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Simon Schaffer

In summer 1823 the new and controversial Astronomical Society of London decided to award its gold medal to one of its own founder members, the equally controversial Cambridge-trained mathematician Charles Babbage. The award formed part of an energetic campaign to launch the construction of a Difference Engine, a machine to calculate navigational and astronomical tables. In his address to the society in early 1824, its president, the financier, mathematician, and orientalist Henry Colebrooke, summed up the significance of Babbage's planned device: 'In other cases, mechanical devices have substituted machines for simpler tools or for bodily labour. . . . But the invention to which I am adverting . . . substitutes mechanical performance for an intellectual process'. In other words, 'Mr Babbage's invention puts an engine in place of the computer'.[1] This may seem a paradoxical comment on the man who is now lauded as the computer's inventor. But as with terms such as *typewriter,* the word *computer* referred here to a human being, in this case the hireling employed to perform the exhausting reckoning which every astronomical operation required. Babbage himself applied for the post of computer at the Royal Observatory, Greenwich, in summer 1814, until dissuaded

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1. Henry Thomas Colebrooke, 'On Presenting the Gold Medal of the Astronomical Society to Charles Babbage', *Memoirs of the Astronomical Society* 1 (1825): 509–10; Charles Babbage, letter to John Herschel, 27 June 1823, Royal Society Herschel Papers, HS 2:184.

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from the thankless task. The labour of verifying 'the calculations of the computers' required in compiling astronomical tables soon prompted a characteristic expostulation: 'I wish to God these calculations had been executed by steam!' Hence developed the plans for the Difference Engine.[2]

Gesturing toward the urgent issues of technological redundancy and the subordination of the labour process, Colebrooke's remark provides the theme of my story of the connexion which Babbage helped forge between the development of machinofacture and the design of intelligent machines. A key to this link is the term *intelligence.* The word refers both to signals received from without and to the capacity to register and interpret these signals. In early nineteenth-century Britain the word *intelligence* simultaneously embodied the growing system of social surveillance and the emerging mechanisation of natural philosophies of mind.[3] In what follows, I explore the coproduction of ideologically freighted accounts of intelligence and politically charged systems of machinery. To make machines look intelligent it was necessary that the sources of their power, the labour force which surrounded and ran them, be rendered invisible. This is why Siegfried Giedion's brilliant study of automation is subtitled *A contribution to anonymous history.* Like him, I am concerned with the mundane *places of intelligence.* London in the 1820s and 1830s was a fractured world. South of the river, in Lambeth, were the workshops of the machinists whose labours drove the production of automatic tools and accurate design (see fig. 1). In the fashionable milieu of the West End, genteel Londoners could witness shows of the triumphs of these new machine systems in public lectures and carefully orchestrated museums. Here, too, were the wardens of scientific reason—the Astronomical Society, the Royal Society, the Royal Institution. Northwards again, in the fashionable houses of Marylebone, lived men such as Charles Babbage and Charles Darwin, ambitious reformers who sought to rethink human nature in the name of a reconstructed scientific and social order. And in the northeast were the huge working-class districts, areas where Babbage sought to run for parliamentary office and where his socialist critics de-

2. Herschel, letter to Babbage, 25 Oct. 1814, Royal Society, HS 2:31, and H. W. Buxton, *Memoir of the Life and Labours of the Late Charles Babbage,* ed. Anthony Hyman (1880; Cambridge, Mass., 1988), p. 46; hereafter abbreviated *M.*

3. For the uses of intelligence, see Michel Foucault, *Discipline and Punish: The Birth of the Prison,* trans. Alan Sheridan (New York, 1979), pp. 195–228; Ian Hacking, *The Taming of Chance* (Cambridge, 1990), pp. 55–63; and Adrian Desmond, *The Politics of Evolution: Morphology, Medicine, and Reform in Radical London* (Chicago, 1989), pp. 114–17.

