley was exactly his age, with similar Nonconformist connections, but he was far more accomplished and confident and could open Wedgwood's eyes to new vistas. He was classically educated, had travelled on the Continent, spoke French and Italian and knew about ancient and Renaissance art; he had an elegant house in Paradise Street and was energetically involved in local life as the Liverpool Trustee for the Dissenting Academy at Warrington, co-founder of the new Octagon Chapel and later of the Public Library and the Academy of Art.[23] Brave in his beliefs, he was also a dogged opponent of the slave trade on which much of Liverpool's new wealth depended.

As soon as he was back in Burslem Wedgwood wrote rapturously to thank Bentley for his kindness, taking the liberty, he said, of addressing him as 'My much esteemed friend'; if Bentley did not think the address too free, he added, 'I shall not care how Quakerish or otherwise antique it may sound, as it perfectly corresponds with the sentiments I wish to continue towards you.'[24] Much of their talk during Wedgwood's convalescence had been about chemistry and he reported that he had since 'found time to make an experiment or two upon the Aether', and was now assaulting Turner with 'a tedious Account of Acids & Alcalies, Precipitation, Saturation &c.'

They talked on other subjects too. Indeed from the start they could discuss everything under the sun: when they met, Bentley was writing on female education, and Wedgwood asked his opinion of Rousseau's *Emile*, published that year. The firm of Bentley and Boardman soon became Wedgwood's Liverpool agents, and in years to come, Bentley would keep Wedgwood up to date with new fashions and artistic taste, as well as wooing wealthy customers.[25] Bentley gave ballast to Wedgwood's mercurial, questing mind – made him slow down and think things through – and his letters were a window on the world: 'The very feel of them, even before the seal is broke, cheers my heart and does me good,' Wedgwood wrote. 'They inspire me with taste, emulation and everything that is necessary for the production of fine things.'[26] (Sarah Wedgwood, not surprisingly, sometimes became impatient as he eyed his mail over the breakfast table.)

Wedgwood's meeting with Bentley and Turner gave him confidence to speak out on poetry and politics as well as pots. Praising James Thomson's poem 'Liberty', he commented, 'Happy would it be for this island, were his three virtues the foundation of British liberty – independent life – integrity in office & a passion for the common weal more strictly adhered to amongst us.'[27] But to create that independent life, Wedgwood looked for guidance not to the men of culture and ideas but to the practical visionaries – like the rising star of Birmingham, the toymaker Matthew Boulton.

Notes – 5 POTS

1 'Burslem in 1750 based on a plan by Enoch Wood', F. Falkner, *The Wood family of Burslem* (1912). Bu the unreliability of Burslem maps of this date, see Lorna Weatherill, *The Pottery Trade and North Staffordshire, 1660–1760* (Manchester, 1971) 155–6.

2 JWe Experiment Book 1759–74, W. E26–19115.

3 See 'The Earliest Entrepreneurs', Young 33–53.

4 JWe Memorandum, 'Pot-works in Burslem about the year 1710–1715' (1776), *SL* 24.

5 Simeon Shaw, *History of the Staffordshire Potteries* (Hanley, 1829) 110–12.

6 Ibid., 97–8.

7 JWe to TB, 3 April 1765, W. E25–18072.

8 Meteyard I 200.

9 Ibid., 104–5. See also Enoch Wood, quoted in Reilly 5.

10 Seward 2.

11 Indenture, Wedgwood Archives, signed by his mother, and his uncles Abner Wedgwood and Samuel Astbury; Reilly 3–4.

12 JWe Notebook, *c*.1749, W. E26–19115.

13 Reilly 18.

14 Thomas Whieldon's notebook, Weatherill, *The Pottery Trade*, 104–8.

15 *Aris's Birmingham Gazette*, 17 June 1754.

16 Weatherill, *The Pottery Trade*, 87.

17 For Wedgwood's technical experiments, see N. McKendrick, 'The role of science in the Industrial Revolution, a study of Josiah Wedgwood as a scientist and industrial chemist', in M. Teich and R. Young (eds), *Changing Perspectives in the History of Science* (Dordrecht, 1973).

18 JWe Experiment Book 1759–74, W. E26–19115.

19 See Lilian Beard, 'Unitarianism in the Potteries from 1812', *Transactions of the Unitarial Historical So* VI (1935–8), 14–16.

20 *Wedgwood Circle* 11.

21 See *Genius* 63–7.

22 See Richards 53–5, and 82, nn. 62–5.

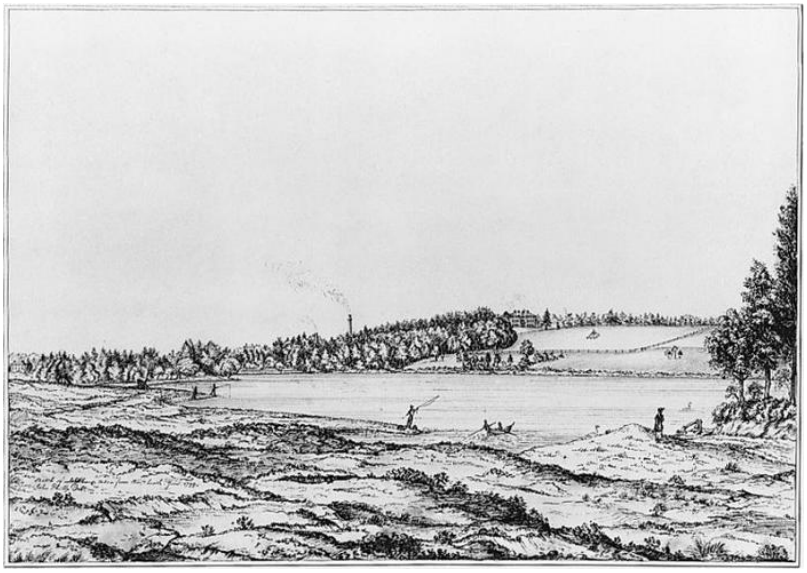
23 See Richard Bentley, *Thomas Bentley* (Guildford, 1927).

24 JWe to TB, 15 May 1762, W. E25–18048.

25 See Neil McKendrick, 'Josiah Wedgwood and Thomas Bentley: an Inventor–Entrepreneur Partnership i Industrial Revolution', *Transactions of the Royal Historical Society*, 5th ser., XIV (1960), 1–33, although this occasionally overstates Bentley's role.

26 JWe to TB, 16 September 1769, W. E25–18254.

27 JWe to TB, 26 October 1762, W. E25–18049.



Soho from the Heath, by John Phillp, 1790

6 : HEADING FOR SOHO

Boulton always signed his business letters ‘from father and self’ but by 1757 it was already clear who was the driving force. That year his father retired to the relative peace of Sarehold Farm, leased from relations of Baskerville’s companion Sarah Eaves. Their trade was expanding and Boulton now paid rates for workshops on both sides of Slaney Street behind the old house on Snow Hill. He was fired by each new invention, quick to snap it up. At the start of this year, when he placed an order with Benjamin Huntsman, the Sheffield inventor of fine ‘crucible steel’ so perfect for watch springs, pendulums and metal-cutting tools, he added, ‘I hope thy Philosophic Spirit still laboureth within thee, and may it soon bring forth Fruit useful to mankind, but more particularly to thyself, is the sincere wish of Thy Obliged Friend.’[1]

His own philosophic spirit was unbounded. From the start of the 1750s he kept a notebook, its headings ranging widely: notes on precipitation; on the temperatures of different liquids; the freezing and boiling points of mercury; the expansion and contraction of different types of cords, flax and wire and their different behaviour when wet or dry; on people’s pulse rates at different ages; on sunbeams; on the movements of the planets; on how to make phosphorus and sealing wax and even ‘To write in a secret manner’ – a recipe for disappearing ink.[2]

Many memoranda jotted down on odd scraps of paper were concerned with his own trade, with entries on alloying copper and silver andhardening tin, or the recipe for semilor, a gold-hued metal finish used in button gilding.[3] He was also searching for accurate measurements of heat, a universal problem at the time. Thermometers were the trickiest of all instruments and up to now most people had been content

to note changes in temperature without quantifying them, but in the 1720s and 1730s three new systems were put forward, those of Réaumur, Fahrenheit and Celsius. Boulton tested both Réaumur's and 'Ferenheath's' scales, and tried making his own thermometers. In 1762 Darwin told him jokingly that a mutual friend, Dr Petit, 'desires I would use my Interest with your Worship, to procure him a Thermometer or two – now why won't you sell these Thermometers, for I want one also myself'.[4]

But Boulton was interested in such things for their own sake as well as their commercial value. As Keir wrote after his death:

> Mr B is proof of how much scientific knowledge may be acquired without much regular study, by means of a quick & just apprehension, much practical application, and nice mechanical feelings. He had very correct notions of the several branches of natural philosophy, was master of every metallic art, & possessed all the chemistry that had any relation to the objects of his various manufactures. Electricity and astronomy were at one time among his favourite amusements.[5]

Like Watt in Glasgow and Wedgwood in Liverpool, he learned most of all through friendship, as Keir acknowledged: 'It cannot be doubted that he was indebted for much of his knowledge to the best preceptor, the conversation of eminent men.'

Soon Boulton was in close contact with one of these eminent men, the Derby clockmaker John Whitehurst. As young men in their twenties, keen for knowledge and seeking mentors, both Boulton and Darwin learned much about instrumentation and invention from Whitehurst – who seemed impressively old and experienced in 1758, aged forty-five. That January, Whitehurst sent Boulton a bill for some work, adding a note announcing that he had finally built a pyrometer that pleased him: 'It has all the perfection I could wish for, and will, I think, ascertain the expansion of Metals with more exactness than any machine extant.' He would come over to Birmingham soon, he said, 'and hope to spend one day with you in trying all necessary experiments'.[6] He was full of excitement at all the subjects they were tackling, from barometers and heat expansion to the problems of stopping 'the vibration of bells in chime music'.

Boulton found such experiments irresistible. And in 1758 his hero Franklin – who also knew Whitehurst and had worked on clock design with him – came to Birmingham. The previous year, aged fifty-one, Franklin had settled in London as the agent of the Pennsylvania Assembly and had demonstrated his electrical experiments at the Royal Society. He was now touring the Midlands, partly, he said, 'to recover my health, and partly to improve and increase Acquaintance among Persons of Influence'.[7] Having made his money as a printer in Pennsylvania, he was keen to meet Baskerville, to whose *Virgil* he too had subscribed, and was tracking down his innumerable family connections, including several Birmingham buttonmakers. One was a prosperous master, another a lively old lady

who looked just like his daughter, with ‘exactly the same little blue Birmingham eyes’.[8] All were ‘industrious, ingenious working people and think themselves vastly happy that they live in dear old England’.

Unstuffy and enthusiastic, Franklin had great appetites and varied interests; his inventions included fire-grates and water-closets as well as lightning rods; like Darwin (who admired Franklin greatly) he believed in the virtues of fresh air, advocating flinging wide your casement and baring all to the breezes. In Birmingham, his party dined at different houses and went ‘continually on foot, from one manufactory to another and were highly entertained in seeing all the curious machines and expeditious ways of working’.[9] John Michell had sent a note to Boulton, introducing ‘the best Philosopher of America, whom you are already very well acquainted with though you don’t know him personally’.[10] With infectious excitement, Boulton swept the great man round his friends.

Boulton was now one of the electrical brotherhood. Just after Franklin’s visit, the poet William Shenstone wrote from his nearby estate at the Leasowes, thanking him for introducing them. He also asked if Boulton could ‘procure an electrical apparatus’ for a friend, adding, ‘He wishes it to be such as may effectually exhibit all the common experiments in electricity; & *This* he leaves entirely to your Judgement who are so much better vers’d in it.’[11] Within a month, Shenstone, who swore he had no technical interests, was confessing, ‘I have burnt my fingers with electricity already; having told ye story of Mr Franklyn’s bottling up ye Lightning, till I am thought as great a lyar as a Popish legendary.’[12] Soon he was commissioning gilded pineapple ornaments for his carriage, shoe and knee buckles and ‘enamel’d stars for Horses fore-heads’.[13] Boulton quickly saw that in business his philosophic contacts could, most definitely, be put to good use.

*

But while Boulton’s public reputation was rising he faced grief and anxiety at home. The house at Snow Hill was a sad one: in the early years of the Boultons’ marriage, before 1753, three babies were born, Dorothea, Anne and Maria: all died in infancy and now Mary herself was far from well.[14] She is the silent woman in this male story: we have no picture, no letters, no reminiscences. And in 1759 she vanishes altogether. In August that year she died suddenly and was buried in the family vault at Whittington.

There is no hint as to whether Mary died in childbirth or from a fever, although some suggestive sheets lie among Boulton’s early papers, covered with notes on ‘Hystericks’.[15] One sheet gives the

symptoms, beginning with creeping coldness and continuing to headaches and spasms: ‘Hence it is that Hysterickal Women feel constriction in the throte as if strangled.’ A list of cures ends in a desperate sequence of antiepileptic remedies:

Roots of Peiony, leaves of Lily of the Valley, Seeds of rue, misseltoe of ye Oak, or hazle, Box wood, Spt. of Black Cherry, Spt. of human blood … human Cranium, tooth of Sea Horse, Castoroum, peacocks dung, Camphor & ye Salt & oyl of amber. To recover a person in a fit tobaco smoak, the flowers & spts. of Sal Armoniac is good. Elks Claws is good.

But sea-horses and elk’s claws were hard to find in Birmingham: nothing could help Mary. Before her funeral Boulton wrote a poem to put in the coffin, grasping at formal phrases, praising her sincerity, compassion, duty to her family, and love for him:

If bearing many Children, & enduring many pains & illnesses,
with patience under his Eye,
If preserving fair Virtue around her unpolluted Bed,
If passing through Life without one Black Spot upon her Fame,
If these things can endear a Wife to a Husband
Thou wert dear to me.[16]

He added a prayer for himself and for her. ‘Farewell,’ he ended. ‘Farewell.’ Mary’s ghost is there in the chiselled phrases; forthright, plain-spoken, tender-hearted and stoical. Yet the tone is circumscribed: she is the one who loves to excess, while her sterling qualities only ‘endear’ her to Matthew.

