One

The Making of a Scottish Improver

The port of Greenock, where James Watt took his first salt-laden breath on January 19, 1736, was then a small coastal town but very much on the rise. Located on the southern bank of the mouth of the River Clyde, twenty-five miles west of Glasgow, Greenock was in fact a recent settlement, with a population of about three thousand in 1741, rising sixfold by the end of the century. It was one of those towns created by landowners granting charters by which a group of local worthies could form a burgh council and raise taxes to develop the town. The local landowner in this case was Sir John Schaw. The granting of charters in this way indicated that landowners were seeking to turn their estates to business and profit rather than, as in the past, to military power and authority. The improving impulse that was to be so important in Watt's life came from the top of his local community.[1]

The development of the town, the building of its docks and harbors, churches, schools, and civic buildings, occurred in the decades around Watt's birth. His grandfather and father played an active role in this development. Greenock grew on account of trade, partly in agricultural products and linen (mainly with England) but increasingly, and rapidly from the 1740s, through the import of tobacco from the American colonies. By 1769 Greenock, Port Glasgow, and Glasgow handled the bulk of the Scottish tobacco trade, which in turn accounted for 52 percent of the total British trade in that commodity. The American colonies received in return a vari-

ety of basic needs channeled into Greenock by local industry and launched from its docks.[2] Between 1730 and 1750 Glasgow's colonial traders invested heavily in other manufacturing enterprises, including leather production and boot and shoe making. Textiles were another key area, especially the finishing processes such as bleaching fields and textile print-works, which required significant injections of capital. This expansion as well as trade in iron products made possible key initiatives in iron production, notably the Carron Iron Works, established in 1759 near Falkirk in Stirlingshire. Both the investors in those works and the skilled workmen often imported from England to establish and operate them represented links between Scottish economic development and the industry of the English Midlands that were to be important in Watt's life trajectory.

Twenty years before Watt's birth (in 1715) and again when he was nine years old (in 1745), the political settlement on which the prosperity of Greenock and Scotland was being built was challenged. The Jacobite rebellions of those years challenged the political and economic union between Scotland and England that had been sealed in the Act of Union of 1707. The Watt family, like other enterprising inhabitants of Greenock, were firm in their political, economic, and religious support of the Union. For them the Jacobites threatened a return to a less prosperous and less promising past. The future, as they saw it, lay with expanding trade and industry, enterprise and thrift. The politics of the Union, and the philosophy of "improvement" and Presbyterian accountability, ran deep in Watt's background.[3] They were thoroughly ingrained in the lives his family led and the futures they imagined for themselves. Watt's paternal grandfather, Thomas Watt (1642–1734) was an import to Crawfordsdyke near Greenock in its early days, coming from Aberdeenshire and carrying skills as a teacher of mathematics, or "professor" of the subject as he was sometimes styled. His skills were valuable in a town with an economy based on shipping, trade, and construction.[4] Whether teaching basic mensuration or high astronomical and navigational skills, Thomas Watt found a strong demand for his services. He had a house in Crawfordsdyke, then a separate burgh but subsequently part of Greenock. The fact that he owned another house besides his family residence evidences his prosperity. He had been an elder of West Parish of Greenock since 1685 and was for several years Baron Bailie (or chief magistrate) of Crawfordsdyke, denoting authority in the community as well as prosperity. Thomas Watt married Margaret Shearer in 1679, and they had six children, only two of whom reached maturity. One of these was Thomas's elder son, John (1694–1737), who was also a teacher of mathematics and had been educated as a mathematician and surveyor. He produced a survey and map

of the Clyde that was later published by the other surviving child, his younger brother James (1699–1782), the father of our protagonist.

James Watt Sr. was trained as a "wright," or house carpenter, having been apprenticed to a John McAlpine. He married Agnes Muirhead in 1729, and between 1730 and 1734 two sons and a daughter were born, but all died in infancy; James, also a sickly child, arrived two years later. Tragedy in the loss of children in infancy and childhood haunted generations of Watts, as was common in those days even though mortality rates were improving. Amid all this, Watt Sr. became a prosperous builder. He was engaged by Sir John Schaw to extend his Greenock mansion house. Since Watt Sr. would have required financial reserves and access to credit to undertake that venture, we can conclude that he was a man of some substance. Watt Sr. also went into business as a ships' chandler, which involved him in fitting out ships and carving their figure heads, as well as attending to the working of their instruments, compasses, and quadrants. This suggests that the family decision in 1756 to have Watt train with an instrument maker was perhaps not unrelated to the requirements and possibilities of his father's business. Like his father before him, Watt Sr. was an important figure in the community. In fact, he was one of a select few who were entrusted with the funds raised by the community for public improvements. Thus in 1741, under the charter of the town issued by Sir John Schaw, Watt Sr. was one of nine residents selected to manage the funds raised by a tax on the malt ground in the mills west of Greenock. Ten years later, Sir John and the inhabitants of Greenock applied to the British Parliament for an act to levy a duty on every pint of ale and beer brewed, brought into, or sold in Greenock. The funds raised were to be applied to harbor repairs and to the construction of a new church, poor house, school house, marketplaces, and a public clock. Watt Sr. was one of the trustees of this fund. He also held a number of other public offices in later years. On a tombstone erected long after his death by his son, Watt Sr. was described as a "benevolent and ingenious man, and a zealous promoter of the improvements of the Town."[5]

The Watts were Presbyterians, adherents of the Church of Scotland. Watt Sr. was buried not in the grounds of the church that he helped to construct but in those of the Old West Kirk that dated back to 1591 and of which his father, Thomas, had been an elder.[6] We know little about the family's religious observances, though it seems likely that their enthusiasm for the Kirk declined over the generations. Watt was to attend Kirk when in Glasgow; his payment for a pew there seems to be evidence of that. He also on one occasion told a business partner that he would be happy to experiment with him but would prefer to avoid sacrament days, "as we cannot decently

try any experiment upon them."[7] After moving to Birmingham, Watt made public his Presbyterian religion seemingly only on convenient occasions, attaching himself, by all appearances, to the Church of England.[8] But the old family pew, for which Watt continued to pay rent after his father's death, was abandoned only in the early nineteenth century along with other property in Greenock.[9] In a cultural sense, the family's Presbyterianism died hard, and it left an important and lasting mark on Watt's life and work through the moral precepts it supplied.

The harsh Calvinism of seventeenth-century Scotland softened in the early eighteenth century, rendering it reconcilable for many with thrusting commerce and, later, moderate Enlightenment views.[10] Presbyterianism supported commercial activity in various ways in Scotland during the period of Watt's youth. Not the least of the supports was the impulse that it provided to order and accountability. The inordinate influence of Scottish accounting texts in the eighteenth century has been noted. So too have the high levels of financial literacy in the population, especially among those of the "middling sort."[11] There was a related strong commercial aspect to school education. Accountability practices were central to the Scottish Presbyterian churches in their forms of governance but also, crucially, formative of individual behaviors that the church encouraged, notably confessional diaries. Also part of such individual behaviors was the careful, routine, and accurate keeping of business and personal accounts, the latter in particular as a form of moral discipline inculcated by habitual personal practices.[12]

This accounting habit was impressed upon Watt as a child and young man, and he in turn impressed it upon his children. We will see that such accountability issues lay at the heart of some of Watt's struggles with his family and with his business partner, Matthew Boulton. More positively, in a way parallel to findings concerning some of Watt's nineteenth-century coreligionists, we will see that Watt's concerns with engine efficiency and the improvements that they impelled were also underwritten in part by this cultural Presbyterianism.[13] Suspicion of trifling entertainments as a waste of valuable time, and the stoic invocation of Providence at times of loss, also came naturally to this son of Greenock.