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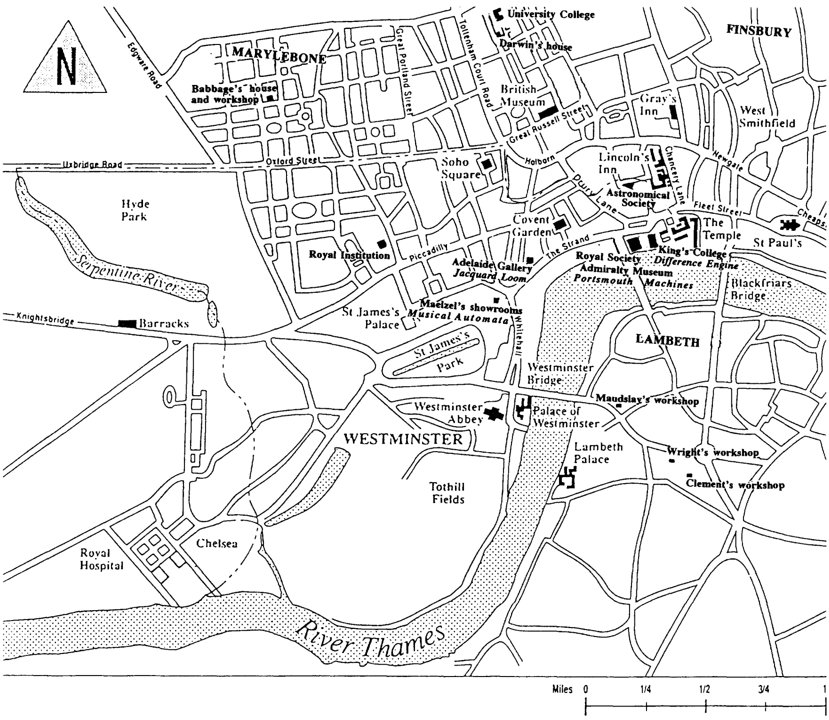


FIG. 1.—Map of London in the 1830s.

bated with him on the hustings about machinery's effects. This is the geography of Babbage's intelligence, the world where his systematic vision was forged.[4]

Systems are socially constructed and so, as we are increasingly reminded, are the productive and unproductive bodies which inhabit them. This is why Babbage's most penetrating London reader, Karl Marx, famously reckoned that it would be easier to write 'a critical history of technology', 'a history of the productive organs of man in society' than to produce Darwin's 'history of natural technology'. Babbage's moment was decisive for the construction of sociotechnical systems and for the perception that the world of the productive work force was ordered systematically. These processes of construction and perception should not be separated; but there is a whole history to be written of the counterclaim that they can be teased apart, that the point of view from which the systematic character of the sociotechnical world can be detected is independent of that world. Early Victorian society provided major re-

4. 'History writing is ever tied to the fragment' (Siegfried Giedion, *Mechanization Takes Command: A Contribution to Anonymous History* [1948; New York, 1970], p. 3). For London's geography, see Iwan Morus, Jim Secord, and Simon Schaffer, 'Scientific London', in *London–World City 1800–1840,* ed. Celina Fox (New Haven, Conn., 1992), pp. 129–42.

sources for this claim and it must be studied in detail to show how this position was developed. The philosophers of manufacture, such as Babbage, carefully constructed a place from which they could make out the lineaments of the factory system. Critics of this philosophy, such as Marx, pointed out the political implications of this construction. During the London Chartist debates in 1856 about the science embodied in the machinery of the automatic system and the fate of the worker's body, Marx announced that 'all our invention and progress seem to result in endowing material forces with intellectual life, and in stultifying human life into a material force', and in his notebooks of 1857–58, where he observed that 'it is the machine which possesses skill and strength in place of the worker, is itself the virtuoso, with a soul of its own in the mechanical laws acting through it'. Within the 'system of machinery', as Marx defined it, 'the *automatic* one is merely its most complete, most adequate form, and alone transforms machinery into a system'. What follows is not a 'critical history of technology', but it is an attempt to show where the systematic vision came from, the geography of its development, and some of the political and technical effects it had.[5]

1. Intelligence in Marylebone

Babbage's designs for intelligent machines dominated his career from the moment he reached Marylebone as a wealthy and ambitious analyst in the 1810s. His Difference Engine was based on the mathematical principle that the successive differences of values of polynomials were ultimately constants, so tables of these values could be computed by addition and subtraction of predetermined constants. The device was launched in London in summer 1822, and after many vicissitudes, including its nationalisation in early 1830, it collapsed forever amidst recriminations between Babbage and his master engineer Joseph Clement in summer 1834. Then in the mid-1830s Babbage began negotiating a new contract with Clement's former draftsman, C. G. Jarvis, to plan an Analytical Engine, an unprecedented technical system with a huge memory, a store, an input-output device using number and variable cards, and