In 1759 his father also died, and from now on, running the business on his own, he became even more ambitious, travelling to London in search of customers for his silver buckles, sword-hilts and snuff-boxes. In December he and his brother John were staying at the George in Aldersgate, ‘a Noisy Hurrying Inn’, preparing their assault on the Quality.[17] Boulton arranged for a friend to present a sword-hilt to Prince Edward, who wore it to the play; the Prince of Wales then ordered one and a delighted Boulton thought he could take some time off and ‘indulge one day Now with some of my Philosophical Friends’.[18] Back in Lichfield Dorothy Robinson was clearly devoted to her handsome widowed son-in-law, to the growing irritation of her own son, Luke. Within months Boulton was writing chatty letters to his ‘dear Mamma’ as if Mary’s death had never happened. On the way back from London, he wrote of how pleased he was at getting to his journey’s end ‘but should feel much more so could I peep through a little hole & see you pert or could by any means be satisfied that you & your Fireside were chearfull & well

… I shall not forget the China or Fiddle Strings or drops or any other commissions.'[19] In the margin of one effusive letter he scrawled, 'excuse my manner of writing, for you know that I write always in that Style which Floats uppermost'.[20]

Even more startling than the buoyant jollity so soon after his wife's death was a new and insistent theme – Mary's younger sister Anne. He begged Anne to write to him in London and when she did his reply showed more than brotherly affection: 'be assured that my Love and friendship for thee is as steady as the very Foundations of the Earth'.[21] A little later she was 'the source of all the real joy & happiness that does or ever will attend thy very sincere & loving Swain, Matt^w· Boulton'. Once he had a goal, Boulton fixed on it, in love as in business. As winter thawed into spring his letters flew faster and his tone grew ever warmer: 'My dear Heart', 'My Dear Charmer', 'My dear Angel'. Obstacles made him only more determined. By chance, among the gossip Darwin had passed on to Polly in 1758 was that 'Lamb pays close addresses to Miss Robinson so that Sudal [a rival suitor] is quite turn'd off.'[22] Yet in early 1760 Boulton was writing to Anne anxiously about this same Sudal, having assured her mother 'that I was very certain you would never have him'.[23]

This spring he was in London with other Birmingham worthies, including Baskerville, giving evidence on behalf of local buckle-makers who were supporting a Bill to prohibit the export of buckle-chapes – the tongue that fastens the buckles to the strap. On 22 April 1760 he appeared before the House of Commons Committee. His stand was entirely self-interested: if the chape-makers continued to export, then foreign buckle-makers would benefit and his own trade would suffer. He was clear and to the point, arguing unashamedly for this ruthless restriction on fellow manufacturers.[24] All the time, though, he was brooding on marriage. He and Anne had a serious problem: under ecclesiastical law (though not common law) marriage with a dead wife's sister was forbidden. Anne was daunted and Matthew feverishly begged her not to torture him, swearing he would be torn to pieces by wolves before his own resolution faded, protesting that he would never live to see her in the arms of another, 'for if I do my brain will be overturned with madness, & I should do some desperate deed'.[25] As ammunition he seized on a recent pamphlet, 'Fry on Marriage', which argued that such a marriage was quite 'fit and convenient being opposed neither to law nor morals'.[26] On 22 April, the very day he was appearing before the Commons Committee, he ordered 180 copies of this tract from a Fleet Street bookseller (shrewdly getting a 50 per cent discount on his massive order). As soon as the chape-makers' Bill was dropped, he rushed back to the Midlands, his bags filled with presents and pamphlets, which he scattered like confetti.

One person, however, spurned his gifts and his tract. As Luke Robinson watched both his sisters and his mother succumb to Boulton's charm, he began, understandably, to fear that all their wealth might be

sucked into Boulton's speculations. And this amounted to quite a sum. By a deed of gift, both Robinson girls stood to inherit £14,000 each from the family estate, and on Mary's death her share had passed to her sister. Anne was now heiress to £28,000 – somewhere between £1½ million and £2 million in today's money. No wonder Luke was suspicious. Dorothy Robinson was now seriously ill and Luke's hostility was fuelled by rumours. 'I find it is told thy Brother,' Boulton wrote, 'that you and I are laying our Heads together to persuade thy Mamma to give all she has from him unto us which is a most Vilinous, Enveyous & Malicious insinuation.'[27] He had to work hard in protesting that his interest in Anne was romantic, not financial. And when her mother died at the end of May his chief ally was lost. Swiftly, he sent Anne to London, where no one who knew them was around to oppose the banns. On 25 June 1760 – witnessed by the clerk and by Boulton's elder sister – they were married at St Mary's Church, among the warehouses and docks of Rotherhithe. A month later came a dressmaker's bill for a white satin négligé, with Persian sleeve linings.[28]

Twenty years after this Richard Lovell Edgeworth found himself in the same situation, hoping to marry his dead wife's sister. He appealed to Boulton, who promptly recommended he read Fry. And if he did decide to go ahead, Boulton added:

> I advise you to say nothing of your intentions but go quickly and snugly to Scotland or some obscure corner in London, suppose Wapping, and there take Lodgings to make yourself a parishioner. When the month is expired and the Law fulfilled, Live and be happy. The propriety of such a marriage is too obvious to men who think for themselves to need my comments … I recommend Silence, Secrecy & Scotland.[29]

After their marriage Boulton and Anne settled in Snow Hill, where he fitted up the house, finding servants and cookmaids and organizing upholsterers, painters and cabinet-makers. Anne took easily to being the wife of a leading manufacturer, ordering striped silk gowns, dresses of Italian crêpe and black silk petticoats.[30] Like her husband, she made good use of credit, staving off this bill for five years.

Boulton had need of credit. The 1750s had been fruitful for trade: Britain's population was increasing and, with rising markets at home and in the colonies, the economy started to flourish. The towns grew and spread. Old market towns and cathedral cities such as Lichfield, with their assemblies and concerts and race-meetings, were rivalled by upstarts such as Birmingham. There was ample work for builders and decorators and furnishers, and the windows of the shops were crammed with goods. For the first time people were buying on impulse, eager to be ahead of fashion. In the newspapers advertisements blossomed like flowers for china and silver, clothes and toys, while exotic goods from the colonies now came within reach of all but the poor – silk, coffee, tobacco and tea. Stairs were carpeted for the first time and instead of looking to Turkey and France, purchasers could simply buy from the new English workshops at Wilton and Kidderminster.

The toy-makers thrived in this climate of consumption, providing everything from buttons and snuff-boxes down to the tiniest hooks for pinning jewellery to dresses, bonnets and wigs. And while the quality of its goods was often questioned, Birmingham was already known for its efficiency and cheapness. In 1759, the leading manufacturers, John Taylor and Samuel Garbett, told Parliament that 20,000 people worked in the toy trade in Birmingham and the surrounding districts. The annual output of the trade could be valued at £600,000, of which five-sixths was exported. This was a cosmopolitan business, alert to fashion and design. The town already had 'two or three drawing schools for the instruction of youth in the arts of designing and drawing', Taylor said, where 'thirty or forty Frenchemen and Germans' were working.[31]

Taylor was a role model for budding manufacturers. A real pioneer, he had broken with the old practice of 'putting-out' work, whereby a manufacturer received an order and then delegated the work to different craftsmen – to one man who made the button 'shells', another who made the thread rings, a third who made the decorated tops. Instead he had set up a 'factory', not a huge building on one site, but a system of linked, specialized workshops, and was already employing five hundred people. In 1765 he would join with Charles Lloyd, another rich local manufacturer, in founding the Birmingham Bank, which funded many local projects and became the ancestor of Lloyds Bank.

For old-established merchants such as Taylor and for young bucks such as Boulton, these were promising times. Taxes were minimal; trade drove prosperity, and commerce became a badge of patriotism. In particular the old trading war with France revived sharply in the reaction against all things Catholic and French after the '45. And while France held the lead in luxury goods, Britain was showing the way in new machines and technologies. Increasingly, French attention was concentrated on acquiring these – the French Government declaring openly that it was foolish to waste time reinventing what had already been discovered across the Channel.[32] In Britain patriotic clubs sprang up, such as the Society for the Promotion of Arts, Manufactures and Commerce, founded in 1754, which gave prizes and premiums for designs, inventions and improvements.[33]

Even when trade plummeted at the start of the Seven Years War in 1756, Boulton's business had kept growing. His letter books were packed with orders and his evidence to Parliament in 1759 already showed a knowledge of the trade in Holland, Spain and Portugal. He shared the buoyant mood of the nation at large, dazzled by the victories of this year – Pitt's *annus mirabilis*. In India Clive had driven the French down the Coromandel Coast; in the Caribbean British gains included the rich sugar island of Guadeloupe; at sea the French fleets were routed and Britain controlled the Mediterranean; in North America the fortresses on the Great Lakes were finally taken, and Wolfe's daring, fatal attack on Quebec secured the conquest of French Canada. When George II died in October 1760 and the eighteen-year-old

George III took the throne – the first Hanoverian monarch to be born here and to speak English as his first language – patriotic fervour knew no bounds. Huge crowds welcomed his bride, the young Charlotte of Mecklenburg, and cheered the couple at their coronation. Briefly, helped by a fine summer with good harvests and orchards heavy with fruit, the nation was at ease: the moment felt right for new projects, new adventures.

Armed with the security of Anne's money and his own inheritance from his father, Boulton made plans. The workshop and warehouse on Snow Hill were too small and he dreamed of a site big enough to have stores of raw materials, drawing and design rooms, workshops for all stages and products, and a warehouse for finished goods. He also wanted a mill to drive machines for basic operations such as rolling and polishing and possibly lathe-turning. He got in touch with the engineer John Smeaton, an expert on watermills, and began to look for a mill of his own. Soon he approached Edward Ruston and John Eaves who held a ninety-nine-year lease on thirteen acres at Handsworth, a mile and a half north of Birmingham, just over the Staffordshire border. Their plot ran down a steep slope to the valley below, and by making a half-mile 'cut' and damming the Hockley Brook as it tumbled downhill, they had created a wide millpond, with a steep drop for the water to rush down to power their new Soho Mill. Meanwhile, on the hilltop, they replaced an old cottage with the new Soho House. In 1761 Boulton bought the lease and all the buildings for £1,000 – just about what they had spent on the improvements alone.

In the past Soho had been no more than a scrubby heath covered with heather and gorse, with nothing but rabbit warrens and the old warrener's hut. But although Boulton always romanticized his venture as creating wealth out of a desert, this waste was common land. Even though most of the Soho site was already enclosed, and his own enclosures took in only a relatively small amount of common, this could still be seen as robbing the poor of their rights. In his sixties, writing with the careless intolerance of a proud merchant prince, he dismissed this as nonsense:

> I speak from experience; for I founded my manufactory upon one of the most barren commons in England, where there existed but a few miserable huts filled with idle beggarly people, who by the help of the common land and a little thieving made shift to live without working. The scene is now entirely changed. I have employed a thousand men, women and children, in my aforesaid manufactory, for nearly thirty years past.[34]

The tumbledown cottages had gone, and the area now boasted 'hundreds of clean comfortable cheerful houses'.

This was true, but it was also a classic justification, used by a whole class. The sweeping change from the old rural economy to the 'wage-slave' economy demanded a certain iron in the blood and in 1761 Boulton firmly closed his ears to any disquiet. In February, apologizing for delay in fulfilling an

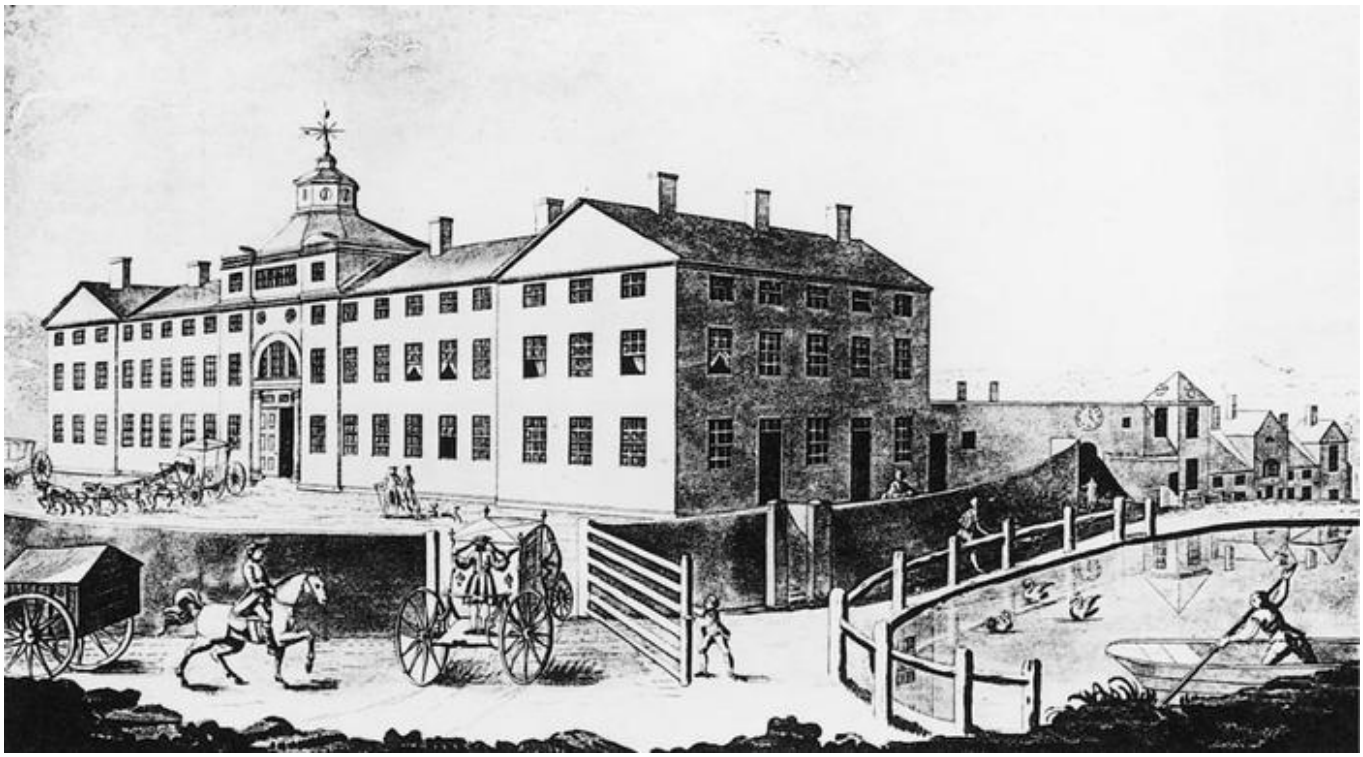
order, he simply explained to the London merchant Timothy Hollis that he had just bought 'the most convenient water-mill in England for my business, which I shall not work before Lady day'.[35] When it was working it would help him to send some new patterns 'upon such terms as I presume will greatly increase our dealings'.

He set about finishing the house, so that his mother and sister Mary could move in. Then he laid out a kitchen garden and plantation of firs and built a warehouse, workshops and workmen's dwellings.[36] Most of his energy, however, went on the mill itself, which he thought inefficient and promptly demolished and rebuilt.[37] The work dragged on into the winter when he built his own brick kiln and dug a clay mine, planning to make bricks for the work in the spring and sell the surplus. All this time he still kept his house and workshops on Snow Hill, rushing between there and Soho, and as the new year came he acknowledged that he needed help. In the icy January of 1762, on a business trip to London, he was approached by John Fothergill, a Russian-born Birmingham merchant who had just separated from his employer; the partnership agreement was signed on Midsummer Day and Fothergill replaced Boulton's sister and mother in Soho House.[38]

Fothergill had been apprentice to a cousin in Konigsberg and his mercantile experience on the Continent proved invaluable, but he was a cautious man and, unlike his partner, tended to worry about money. Even before the partnership began he wrote from London to warn Boulton of the cut-throat competition. One jeweller said that Taylor and others had already been down 'like so many wolves for orders', offering him 'any encouragement he would accept of for the sake of a little business'.[39] But Boulton was sure he could beat the pack. Although several large workshops were started in Birmingham around this time, making light metal and japanned wares, in terms of innovation Soho led the way: within two years Boulton introduced fusion-plating or 'Sheffield plate' and remained its sole maker in the district for many years. Finance, however, was always the problem. He operated on a knife edge, pouring all funds back into the business and rarely having cash in hand. This was typical of the era, where the credit chain ran from manufacturers buying raw materials to wholesalers and exporters and retailers and sometimes even labourers; many rich merchants, like Taylor and Lloyd, moved gradually into banking.

To build up the business at the new Soho site Boulton needed still more cash. And once again it came through his wife. In September 1764, having suffered delirium and fits, her brother Luke Robinson died. Immediately there was a row about his will. A tattered notebook is filled with depositions of local people, among them his doctor – none other than Erasmus Darwin – who found Luke's 'pulse, body & mind' so agitated by the anxiety that Darwin 'was almost in a passion with his servants for suffering him to be disturbed'.[40] But the will was confirmed, and on Luke's death Anne inherited the whole Robinson

estate. Almost at once Boulton began siphoning his in-laws' old farm-based wealth straight into his factory. With this security he could raise yet more funds: soon Baskerville arranged a hefty loan of £3,500 (later increased to £10,000) from the London publisher Jacob Tonson.