Watt Sr.'s carefully accounted-for prosperity, then, was built significantly by servicing the ships that used the port of Greenock in plying the English and Atlantic trades. He had an interest in virtually everything that contributed to that trade, whether it was the infrastructure to support it or the commodities involved in it. From the time Watt first left home for Glasgow at the age of sixteen, through his time in London and then back in Glasgow, his correspondence with his father includes a

FIGURE 1.1: Marcus Stone, *Watt Discovers the Condensation of Steam* (1863). Engraved by James Scott (1869). Reproduced from A. L. Baldry, *The Life and Work of Marcus Stone, R.A.* (London: The Art Journal, 1896). Author's collection.

miscellany of topics showing that both men were alert to, and concerned with, any commercial or industrial development affecting the prosperity of their community and offering an opportunity for themselves: tobacco, coal, iron, pottery, instruments, and all manner of merchant goods included. Father and son were enterprising and opportunistic to the core.[14] Ventures in shipping were financially risky, and there are signs that Watt Sr. suffered a severe financial reversal at some stage, which Williamson describes as telling heavily "upon a fortune, till then in all respects adequate to the maintenance of an easy respectability."[15]

Watt's younger brother John (b. 1739), known as "Jockey," was also directly involved in business with his father. Marcus Stone's well-known nineteenth-century painting of the Watt family at a table shows Jockey at the window, or counter, of his father's business, oriented to the world of ships and the sea (see figure 1.1). Despite family trepidation Jockey went to sea as part of a trading venture to the West

Indies—this at a time, the early 1760s, when there were moves to diversify a trade heavily reliant upon the increasingly fractious American colonies. Jockey drowned at sea on 30 October 1762. News from distant parts traveled slowly and uncertainly in those days. The correspondence between Watt and his father in which Jockey's death is first feared, and its circumstances gradually revealed, shows a deep tenderness between the two men in their common loss. His father wrote: "I pray God may comfort you under the loss of so deir a brother who if he had been spaired would have been a credit & support to both you & me, but since Providence has Deprived us of that comfort we must Indivor to support it & confort on[e] another."[16] Watt, who had already lost his mother in January 1753, was to exhibit similar stoicism in the face of many other losses in his life.

What manner of child had the young James Watt been? Stone's painting famously depicts him playing with a steam kettle under the watchful, admiring, and slightly perplexed gaze of his parents. This is nineteenth-century mythmaking rendered graphic, but the little evidence we have does paint the young Watt as a studious, often sickly, rather gentle child, teased by his more rough-and-tumble schoolmates at Mr. M'Adams' commercial school.[17] He spent much time at home with his mother, Agnes, who reputedly created a "genteel" and "orderly" domestic environment.[18] At about the age of fourteen, Watt attended Greenock Grammar School under its first headmaster, Robert Arrol, a classicist and author of some reputation who published translations of Cornelius Nepos and Eutropius, the Roman historians, and also some of the colloquies of Erasmus. Whilst at that school Watt was instructed in mathematics by John Marr, who in the early 1750s was retained by the lord of the manor, Sir John Schaw, in some capacity and also appears to have had a salary from the town.[19] Marr presided briefly over a very well-equipped schoolroom containing, among a great variety of instruments, a brass telescope and quadrant, and a "pair of Mr Neals Globs" as well as a good collection of books on geometry, arithmetic, trigonometry, navigation, pilotage, and annuities. At this stage of his life, his early teens, Watt was thoroughly exposed, both at home and at school, to mathematics and its practical applications. An interest in electricity, a popular preoccupation in the 1740s and 1750s, may have been encouraged in Marr's classroom, which also contained a "frame for Electricity."[20]

Until the year 1753 Watt had spent most of his time in Greenock, apart from brief trips to Glasgow to see his mother's brother, Uncle John Muirhead, whose country estate Watt also visited. The Muirhead family was an old and distinguished one: it had contributed a number of men who held high office over the centuries and

provided the bodyguard of the king at Flodden Field. More immediately, Agnes Muirhead's father was Robert Muirhead, a merchant in Hamilton and Glasgow of whom we know little. Her brother John was later recalled as being a builder and timber merchant in Glasgow.[21] The signs are that the Watt and Muirhead families were close after Watt Sr. married Agnes in 1728. Watt Sr. engaged in joint trading ventures with John Muirhead, those we know of involving salt and herrings. The two men pursued their joint activities without need of formal partnership arrangements—such was the trust between them. After John Muirhead died in 1769, the family relationship remained strong, with Watt maintaining close contact with John's son and heir, Robert, throughout his life. Although John Muirhead's fortunes took a turn for the worse late in his life, his son Robert inherited from him the estate of Croy Leckie in the parish of Killearn, Stirlingshire. That estate was located on the River Blain (or Blane) near its junction with the River Eldrick and about four miles east of Loch Lomond. It had been owned by John and Agnes's father, Robert, who had been responsible for substantial planting improvements, especially on the fifty acres around the mansion house.[22] His mother's family both historically and during his young years were clearly a cut above the Watts, economically at least. We know from the testimony of John Muirhead's daughter Marion (later Mrs. James Campbell) that the young Watt had substantial exposure to their way of life, spending some summers at her father's house near Loch Lomond, presumably on the Croy Leckie estate.[23]

Many of the stories told of Watt in his younger days rely upon Marion Campbell's recollections. She describes him as a "sickly, delicate child" taught reading by his mother and mathematics by his father. She tells a number of stories that address the capabilities of the young Watt. First, there is the tale of the visitor to the Watt household when the boy was six who reproached his parents for not sending Watt to public school, only to find that the child's seemingly idle chalking on the hearth was in fact a precocious exercise in trigonometry. The visitor withdrew his criticism and concluded that this was "no common child." Then, there was his practical manual prowess: "His father gave him a set of small carpenters tools & one of James's favourite amusements was to take his little toys to pieces, reconstruct them, & invent new playthings." His powers of "imagination & composition" were illustrated by a story of him staying for a while with some friends of his mother's when he was about thirteen. The friend was relieved when his mother recovered him because the whole family was deprived of sleep, having been kept awake until late at night by Watt's humorous, dramatic, and compelling storytelling. Then, of course, there is the famous kettle anecdote in which Watt, aged fifteen, is having tea with his Aunt Muirhead,

who scolds him for his idle playing with the kettle, lifting its lid, capturing steam in a cup, letting it play upon a spoon, and watching it condense.[24] The account continues: "It appears that when thus blamed for idleness, his active mind was employed in investigating the properties of steam. . . . Once in conversation he informed me that before he was [fifteen] he had read twice with great attention Gravesand's Elements of natural Philosophy, adding that it was the first book upon that subject put into his hands, & that he still thought it one of the best." The book must have been the recent popular English translation of Willem 's Gravesande's *Elements of Natural Philosophy* that was widely admired for its presentation of the foundations of Newton's mechanics through experimental demonstrations.[25] We are told that when a little older and in Glasgow with his Uncle Muirhead, Watt read and studied a great deal in chemistry and anatomy, showing particular interest in "the medical art."[26] A strange, gory tale has him carrying off the head of a dead child for dissection. In a more bucolic vein, the time Watt spent in the summer months at Croy Leckie on the shores of Loch Lomond saw every excursion as an occasion for research into the botany and mineralogy of the area. He also studied the poor and their traditions, songs, and superstitions, and read indiscriminately all kinds of literature. These interests were to reemerge in his later years.

When it comes to Watt's character and demeanour, Mrs. Campbell documents numerous traits. From a very young age he displayed "manly spirit, a retentive memory, and strict adherence to truth" and was "docile, grateful & affectionate" in relation to his indulgent but judicious parents. He suffered from violent headaches that left him "for days, even weeks, languid, depressed, & fanciful," and at such times there was a "roughness & asperity" in his manners. He was given to long periods of high activity and of apparent indolence, and he "was subject to occasional fits of abstraction." Although the young Watt was "modest & unpretending yet like other great men, he was conscious of his own high talents, and superior attainments, and proudly looked forward to their raising him to future fame & honour."