5. Karl Marx, *Capital: A Critique of Political Economy,* trans. Ben Fowkes, 2 vols. (1867; Harmondsworth, 1976): 1:493 n. 4, hereafter abbreviated *C;* 'Speech at the Anniversary of the *People's Paper*' (Apr. 14 1856), *Karl Marx: Selected Works,* ed. V. Adoratsky and C. P. Dutt, 2 vols. (London, 1942), 2:428; and Notebook 6 (February 1858), *Grundrisse,* trans. Martin Nicolaus, ed. Nicolaus and Fowkes (Harmondsworth, 1973), pp. 692–93. For Marx as a systems theorist, see Thomas P. Hughes, 'The Order of the Technological World', *History of Technology* 5 (1980): 5–7, and Raniero Panzieri, 'The Capitalist Use of Machinery: Marx Versus the "Objectivists"', trans. Quintin Hoare, in *Outlines of a Critique of Technology,* ed. Phil Slater (London, 1980), pp. 44–68.

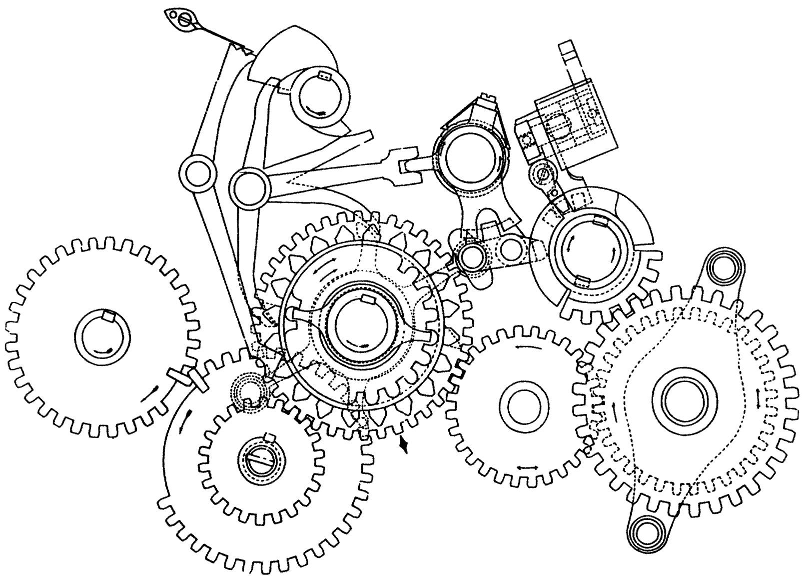


FIG. 2.—The mechanism for anticipation in the Analytical Engine. From Charles Babbage, *The Analytical Engine and Mechanical Notation,* vol. 3 of *The Works of Charles Babbage,* ed. Martin Campbell-Kelly (New York, 1989), p. 250.

a control system of operation cards. The crucial aspects of the new Analytical Engine, its capacity for *memory* and *anticipation,* were profound resources for Babbage's metaphysics and his political economy (see fig. 2).

Babbage organised a series of remarkable publicity campaigns for his engines, both in Britain and elsewhere—in Berlin, Paris, and Turin. The terms of this propaganda revealed the politics of his campaign for the mechanisation of intelligence. In 1838 he confessed that 'in substituting mechanism for the performance of operations hitherto executed by intellectual labour, . . . the analogy between these acts and the operations of the mind almost forced upon me the figurative employment of the same terms'. He was committed to phrases such as 'the engine *knows*' to describe its predetermined move from one calculation to the next (*M,* p. 216 n. 8). Babbage's new science of operations, an algebra of machine analysis designed to describe the engines' work, was proposed as a discipline of complete generality both within the surveillance of mental labour and in the manufacture of exact values. Initially designed to 'see at a glance what every moving piece in the machinery was doing at each instant of time', this panoptic notation was proffered as a technology of universal management. Babbage stressed the advantages of machine semiotics because 'of all our senses that of sight conveys intelligence most rapidly to the mind'.[6] The industrial journalist Dionysius Lardner reported that the working of the human body and the factory system could both be represented and managed this way. The analogy of machine, body, and workshop was developed at once: 'not only the mechanical connection of the solid members of the bodies of men' but also, 'in the form of a connected plan or map, the organization of an extensive factory, or any great public institution, in which a vast number of individuals are employed, and their duties regulated (as they generally are or ought to be) by a consistent and well-digested system'. It is for this reason that the term *system* requires further historical analysis. The panoptic gaze which revealed the order of the factory system and the mechanism of the body also rendered the work force and its resistance rather hard to see.[7]