Soho Manufactory

As soon as the money was secured, or promised, Boulton decided to build a new warehouse and workshops. Everything was done on a grand scale. The warehouse, which was known as 'the principal building', was nineteen bays wide, on three floors, with a Palladian front, a clock tower and a carriage drive worthy of a stately home. Clerks and managers and their families lived on the upper floors, and on each side were wings enclosing a great yard. The partners had their own rolling-mill below this yard, and later, when their needs increased, they rented another at Holford Mill, a couple of miles away on the river Tame.[41] The production was arranged in different workshops according to the objects made or the techniques needed.[42]

As soon as Boulton's factory opened it was cried up as a marvel of the new industrial scene. In 1765 Fothergill estimated that it could hold four hundred workers – although Boulton, in flamboyant mood, upped this to seven or eight hundred.[43] Money was invested in every possible machine for working metals and alloys, stone and glass, enamel and tortoiseshell. But if the works were magnificent, so were the bills. The cost of the principal building turned out to be £10,000 instead of the estimated £2,000: however high the turnover, it could never compensate for these costly fixed assets – a difficulty made worse by the partners' hopeless inability to cost and price their products properly.[44] By 1764, Boulton &

Fothergill had losses of over £3,000. Both partners poured more money in and their constant borrowing built up a huge 'Bill Account', a major headache for years. And as the loans piled up so did the plaintive appeals from creditors: Boulton became a dab hand at persuasive, Micawberish letters.

Gradually he brought all the production under one roof. He had never really intended this, he said later, but the out-work across Birmingham was making his clerks despair and at the Christmas stock-taking in 1765, 'all our assistants declared that it was impossable almost to guard against the Losses we were so exposed to by haveing our patterns goods & materials scattered about in so many different Streets & places'.[45] He also felt that the partners had to trust their workmen more than was prudent '& therby were obliged to give em greater prices than we ought or should do if it was more under our Eyes & immediate management'.

He now decided to move to Soho House himself, ousting Fothergill, who was far from pleased at the announcement that he would be more useful overseeing the warehouse in town, meeting foreign agents and taking orders. Boulton, who was something of a man for lists, numbered his reasons indignantly over a sheaf of pages: 'As Fothergill is not of the least use in the Manufactory, if he will not live near a warehouse in Town Query of what use will he be?' (He had not even, Boulton argued, put 'one load of muck' on the garden.) By contrast, Soho needed 'a master of some resolution some knowledge of human nature & great skill & ingenuity in all mechanick arts both in theory & practice'.[46] He must live on the spot, since issues would arise hourly. But where would they find such a master?

> shall we find him among the unlettered Birmingham handycraft men or shall we find him amongst the speculative theorists whose knowledge have been drawn from Books no neither will do: but he must be one that is both … if B hath any claim to that character let it be him.

Having thoroughly convinced himself that he was a man of both books and business and therefore the only person fit to run things, Boulton never looked back. But the wonderful 'manufactory', which looked so fine, nearly ruined both partners: the search for new sources of income, new contacts and new ideas became even more vital.

Notes – 6 HEADING FOR SOHO

1 MB to Benjamin Huntsman, 19 January 1757, MBP Letter Book 1.

2 Notebook 1, 1751 (later dates inside), MBP 376.

3 I am indebted to Shena Mason for this detail.

4 ED to MB, [30? October 1762].

5 JK Memorandum 1809, MBP 290/112.

6 MBP 366/1. See the memoir prefacing Whitehurst *Works*; also W. Douglas White, 'The Whitehurst fam *Derbyshire Miscellany Supplement*, March 1958.

7 BF to Joseph Galloway, 6 September 1758, *Franklin Papers* VIII 146.

8 BF to Deborah Franklin, 6 September 1758, ibid.

9 Ibid.

10 John Michell to MB, 5 July 1758; Schofield 24.

11 William Shenstone to MB, 19 July 1758, Marjorie Williams (ed.), *The Letters of William Shenstone* (Ox 1939) 484.

12 Ibid., 489.

13 Ibid., 490–93.

14 Since Matthew paid tribute to Mary 'bearing many children', there may have been more who died at bir twins as in her own family. See MBP 252/60, Dorothy Robinson's Memoranda, 'account of my children': twins, 1725 (John, d.1728, and one stillborn); twins, 1727 (Mary, and one stillborn); son, 1728 (stillborn); twins, 1731 (Luke, and William, d.8 weeks); daughter, 1733 (Anne).

15 Notes, MBP 290/6.

16 'Upon seeing the Corps of my Dear Wife many Excellent Qualitys of Hers arose to my Mind which I co not then forbare acknowledging Extempory with my pen & depositing it in her Coffin', MBP 291/72.

17 MB to Dorothy Robinson, n.d., MBP 252/62. The letters in MBP 252 and 279 are undated, but the sequ can be established from internal evidence.

18 MB to AR, n.d., MPB 279/8.

19 MB to Dorothy Robinson, n.d., MBP 252/62.

20 MB to Dorothy Robinson, n.d., MBP 252/61. For his irreverence, see MBP 279/4 on offending Mr Bark casual jokes about working on a Sunday.

21 MB to AR, n.d. [December 1759, not 'April 1763' as marked], MBP 279/8.

22 ED to MD, 12–13 June 1759, DAR 227: 1.17.

23 MB to AR, n.d., MBP 279/4.

24 *Journal of the House of Commons* XXVIII (1757–61) 785–901.

25 MB to AR, n.d., MBP 252/8.

26 John Fry, *The case of marriage between near kindred* (1756), published at Boyle's Head in Fleet Street. Boulton's order is dated 22 April 1760: Dickinson *Boulton* 34–5.

27 MB to AR, n.d., MBP 279/9.

28 Dressmaker's bill, Elizabeth and Hannah Concher, 17 July 1760. Soho House.

29 MB to RLE, 20 November 1780 (MBP 143, Letter Book K, 58); and RLE to MB, 2 October 1780 (MBI /101).

30 Dressmaker's bill, 14 May 1763; paid 28 September 1768. Soho House.

31 John Taylor, testimony to House of Commons, 1759, quoted in *Genius* 100.

32 See Harris 114.

33 See D. G. C. Allan, *William Shipley: Founder of the Royal Society of Arts: A Biography with Document* (1968) 169–88.

34 MB to Lord Hawkesbury, 17 April 1790, MBP 237.

35 MB to Timothy Hollis, 3 February 1761, Schofield 26.

36 His first architect was Joseph Pickford (who also built a house for Whitehurst), Craven 65.

37 Notes, MBP 308/9.

38 See E. Robinson, 'Boulton and Fothergill 1762–68 and the Birmingham Export of hardware', *University Birmingham Historical Journal* VII, no. 1 (1959). The partners would share profits equally after receiving interest on the amount invested. Boulton's capital investment was £6,206 17s 9d, including buildings, tools and materials; Fothergill's £5,394 16s 0d.

39 JF to MB, 7 May 1762, *Ormolu* 10.

40 Robinson notebook, 31 August 1764, MBP 252/68. The dispute centred on a codicil signed with his mar leaving a farm to cousins if Anne should die without issue.

41 Kenneth Quickenden, 'Boulton & Fothergill's Silversmiths', *Silver Society Journal* vii (autumn 1995) 3

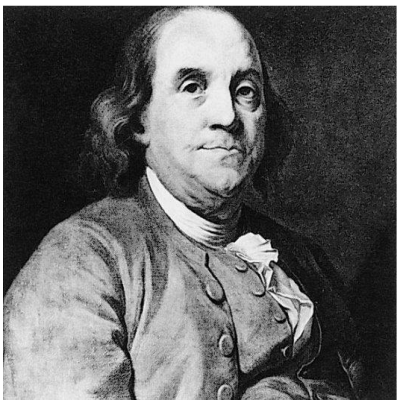
42 Ibid., 348–54: a fascinating picture of workshop organization. For extracts from the Inventory, taken by Scale after Fothergill's death, see *Ormolu* Appendix V, 269–77.

43 JF to John Lewis Baumgartner, 13 July 1765, Letter Book B, 158; MB to James Adam, 1 October 1770, Letter Book D, 29–30. See Quickenden, 'Silversmiths', 347.

44 See Robinson, 'Boulton and Fothergill', and *Ormolu* 15–18, and J. E. Cule, *The Financial History of Matthew Boulton, 1759–1800*, unpublished thesis, University of Birmingham, 1935.

45 Notes on dispute with Fothergill, MBP 308/54.

46 Ibid.



Benjamin Franklin

7 : INGENIOUS PHILOSOPHERS

Even when he was scurrying to sort out his factory, Boulton kept up his experiments. In the late 1750s he had been reading Réaumur on incubating eggs; Louis XV had patronized him and liked helping the chickens escape from their shells. What was good enough for a king would do for him. He tested equipment, commandeered his friends' hens, and noted when the eggs hatched.

I placed my thermometer under Lee's Cocks wing & it rose to 103

I then placed it under his Hens wing & it rose to 103 also

I then placed it under the Wing of Harris's Hen & it rose to 99

but when placed among the Eggs it rose to 96.

June 19th, Monday, 3 o'clock placed my Thermometer in the Heat of Sun wch. rose to 121 at wch. time it stood at 72 which 49 Difference …[1]

Really, it was the thermometers that excited him. But the eggs were good too: the Earl of Hopetown told him that eggs were the most nutritious food of all, 'so that he thinks two with Salt & Bread only are sufficient for a Meal'.[2] Three and a half minutes, Boulton thought, should do the trick.

Once Soho was up and running, he had less time for dabbling with hens. Yet the interest in natural philosophy was like a fever; once caught there was no cure. The 1760s were alive with discoveries and as circles of friends spread in Birmingham and Scotland, Liverpool and Warrington, the sense of individuals working on their own began to give way to a feeling of shared ground. Although Boulton and Wedgwood were brimming with a passion for modern methods, they also knew that innovation depended on exchange. They began to link up with others: with the men of the Dissenting academies, such as Joseph Priestley, and the 'electricians' and idealists who clustered around Benjamin Franklin in London.

These men were interested in experiment, but sometimes for very different reasons. To Joseph Priestley, for example – a member of the Dissenting circle that included Matthew Turner and Thomas Bentley in Liverpool – exploring electricity, magnetism or chemistry meant uncovering the workings of Providence in nature. Such learning opened men's eyes, allowing them to question authority and cast off the chains of the past. Knowledge was a light and a guide, a right and a weapon. And as James Thomson had shown in *The Seasons*, or Mark Akenside in his *Hymn to Science*, the divine and the scientific could share the same language:

> Science! thou fair effusive ray
> From the great source of mental day,
> Free, generous and refined!
> Descend with all thy treasures fraught
> Illumine each bewilder'd thought
> And bless my labouring mind.[3]

Priestley was always in search of this all-illuminating light. Slight and eager, with a long nose, bulging eyes and gentle mouth, he was a comical figure at first glance. He had a disconcertingly lopsided face so that his two profiles looked like two different people; he walked with 'a kind of disjointed, bird-like trot'; he talked non-stop at a rattling speed, the flow chopped into jerky waves by a terrible stammer. (He eventually tamed this by reading 'very loud and very slow every day'.[4])

In 1762 Priestley was teaching at the Academy on the banks of the Mersey at Warrington. 'I bless God,' he once stoutly declared, 'that I was born a dissenter, not manacled by the chains of so debasing a system as that of the Church of England, and that I was not educated at Oxford or Cambridge.'[5] Ironically, the Nonconformists' exclusion from the old universities, where the classics-based courses had hardly changed since Tudor times, was a great spur to British culture. Many Dissenters went to Europe or to Scotland, returning to work in the Dissenting academies, which positively welcomed the new, teaching modern languages, modern history, politics, mathematics and natural philosophy.

Priestley was born in March 1733, the son of a Yorkshire cloth-dresser, and after his mother died when he was six he was brought up by his aunt, an open-minded Presbyterian who welcomed all neighbouring preachers, however heretical, if she thought them 'honest and good men'.[6] Like Josiah Wedgwood and Erasmus Darwin, he played with experiments – his brother Timothy remembered him shutting spiders in bottles to see how long they could live. Also like Wedgwood, he was helped by a local minister, who had studied at Edinburgh and introduced him to Locke, Newton and 'sGravesande.[7] A natural scholar, he studied Latin, Greek and Hebrew and seemed destined for the priesthood, but next turned towards commerce, learning French, German and Italian and acting as translator for a merchant

uncle. As a teenager he suffered consumption and his family was about to send him off to Lisbon, to work in a counting-house and breathe warmer air, but at the critical moment – suddenly frozen by visions of physical extinction and spiritual damnation – he swerved back to the idea of medicine or the ministry and enrolled at Daventry Academy. His sense of doom vanished in this liberal school, where work was sweetened by fun; blind man's buff, kissing and skating, bowling and singing, and flirtation with 'the cuddliest creature I ever beheld'.[8]

He arrived in Warrington in 1761 after a first, miserable, ill-paid job at Needham Market in Suffolk (where he was virtually ostracized as a 'furious unbeliever'), and then four happier years as minister at Nantwich in the Cheshire salt district. Here he founded a successful school, creating a lively new curriculum for girls as well as boys and sneaking in a science course which enabled him to 'purchase a few books, and some philosophical instruments, as a small airpump, an electrical machine, &c.'[9] He taught his older students to care for these and to entertain their parents and friends with experiments, with the result, he confessed, that 'I considerably extended the reputation of my school: though I had no other object originally than gratifying my own taste'.

In Warrington it was still easier to gratify these tastes. The atmosphere was lively and progressive, and the school was patronized by the local iron-masters, glass-makers, linen-weavers and rich Merseyside merchants. He made many friends: the rector John Seddon; the former student Thomas Percival, a doctor and campaigner for public health; and John Aikin, the theological tutor. The Aikins were a prime example of the scientific and literary families found everywhere in Dissenting circles: their son John became a physician, while their daughter Anna Laetitia won fame as a poet under her married name of Barbauld. In later years her writings for children became standard fare for a whole generation, but in 1760 she was a slender, witty young woman with startling blue eyes and, although there were no official women students, 'we have a fine knot of lassies', she told a friend, 'as merry, blithe and gay as you could wish; and very smart and clever'.[10]

There were dances, card games and parties, and classes took the form of open discussion. Priestley was obviously a natural teacher – his *Chart of Biography* and *New Chart of History* were popular for decades. He was clear and direct, unless his stammer got the better of him. He asked his students round, lent them his lectures to read at home, and was delighted when they challenged him. 'I do not recollect', wrote one former student,

> that he ever shewed the least displeasure at the strongest objections that were made to what he delivered; but distinctly remember the smile of approbation with which he usually received them, nor did he fail to point out in a

very encouraging manner the ingenuity or force of any remarks that were made, when they merited these characters. His object … was to engage the students to examine and decide for themselves, uninfluenced by the sentiments of any other person.[11]

Priestley's attractiveness came both from his openness to questioning and his deep-held visions of a better future. Growing up in a Calvinist household he had been terrified by ideas of predestination, which divided humanity into saved and damned, and he could find no 'sign' that assured him he was not destined for hell – it was now that his stutter began. 'I felt occasionally such distress of mind,' he remembered, 'as it is not in my power to describe, and which I still look back upon with horror.'[12] Slowly, he threw off this grim doctrine and looked for a more rational religion – the start of his later attacks on all dark, tyrannical authority.