This, then, is the young Watt that his cousin Marion remembered. Or did she? Like other retrospective accounts, it is likely much embroidered with a mix of distant memory and family folklore. To that extent it is part of the extensive mythmaking that went on around Watt.[27] Yet, as we will see, it is also the case that some of Marion's account rings true, given what we learn about the man from better-documented periods of his life. Watt himself indirectly vouchsafed Marion's memories when he noted on her death that he was "in great measure brought up" with her.[28]

Our other major sources for the very young Watt's life and character are the memo-

rials assembled by George Williamson, the president of the Watt Club of Greenock, in the nineteenth century. He lamented the paucity of information but relied upon gathering the oral testimony of Watt's old school friends and of others who knew him in his young days. There are many points of coincidence between George Williamson's stories of the young Watt and those offered by Marion Campbell. Indeed, it may well be that he relied on the latter to some extent. But he did differ in important respects. He was very skeptical about the story of six-year-old Watt as trigonometer, regarding it as apocryphal, and regretted the fact that it had already received wide circulation thanks to the efforts of an "Academician." This must be a reference to François Arago's eloge of Watt, first published in English in 1839, which had relied upon Marion Campbell's recollections as supplied to him by Watt Jr. Williamson's skepticism about that anecdote is based on the testimony of Watt's schoolfellows, who found in him in his early years an apparent mental dullness: "The truth in regard to young Watt's first years in the public school is, that, owing doubtless to infirm health, to the suffering and depression which affected his whole powers, he was unfitted for a considerable time for displaying even a very ordinary and moderate aptitude for the common routine of school lessons; and that during those years he was regarded by his schoolmates as slow and inapt."[29] Williamson inclines to the view that Watt's genius did not begin to reveal itself until his thirteenth year, when, as one of his schoolmates testified, he was put in a mathematical class and began to excel in that field. This was where John Marr played his role. Watt began, according to Williamson, not only to love geometry and mathematics but also to study the skies, perhaps taking advantage of instruments that his father traded in. One further outdoor pastime of the young Watt that Williamson's sources revealed was angling, the suggestion being that the house in which Watt grew up on the high street in Greenock then had direct access to the river, so that Watt might have dangled a line almost out of the back window!

Williamson also confirms Watt's early love of handiwork and mechanism, which was naturally encouraged by the environment that Watt Sr.'s business provided. The evidence here comes from the testimony of John Rodger (1754–1827), a master shipwright and blockmaker of Greenock, who had been apprenticed to Watt Sr., as also many years earlier had been his father, James Rodger. John Rodger recalled that when he was a boy, he was sent to clear out the attic of Watt Sr.'s house, which contained miniatures and ingenious models of numerous devices. Watt Sr. told him that they had been made by his son, who was then in business in Glasgow.[30]

The sudden death of Watt's mother in January 1753 at the age of fifty-two must have been a serious blow to the seventeen-year-old. It seems to have been the occa-

sion for Watt to achieve more independence. Early biographies often stated that in 1753 Watt was sent to Glasgow to be apprenticed to a mathematical instrument maker. But there is little evidence for this. Richard Hills has argued very cleverly, partly upon the evidence of the kind of clothes that young Watt took with him to the city, that the intention was rather that he train as a merchant with his Uncle John Muirhead so that he could act as a representative of his father's business. This is convincing, not least since letters exchanged with his father during this period are preoccupied with innumerable instances of sourcing supplies and settling accounts.[31] (In contrast, subsequently when Watt really was training in London, he reported regularly to his father on his accumulating knowledge and skills.) Also, Watt clearly had enjoyed a good and close relationship with his Uncle Muirhead during his younger years, so that learning from him would be a comfortable arrangement, another example of close family trust.

The move to Glasgow also brought Watt into his first close contact with a number of prominent members of the university there, usually referred to in those days as Glasgow College. This medieval institution entered a remarkable new period of dynamism during Watt's early life, becoming an important part of the expression of the Scottish Enlightenment.[32] There was a family connection here, too, in the form of George Muirhead (1715–1773), another relative of Watt's mother, who was appointed to the chair of Oriental Languages at Glasgow in 1753 and that of Humanity (Latin) in 1754. Though in many respects George Muirhead, reputedly the best Greek scholar in the country at that time, might seem a long way distant from his young relative from Greenock, his activities too were part of the improving mentality.[33] The seventeen-year-old Watt was welcomed by George Muirhead and introduced to a number of key figures in the college's renaissance, including the famous mathematician Robert Simpson; Robert Dick, the younger (who succeeded his father as professor of natural philosophy in 1751); and William Cullen (1710–1790), the prominent medical teacher then in the early years of professing chemistry at Glasgow before his move to Edinburgh University in the mid-1750s. Another important acquaintance for Watt at this time was Adam Smith, who had beaten George Muirhead to the Glasgow chair of logic in 1751. These men were part of a cultural vanguard of the Glasgow Enlightenment. Under the watchful eye of major patrons such as the Duke of Argyll, they were as much concerned with "improvement" as were the likes of Watt and his father, but in a different way. George Muirhead, for example, was an editor of classical works issued by the local Foulis Press. These editions, renowned for their accuracy and the quality of their production, helped to make Glasgow well known in

the classical literary world. The more astute among Scotland's economic and political elite saw great value in such cultural celebrity as well as in more practical forms of improvement. Edinburgh was becoming known as "the Athens of the North" at this time, but Glasgow had its place and its ambitions too.[34]

The Duke of Argyll's control over academic appointments in Scotland saw him favor those philosophers and chemists (Cullen among them) who could turn their academic knowledge and expertise to practical improvement. Even bodies such as the Philosophical Society of Edinburgh were significantly shaped by this impulse, a third of its members being connected into the networks of Argyll and Lord Milton. The latter also worked through the Board of Trustees for Fisheries and Manufactures, established in 1727 out of patriotic concern to promote the linen, woollen, and fishing industries, to encourage technical expertise and development at all levels. Many of the men with whom Watt associated, and from whom he learned, as he built his various early careers had been aided by the Duke's patronage. The political management of Scotland was pursued in significant part through this encouragement of economic improvement.[35]

During these early years in Glasgow, Watt's associations with professors and students, as well as merchants, encouraged him to cultivate learning of all sorts. In a letter to John Craig in 1805, Watt recalled an "irregular club" that met in the early 1750s at Mrs. Scheid's (who had a tavern in the Trongate), whose members included John Millar (from 1761, professor of law at Glasgow College), William Morehead of Herbertshire, John Allan of the Row, and Craig's father. Watt recalled, "Our conversations, besides the usual subjects with young men, turned principally upon literary subjects, religion, morality, belles-lettres &c.; and to those conversations my mind owed its first bias to such subjects, in which they were all my superiors, I never having attended a college, and being then a mechanic."[36]

The John Craig to whom Watt wrote this letter provided another angle on this grouping in his edition of one of John Millar's key works, there recalling that Millar often visited the "house of Mrs Craig whose eldest son had a taste for literary conversation and philosophical experiment," where he met a number of young men including Watt.[37] The Craig family in question here were probably the timber merchants whose yards were located at one time at Waterport, the southern gateway of the city, a little west of the bridge and in line with Clyde Street. The John Craig (d.1765) we will come across financing Watt's mercantile ventures from 1759 was probably a member of this family.