According to Babbage's leading Italian disciple, the military engineer and future Piedmont premier Luigi Federigo Menabrea, Babbage's 'engine may be considered as a real manufactory of numbers'. As historians such as Maxine Berg have demonstrated, these engines for manufacturing numbers and mechanising intelligence were developed alongside the discourse of Ricardian political economy. The 'philosophy of manufactures' provided Babbage with an account of what he 'called the "domestic economy of the factory"' and also with an analysis of the skilled labour embodied in machinery.[8] Babbage's publications on the economy of the factory culminated in his masterly book of 1832, *On the Economy of Machinery and Manufactures,* a work based on intelligence gathered throughout the factories of Britain, soon translated into every major European language. As the Analytical Engine was a 'manufactory of figures', so Babbage had to outline his definition of a *manufactory.* 'A considerable difference exists between the terms *making* and *manufacturing*', he explained in his economics text.[9] The difference lay in the economical regulation of the domestic system of the factory. This led to Babbage's

6. Babbage, draft of 'On a Method of Expressing by Signs the Action of Machinery', University of Cambridge Library, Add. MSS 8705:21, later published in *Philosophical Transactions* 116, no. 3 (1826): 250–65. For analysis and the science of operations, see Marie-José Durand-Richard, 'Between Science and Industry: The Principle of Analogy and the Mechanization of Operations', in *The Interaction between Technology and Science,* ed. B. Gremmen (Wageningen, 1991), pp. 23–42.

7. [Dionysius Lardner], 'Babbage's *Calculating Engine*', *Edinburgh Review* 59 (July 1834): 319. For Lardner's collaboration on mechanical notation with Babbage and its publicity in Paris and Berlin, see Babbage, letter to Charles Dupin, 20 Dec. 1833 and Babbage, letter to Alexander von Humboldt, Dec. 1833, British Library, Add. MSS 37188, fols. 117, 123.

8. A. A. Lovelace, 'Sketch of the Analytical Engine Invented by Charles Babbage Esq. by L. F. Manabrea, of Turin, Officer of the Military Engineers, with Notes upon the Memoir by the Translator', *Scientific Memoirs* 3 (1843): 690; rpt. as *Sketch of the Analytical Engine,* in *The Analytical Engine and Mechanical Notation,* vol. 3 of *The Works of Charles Babbage,* ed. Martin Campbell-Kelly, 11 vols. (New York, 1989), p. 89; and Maxine Berg, *The Machinery Question and the Making of Political Economy 1815–1848* (Cambridge, 1980), pp. 181, 183.

9. Babbage, *On the Economy of Machinery and Manufactures,* 4th ed. (London, 1835), p. 120; hereafter abbreviated *E.*

reinterpretation of Adam Smith's notion of the division of labour, and, as he emphasised, the fundamental principle of that division which allowed the sensitive analytical regulation of the process of manufacture. The 'Babbage principle', as it came to be known, applied equally to the regulation of the factory and the calculating engines:[10]

> The master manufacturer, by dividing the work to be executed into different processes, each requiring different degrees of skill or of force, can purchase exactly that precise quantity of both which is necessary for each process; whereas if the whole work were executed by one workman, that person must possess sufficient skill to perform the most difficult, and sufficient strength to execute the most laborious, of the operations into which the art is divided. [*E,* pp. 175–76]

As Babbage and his allies among the political economists showed, the disaggregation of the production process into its simplest components allowed a series of economies and practices of surveillance. Mechanised production required strict discipline. The same was true of the Analytical Engine. Parcelling the processes of Lagrangean algebra into specific components allowed the increase in speed of the machine, the transformation of infinities of space into manageable durations of time, the most economical recompense to each component in terms of consumed power (if mechanical) or consumed wages (if human). 'The whole history of the invention has been a struggle against time', Babbage wrote in 1837 (*M,* p. 194). The replacement of individual human intelligence by machine intelligence was as apparent in the workshop as in the engines. This task was both *politically* and *economically* necessary. 'One great advantage which we derive from machinery is the check which it affords against the inattention, idleness or the dishonesty of human agents' (*E,* p. 54). Such failings could produce erroneous results. This was why Babbage was always fascinated by French Republican attempts of the 1790s to compute new logarithm tables by an ingenious division of the labour of teams of subordinate calculators. The French reported that their least intelligent computers, when subject to the right management, were the most reliable. Unreliable agents could also form trade union combinations, which, Babbage held, were always 'injurious' to the work force itself (*E,* p. 297). His aim here was to contest the influence of 'designing persons' and show the working classes that 'the prosperity and success of the master manufacturer is essential to the welfare of the workman', even though 'this