One significant step was his reading at Daventry of David Hartley's *Observations on Man, his Frame, his Duty and his Expectations* (1749), a book that also influenced Darwin, Godwin and many others.[13] Hartley, a doctor and the son of an Anglican clergyman, combined some dubious physiology (based on a mechanical theory of the mind) with the ideas of Locke and Hume – that far from being born into original sin, the child's mind was a blank, inscribed through sensation and perception and the association of ideas. At base Hartley hoped to prove that both our 'inner' and social lives were governed by Newtonian laws – a sort of moral push–pull mechanism. Pleasure and pain were the key: attraction to good and sympathy for others created happiness while their rejection caused misery: 'self-interest' was thus synonymous with benevolence. Social change would spring from 'the diffusion of knowledge to all ranks and orders of men, to all nations, kindred, tongues and people', setting humanity on a trajectory, 'which cannot now be stopped, but proceeds ever with an accelerated velocity'.[14]

Whereas Darwin was intrigued by Hartley's physiological ideas of the nervous system, Priestley responded passionately to his missionary view of learning. If people were moulded by circumstances then they could change, become 'perfected' – finally reaching the happiness intended by Providence. This necessitarian confidence resembled that of Hume and Adam Smith, who wrote in his *Theory of Moral Sentiments* that 'The happiness of mankind, as well as of all other rational creatures, seems to have been the original purpose intended by the Author of nature, when he brought them into existence.'[15] In Priestley's mind this goal merged with wider political battles for liberty and reform. The ex-Calvinist was always, in some way, looking for a new millennium: 'The morning is upon us', he wrote, 'and we cannot doubt that the light will increase, and extend itself more and more into the perfect day.'[16]

Priestley confessed that he was a materialist. As he would explain it later, mankind did not consist of two opposing principles of matter and spirit or 'soul'; the mental powers were part of the organic structure of the brain itself. When the body died that was the end. (He did manage to hang on to a belief

in Judgement Day, but declared that the dead were still thoroughly dead; they would be reconstituted only by a process 'derived from the scheme of revelation'.[17]) There was certainly a God, whose plan could be mistily discerned in the workings of the universe, but no 'Holy Spirit' or divine Christ. Yet, if he was a materialist, to Priestley matter itself was far from inert. Not even molecules or atoms were solid or hard. Instead, inspired partly by his work on electricity and partly by the Jesuit theorist Boscovich, he saw matter as made up of points, centres of force in perpetual motion governed by attraction and repulsion – our feeling of 'solidity' was simply resistance to force.[18] In this eighteenth-century prevision of atomic physics, all matter was energy, and thus in some sense spiritual. Religion and politics and science swept together. Around all his experiments and ideas hovered a shimmering aura of transformation.

Sometimes Priestley can sound like Voltaire's Pangloss in his belief that all is for the best. His landlord taught him to play the flute and although he was never any good, he enjoyed it for years, recommending it to all 'studious persons' especially if they had no ear for music, since they would be 'more easily pleased, and be less apt to be offended when the performances they hear are but indifferent'.[19] Life in Warrington did seem to offer all the cards to this eternal optimist. Among his former Nantwich pupils was William Wilkinson, the son of a Wrexham iron-master (he and his brother John would themselves, in time, become the wealthiest ironmasters of the age). They had a younger sister, Mary, now seventeen and one of Anna Laetitia Aikin's close friends among the 'knot of lassies'. In June 1762, just before Priestley's thirtieth birthday, he and Mary were married. Like her fierce-tempered brothers, she spoke her mind, had a penetrating glance and startling smile: she was also well read, generous spirited and a fiendish organizer. With a happy sigh, Priestley admitted that 'greatly excelling in every thing related to household affairs, she entirely relieved me of all concern of that kind', so he could give all his time to his studies and 'other duties of my station'.[20]

These duties apparently embraced long visits to friends, and he often visited Bentley in Paradise Street, sitting up late to talk. Here he met Wedgwood and Turner, and helped to arrange for Turner to teach chemistry and anatomy at the Academy (later admitting that he knew almost no chemistry before he went to Turner's lectures). Riding a new wave of enthusiasm he now decided that experimental philosophy needed a written history, to show how the discoveries of nature were linked to social progress. Why shouldn't he write one himself? Or at least begin one – if it was beyond him, others could take it up. With the same confidence that Boulton and Wedgwood applied to business empires, Priestley attacked science – nothing was impossible. He would begin with electricity, about which he knew most. In 1765, he launched himself on London, armed with a letter of introduction from the rector, John Seddon. Here he found a second support network, the 'electricians', who were linked to what Benjamin

Franklin called ‘the Club of Honest Whigs’, a philosophical and political club that met at St Paul’s Coffee-House. Priestley soon became close to several members of this group: Franklin, the veteran electrician William Watson, John Canton, and the mathematician and theologian Richard Price, who took him to the Royal Society. On his return (telling Canton that the visit seemed like ‘a pleasing dream’), he tackled his book.[21]

He tried out disputed experiments before he wrote about them, revving the handles of his electrical machines for hour after hour until he was completely ‘fatigued with the incessant charging of the electrical battery and stunned with the frequent report of the explosion’.[22] His brother Timothy – a carpenter as well as a Calvinist minister – came over from Manchester to help him build equipment, including a large kite for bringing electricity down from thunder clouds. This was six feet wide, said Timothy, but ‘Joseph could put the whole thing in his pocket, for the frame would take to pieces, and he could walk with it as if he had no more in his hands than a fishing rod’.[23] The kite worked fine. Priestley added a clanking chain to earth it (which protected the experimenter but proved fatal to a curious goose), and his London friends sent a thermometer, hygrometer and barometer so that he could make meteorological soundings when he flew it. In June 1766, to help the reception of his book, they proposed his election to the Royal Society.

Priestley pressed on. In September 1767 he moved from Warrington to Leeds, to become minister at Mill-Hill Chapel, and that autumn the *History and Present State of Electricity* was published. Its success was immediate. Priestley’s style was vivid, his account was accurate, his information was fresh. Some of his findings had important consequences, especially his linking of electricity and chemistry when he discovered that charcoal was an excellent conductor. And although mathematics and theory were not his strongest points, he had some shrewd hunches, including his suggestion that electrical attraction worked according to the same law as gravity.[24]

His style was almost as significant as his content. His whole approach sprang from his belief that knowledge could be a democratic weapon to fight obscurantism and tyranny and he put this forcefully in his stirring preface to *Experiments and Observations* in 1772:

> The rapid progress of knowledge, which like the progress of a wave of the sea, or of light from the sun, extends itself not in this way or that way only, but in all directions, will, I doubt not, be the means, under God, of extirpating all terror and prejudice, and of putting an end to all undue and usurped authority in the business of religion as well of science; and all the efforts of the interested friends of corrupt establishments of all kinds, will be ineffectual for their support in this enlightened age.[25]

Priestley chose to write a ‘history’ rather than a treatise because he felt this was a form that showed knowledge forever advancing, telling a broad, onward-driving story that would arouse ‘sublime’

emotions.[26] In writing his book he supplied his own neat drawings and described his own experiments, failures or not. Although he realized the admission of failure was 'less calculated to do an author honour', he hoped, he said, that by showing that no special genius was required for experiments, others might be encouraged to have a go. Even if he looked a fool he could 'contribute more to make other persons philosophers, which is a thing of much more consequence to the public'. And his political agenda also underlay his choice of form. Whereas works of fiction were like mechanical demonstrations 'such as globes and orreries', offering limited models of human ingenuity:

> real history resembles experiments by the air pump, condensing engine and electrical machine which exhibit the operation of nature, and the God of nature himself. The English hierarchy (if there be anything unsound in its constitution) … has equal reason to tremble even at an air-pump, or an electrical machine.[27]

Bentley and Wedgwood shared Priestley's democratic ideals, and Bentley also helped with his experiments, telling Wedgwood at one point that perhaps electricity might be used in decorating pottery. Wedgwood replied that he would be pleased to assist in any way towards rendering Priestley's experiments 'more extensively usefull', but, he teased:

> What daring mortals ye are! to rob the Thunderer of his Bolts, – and for what? – no doubt to blast the oppressors of the poor and needy, or to execute some public piece of justice in the most tremendous and conspicuous manner, that shall make the great ones of the Earth tremble! … But peace to ye mortals! – no harm is intended – Heaven's once dreaded bolt is now called down to amuse your wives and daughters – to decorate your tea-boards and baubles.[28]

He would be happy to work with them, and wished all success to the Doctor's 'delightfull and ingenious researches into the secrets of nature'.

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In Birmingham – with no theological baggage of any kind – Boulton had also been tinkering with electricity. In 1760 he worked with Franklin, describing their efforts as an attempt to seal the Leyden jar to prevent leakage of electrical 'fluid' (although electricity cannot 'leak'), and soon he had two electrical machines and was even receiving enquiries about using electricity to cure rheumatism.[29] Franklin also showed off his pet invention, his famous 'glassychord', a mechanized version of musical glasses[30], and, from time to time, Boulton would supply him with new glass.

Boulton basked in vicarious fame. He met experimenters from across Britain, like the Scottish astronomer James Ferguson, an associate of both Franklin and Whitehurst, who lectured in Birmingham in 1761. The town saw plenty of such lectures – four years later a set of twelve talks covered everything from electricity to lenses, hydraulics to magnets.[31] Almost every second man, it seemed, was working on

new processes or tools, leading to a rash of patents.[32] And the most famous Birmingham scientist–industrialist of them all was Samuel Garbett's partner, John Roebuck. The sulphuric acid plant at Prestonpans was flourishing and in 1760 Roebuck and Garbett opened their ironworks at Carron. Skilled workmen came up from Coalbrookdale, Smeaton designed machinery, and in the first year they melted 1,500 tons of iron. In Birmingham around this time Roebuck and Boulton were working together on thermometers. 'Mr Bolton & I have spent many Pounds in the structure of thermometers but have not yet finished any which we are thoroughly satisfied with,' Roebuck told John Seddon of Warrington Academy (Roebuck was the Birmingham Trustee for the Academy, as Bentley was for Liverpool) 'as soon as ever we finish any we shall remember our promise to yourself and also return your own.'[33]

Another elder statesman among Birmingham experimenters, of course, was Boulton's old friend Baskerville. In 1760 he was fifty-four and Boulton thirty-two, yet they shared a cast of mind that crossed the generations, common to many innovators of the time – Wedgwood is another example. They were 'gaffers', masters who could do all the tasks their men did but were quick to buy in skills they needed. They combined an equal passion for design and techniques, and were imaginative experimenters who persisted and persisted in their drive for perfection.

Perhaps it was because they were self-taught that such men seemed to think that anything they set their heart on was achievable. Baskerville had worked for years, challenging a notoriously conservative craft, before he printed his ground-breaking *Virgil* of 1757. He not only designed new typefaces but cast the type and set it and improved printing-press design, paper-making and ink-making. Many of his experiments had the lateral-thinking quality that marked the Lunar circle – an *ad hoc*, quick readiness to seize the potential of things near to hand, to test the properties of everything they stumbled across, whether it be rocks, metals, acids or tools. Baskerville's lustrous, oily, near-purple ink gained its unique colour from being mixed with 'fine-black', soot collected from the glass-pinchers' and solderers' lamps; his paper's prized glaze came from 'hot-pressing', a mysterious process probably based on a technique from his japanning work.[34]

Despite phases of depression, Baskerville won through. So did another flamboyant pioneer, Henry Clay, an apprentice of Baskerville's who would make a fortune in the 1770s by patenting hard papier mâché, varnished for use in panels, screens, tables, even the roofs of coaches. Other inventors were less lucky. One of Boulton's neighbours in Snow Hill was John Wyatt, the eldest of eight brothers, fathers of a branching dynasty of inventors, sculptors and architects. A mechanical and mathematical genius, Wyatt saw the future – from the 1730s he worked on machines to replace manual labour – but he was absolutely hopeless at business. First he invented a machine to cut files (sold to a Birmingham gunsmith who went bankrupt); then, with Lewis Paul, he developed the first machine for spinning cotton yarn,

using rollers revolving at different speeds. So fast did this run that it devoured the slivers of cotton before the carders could supply them by hand, so Paul went on to invent the first carding machine. With the support of two unlikely projectors, Johnson's friend the bookseller Thomas Warren and Edward Cave of the *Gentleman's Magazine*, they set up a mill in Birmingham and then another in Northampton, employing fifty people – often called the first textile factory. This too failed, although twenty-five years later, in 1769, Richard Arkwright developed their ideas, and made a fortune. Wyatt also designed the first suspension bridge (dismissed as an airy fantasy), drew plans for piped water supplies, ball-bearings and new types of harpoon, and his weighbridge for loaded carts was snapped up by corporations keen to stop fraud at markets. A fraction of the royalties on this would have made him rich. Yet in February 1760, the father of six children, he wrote sadly to Boulton, 'I am on the brink of Ruin … I am sorry to give you this trouble but if I attempt to speak to this purpose the subject chokes me.'[35] Boulton made him his foreman until his death in 1766, and later took on his two sons, John and Charles. But if he proved a generous friend to the family, he also bought a good mind very cheap.

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Outside the smoky rush of Birmingham, Boulton's strongest friendship was still with Darwin. In the calm shade of Lichfield Cathedral, Darwin was prospering. He finished his house, with its airy rooms and curving staircase. He shone in the Seward circle. He took inordinate pride in his sons – Charles was four in 1762, and Erasmus a sturdy three-year-old. The only shadow was Polly's poor health, which he briskly prescribed for. And his reputation as a doctor was still growing. In October 1762 he was confidently advertising his 'Anatomical Lectures' in the *Birmingham Gazette*, the corpse dwindling, presumably, after each gory session.[36] In the same month he sent Boulton Dr Petit's request for some thermometers, adding that Petit 'desires you'll write a Paper and become Member of the R.S.'[37] He himself had written a second paper for the Royal Society's *Transactions* in 1760, about a patient who woke in the night spitting blood. His Boerhaavian diagnosis was that while the man slept his lungs were not 'sufficiently sensible' to drive the circulation, so the blood gathered, putting pressure on the blood vessels. His proposed remedy was simply to wake the patient in the middle of the night, before the tiny veins in his lungs ruptured.[38] On the strength of his two papers Darwin became a Fellow of the Royal Society in 1761. He liked the cachet, but never signed the Charter Book and did not visit London for another twenty years.

Boulton was often in Lichfield and Darwin occasionally came to Birmingham. In 1763 both men may have seen the 'Microcosm' which toured the Midland towns, an embellished orrery which showed the planets, 'with a wonderful variety of Moving Figures, Landscapes, &c, &c'.[39] Darwin watched Boulton'

s business grow with amusement and some envy. In July 1763 he wrote wryly, ‘As you are now become a sober plodding Man of Business, I scarcely dare trouble you to do me a Favour in the nicknachatory, alias philosophical way.’ This time, he needed Boulton’s practical help in making some equipment, having spent all day ‘twisting the necks of Florence-Flasks – in vain!’