Watt is also mentioned as a member of the "Literary Club" of Glasgow, which

was founded in 1752 and included most of the professors of the college, and which some of the students attended. Watt seems to have partaken of some of the "clubability" that was characteristic of the period both among young men of his own age and among more senior figures in the college and city. He was perhaps representative of the nexus between Glasgow's merchant community and the college, which was a strong one. One assessment of that connection has found that of 166 tobacco merchants identified in Glasgow between 1740 and 1790, no fewer than 36 had matriculated at Glasgow College, and many others attended college classes without matriculating.[38]

Despite the commonalities of improving purpose between his life in Greenock and in Glasgow, Watt's new Glasgow connections and the society he enjoyed at his Uncle John Muirhead's house began to draw him ever so slightly out of the orbit of his father's business in Greenock. Watt's abilities were no doubt recognized by his new acquaintances, and the idea that the young man might be trained to take advantage of his mathematical and craft skills must have occurred to them. It appears that it was Professor Dick who suggested that Watt go to London for training as a mathematical instrument maker and bring back skills that, while they would certainly be useful to his father's business, would also be of potential value to the college, and to Scottish development more generally. Dick provided Watt with an introduction to the instrument-making community of the English metropolis in the form of a letter of introduction to the celebrated telescope maker James Short. Armed with this Watt set out for London in June 1755.

London

Watt was not the only son of Greenock who left Scotland to find ways to develop his talents. For all the aspirations of the economic and cultural improvers, there were still limits on what even Glasgow could offer bright and enterprising young men. Watt did not make his journey to London in June 1755 alone. John Marr, the son of his former mathematics teacher of the same name, accompanied him. Marr the younger was going to London to take an examination for a post as instructor in the navy. Leaving on 7 June, the two of them traveled on horseback via Coldstream, Berwick, Newcastle-upon-Tyne, and then along the Great North Road, arriving in London on 18 June.[39]

Marr at the time of this journey was in his early thirties and was probably assigned by their fathers to watch over the younger man.[40] He was instrumental in gain-

ing Watt temporary employment with John Neale, a watch and globe maker, almost certainly the fabricator of the globes that Watt had used in his Greenock classroom and by that channel a business acquaintance of the Marrs. Soon Watt was working informally for the instrument maker John Morgan (d.1758), and after a month or so terms were suggested on which Watt might receive instruction from Morgan. The latter was to be paid twenty guineas for nine months of instruction. With involvement from Watt Sr. and a surety offered by James Short, a payment was made to Morgan, and Watt's training began.[41]

Although Watt later became well known in scientific circles, his London situation in itself gave him few possibilities for contact with the scientific community of the metropolis. Instrument making was a large industry in London in the mid-eighteenth century but also highly stratified. A small number of leading makers supplied natural philosophical instruments to prominent fellows of the Royal Society, and to collectors among the aristocracy, gentry, and rich merchant class. They also supplied specialized metrological instruments to institutions such as the Royal Observatory. The general metrological instrument market was supplied by a host of other makers, and it would have been among this group that Watt's instructor John Morgan sat.[42] As a short-term, informal trainee rather than a long-term formal apprentice to such a maker, Watt was very marginal to the metropolitan instrument-making community. His work for Morgan reflected this. And yet Watt would have gained some awareness of the more elite business of instrument making for, and within, natural philosophy. When he returned to London in 1767 on canal business, Watt clearly already knew Jesse Ramsden well enough to use his business in Haymarket as a postal address and may well have stayed with him at that time.[43] They were of a similar age, and it is possible that they had become acquainted during Watt's training. James Short, himself a Scot, clearly did what he could to assist his young compatriot,[44] and Watt would have become aware, if he was not already, of these higher possibilities. Short was celebrated for his reflecting telescopes and, like most English makers, for the excellence of workmanship rather than theoretical sophistication. As well as supplying the apex of the market, Short made large numbers of high-quality instruments for the burgeoning consumer market among wealthy dabblers in astronomy. Short, like much of the industry at this time, was moving from a craft to an industrial mode of production. In these circumstances of the industry, it would be likely that a youngster eager to learn would find himself engaged too much in routine and repetitive work rather than ranging over a variety of skills. The latter was what Watt and his father want-

ed. So, in a sense, the position with the rather marginal Morgan was fortunate in the variety that it offered. Watt reported to his father that Morgan was "very ready to show me anything I want to know."[45] So it was on Morgan's premises on Finch Lane, a small north-south lane running between Threadneedle Street at the northern end and Cornhill to the south, with the Royal Exchange a short distance to the west, that Watt knuckled down to learn the instrument trade.

What skills did Watt acquire during his time with Morgan? Quite quickly, he was learning how to make brass rules and quadrants, and, crucially, how to "divide" them, that is to mark scale divisions accurately. Subsequently, he worked on making azimuth compasses, a brass sector, and a theodolite. By his own assessment, the quality of Watt's work was as good as that of most journeyman makers, though he lacked speed, an important consideration when making articles for sale at a competitive price. While with Morgan, he worked hard and long hours, both he and his employer hoping to extract the most from the situation. He had time, however, to act as his father's agent with London suppliers, compare prices, shop around for supplies, and gain experience in shipping items to Scotland. In this way his business skills were undoubtedly also developed by the London experience.

Watt's health, which was to be such a preoccupation through much of his life, was actually quite good in London for most of the time he was there, contrary to stories that circulated later and were taken up influentially by Samuel Smiles. Smiles has Watt essentially fleeing London wracked by colds and headaches, seeking recovery back in Scotland. This, as Richard Hills has argued, is pure fantasy.[46] So is the idea that Watt was miserably isolated in the metropolis. His correspondence with his father shows him having an active time and crossing paths with others of their acquaintance who had business in London. This was a situation bolstered by Watt's attention to his father's business affairs. He sought out good prices for goods that his father wanted shipped up to Greenock, buying a great variety of things from drinking glasses and punch bowls to compasses and stoves to quadrants and telescopes. He also on occasion cut out the middleman in finding these supplies. He spent a good deal of time on these activities. Watt was conscious that his father was extending himself financially to support his training with Morgan, and he must have been keen to do what he could to help his father's business affairs.

Watt was careful with his expenditure, finding that he needed to spend eight shillings a week to feed himself. He sought to economize where he could, and he was able sometimes to undertake a little paid work on his own account in the morning before

he started on the tasks that Morgan had laid out for him. He kept careful accounts regarding expenditure for his father, although his personal accounts were not kept consistently, either through lack of time or perhaps as a small act of rebellion. But Watt must have felt that he was doing his best to live very frugally.

The extent to which Watt explored the metropolis is difficult to judge. The errands for his father took him to a range of businesses around the city, and he had to visit the docks in order to load goods for shipping to Scotland. There were times in the spring of 1756 when he was very wary about going out because of the concern that naval press gangs were active in the city. Between 1755 and 1757 over seventy thousand men were recruited to the navy, and over half of these were victims of impressment, at least initially. While a landsman (someone without sailing experience) in times of peace would usually be let go, in wartime that was less likely. Even in wartime a legitimate apprentice or tradesman, or a "gentleman," would have a good chance of successfully fighting impressment.[47] Watt was particularly vulnerable because he was not officially an apprentice. Apart from making it less likely that he would escape being pressed into naval service, his situation, once discovered, would likely get him into trouble with the trades.[48] So, Watt had reasons for keeping his head down.

The years 1755 and 1756 were eventful ones for Britain, and Watt was curious about the centers of power, those distant fulcrums about which Scottish improvement turned. Military tensions had been building for some time, and war against France was formally declared on 17 May 1756. Watt witnessed the public declaration. There is little evidence beyond this, and his witnessing of King George II's return to London in September 1755 from one of his habitual visits to Hannover, that Watt involved himself much in the wider life of the metropolis.

Throughout his time in London, Watt clearly had in mind putting the skills he was acquiring to use in his father's business. He also had an eye on his new friends at Glasgow College; before he left London he was contemplating communication with Robert Dick to see if the professor had any assignments for him in London before he left.[49] Dick had already been very useful to Watt in gaining James Short's support in London, and Watt would have been acutely aware that continued sponsorship from college people would be valuable when he returned to Glasgow. We know from the nature of the supplies that Watt purchased to take back to Glasgow that he contemplated producing Hadley's quadrants, barometers, spirit levels, and the like, all to a quality finish.[50]

Glasgow and the Business of Natural Philosophy

It is unclear exactly when Watt journeyed from London back to Glasgow. His engagement with Morgan according to the agreed term would have ended in June 1756. Thereafter he spent time on business for his father, to whom he wrote his last letter from London on 19 August 1756. By late September we can place him in Glasgow. Watt returned without his former traveling companion, John Marr. Marr had passed his examination to become an instructor in the navy and had gone to sea shortly thereafter. Watt reported that his friend had been in Lisbon at the time of the great earthquake on 1 November 1755. Marr went on to a career as an engineer in the army, helping to fortify Quebec during the American Revolution. They remained friends, and they became relations when Marr married Agnes Millar, known as "Nancy," a sister of Watt's first wife, Peggy. The two engineers were on different paths. Watt's, the less adventurous, with no particular sign of the celebrity to come, led back to Glasgow.

Watt appears to have returned to Glasgow rather than going straight to Greenock to see his father and brother Jockey. He had resumed work for his father's business, especially efforts to secure money from creditors. But he also had an opportunity to deploy his new knowledge of instruments, thanks to Professor Dick, who likely persuaded the college to hire Watt for a fortuitous assignment in October–November 1756. This related to a collection of instruments, including an astronomical clock, reflecting telescopes, and transit instruments, that had been bequeathed to the college by Alexander Macfarlane F.R.S., one if its graduates. Macfarlane was a merchant, long based in Jamaica and engaged in the sugar trade. He had decided that the college should have his observatory instruments after his death.[51] The instruments arrived in a rather disheveled condition, and Watt's assignment was to clean them and to ensure that they were properly reassembled and set up. He was paid the sum of five pounds for the job, which he must have finished by early December because at that time he finally returned to Greenock. The instruments were deployed in the Macfarlane Observatory erected on the college green by 1760 (see figure 1.2).

It was while working on these instruments that Watt first met John Robison (1739–1805), who was to be a lifelong friend.[52] Robison was instrumental in introducing Watt to the steam engine, and he also became an important, if not always reliable, source of historical information about key periods of Watt's life. Robison came from a Glasgow mercantile family and was educated at Glasgow Grammar School. He entered Glasgow College in 1750 and graduated with a Master of Arts degree in

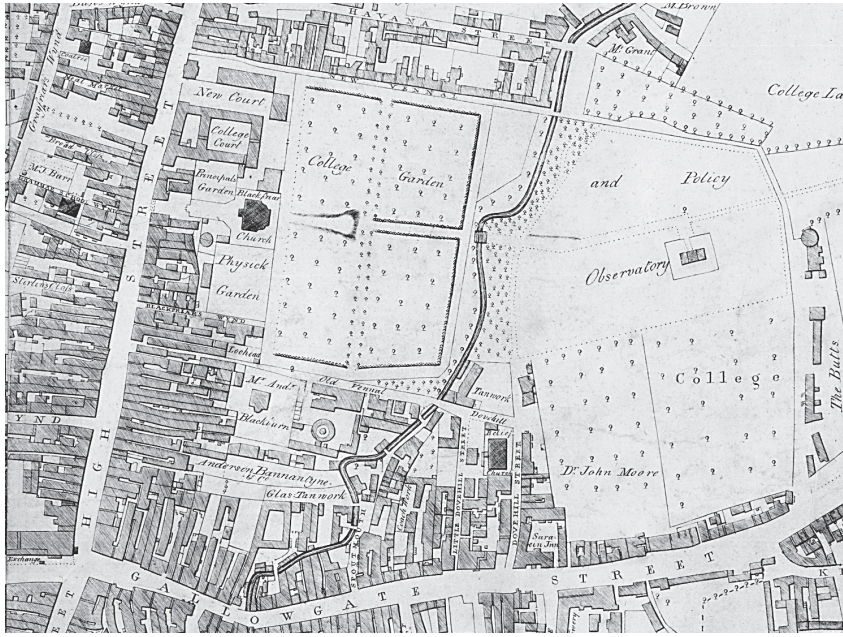

FIGURE 1.2: Map of Old Glasgow College (circa 1778). Watt's workshop was in College Court, and his shop on High Street was near the gate to the Principal's Garden. Extracted from John McArthur's *Plan of the City of Glasgow: Gorbals and Caltoun* (1778). Image courtesy of the University of Glasgow Library.

1756. Not long after that he published an improved design of the Newcomen steam engine in *Universal Magazine*. His subsequent career was to include a brief career in the navy as tutor to an admiral's son and as a member of an expedition to Jamaica to test John Harrison's famous chronometers; the chair of chemistry at Glasgow in 1766; a period in Russia on the coattails of his naval patron the admiral; and then election to the chair of natural philosophy at Edinburgh University in 1774, where he remained for the rest of his career. Robison recalled of his first meeting with Watt that he "saw a workman, and expected no more; but was surprised to find a philosopher, as young as myself, and always ready to instruct me."[53]

During the six months after he finished with the Macfarlane instruments, Watt appears to have been laying the foundations of an instrument-making business, undertaking smaller repair projects, selling the occasional Hadley's quadrant, and expanding his own collection of tools. His father's business and contacts provided an

Figure 1.3: North side, inner court, Old Glasgow College, High Street Glasgow before its demolition in 1870. Watt's workshop was on the first floor above the right-hand turret. From Thomas Annan, *Photographs of Glasgow College* (Glasgow: T. Annan, 1866). Reproduced courtesy of University of Glasgow Library, Special Collections.

outlet for his productions and a source of commissions. The local Greenock bookseller, a William M'Dowal, also took one of Watt's quadrants at this time. It is not clear whether Watt ever considered that he would be able to build a successful business along these sorts of lines. But in mid-1757 he seized the chance to relocate his workshop and tools to the college, where he was appointed mathematical instrument-maker.

The college was in the habit of hosting other ventures like the Foulis Press and the Foulis Academy of Art and Design, which was granted quarters above the library from 1752. It also hosted a type foundry run by Alexander Wilson, which supplied the Foulis Press and other printers with high-quality type. The foundry was housed in a building abutting upon the "College Open."[54] It is possible that granting Watt a role and space in the college was part of an effort to balance these earlier concessions to the literary and visual arts by providing assistance to the mechanical arts and nat-

ural philosophy. Whatever the case, Watt was given generous accommodation. He was provided with a workshop on the first floor of "the north-west side of the inner quadrangle, immediately under the gallery of the natural philosophy class, with which it communicates."[55] The building pictured in figure 1.3, which was located in "College Court," as the inner quadrangle was also called (see figure 1.2), was where his work for the college and its professors would have been done. But, like the Foulis brothers and Wilson, Watt was enabled to pursue his private trade, and for this purpose he had a shop that "formed the ground floor of the house situated next to the Principal's Gate." The house had an entrance directly from the high street.[56] So, the move to the college was not to mean that he abandoned his instrument making and general mercantile activities on his own and his father's account. Rather, the college appointment provided a source of income and accommodations around which his private business could be gradually fostered. It was later suggested that Watt's desire to establish a business in Glasgow had been stymied by the opposition of the guilds and that the college had provided a haven for him in that sense.[57] Whether or not that is true, the college certainly provided a haven for him in terms of building a viable business. Watt's workshop was to be based there until he relocated it in the early 1760s during his partnership with John Craig, which saw Watt gradually withdrawing from the shelter of the college.