> Now if you like Florence Wine I beg leave to make you a present of one Bottle, or two, if the first does not answer, to drink Success to Philosophy and Trade, upon condition that you will procure me one of their Necks to be twisted into a little Hook … it must be truly hermetically seal’d, air-tight, otherwise it will not answer my End at all.[40]

‘I am extremely anxious for this new Play-Thing!’ he added. A little drawing showed exactly what he needed. Using a balance and a glass box, he planned to make a hygrometer to test the humidity of air. Letting his ideas free-wheel, Darwin tossed out theories that foreshadowed discoveries made decades later.[41]

But while Darwin, Boulton, Wedgwood and Priestley made their experiments, built their careers and raised their families, they were always aware of the political swings that could affect their lives. The honeymoon glow of George III’s accession had not lasted: soon people started to count the cost of the French war, while the Whig politicians were dismayed at the new King’s support of their Tory rivals and his reliance on his former tutor, the hated Earl of Bute. In March 1763, Wedgwood was writing excitedly from London about the ferocious debates against Bute’s plan to extend the excise laws – ‘It gives universal disgust here & is the general topic of every Political Club in Town’ – and noting that ‘Mr Wilks ye Author of ye North Briton is gone to France but I cannot learn on what account’.[42] In April Bute resigned as Secretary of State but in the same month his opponent Wilkes was tried for seditious libel for the outspoken article in No. 45 of his paper the *North Briton* and London heaved with chants of ‘Wilkes and Liberty’. By the end of the year Wilkes had fled to France, four years later he would return in triumph as a popular hero, elected MP for Middlesex.

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Although Wilkesite riots filled the papers, work and new discoveries were of even more interest to these slowly converging groups of friends in Liverpool and the Potteries, Birmingham and Lichfield. And in May 1765 a new figure arrived who would become a linchpin of their circle over the next decade. This was the thirty-year-old Scottish doctor William Small, who landed on the doorstep at Soho clutching a letter from Franklin that proclaimed him ‘both an ingenious Philosopher & a most worthy honest man’.[43]

William Small, drawing by unknown artist

For the past seven years Small had been Professor of Natural Philosophy and Mathematics at the College of William and Mary in Williamsburg, Virginia, an oasis of white clapboard in a region of rivers and swamps. His lectures fired a generation of students, among them the future President Thomas Jefferson, who said that meeting Small, with his liberal views and 'happy talent of communication', was 'my great good fortune, and what probably fixed the destinies of my life … and from his conversation I got my first views of the expansion of science & of the system of things in which we are placed'.[44] Not everyone was so impressed. Small had graduated from Marischal College in Aberdeen, where he was a protégé of Dr John Gregory, the friend of Hume, Kames and Black, member of the Royal Society and later the King's physician: it was probably through his influence that Small landed the Williamsburg job, answering an appeal sent through the Bishop of London. He was only twenty-three when he arrived and to the jealous, enclosed faculty, almost entirely composed of Anglican clergymen, he seemed a dangerous young man. His father and brother were Presbyterian ministers: his liberalism was threatening, his ideas were new, his closest friends were students. The whole college was in turmoil with the faculty violently at odds with the Board of Visitors, local gentry who included many of Small's cronies. There were drunken rows and sudden dismissals and, despite his inexperience, he found himself having to teach humanities as well as natural philosophy, and to write a completely new curriculum, replacing rote-learning with lectures, adding *belles-lettres*, ethics and modern languages.[45]

Small lived well here, boosting his salary by working as a physician (and building up a fat bill at the wine merchants), but the backbiting and the climate defeated him. Giving advice to Stephen Hawtrey, a young ex-Etonian about to sail for Williamsburg, he warned of the severe winters and blasting summers, 'for the heat is beyond conception', and advised him to take large linen waistcoats, 'that they mayn't stick to your hide when you perspire', and 'Callico shirts, as they suck up the moisture'.[46] As soon as he

was offered the chance to come to England to buy scientific instruments for the College, he seized it. In late June 1764 he packed his bags. Although the Williamsburg archives show that he did in fact send back the instruments, jokes are still made there about 'that rascal who ran off with our money'. He had also refused to take an oath that would allow peremptory dismissal of professors, and part of his brief in England was to find out if such a power was valid. The rows and politics of Virginia dogged him: 'I find he is rather inclined to party & Opposition', wrote Hawtrey's brother.[47]

Small soon gave up any idea of going back. He spent much of the autumn of 1764 in Edinburgh and Glasgow, before returning to London where he met Benjamin Franklin, whom he had known in America.[48] The London clubs and societies were friendly and welcoming, like the Monday Club at the famous George and Vulture tavern in the City, 'The Club of Honest Whigs'.[49] Franklin and Small later lived a few streets apart in the Charing Cross district, and in January 1765 Franklin took Small to the Royal Society – as he would soon do with Priestley – and introduced him to his friends. For a short time Small toyed with the notion of lecturing to medical students in the capital, but when he heard that a practice was vacant in Birmingham, he realized that this would suit him perfectly. Equipped with an Aberdeen MD fixed by his old friend Dr Gregory, he set off for the Midlands. Within months he was so settled that he turned down an offer to go to work in Russia, and soon he was sharing a house and opening a clinic with John Ash, the chief campaigner for the new Birmingham infirmary. With his easy, dry manner, Small quickly became Boulton's confidant, doctor and unofficial secretary. In December this year, when Baskerville suggested taking Anne to London to meet Boulton, who was on his way home from a trip, he added that Dr Small thought it a good idea: 'He observed that it would be as useful as a Journey to Bath, & the Consequence no doubt a Son & Heir, at which she laughed heartily, & said, then she would not go.'[50]

In many ways Small sounds an ideal doctor yet he often joked that medicine was 'a prison'. His real interests were in mathematics, mechanics and chemistry but, like Darwin, he was reluctant to step forward as a 'crankish' inventor, so he had no empire of his own to guard. He was one of those people of whom everybody becomes increasingly fond, with a charm that is hard to pin down. Slight and delicate, he was completely unthreatening and absolutely open to ideas, able to pick them up and play with them, bringing to bear his own crisp intellect. He carried no heavy philosophical baggage or commercial ambition and was blissfully nonjudgemental. To his 'extensive, various and accurate knowledge', wrote James Keir, he added 'engaging manners, a most exact conduct, a liberality of sentiment, and an enlightened humanity'.[51] In short, he was a perfect addition to any network – unassuming in himself yet accelerating the flow of information between others. Even more valuable, he proved an instinctive diplomat who could ease potential conflicts while somehow managing not to betray confidences.

Franklin – who was keen on encouraging groups that would work together for knowledge and reform, openly or secretly – had been clever to direct his steps here.[52]

Boulton soon introduced him to Darwin. His new closeness to Small involved a slight adjustment to their relationship, but although there is a tinge of hurt pride in one or two of Darwin's letters, the correspondence soon became three way. In March 1766, when Darwin heard a new doctor had arrived in town, he hoped this would bring no uneasiness to

> our ingenious Friend Dr Small, from whom and from you, when I was last at Birmingham, I received Ideas, that for many Days occured to me at the Intervals of the common Business of Life, with inexpressible Pleasure.[53]

This total permeation, the way 'pure' and 'applied' scientific pursuits fused together, characterizes the nature of the group. For Darwin, Boulton and Small – as for Wedgwood, Bentley and Priestley – 'philosophical friendship' would increasingly become one of the great pleasures, not separate from, but inextricably linked with, the common business of life.

Notes – 7 INGENIOUS PHILOSOPHERS

1 MBP 367/1 Notebook 1751–59, 376. Boulton used the English translation of 1750, *The art of hatching a bringing up domestic fowls of all kinds at any time of the year, either by means of the heat of hotbed or that of the common fire*. See also MBP 290/7.

2 Ibid., 21.

3 Mark Akenside, *Hymn to Science* (1744).

4 Priestley *Autobiography* 92.

5 JP, *Familiar Letters Addressed to the Inhabitants of the Town of Birmingham, by the Revd. Mr Madan* (1790–92), Letter 4, 6. See *Enlightenment* 398.

6 Priestley *Autobiography* 71.

7 The Reverend George Haggerstone had studied at Edinburgh under Maclaurin; the books included Isaac Watts's *Logic*, Locke's *Essay on Human Understanding* and 'sGravesande's *Elements of Natural Philosophy* . See Rutt *Life* I 13.

8 Rutt *Life* I 62.

9 Priestley *Autobiography* 85.

10 Anna Laetitia Aikin to Betsy Belsham, quoted in Betsy Rodgers, *A Georgian Chronicle: Mrs Barbauld her Family* (1958) 52.

11 Rutt *Life* I 50.

12 Priestley *Autobiography* 71.

13 See *Enlightenment* 180–83, and Richard C. Allen, *David Hartley on Human Nature* (New York, 1999).

14 Quoted by Roy Porter in 'Matrix of Modernity', Royal Historical Society Gresham Lecture, November 1 reprinted in *History Today*, April 2001, 24–31.

15 Adam Smith, *Theory of Moral Sentiments* (1759), edited by D. D. Raphael and A. L. Macfie (Oxford, 19 166, part III, ch. 5.

16 Joseph Priestley, *History of the Corruptions of Christianity* (1782). See Rutt *Works* IV, Introduction, 7.

17 JP, *Disquisitions relating to Matter and Spirit*, 2nd edn (Birmingham, 1782) I vii.

18 In his *Naturalis Philosophiae Theoria*, the Jesuit Roger Joseph Boscovitch (1711–87) put forward the id forces and '*puncta*'.

19 Priestley *Autobiography* 86.

20 Ibid., 87.

21 JP to John Canton, 14 February 1766; *Scientific Autobiography* 15.

22 Gibbs 27.

23 Ibid., 28.

24 That the force of attraction between two charged bodies varies inversely with the square of the distance between them. Demonstrated by Coulomb in 1784–85.

25 *Experiments and Observations* I xi, in Golinski 81; see 51–90 for Priestley's writing.

26 See Jan Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (Cambridge,1 2–4.

27 *Experiments and Observations* I xi.

28 JWe to TB, 9 October 1766, W. E25–18130.

29 Schofield 28.

30 'Franklin's "glass harmonica" used glass basins of graduated size (and so pitch) half-submerged in wate mounted on a spindle. When the spindle was rotated the glasses revolved and the friction of the player's fingers produced the sound.' Shena Mason, unpublished paper on music at Soho, 1998.

31 Lectures noted in *Aris's Birmingham Gazette* from 1750 include William Griffiths, 1755; Joseph Hornblower, 1757; James Ferguson, 1761 and 1771; John Arden, 1765, 1767 and 1771; John Warltire, annually from 1776 to 1782, 1784 and 1789. See Money 151.

32 See Berg *Manufactures* 295–301. For patents, see Christine McCleod, *Inventing the Industrial Revolutic The English Patent System, 1660–1800* (Cambridge, 1988), and for a nineteenth-century view, see Richard Prosser, *Birmingham Inventors and Inventions* (1881).

33 JR to John Seddon (probably pre-1762), Schofield 29.

34 T. C. Hansard, *Typographia* (1825) 717–18, 311.

35 See J. M. Robinson, *The Wyatts: An Architectural Dynasty* (Oxford, 1979).

36 *Aris's Birmingham Gazette*, 25 October 1762.

37 ED to MB, [30] October 1762.

38 'An uncommon case of a Haemoptysis', *Phil. Trans.* LI (1760) 526–9. For ED's election to the Royal Society, see King-Hele 45–6.

39 *Aris's Birmingham Gazette*, 17 January 1763; Schofield 31.

40 ED to MB, 1 July 1763.

41 King-Hele 50 points out that the ideal gas law is credited to J. A. C. Charles (1787) and partial pressures John Dalton (1801).

42 JWe to TB, 31 March 1763, W. E25–18052.

43 BF to MB, 22 May 1765, MBP 233/119.

44 Merrill D. Perriman (ed.), Thomas Jefferson, *Writings* (New York, 1984), 'Autobiography', 4.

45 See Gillian Hull, 'William Small, 1734–1775:no publication, much influence', Journal of the Royal Soc of Medicine, 90 (February 1997), 102.

46 Small's advice, in a letter from Stephen Hawtrey to New Hawtrey, 26 March 1765. Swem Library Archi College of William and Mary, Williamsburg, Virginia. Herbert Ganter Collection, Box III, Folder 21. Cited by Martin McClaggett, unpublished paper.

47 Ibid.

48 Both were friends of the postmaster William Hunter, and in April 1763 Franklin went to Virginia to dea with Hunter's will, in which he and Small were mentioned.

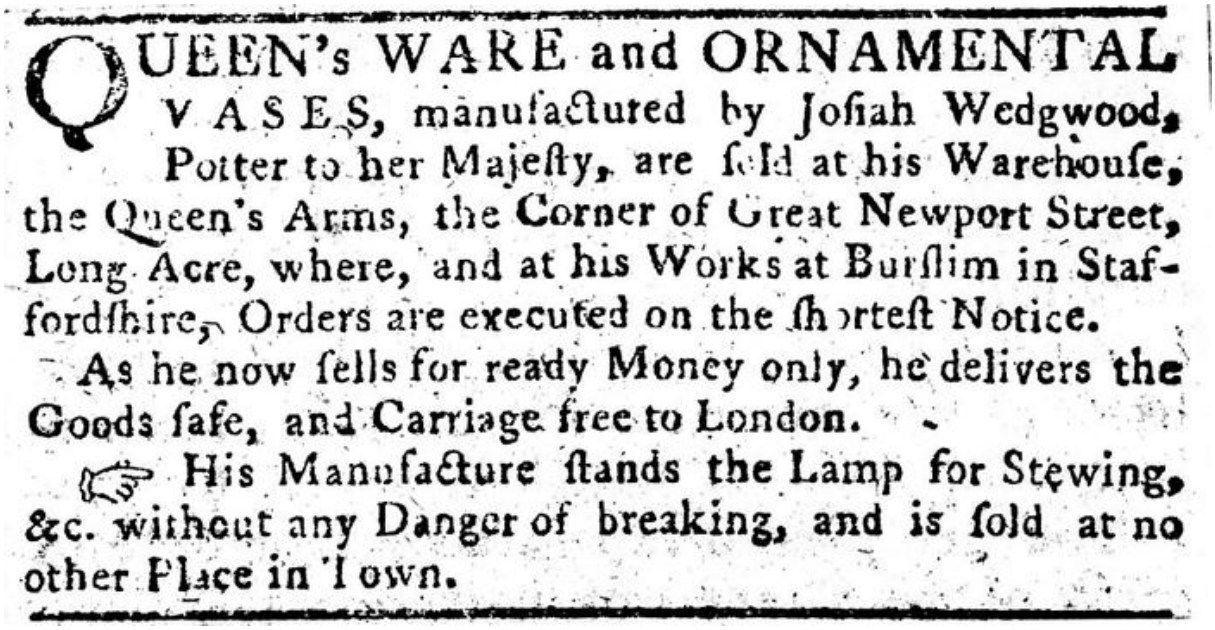
49 For Franklin's connections with these clubs, see Carl van Doren (ed.), *Benjamin Franklin's Autobiographical Writings* (New York, 1945) 141–2, and for Lunar links, see E. Robinson, 'R. E. Raspe, Franklin's "Club of Thirteen" and the Lunar Society', *Annals* II, 2 June 1955.

50 John Baskerville to MB, 9 December 1765, MBP 219/201.

51 Keir *Day* 29–30.

52 Sending envoys and setting up cells was an acknowledged aspect of Franklin's proselytizing technique.

53 ED to MB, 11 March 1766.


QUEEN's WARE and ORNAMENTAL VASES, manufactured by Joſiah Wedgwood, Potter to her Majeſty, are ſold at his Warehouſe, the Queen's Arms, the Corner of Great Newport Street, Long Acre, where, and at his Works at Burſlim in Staffordſhire, Orders are executed on the ſhorteſt Notice.

As he now ſells for ready Money only, he delivers the Goods ſafe, and Carriage free to London.

☞ His Manufacture ſtands the Lamp for Stewing, &c. without any Danger of breaking, and is ſold at no other Place in Town.

Advertisement for Queensware, 1769

8 : REACHING OUT

Soon Wedgwood too joined this fellowship of ingenious philosophers, and like the circles of inventors, his flexible web of commerce also spun out from the Midlands to the wider world. Wedgwood was now a master and a married man: in 1763 he had finally decided it was time to ask his uncle for Sally's hand. He turned to Bentley, whose wife Hannah had died in childbirth in 1759, and who was immensely understanding about Wedgwood's lengthy wrangling with Sally's father. 'You will be sensible how I am mortify'd', Wedgwood wrote,

> when I tell you I have gone through a long series of bargain makeing – of settlements Reversions – Provisions &c: &c: Gone through it did I say: would to Hymen I had. No, I am still in the Attorney's hands, from which I hope it is no harm to pray '*good Lord deliver me*' Miss W: & I are perfectly agreed, & could settle the whole affair in three lines & so many minutes, but our Pappa, over carefull of his Daughter's interest, would by some demands which I cannot comply with, go near to separate us if we were not better determin'd.[1]

When all was settled Josiah persuaded Sally to name the day, 'the blissful day! when she will reward all my faithfull services, & take me to her Arms! to her Nuptial bed! to – Pleasures which I am yet ignorant of'.[2] They were married at the end of January 1764. On their wedding day Wedgwood asked Bentley to 'think it no sin to wash your Philosophic evening pipe with a glass or two extraordinary, to hail your friend & wish him good speed into the realms of Matrimony'.[3] By May he was sending him the best respects of 'two married Lovers, happy as this world can make them'.[4]

Bentley remained his chief adviser, but another was his brother John, nine years older, a dandified, depressive, effervescent character, partner in the London warehousing firm of Wedgwood & Bliss. John belonged to the group that gathered around Ralph Griffiths, a Staffordshire watchmaker turned bookseller who had made a pile from publishing John Cleland's scandalous novel *Fanny Hill* in 1750, and then founded the *Monthly Review*, which he edited for fifty-four years. Writing to John in the early 1760s Wedgwood presented himself meekly as an aspiring provincial potter, pressing his face to the windows of Griffiths's mansion at Turnham Green, envying his brother for being part of 'the meeting & collision of such Geniuses', and wishing for 'a pair of wings, & a learners seat amongst them'.[5]

In fact Wedgwood was learning fast, and his modesty, though genuine, was also a useful tactic for winning allies. But it was true that the provinces were his base: his family, his home and his pottery were always closest to his heart. When his first child, Susannah, was born on 3 January 1765, John sent lobsters from London to celebrate her christening. 'Sukey is a fine sprightly lass', Wedgwood told him, 'and will bear a good deal of dandleing, and you can sing – lulaby Baby, whilst I rock the cradle.'[6] From now on her teething, her schooling, and her mishaps would all figure large in her father's letters. Wedgwood was very much a family man, and this was very much a family business, involving uncles and cousins and brothers. Boulton too used his family connections[7] but Sally Wedgwood took far more interest in the business than Anne Boulton, being a useful guide to the growing female market in giving her opinion on all new designs and learning to read her husband's shorthand to keep up his experiment book. When Sukey was three months old, Wedgwood was deep in experiments, explaining that 'Sally is my chief helpmate in this as well as other things, and that she may not be hurried by having too many *Irons in the fire* as the phrase is I have ordered the spinning wheel into the Lumber room.'[8]

Overseeing firings, designing new models and testing new clay bodies and glazes, Wedgwood turned out his pots. Two years earlier, at the start of 1763, he had leased the Brick House Works in Burslem (known as the Bell House after he installed a bell to call his workers, rather than using the traditional horn). This was an elegant house with a large garden, with several two-storey workshops attached, and several more behind. For the past few years his main effort had been concentrated on improving his cream-coloured ware, aiming at a fine, uniformly coloured body whose glaze would not crack or craze. By 1763 he had developed 'a species of earthenware for the table quite new in its appearance, covered with a rich and brilliant glaze bearing sudden alterations of heat and cold, manufactured with ease and expedition, and consequently cheap having every requisite for the purpose intended'.[9] The new ware was an astonishing advance and was quickly copied throughout the Potteries, especially since Wedgwood asked local potters to supply it to his specification when orders came too fast.

The next step, as soon as he married in 1764, was to put Sally's dowry to use.[10] He rented more workhouses from his uncle and began to take a lead in local affairs. More family members were brought in: in the spring of 1765, when John sold his partnership in the warehouse for a healthy profit, he agreed to become his London agent. Meanwhile, their nephew Tom Byerley was taken on to help with accounts and French correspondence. Tom caused Wedgwood much gnashing of teeth – wanting first to be an author, then a strolling actor, and next sailing for America, where he overspent and got gaoled – but eventually he returned to Burslem, a loyal manager for many years. Beyond the family, waves of contacts rippled out through local patrons, and in 1765 Wedgwood heard to his delight that Lord Gower had talked of his creamware at dinner and had 'said that nothing could exceed them for a fine glaze'.[11]

Word spread. In early 1765, through Lady Chetwynd, a lady-in-waiting with Staffordshire connections, an order came for a tea-set for Queen Charlotte, complete with candlesticks and fruit baskets, 'with a gold ground, and raised flowers upon it in green'.[12] Wedgwood shrugged off the honour by claiming it came only 'because nobody else would undertake it', and he may have been right that the gilding was too costly and difficult for most potters to risk it. But he set to work at once, asking John to buy the gold powder made only by a certain Mr Shenton, to an exotic-sounding recipe in which gold leaf was ground in honey then steeped in water, so that when the honey dissolved the gold was left at the bottom. 'Pray put on *the best suit of Cloaths you ever had in your life*,' he told his brother, 'and take the first opportunity of going to Court.' Wedgwood then went himself, in *his* best clothes: new blue surcoat, scarlet waistcoat with lace, 'a lite brown Dress Bobwig', and a sword bought at the Sign of the Flaming Sword in Great Newport Street.[13]

Making the service was not easy – 'I am just teazed of my life with dilatory, drunken, Idle, worthless workmen,' he fumed – but the royal commission sealed his reputation.[14] He followed it up by sending a box of patterns and vases to the Queen and soon won permission to style himself 'Potter to Her Majesty' while his creamware was granted the name of 'Queen's Ware'. A second service was ordered by the King, to a simpler design which became known as 'the Royal Pattern'. Two years later he was still stunned by his success:

> The demand for this said *Creamcolour*, Alias *Queens Ware*, alias *Ivory* still increases. It is really amazing how rapidly the use of it has spread allmost over the whole Globe, and how universally it is liked. How much of this general use and estimation is owing to the mode of its introduction – and how much to its real utility and beauty? are questions in which we may be a good deal interested for the government of our future Conduct …[15]

If a royal or aristocratic introduction was 'as necessary to the sale of an Article of Luxury as real elegance and beauty', then the manufacturer should bestow as much pains, 'and expence too if necessary', in gaining such patronage as he would on the design itself.

From this time on Wedgwood realized that the future, as far as finding ideas and marketing products went, lay in London. Boulton knew this too, however much he moaned that he still had a hundred and fifty people to see at all corners of town, and was 'heartily tired of London & want sadly to be home, nor shall I have any repose until I am got into my old green bed'.[16] But while Boulton dealt through London agents, Wedgwood was beginning to think of setting up a permanent base there. In August 1765 he told John, 'I have just had the honour of the D. of Marlbro., Ld Gower, Ld Spencer, & others at my works – They have bought some things & seem'd much entertain'd & pleas'd.'[17] His visitors, he added, had been surprised there was no London warehouse to show off his patterns. Potters traditionally sold their wares through the big London dealers, or 'china-men', but some porcelain manufacturers already sold from warehouses in the city and now Wedgwood followed their lead.[18] Within a year he had rented space at 5 Charles Street, off Grosvenor Square, sending his Burslem accountant William Cox down to look after it and taking on a new man, Peter Swift, in Cox's place.

In 1766 he made his cousin Thomas a full partner, responsible for all the 'useful' ware (later defined as 'such vessels as are *made use of at meals*').[19] And he had three other things firmly in mind: to start a grander 'ornamental' line, to fix a partnership with Bentley and to build a new factory. From late 1765 onwards, when Boulton was developing Soho, Wedgwood was negotiating to buy the Ridgehouse Estate, 350 acres lying between the villages of Hanley, Burslem and Newcastle. The stubborn proprietor, Mrs Ashenhurst, grumbled and delayed but Wedgwood persevered, though 'she scolds and huffs away at a hard rate, and seems to be in a good way for making me a hard bargain'.[20]

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A factory alone was not enough, even for the Queen's potter, and Britain alone was not enough of a market. In 1763 the Seven Years War had finally ended, bringing new dominions – Canada, Nova Scotia, Dominica, Grenada and Tobago. And although trade had never stopped during the war, the Continent itself was now more open to merchants and manufacturers. Boulton had long traded with agents in Europe and once his partnership with Fothergill got under way this was one of the areas he developed most keenly. Over the next few years letters flew from Soho not only to London or Sheffield, but to Aix en Provence, Altona, Augsburg, Berlin, Bordeaux, Breslau, Cadiz, Dresden, Frankfurt, Geneva, Ghent, The Hague, Hamburg, Hanover, Holland, Iserlohn, Königsberg, Leghorn, Leipzig, Liège, Lyons, Marseilles, Nancy, Naples, Nuremberg, Orléans, Riga, Rotterdam, Smyrna, Vienna, Wesel.[21] Some of the correspondents have code names, such as 'Montreal', 'Niagara', 'Guadelupe', 'Senegal'; many later ones are in French, and even more in German as so much business was done with the German states. The names of the cities were strung like beads on the thread of Boulton's ambition.

Trade crossed all boundaries and legal restrictions were merely obstacles to be overcome. One Birmingham export salesman sent some typical advice from Lyons:

> The inlaid buttons must be wrapped in Paper Parcels, as if they were Links, and have a card of Links on the outside, and placed in the second row near the bottom of the Cask, about the middle – that is to say, all round near the wood there must be other goods, being as in the Custom House they frequently cut the Casks in one or two places, and take out the Parcels that come first, so you will please to disguise well and place carefully for all your friends in France, the Gilt, mettal, inlaid, and lacquered coat and breast buttons, all of them being prohibited in France …[22]

The cheerful skulduggery was manageable. No rules would block the way.

Boulton made skilful use of his foreign contacts. One of his silent partners was a German merchant; another was a Dutch financier; a third was the founder of the Royal Danish Guinea Company. All these men were sources of information as well as capital.[23] But the plundering of skills went both ways. One Birmingham hardwareman, Michael Alcock, had already skipped the country in 1755, and with French Government support he set up a foundry in La Charité sur Loire. Boulton himself was wooed by offers to establish an iron foundry in Sweden, where he bought much of his steel. He toyed quite seriously with the idea, so much so that the Earl of Halifax, Secretary of State, effectively asked Roebuck to spy on him to find out the truth.[24]

He was far keener, however, on pinching ideas from the Continent than on selling his own. In late November 1765 he was on his way to France, crossing the Channel in a ‘hurricane’ with four shabby Frenchmen and an old Dutch woman and her family. Everyone, beginning with himself, was violently sick. Pale but exhilarated, he smuggled his patterns and samples into Calais ‘by the help of wide breeches and pockets’ and from there he launched himself on a Paris choked by winter frost and fog.[25] His aim was to win orders and spy out new techniques, but also, secretly and illicitly, to get his hands on various Boulton & Fothergill goods held by a recently bankrupted agent. ‘Silence at my being here & concerning Oppenheim answer nothing,’ he warned Anne. He succeeded, in part, but the real gain was his first-hand experience of high French style: ‘Fine painting, very fine sculpture in marble, porphyry & Brass – Water works & curious workmanship without end or number.’[26] He mingled with the English merchants, took coffee with the Ambassador, the Duke of Richmond, and investigated French silvering and brassfounding.

Although he complained half-heartedly that it was taxing to have to dress up, he was in his element. He headed his letters ‘Paris’ in huge swirling copperplate. He enjoyed the flirtations in the Tuileries Gardens, the smart dinners, the playhouse and the singers, and he bought the sweetest and most fashionable French silk for Anne. Paris, he found, was well stocked with Birmingham goods. Much to his delight he even met the hero of the day, ‘that exiled patriot & friend to English Liberty’, John

Wilkes. It all made a great impression. In January the architect William Wyatt told Boulton that the builder had a sketch of his new house at Soho, 'but tells me the manner of it will not please you & thinks your journey to France has alterd your Tast in regard to the alterations there, I did not know that France was very famous in Architecture –'.[27] Calming down, instead of a mock Versailles, Boulton settled for a solid Georgian mansion looking down through spreading parklands to his new works.

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It was good to feel part of Europe and to mingle with high society in London and sell to the court. But Boulton and Wedgwood found it maddening being linked to the ports and the capital only by long, tough journeys. Pack-horse trains and overloaded carriages struggled across quagmires in winter and rock-hard ruts in summer: often a third of Wedgwood's pots were smashed when they reached their destination. turnpike trusts, set up by Acts of Parliament to raise money for repairs, repaid by tolls. A petition for a turnpike in the Potteries in 1763 claimed that there were now a hundred and fifty potteries around Burslem employing seven thousand people, exporting 'in vast quantities' to America, the West Indies and Europe from Bristol and elsewhere, while imported flintstones and West Country clay were brought first by sea and then down the rivers and finally overland by carrier to Burslem.[28] Wedgwood – articulate and charming and coolly persistent – became the potters' spokesman. He rode to countless meetings, soothed nearby turnpike towns who feared new roads would cut their trade, and campaigned in London.

Crucial to his effort, and providing a useful lesson in lobbying, was the support of the local landowner Lord Gower, former MP and Lord of the Admiralty and now a highly placed official at court. Gower ensured the presentation of the turnpike petition to Parliament in 1763, which brought a new road to Burslem. But even the turnpikes were badly maintained. When Arthur Young toured the country in 1770 he filled his notebook with curses:

Newport Pagnall to Bedford so narrow that it was at the peril of our necks to drive on …

Rotheram to Sheffield excruciably bad, very stony and excessively full of holes …

To Lancaster (turnpike) and to Preston (turnpike) and again to Wigan (turnpike) very bad with ruts which measured 4 foot deep and floating with mud only from a wet summer …

From Billericay to Tilbury of all the accursed roads that ever disgraced this Kingdom none can equal this.[29]

There must be a smoother, cheaper way for manufacturers to reach their suppliers and their markets. Surely water was the answer – for all the land-bound makers who sent their goods to the coast, and reached out eagerly to the wide shores beyond.

Notes – 8 REACHING OUT

1 JWe to TB, 9 January 1764, W. E25–18055.

2 JWe to TB, 23 January 1764, W. E25–18056.

3 Ibid.

4 JWe to TB, 28 May 1764, W. E25–18057.

5 JWe to JnWe, 11 March 1765, W. E18071–25.

6 JWe to JnWe, 2 February 1765, W. E25–18059.

7 Zaccheus Walker married Mary Boulton and was a clerk at Soho from 1760 and later accountant; Thom Mynd married Boulton's sister, set up on his own in 1773 but took Soho commissions; John Bentley, a second cousin, whose father Richard also worked for Boulton and Fothergill, went independent in 1776, but continued to supply goods.

8 JWe to TB, 6 March 1765, W. E25–18070.

9 *Arts and Sciences United* 12; see generally, D. Towner, *Creamware* (1978).

10 Supplemented by a £500 loan from her brother John. Josiah C. Wedgwood and Joshua G. E. Wedgwood *Wedgwood Pedigrees* (Kendal, 1925) 174, n. 3; Reilly 36.

11 JWe to JnWe, [summer 1765], *SL* 34.

12 JWe to JnWe, [17 June 1765], W. E25–18073.

13 *Wedgwood Circle* 20.