Aside from its official purpose, according to Robison, Watt's workshop at the college became an important gathering point for young men interested in natural philosophy:

> 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 beginning of a new and serious study; and we knew that he would not quit it till he had either discovered its significance, or had made something of it. No matter in what line,—languages, antiquity, natural history,—nay, poetry, criticism, and works of taste; as to anything in the line of engineering, whether civil or military, he was at home, and a ready instructor.[58]

This image of Watt, though put forward many years later in a context where hyperbole was at a premium, tends in the same direction as stories of him as an even younger man and also accounts of him in his old age. There is likely much truth in it.

The workshop, however, was not intended to be a "drop-in" center for the young

men of the college. It was to serve a serious purpose. As Professor Dick may have foreseen when he first suggested that the young Watt seek training in London, there was certainly an increasing need for the services of a versatile instrument maker and mechanic at Glasgow College. At that institution and at Edinburgh University in particular, the mid-eighteenth century saw the efflorescence of a distinctive teaching regime in the sciences that attracted students from far afield, especially from dissenting communities in Britain but also from the American colonies and from Europe. Centered upon medical education but not confined to it, the teaching of the natural sciences assumed greater prominence.[59] Old teaching methods using a tutorial system were superseded by large-scale lectures. Charismatic professors attracted large numbers of eager students to lectures in chemistry and natural philosophy, and they informed and enlivened their teaching through sometimes spectacular and often impressively deft experimental demonstrations. Those demonstrations required equipment of various sorts, which had to be kept in good repair and set up as occasion demanded. The professors also conducted research very often; this was more of a private matter. However, advanced or particularly favored students might be inducted into the mysteries. Watt's function, then, was to keep the college's instruments, particularly those used in teaching, in good working order. Given the extent to which the reputation of professors as teachers—and hence their salaries, which depended heavily on student fees—and the success of the institution relied upon proficient demonstrations in lectures, Watt's function was an important one.

Watt's arrival at the college coincided with some important shifts in personnel. Professor Dick died in May 1757, which would have been a personal blow for Watt since the professor of natural philosophy had been an important guide and support. Dick was replaced by John Anderson (1726–1796), who also proved supportive in the sense that he gave Watt considerable employment in cleaning and repairing the full gamut of apparatus that was used in his lectures to demonstrate principles across the whole range of natural philosophy. Anderson, who was at one time known to his students as "Jolly Jack Phosphorus" because of his predilection for using explosives in demonstrations, also employed Watt as an assistant and demonstrator in his lectures. Hills considers that the education Watt received from Anderson as a result of these activities was invaluable and has not been fully appreciated in its relevance to his later work on steam engines.[60] Watt's marvellous powers as an autodidact were given considerable play by the opportunities that Anderson gave him. The impulse that later led Anderson to institute lectures on the principles of natural philosophy for working men and to bequeath his estate for the education of workers may well

have guided his treatment of Watt, who was also given the run of Anderson's personal library.[61]

Another major field of teaching at the college was chemistry. This found much of its rationale in its medical connections and had been given a boost by the appointment of William Cullen at Glasgow. Cullen was part of a movement that sought to expand chemical teaching beyond the field of pharmaceutical chemistry, the original rationale for its inclusion in the medical curriculum. Eventually Cullen taught chemistry as a "liberal art" in itself, creating a curriculum that combined "philosophical chemistry"—by which was meant a form of pure inquiry into the nature and combinations of matter and heat—with the applications of chemistry in agricultural and industrial improvement.[62] With Cullen, academic chemistry and practical improvement achieved close proximity in a way that greatly pleased the impresarios of Scottish academic development, especially the Duke of Argyll. Cullen left Glasgow College for a chair at Edinburgh in 1755.

Cullen's successor at Glasgow was Joseph Black (1728–1799), who had himself studied with Cullen at the college before moving to Edinburgh to take his MD. Black was appointed to the chair of medicine at the college in April 1757 and probably took up the position at about the time that Watt transferred his workshop there. The two men were to become close associates, business partners, and lifelong friends. For historians and others, the nature and significance of their relationship has been of great importance and sometimes controversial, particularly the question of how much Watt relied on Black's scientific ideas about heat in conceiving his improvements to the steam engine.

Black was born in France, but his family were long based in Ulster, which had of course very close ties with Western Scotland and Glasgow in particular.[63] He studied at Glasgow College from 1744 and was inspired to an interest in chemistry by Cullen, whose lectures he attended and who employed him as a laboratory assistant for his lectures. Black was to be a chemist in much the same "improving" vein as Cullen, combining an experimental philosophical chemistry (in Black's case concerned with causticity, the production of airs, and the chemical nature of heat) with close involvement in the applications of chemistry to agriculture and the industrial arts. Professionally, Black had decided to enter medicine and he transferred to Edinburgh University to pursue his MD. It was for the dissertation required for that degree that Black undertook his studies of *magnesia alba* (magnesium carbonate).[64] The decision to work on this material was informed by the search for a remedy for urinary stones but also related to the industrial context, in which alkalis were already of consider-

able importance in the Scottish economy. But the famous outcome of the work was Black's discovery that magnesia alba, when treated with acid, released an air, which Black called "fixed air" (and which we call "carbon dioxide"). For reasons to be explained later, this discovery placed Black as a founder of the study of airs—or "pneumatic chemistry"—a field that was of great importance to changing chemical ideas in the later eighteenth century, and one in which Watt would also claim a role. Black was to be reticent about publishing his work in later years, but this early discovery was published in the journal of the Edinburgh Philosophical Society.[65]

When the two men first coincided at Glasgow College, Watt was twenty-one and Black twenty-eight years old. There is little direct record of their early acquaintance. Understandably, their daily proximity meant that their correspondence only began when Black moved to the Edinburgh chair in 1765, where he was to spend the rest of his career. There are some historical testimonies to their early relations (by Black and by John Robison), but these date from the mid-1790s and were produced as evidence in patent trials in which Watt's character as a philosopher was an important issue, and so are not necessarily reliable. Given Black's work on heat during his years as professor at Glasgow, and given the supposed importance of an understanding of heat to Watt's steam engine innovations, the philosophical relations of Black and Watt have taken center stage. But all that was in the future when they met. How might they have regarded each other at the time?

There was, of course, a significant difference in status: Black was a physician and a professor; Watt was a bright, resourceful, but only partly trained mechanic and instrument maker. However, in some respects their backgrounds and preoccupations were similar. Black's father, though undoubtedly wealthier than Watt Sr., was in the ship-victualling business and a merchant. Also, in the hiatus between his Edinburgh studies and Glasgow professorship, Black ran a shop of some sort. Black shared fully in the "improving mentality" of Watt and his family. He did a great deal of work as a consultant, both formal and informal, on the chemistry of agriculture (for example, the role of lime and marl in soil fertility), mining, and manufacturing. Black also invested in various industrial projects. Watt was to be a partner with Black in some of these, and a recipient of his financial support in a number of improving ventures. Black clearly thought very highly of the slightly younger Watt, both as a "projector" and as a philosopher.