14 JWe to JnWe, 7 August 1865, W. E25–18089.

15 JWe to TB, [after 8 September 1767], W. E25–18167.

16 MB to AB, February/March 1760, MBP 279/14–20.

17 JWe to JnWe, 7 August 1765, W. E25–18089.

18 See *Genius*, 162–9.

19 JWe to TB, 3 September 1770; *SL* 96.

20 JWe to TB, 26 July 1767, W. E25–18160.

21 See MBP Letter Book A (1757–65). Fothergill spoke both French and German; see Eric Robinson, 'Bou and Fothergill, 1762–82 and the Birmingham export of Hardware', *UBHJ* VII 1 (1959).

22 1763. Shena Mason, talk to the Society of Jewellery Historians, 10 April 2000.

23 See Robinson, 'Boulton and Fothergill', 67–8, and Musson and Robinson 218.

24 See Dickinson *Boulton* 49–50; Musson and Robinson 224–7 and Daniel Solander correspondence, MBP /S2/269: there were strict laws against the emigration of skilled workmen.

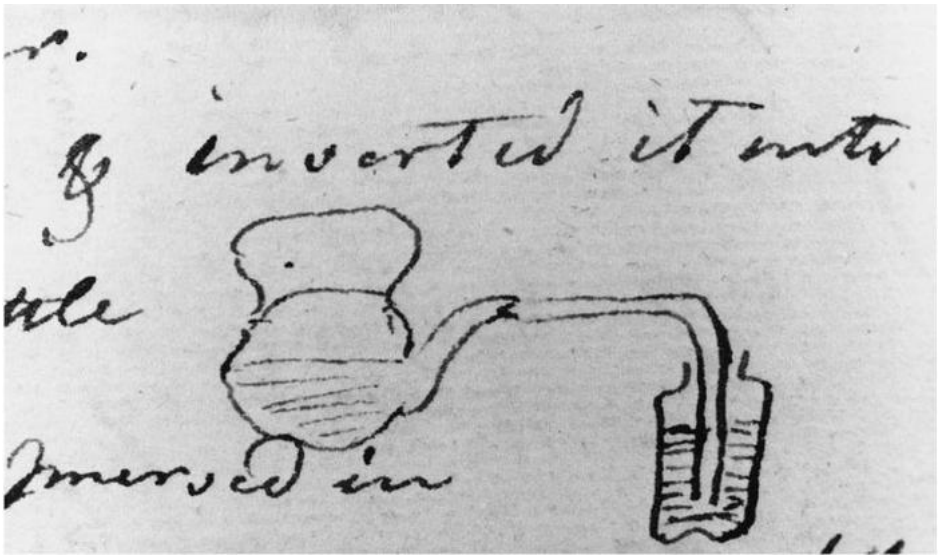
25 MB to AB, 18 November 1765, MBP 279/25.

26 MB to AB, 24 November 1765, MBP 279/27.

27 William Wyatt to MB, 26 January 1766, MBP 375/228.

28 Journal of the House of Commons, 16 February 1763, Petition to parliament for a turnpike from Lawton Stoke; partially quoted in *SL* 24.

29 Arthur Young, 1771, in *English Canals* I (Lingfield, 1967).



Watt's kettle, from a letter to William Small

9 : STEAM

Erasmus Darwin, like Wedgwood, was a man who knew his roads. Many of his best, or wildest, ideas came as he dashed from patient to patient across country: in 1766 he calculated that he travelled ten thousand miles a year, and he once allegedly received a letter simply addressed 'To Doctor Darwin – On the Road'. When the lanes were too narrow, cut deep beneath overhanging trees, he abandoned his carriage and took to his horse, Doctor, returning tired, muddy and stiff, clattering up to the Close in the dusk. Even in his carriage, bumping over ruts and holes and bashing against hedges, his journeys were a bone-shaking business. Not surprisingly he now became immensely keen on designing improvements to carriages, getting local coachbuilders to adapt the wheels, improve the turning circle, soften the jolting of the axles with springs. Sometimes, in a combination of despair and inventive passion, his mind leapt ahead to a different form of transport altogether. 'As I was riding Home yesterday,' he told Boulton one day around 1764, 'I concider'd the Scheme of the fiery Chariot, and the longer I contemplated this favourite Idea, the [more] practicable it appear'd to me.'[1]

Darwin scrawled on, the pages of his long letter spattered with ink from his quill. He wanted to put down his ideas, 'crude and undigested as they appeared to me', to provoke Boulton's own thoughts, but to keep the idea secret from clever inventors such as John Wyatt.

And as I am quite mad of this Scheme, I begg you will not mention it, or shew this paper, to Wyot or any Body.

These things are required. First a Rotatory motion. 2 easyly altering its Direction to any other Direction. 3 To be accelerated, retarded, destroy'd, revived instantly and easyly. 4 the Bulk, Weight and Expence of the Machine as small as possible in proportion to its use.

With admirable clarity, Darwin had laid down the basic principles for any powered vehicle. But should his steam-powered carriage have three wheels or four? And which wheel should the power act on? With four wheels, he could not get over the problem of transferring power in cornering so he opted for three, drawing scratchy diagrams showing a disembodied hand manœuvring a large 'rudder wheel'. He decided he would have a steam-engine with two cylinders and a single boiler. If the steam cocks were opened 'gradually and not with a Jerk' the power could be pretty smooth and adjusting the cocks would allow him to accelerate, brake and stop. 'And if this answers in Practice as it does in theory, the Machine can not fail of Success! Eureka!'

It was far harder to develop this into any machine that could possibly work. He hoped to get rotary power – to make steam turn a wheel – by using a small beam-engine, tilting back and forth to wind and unwind chains around a split back axle. As the beam rose and fell and the cog wheel with the chain moved round, so the wheels would roll forward. If Boulton could tell him how much power he would need, and 'the Expence of coals of a common Fire-engine, and the Weight of Water it draws' he would draw up an estimate, build his machine and take out a patent. He had hoped Boulton would be a partner but he was sceptical and had enough expense anyway at Soho, so Darwin's design fell by the wayside, so to speak. In 1769, the world's first successful steam-carriage was built in France, by Nicolas Cugnot. (Cugnot's car managed only two and a half miles an hour, and even then it had to stop every twenty minutes to get up steam. It was also rather risky: his first model flattened a stone wall and his second overturned dramatically in a narrow Paris street: Cugnot – and his machine – were imprisoned, for fear of more damage.[2])

Although Boulton did not take to the fiery chariot, steam-engines were increasingly on the minds of the Birmingham friends – not as novelties for the road, but as big, thundering beam-engines. At Soho, Boulton's watermill turned his lathes and machines, but summer droughts or work higher upstream often lowered the level and he began to consider using a steam-engine to pump the water back up into the millpond to keep the levels high. He asked Smeaton, Franklin, Small and Darwin for advice. He and Small even built a model and sent it to London for inspection. Darwin was desperate at missing it: 'This Model I am so impatient to see … that I am determined to spend a Day with you, the first vacant day that occurs to me: and shall trust to the Stars for meeting with you at Home.'[3] If Boulton was out, perhaps Anne could be asked to show it to him?

They had corresponded about this for some months, and Darwin's habit of taking nothing for granted had already raised basic questions – did evaporation, for example, take place on the surface of boiling water where you saw the steam, or at the bottom, near the fire? In a flask, you could see bubbles rising, condensed again by the cold water above, 'and their Sides clapping together make that Noise call'd

Simmering'. And when you boiled a kettle, 'what a Quantity of Steam? – is this only at the upper surface? I humbly conceive not.' Although scientifically interesting, this did not get Boulton much further. As if admitting as much Darwin swooped into whimsy. As a man's 'Momentum' depends on the 'vital Steam rising into the Brain from his boiling Blood', so the amount of steam in the steam-engine's boiler, he declared, 'is a Question of the utmost Importance in the Creation of this Animal'.[4]

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Unknown, as yet, to the Midland men, in Scotland James Watt was also working on steam, the great source of energy that would bring him to Birmingham in years to come. His interest had begun in 1757, when his friend John Robison developed a sudden passion for the steam-engine, 'a machine', Watt admitted, of which he was 'very ignorant'.[5] Robison claimed boldly in the *Universal Magazine* that steam could run wheel-carriages and asked Watt to try to make a model to prove it. Their first attempt had two cylinders acting alternately by 'rack motions' on pinions fixed to the wheels – a design very like Darwin's. It did not work, and, 'neither of us having any idea of the true principles of the machine', the scheme was dropped.

Aggravated by this failure, Watt began to chase up the work of the early experimenters, Papin, Savery and Newcomen, but his reading was squeezed into brief leisure hours and his experiments hampered by his need to make a living. By now he too had established his own business. In the summer of 1757 he was appointed Mathematical Instrument Maker to the University and given his own shop in the quadrangle. His mail was now directed to College Green and, anticipating visitors, he asked his father to send not tools but '½ Doz afternoon China tea cups a stone teapot not too small a sugar Box & Slop Bowl as soon as possible'.[6] Over the next two years, notes sped down the Clyde to his father and his brother Jock as he sent instruments they had ordered ('Capt. Rowells glass price 3/–'), asked for the quadrants he was making to be 'approved by some experienced seaman', requested barometer tubes he had left behind and worried about money or crowed about a West Indies order. 'I have a Good deal of things to do,' he wrote, '& can get no lads here to help me.' Did their friends know 'any lads that can file (Brass) tolerably well'?

In 1759, that year of victories, when Wedgwood was moving to the Ivy House and Boulton was buying his land at Soho, Watt opened a shop in Glasgow's Saltmarket, financed by an architect partner, John Craig. Four years later he moved to the Trongate in the centre of the city, selling 'all sorts of mathematical and musical instruments, with variety of Toys and other goods'.[7] One of the best-selling items was his newly invented apparatus for drawing in perspective, based on a pantograph system, cleverly folding away into a pocket-sized box. Apparently he also repaired and made bagpipes, guitars,

fifes and flutes – perhaps even passing some of the latter off as the work of a top French maker.[8] But if his musical instruments showed that Watt sailed near to forgery, they also showed the theoretical scientist at work. 'Tho' we all knew he could not tell one musical note from another,' Robison remembered, to his friends' astonishment Watt agreed to build an organ for a Masonic Lodge in Glasgow.[9] He had already learned a bit from repairing one, which had intrigued and amused him, and he now prepared for this daunting commission by building a small organ for Joseph Black. Starting from scratch, he went back to basics, 'noticing a thousand things that no Organ builder would have dreamt of', such as adjusting the strength of the air-blast to the pipes and improving the regulators. Robison ransacked the university library and Watt immersed himself in the theory of harmonics, especially the new science of tuning keys to 'equal temperament' (an age-old mathematical problem, brilliantly solved in Bach's *Well-Tempered Clavier*, of 1726). Watt's calculations put him ahead of the best mathematicians in Europe and his Masonic organ worked perfectly.

He also bought a share in the Delftfield Pottery Company and soon moved into a house near by. (Wedgwood liked to call him a 'fellow-potter' and in the mid-1760s they were both experimenting in the chemistry of clays and glazes.) By now, Watt's work also had to support others. In July 1764, he had married his lively, down-to-earth cousin, Margaret Miller, always called Peggy. The only person who ever made Watt genuinely light-hearted, Peggy eased his life; his headaches lessened, his panics and depressions calmed. In letter after letter, she told him to look after himself, to keep warm, not to worry, to come home soon, and she kept the shop while he was away, taking orders and dealing with clients. Their first son, John, born in 1765, died in infancy, but he was quickly followed by two healthy children, Margaret and James.

Watt's family made him even more nervous of risking a sound income for a life of experiment. While Boulton, Wedgwood and Priestley snapped up opportunities, everything Watt did seemed agonizingly slow. Before and after his marriage he continued to brood on steam. Around 1761 he got hold of a Papin 'digester' – a round pot with a narrow valve in the neck through which steam burst at terrific pressure, like a sort of primitive pressure cooker. To test this he fixed an ordinary apothecary's syringe to the valve, and put a little piston inside it with a rod pointing out of the top, on which he balanced some weights. Between digester and syringe he fitted a steam cock which he could turn so that the steam either filled the syringe or escaped. This Heath-Robinson contraption worked devastatingly well. When the steam whooshed in, his tiny piston was forced up the syringe so hard that it could lift a weight of fifteen pounds.

The experiment was simple and dramatic – almost too dramatic, making Watt afraid of bursting the boiler. After this he put his inquiries into the expansive power of steam aside and refused to look at it

again. (Half a century later it would be exploited by the Cornishman Richard Trevithick, who built high-pressure engines whose booming, cracking exhaust could be heard five miles away.) Watt was often overly cautious, and it is interesting in this respect that, unlike Boulton, Darwin and Priestley, he was never very interested in electricity. One feels that perhaps it was too sudden and explosive for him – he wanted to harness the simmer, not the lightning.

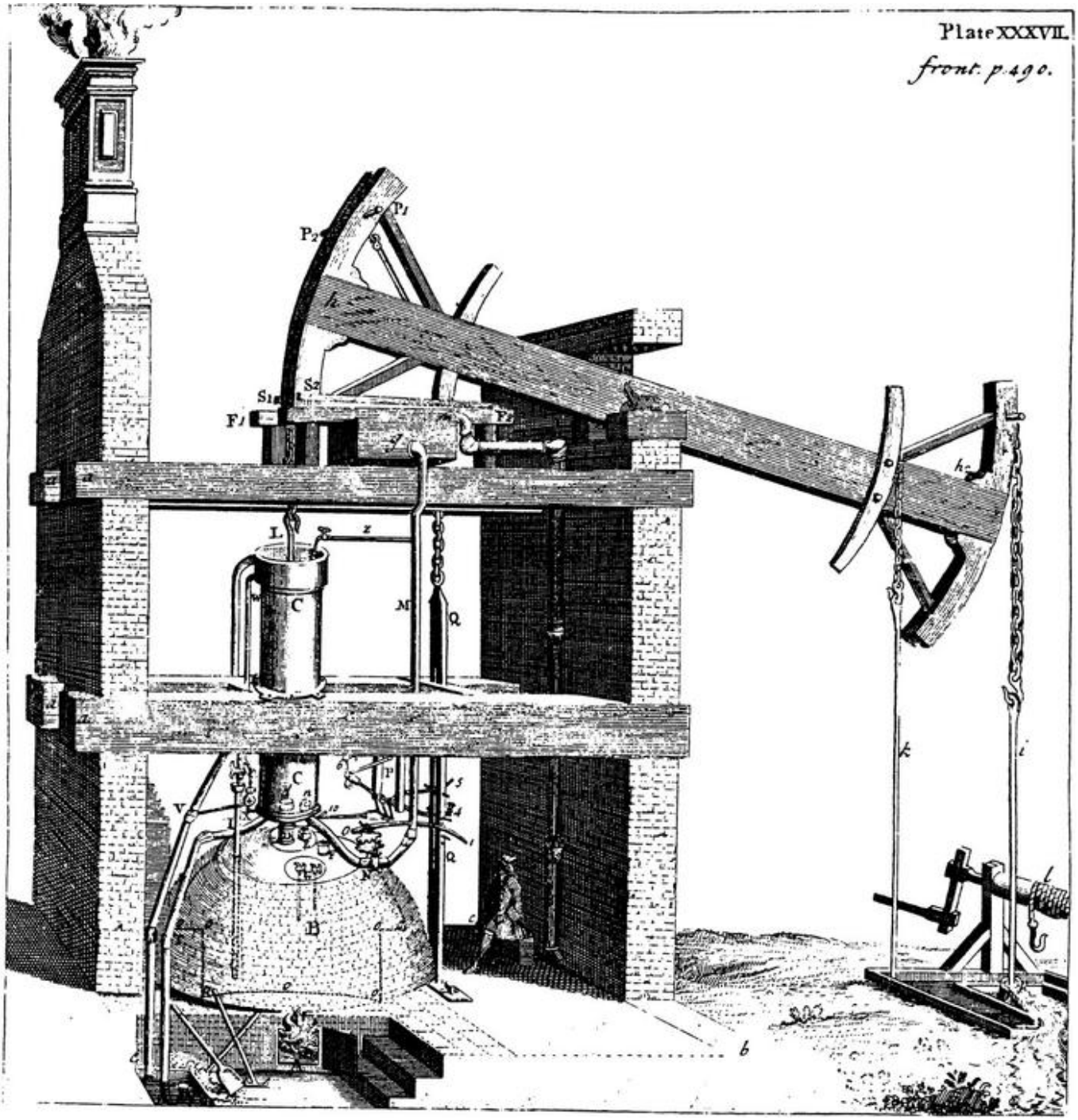
Watt was a craftsman, a perfectionist. He wanted power that was efficient, steady and manageable and so he backed the 'atmospheric' principle used by Thomas Newcomen at the start of the century. Newcomen's engines exploited basic atmospheric pressure, building on the way that air had been found to rush into a vacuum. A vacuum could be created by sucking air out of a closed vessel with a pump, as Boyle had shown, but it could also, as Papin had demonstrated, be created by using steam. If you filled a cylinder with steam this drove out the air, but as the steam cooled it condensed into water which took up only a fraction of the space, so that the rest was almost a vacuum. When a piston was fitted into the top of the cylinder, the ordinary air pressure on its surface would drive it down into this vacuum. Pump steam in again and it forced the piston up – cool it and down it came.