During his time as the Glasgow chair, Black continued his research but became increasingly reluctant to publish it, at least in printed form. He did report on his research in the lectures that he gave, which numerous prospective medical men at-

tended, and no doubt regarded this as a form of publication. His Glasgow research pertained to heat and mixture. On the modern map of knowledge, heat is seen as the preserve of the discipline of "physics," but in the eighteenth century it was part of chemistry, not least because many philosophers regarded heat as a substance that combined chemically with other materials. Black's experiments on heat, which were also inspired by the research agenda handed down from Cullen, almost certainly began at or around the time that he met Watt. Black claimed that he discussed his ideas about what came to be called "latent heat" in his first series of lectures at Glasgow in 1757–1758. Watt later maintained that he pursued his heat experiments of the early 1760s independently of Black, only learning of Black's notion of latent heat after his own rediscovery of it. This seems very unlikely given the close relations of the two men, Watt's location at the college, and his involvement in servicing the lecture programs of the professors. There were also good reasons for Watt, and his friend Black, to subsequently maintain a fiction of Watt's independent philosophical work on heat. But we have no direct evidence to contradict their claims, except John Robison's remark that Watt did attend Black's lectures. However, this testimony, too, was long after the event and was contradicted by Watt himself. It must also be admitted that Robison was not the most reliable of witnesses.[66]

So, whether Watt and Black were close in this later-to-be-consequential respect remains uncertain, but it is known that they shared company and also practical ventures. Indeed, the hardware shop that Watt established in the Trongate, Glasgow, in 1763 with John Craig as his main partner was partly financed by Black and by Alexander Wilson, the type founder and professor of practical astronomy. From the late 1750s Black had lent Watt various sums of money that helped launch and maintain the young man's activities. Black was even to help fund the steam engine project that Watt entered into with his first major collaborator and backer in that field, Dr. John Roebuck. Watt's debts to Black were not finally cleared until 1784, to Watt's evident embarrassment. But in the early days Watt lacked investment capital and had to rely on others, among whom Black was prominent.

Watt undoubtedly saw natural philosophy and chemistry in particular as important to business, indeed as a crucial aid to it. Only later, and then to a limited extent, did Watt regard himself as part of circles of the learned in scientific and other academies. Unlike the professors of the college, he had no formal student audience, despite the attractions of his workshop for some of the collegians. Thus it was the business of natural philosophy that primarily concerned Watt—the market that natural philosophical inquiry and teaching provided for the products of his skills, and also the use

of philosophical acumen and experimental inquiry in the prosecution of business ventures. A key example of the latter was a scheme involving Black, Watt, and Roebuck for the production of alkali from salt. This scheme was also a clear bridge between the trading world from which Watt had emerged and the business of natural philosophy in which he was increasingly engaged.

Salt was an important commodity in mid-eighteenth-century Scotland in both the traditional economy and in the emerging industrial one. The Watts, father and son, traded in salt for use in preserving herring, a traditional use, and also traded in herring. Salt had long been produced in Scotland by evaporation of seawater, but when made in this way the salt contained other impurities (such as magnesium salts) that rendered it unsuitable for use in fish preservation. In consequence, much of the salt used for curing fish was imported. This was where the potential of chemistry came in. William Cullen had developed technically successful but economically unviable ways of purifying Scottish sea salt. John Roebuck also pursued purification techniques, apparently with more practical success; in the mid-1760s he was supplying Watt Sr. with salt for use in preserving herring that were coming into Greenock from the Western Isles.[67]

Another crucial commodity for a number of industries was alkali—used in making glass and soap, as a fertilizer, and in bleaching. The traditional sources of alkali were natural ones: wood or kelp were burned to produce potash. Much alkali was imported in the form of barilla (soda ash, that is sodium carbonate in modern terminology) that was produced by burning halophyte plants. These plants were common in the Mediterranean countries, and Spain was the major source of very pure soda ash. If a chemical way could be found to produce sodium carbonate from salt, then there was a real possibility of significant economic advantage in supplying the user industries with pure alkali. Indeed, the freeing of alkali production from reliance on biological sources was one of the keys, if not *the* key, to the foundation of the heavy chemical industry, or what has been called the "palaeotechnic transition."[68] Although this was not fully realized until the adoption of the Leblanc process in Britain beginning in the 1820s, John Roebuck and our Scottish improvers, including the Watts and their circle, were one of the key groups trying to make improvements in that area.

Watt's own account of the beginnings of this episode credited Joseph Black with the initial chemical insights suggesting how alkali could be produced by treating salt with lime. This was in 1765. Thus Watt informed his Birmingham friend William Small in 1769: "As to the Alcali affair you know Dr. Black first invented the theory which he communicated to me I tried experiments & found it succeed. After I had

given it up, I went on with Experiments till I brought it to a probability of succeeding in practice."[69] Watt recalled that Roebuck had been brought into the venture shortly thereafter. Eric Robinson suggested that there was a division of labor between the three men, Black being the laboratory chemist, Roebuck the entrepreneur and capitalist, and Watt the industrial chemist and practical man-of-affairs.[70] Although this is broadly correct, it was not quite so simple. For one thing, the intention was that both Black and Watt have a financial interest in the venture, not just a technical role. Watt also exhibited tactical business insight. There was no immediate outcome, and the affair carried on through the next decade and beyond. There were initial plans to take out a patent on the process, perhaps in Black's name, especially when they learned that another of the Birmingham group, James Keir, was working in a similar direction, as was George Fordyce in London. But then secrecy seems to have been preferred. The scheme effectively ground to a halt as Watt became preoccupied with other things, notably steam, and with earning a living. The project was apparently left in Black's hands, but his efforts were desultory before they ceased.[71] Throughout, though, Watt was a key figure and active experimentalist. We need not explore the story further here, since the important point to be made is how quickly and how expertly Watt was operating, by the time of his thirtieth year, in the business of natural philosophy.

Another venture in which Watt was involved beginning at this time was the Delftfield Pottery in Glasgow.[72] This episode illustrates further how he brought technical expertise and insight to bear on business. It also shows us how Watt relied upon others, in this case members of his extended family, for necessary investment capital.

The Delftfield Pottery had been operating for twenty years or so when Watt became involved in it. Like much investment in manufacturing in the West of Scotland in the mid-eighteenth century, it came from tobacco merchants, in this case Laurence Dinwiddie of Glasgow and his brother Robert, who had traded in London before becoming governor of the colony of Virginia, no doubt a useful posting for a tobacco trader. Together with two other minor partners, they founded the pottery in 1748. Although they had to import technical and managerial expertise, the original partners did have a clear business plan and rationale. This was to produce tin-glazed delftware, inferior of course to porcelain but a cut above crude earthenware pottery. Such produce appealed to the middling classes of Glasgow and was intended also for export to the colonies. The pottery experienced numerous early difficulties but did manage to produce a saleable commodity before a major change in ownership took place in the mid-1760s. At around the same time, Watt came into the picture. What inspired

his involvement is unclear. Richard Hills has suggested, very plausibly, that the fact that improvements in pottery were being made as a result of chemical analysis of new clays and glazes, and that innovative kilns and firing techniques were being used, may have encouraged Watt to think that his growing chemical expertise could help make a breakthrough for what had been up to that time a rather lackluster company.

Much of Watt's expertise had been acquired from Black, and Black himself had a history of consulting on ceramics for others. He took a close interest also in the design and development of kilns. Watt had manufactured kilns for Black, and the two men discussed experiments with ceramics in those kilns. At the time he joined the pottery and shortly thereafter, Watt experimented on glazes and on cobalt production from local supplies. He also experimented on new kiln designs, including kilns fired by coke and coals instead of wood, which promised more economical operation. Importantly, it appears that in all his experimental work, questions of economics, competition, and business practice were ever-present. Watt's command of the chemical and other technical details of pottery manufacture was impressive, but he was no mere technical advisor. He also had a strong business and managerial sense, and kept up with the latest developments in the industry and among competitors. His talents enabled these broader concerns; his financial interest in the pottery impelled them.

When we consider the financial side of Watt's involvement in the pottery, we are reminded of the extent to which he relied upon family and other members of his close circle. Though it is not certain, it appears from Watt's "Journal" of June 1772, where he recorded details of the capitalization of the company and his share of it as £474.4.2, that he was receiving a good return on his investment, but he notes that he owed £120 of that capital to "Mr Moreheid" and £110 to Nancy Millar.[73] This was almost certainly the capital loaned to Watt for his initial investment in the company, on which he paid interest. There was other family investment in Delftfield, by his cousin Robert Muirhead the younger and later by Gilbert Hamilton, who became Watt's brother-in-law by his marriage to the sister of Watt's second wife, Ann McGrigor. When Watt left for Birmingham in 1774, Hamilton became his agent in Scotland and subsequently a partner in the pottery with a close hand in its management.