The 'fire-engines' that Newcomen and his successors built had a great cast-iron cylinder above a domed brick boiler, and a moving piston attached by chains to a huge rocking beam. At the other end of the beam were heavy pump rods. As the steam forced the piston up, the beam tilted and down went the rods. As the steam condensed – cooled by a jet of cold water sprayed into the cylinder – the air pressure drove the piston down, pulling down the beam and lifting the pump rods. Steaming and cooling, pushing and pulling, creaking and thumping, stroke after lumbering stroke, the engines drained the mines.

Watt had never seen a full-size Newcomen engine – there was still only one in Scotland – but Glasgow University had a model, made by Jonathan Sisson of London. This had been sent back to Sisson for repair and in June 1760 Watt's friend Professor Anderson was charged to get it back. When it arrived it was still not right, and Watt was asked to make it work. He did so, though fuming at how badly it was built. Nothing maddened him more than bad workmanship, and even when the model was mended he was still bothered by the immense amount of fuel it consumed in proportion to its tiny cylinder, only two inches in diameter. From this point, obsession took hold.

As he watched his small model Watt could hardly believe how much steam he had to create to keep it going: the engine could manage only a few strokes before it boiled dry. Nothing he tried affected this – changing the type of boiler, moving the fire, even making a wooden cylinder-cover so it would lose less heat. Slowly, doggedly, he set to work to find out why, helped by Black and Robison, who returned to Glasgow in 1763 after four years at sea. In his years away (besides adventures such as accompanying Wolfe to Quebec on the fatal night he scaled the heights), Robison had learned surveying and had been

employed by the Admiralty to make observations on Harrison's chronometer in the West Indies. He felt more on a par with Watt now, he said, and found him 'good and kind as ever', but 'continually striking into untrodden paths, where I was always obliged to be a follower'. He also remembered how Watt's wide range of knowledge and insatiable curiosity made him popular at Glasgow:



A Newcomen atmospheric engine, engraving by Henry Beighton, 1717

All the young Lads of our little place that were any way remarkable for scientific predilection were Acquaintances of Mr. Watt; and his parlour was a rendezvous for all of this description – Whenever any puzzle came in the way of

any of us, we went to Mr. Watt. He needed only to be prompted – everything became to him the subject of a new and serious study; and we knew that he would not quit it till he had either discovered its insignificancy or had made something of it.[10]

Those china tea-cups must have come in handy.

Watt loved puzzles, and the steam-engine presented plenty. He had a craft background, and was not afraid of getting his hands dirty, but he was no on-site experimenter, working by trial and error. He was concerned with the principles of his subject, the laws of hydraulics and hydrostatics, the findings on variable temperatures and pressures, the application of mathematical theory. The first questions he asked were very like those Darwin had put to Boulton, about the nature of heat and steam. He experimented with the capacities for heat of different liquids, apart from water. He worked out how much water could be evaporated in a particular boiler by a pound of coal; how much steam was needed for each stroke of Newcomen engines of different sizes; how much cold water was required to condense the steam.

This last was a very real problem, since Watt and others discovered that water boils at a far lower temperature in a vacuum, so the danger was that instead of cooling the steam the opposite might happen – the steam might make the cold water boil. Investigating this Watt turned to the most obvious domestic example, a battered copper kettle. He took a bent glass tube, inserted one end in the kettle's spout and put the other into a marked flask of cold water. As the steam poured into the flask it gradually heated the water to boiling point, and Watt saw that the water level had risen by a sixth: this was the steam that had condensed before the whole flask bubbled and boiled. So steam could raise six times its own volume of water to boiling point.

When he turned this into measures of temperature and calculation of heat units it appeared to Watt that water in the form of steam could contain more heat than it could as pure water:

Being struck with this remarkable fact, and not understanding the reason of it, I mentioned it to my friend Dr Black, who then explained to me his doctrine of latent heat, which he had taught for some time before this period, but having myself been occupied with the pursuit of business, if I had heard of it, I had not attended to it, when I thus stumbled upon one of the material facts by which that beautiful theory is supported.[11]

Black then explained his theory of 'latent heat' – as the water continues to boil, although its temperature doesn't rise any further, the process of making steam continues to absorb heat. When the steam cools, this heat is released.

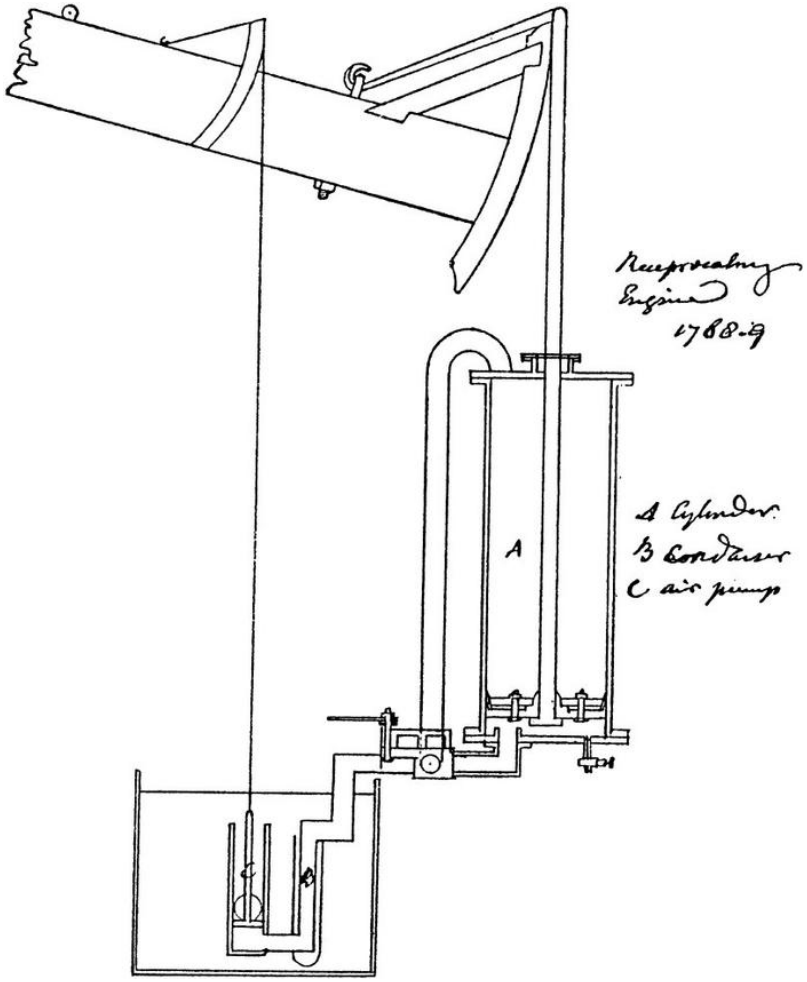
Watt now saw that the great drawback with the Newcomen engine was the loss of this extra heat through the alternate heating and cooling of the cylinder. Although Black's theory, he said, did not *suggest* his improvements to the engine, his knowledge and method – 'the correct modes of reasoning,

and of making experiments of which he set me an example' – helped his work immeasurably.[12] But however much he fiddled with different ways of injecting the water or letting in the steam, he could never get round the insuperable problem: the cylinder had to be kept hot to make it efficient, yet the steam had to be cooled to create a vacuum. It was impossible to do both.

For months this worried him, and then in the spring of 1765 the answer came, so dazzling in its simplicity that the moment stayed sunlit and sharp in his memory. It was on the College Green:

> I had gone to take a walk on a fine Sabbath afternoon. I had entered the Green by the Gate at the foot of Charlotte Street – had passed the old washing-house. I was thinking upon the engine at the time and had gone as far as the Herd's house when the idea came into my mind, that as steam was an elastic body it would rush into a vacuum, and if a communication was made between the cylinder and an exhausted vessel, it would rush into it, and might be there condensed without cooling the cylinder … I had not walked further than the Golf-house when the whole thing was arranged in my mind.[13]

Standing on the Green, which on weekdays was white with linen laid out to bleach, the realization 'flashed on his mind at once, and filled him with rapture'.[14] But it was the Sabbath, and no good Presbyterian could work. The grass was bare of cloth and Watt had to wait. On Monday, in his workshop in a courtyard behind the Beef Market, he built a model. This was not a beam-engine, but an inverted engine, pulling weights up by a hook. The cylinder, once again, was simply a large brass syringe, borrowed from a friend. Next to the cylinder he fixed an air pump, and instead of using a jet to cool the steam, he made a 'surface condenser' by soldering a rectangular tank on to the bottom and filling it with cold water. With the steam rushing out of the cylinder into the separate condenser, and the cylinder kept hot by a special insulating jacket, his makeshift model worked.



Drawing showing Watt's separate condenser, prepared for the Patent Specification, 1769

He was now sure that his calculations were accurate and convinced that a full-size engine on these lines would prove more powerful and use less fuel than its predecessors. At the end of April 1765 he wrote exuberantly to James Lind:

> and if there is not some devil in the hedge mine ought to raise Water to 44 feet with the same Quantity [of] steam that theirs does to 32 … in short, I can think of nothing else but this Machine. I hope to have the decisive tryal before I see you.[15]

His excitement was balanced by caution. As he tried out valves and steam-cocks and different arrangements of cylinders and surface condensers – soldering together tin-plate into little tanks, with tubes or cells for the water to circulate – he became extremely cagey. When the enthusiastic Robison dashed unannounced into Watt's parlour he found him sitting by the fire, gazing at a little tin cistern on his knee. As Robison talked – 'something about Steam' – Watt gently put the cistern on the floor. When pressed, 'at last he looked at me and said briskly, "You need not *fash* yourself any more about that Man; I have now made an Engine that shall not waste a particle of Steam. It shall all be boiling hot, aye and

hot water injected, if I please."'[16] He looked down at his cistern, saw Robison watching, and shoved it under the table with his foot.

There was, however, a vast difference between an instrument-maker's model in which every part was lovingly tailored to fit, and a massive working engine built of brick and iron. The engine-builders and designers were often millwrights (as Newcomen himself had been), used to huge structures, heavy wheels and gearing and beams made of tree-trunks – not accurate measurements and precision workmanship. Years of frustrating technical problems lay ahead. Watt had no money for large-scale models and although Black generously lent him as much as he could, he too was short of funds and was anyway leaving to take up a professorship in Edinburgh, handing his Glasgow chair on to Robison. Looking for other ways to finance Watt's work, Black thought of John Roebuck. So far, everything Roebuck had touched had turned to gold but he had recently leased the estate of the Duke of Hamilton at Kinneil, near Barrowstoness, with its collieries and salt-works. To pay for the mines Roebuck threw in his own capital, borrowed more money from Garbett, and took out loans against Prestonpans and Carron, but the deep coal seams flooded so fast that his Newcomen engines could not drain them. Knowing this, Black told him of Watt's engine. It was a neat idea: Roebuck needed the power; Watt needed the backer. And in contrast to Watt, so quickly depressed by setbacks and unforeseen costs – 'modest, timid, easily frightened by rubs and misgivings, and too apt to despond' – Roebuck was always 'ardent and sanguine in the pursuit of his undertakings'.[17] His bullish energy, let alone his cash, might finally get the engine into production.

By September 1765, after initial scepticism, Roebuck was keenly urging Watt on. But he did not pay Watt directly so that he could be free of other work, and as Watt made new and bigger models, now with brass cylinders, so he encountered new and bigger problems. His design made it impossible to use a layer of water as a seal above the piston, as Newcomen engines did, and so it proved a nightmare to keep the piston steam-tight, however much he tried sealing it with oil and animal fat, or packing it with oiled paper, pasteboard and rags. And when the work for a large experimental engine was put in hand, the iron cylinder, specially made at Carron, was so clumsily made that it proved unworkable.

Disillusioned, Watt turned to other schemes, planning an improbable 'circular engine', a wheel with a hollow rim which could be filled with steam, and three steam-pipes acting as spokes; with a careful use of valves, the wheel could rotate. This design cul-de-sac diverted his energies over months and even years. And all the time his money troubles were increasing, especially when his old partner John Craig died and he had to repay his capital to his heirs. In the summer of 1766 he sold the instrument-making shop and turned to surveying, opening an office in King Street. The engine at Kinneil lay rusting, in pieces.

Notes – 9 STEAM

1 ED to MB, [1764?].

2 See L. T. C. Rolt, *The Horseless Carriage* (1950) 16.

3 ED to MB, 11 March 1766.

4 ED to MB, 12 December 1765.

5 Muirhead *Mechanical Inventions* II, 204; for Robison's idea see the *Universal Magazine of Knowledge a Pleasure* XXII (1757) 229–31.

6 References in this paragraph are to letters between JW and James Watt senior, and to John Watt, 1757–5 JWP 4/11.7–23.

7 *Glasgow Journal*, 1 December 1763, in Rolt 21.

8 An article by Michael Wright in *New Scientist* (March 2002) describes the flute-making tools found in material from Watt's workshop, now in the Science Museum, and also a steel stamp marked '*TLot*', the mark of the great Paris flute-maker Thomas Lot.

9 For Watt's organ, see 'Robison's Narrative' in Robinson and Musson 38.

10 'Robison's Narrative', Robinson and Musson 24.

11 'Letter to Dr Brewster from Mr Watt', in John Robison, *A System of Mechanical Philosophy*, edited by David Brewster (Edinburgh, 1822) II, 116n.

12 Robison, *Mechanical Philosophy* II, ix.

13 Recounted by JW in 1817 to the Glasgow engineer Robert Hart: 'Reminiscences of James Watt', *Transactions of Glasgow Archaeological Society*, 1859. (The wording varies.)

14 Joseph Black, 'History of Mr Watt's Improvement of the Steam-Engine' [1796–7], Muirhead *Life* 58.

15 JW to James Lind, 29 April 1765, JWP C1/15.

16 Robinson and Musson 27.

17 Muirhead *Life* 95.