Watt's involvement with the Delftfield Pottery, which continued long beyond the period concerning us here, shows us again how Watt turned his knowledge and his experimental capability to business use for himself and others. He relied in these early years upon financial support from his family, and indeed upon other forms of support; Watt Sr. took a keen paternal interest in the fortunes of Delftfield. Watt's family, however, were not engaged in charity here. They were investing in the capabilities

of a young man already noted for his knowledge, skill, and drive, a son of Greenock who was expected to do well in the world through the business of natural philosophy.

We must not, however, as David Bryden insists, allow our knowledge of what was to come to warp our understanding of Watt's Glasgow years or lead us to treat them as merely background to the main story.[74] Despite the variety of projects with which he became involved during those years, Watt was, until at least the late 1760s, primarily engaged as an instrument maker and merchant. The fact that there was limited demand for mathematical instruments encouraged Watt to diversify his products. He and workmen he employed made musical instruments as well as mathematical ones.[75] There are intimations of Watt's mechanical ingenuity and talent for improvement in some of these activities, especially his improvement of a drawing aid—a "perspective machine." He had obtained such a machine, but it was heavily and clumsily constructed. Watt adapted the double parallel ruler in the construction of his machine and made other changes that rendered it both lighter and easier and more convenient to use.[76] These items of his own devising and manufacture were sold through his own outlets but also supplied to retailers in other cities. Watt purchased supplies for his manufacturing activities but also bought goods such as cutlery, other ironmongery, and toiletries directly for sale in his shops. Again, as Bryden says, Watt was not a closeted instrument maker but rather "a business man with vision, taking on employees and trainees, buying in a broad range of merchandise to realise his ambition of significant commercial success."[77] On occasion the pursuit of profits may have involved Watt in dubious practices. Michael Wright has discovered among the tools from this early period left in the garret workshop that Watt established in his Birmingham residence, Heathfield (which is now held by the Science Museum), a stamp bearing the letters "*T LOT.*" This he recognized as an imitation of the stamp placed on his instruments by the Parisian flute maker Thomas Lot. It appears that Watt may have been engaged in passing off his own instruments as of more prestigious pedigree, though the evidence is circumstantial.[78]

It is likely that Watt's business ambition both attracted and necessitated the substantial financial help he received from the merchant John Craig, with whom he entered a partnership in 1759 and whose financial support enabled Watt to employ more apprentices and journeymen as well as open his shop on the Trongate in 1763 and diversify the range of goods that he made and sold.[79] Watt drew himself a salary of £35 per annum, no doubt intent upon trying to build up his capital in the business. Craig invested heavily. By the time he died in December 1765, he had over £750 owed from the business. Paying that sum to Craig's estate proved a major headache

for the young merchant and shopkeeper who had lost his business partner. The debt was to be paid and taken over by John Roebuck as part of his steam engine partnership with Watt. As we have seen, Watt also owed money to Joseph Black, who had invested in the shop and other projects. He had also accumulated debts to others in connection with his varied enterprises.

During the decade after his return to Glasgow from London, Watt developed many strings to his bow. His position as instrument maker at Glasgow College gave him a good start, which acquired other dimensions as he aided the professors in other ways and built up his hardware and general mercantile activities. His contacts and friendships at the college as well as the work itself expanded Watt's knowledge, skills, and capabilities. Watt was a young man who could absorb, recall, and turn to effect all of his experiences. He continued to assist, and to a degree rely upon, his father and his father's style of business, always alert to trading opportunities. But gradually he began to take a part in other ventures that gave play to his ever-expanding natural philosophical and technical repertoire. He was ambitious for success and no doubt hoped that one or more of his projects might begin to pay in a significant way and make his fortune.

The making of that fortune, or at least a reliable sufficiency, became more urgent as Watt contemplated and then acquired his own family. He married a cousin, Margaret Millar, always known as "Peggy," on 16 July 1764. Peggy was the daughter of Daniel Millar, a wright of Hamilton, and his wife Margaret Muirhead (1700–1774), herself a daughter of Robert and Agnes Muirhead, and so sister of Watt's mother. Peggy and James had known each other from childhood. It seems likely that Peggy would also have been a regular visitor at their grandfather Robert's Croy Leckie estate at Killearn near Loch Lomond during some of Watt's summer sojourns there. Given the evident closeness of the Watt and Muirhead families, James and Peggy must also have met at many family gatherings. A preserved item of correspondence between them from 1761 or 1762 (in which Peggy begs Watt to "take cair of yourself for know my happiness depends upon your health") perhaps betrays at least the beginning of a romantic relationship.[80] It was not unusual for cousins to marry, and they seem to have been well suited. For all his ambition, perhaps even because of it, Watt could be easily discouraged and was not of a very sanguine temperament. By all accounts Peggy made up for this and provided the aid and encouragement her husband sometimes needed.

Marion Campbell's recollections, as relayed by her daughter Jane, conveyed a little

about James and Peggy's "early & constant attachment": "My mother even considered it [their relationship] as having added to Mr Watt's enjoyment of life & having had the most beneficial influence on his character. Even his powerful mind sunk occasionally into misanthropic gloom from the pressure of long continued nervous headaches & repeated disappointments in his hopes of success in life. Miss Millar from her sweetness of temper, & lively, cheerful disposition, had power to win him from every wayward fancy; to rouse & animate him to active exertion. She drew out all his gentle virtues, his native benevolence, & warm affections."[81] Watt and Peggy reportedly lived initially in a substantial house belonging to the Delftfield Pottery Company on Delftfield Lane, which was at the western edge of Glasgow, beyond the main dock at Broomielaw. This would have placed them between central Glasgow, where much of Watt's business was located, and his family in Greenock.

Their first child was born in July 1765, and they named him John after Watt's recently deceased brother, Jockey. But young Jockey survived only five or six months. A daughter, Margaret, arrived in 1767. Known like her mother as "Peggy," she lived to adulthood, married, and had children of her own but died at the age of twenty-nine. The only one of their children who was to survive Watt, James Watt Jr., was born in 1769, while another daughter, Agnes, born on Christmas Eve 1770, lived for just over a year. As we have anticipated, Peggy's final pregnancy was to end in late September 1773 with a stillborn child and her own death.

After a couple of years on Delftfield Lane, the young couple moved to central Glasgow, living in a number of properties there. This was a period when Watt was conducting experiments on steam, which we will examine in detail later, and it is interesting to note that a topic of discussion between Watt and Peggy when accommodation was being considered was whether the property had a "garret," preferably with a fireplace.[82] This perhaps suggests that long before Watt established his famous garret workshop at Heathfield House in Birmingham, he needed a domestic workshop with a fire available. When Watt moved out of the college in 1763, he maintained a number of premises in central Glasgow for his shop and workshop, where experiments were conducted.[83] But it looks as if these sites were not enough, and that Watt's incessant experimentation habitually intruded on the domestic space. By May 1767 Peggy, who was pregnant, faced "flitting" again while Watt was in London on canal business: "As to my Garrit," he said, "I beg you would speak to Mr Macintosh to let the things stay in it for a month or so till I come down as they cannot be removed by any body but myself rather offer him a years rent of it for that time."[84] Watt was

obviously very concerned that his workshop or laboratory not be disturbed by uncomprehending others.

Besides the shop, the pottery, and the alkali venture, Watt had been drawn into an investigation that was eventually to make his fortune, the working and improvement of the Newcomen steam engine. But once again financing and prosecuting this proved difficult, and in an effort to bolster his income to support his wife, two young children, and the prospect of more, he turned to yet another line of business that ran in the family—surveying and civil engineering work.