10. Richard M. Romano, 'The Economic Ideas of Charles Babbage', *History of Political Economy* 14 (Fall 1982): 391. Marx's response to the Babbage principle can be found in *Capital:* 'The collective worker now possesses all the qualities necessary for production in an equal degree of excellence, and expends them in the most economical way' (*C,* p. 469).

connexion is in many cases too remote to be understood by the latter' (*E*, pp. 230, 250–51).[11]

Babbage's political strategies of the strife-ridden decade of the 1830s outlined a crucial role for the analytic manager. The machinery of the factory and the calculating engines precisely *embodied* the intelligence of theory and abrogated the individual intelligence of the worker. Only the superior *combination* and *correlation* of each component guaranteed efficient, economical, planned, and therefore intelligent performance. This abstract, lawlike behaviour was only visible to the overseer—men such as Babbage. No doubt his own status as a gentlemanly specialist helped. He inherited one hundred thousand pounds from his banker father in 1827, while the state spent more than seventeen thousand pounds on his engines within the next decade. 'The efforts for the improvement of its manufactures which any country can make with the greatest probability of success', he argued in his text on machinery, 'must arise from the combined exertions of all those most skilled in the theory, as well as in the practice of the arts; each labouring in that department for which his natural capacity and acquired habits rendered him most fit' (*E*, p. 379). Such declarations made the new class of managerial analysts the supreme economic managers and legislators of social welfare. In good Bonapartist style Babbage thought they should be rewarded with newfangled life peerages and political power.[12] The science of calculation became the supreme legislative discipline, just as the calculating engines provided both legislative and executive coordination. This political and managerial language was not merely an elegant reformist metaphor hatched in wealthy London drawing rooms. The calculating engines were themselves products of the system of automatic manufacture which Babbage sought to model. They were some of that system's most famous and most visible accomplishments.

2. *Shows in the West End, Skills in Lambeth*

The first automaton which Babbage ever saw, when a very young visitor to the backstage workshop of a London exhibitor, was a *danseuse*,

11. The first reference to the French project is in Babbage, *A Letter to Humphry Davy: On the Application of Machinery to the Purpose of Calculating and Printing Mathematical Principles* (London, 1822), p. 8; rpt. in *The Difference Engine and Table Making*, vol. 2 of *The Works of Charles Babbage*, pp. 10–11. Babbage got a copy of these tables in Paris in 1819. See University of Cambridge Library, Add. MSS 8705:37. For other responses to the French work, see [Lardner], 'Babbage's *Calculating Engine*', p. 275.

12. See Hyman, *Charles Babbage: Pioneer of the Computer* (Princeton, N. J., 1982), pp. 86–87, and *M*, pp. 115, 111. For Babbage on honours, see Babbage, *The Exposition of 1851: or, Views on the Industry, the Science, and the Government, of England* (London, 1851), pp. 202–31; and for the Bonapartist connexion, see Babbage, *Reflections on the Decline of Science in England, and on Some of Its Causes* (London, 1830), pp. 25–27.

a model one foot high, 'her eyes . . . full of imagination, and irresistible'. Thirty years later he bought the *danseuse* at an auction sale of a bankrupt mechanical show and, after restoring its gears, displayed it at his Marylebone house parties alongside his calculating machines.[13] The anecdote illuminates the social site which the calculating engines occupied as competitors for polite attention with the vast array of automata and mechanisms on display in the London showrooms. In early 1834 two models of the Difference Engine itself were made by the instrument designer Francis Watkins, who plied his trade as electrician and showman at the Adelaide Gallery, the leading London showcase for new engineering. When the Engine had been abandoned Babbage insisted 'it should be placed where the public can see it' (see fig. 3). It was put on display in the museum of King's College London. Next door, at the Admiralty Museum in Somerset House, visitors could view Henry Maudslay's celebrated block-making machinery designed for the Portsmouth naval dockyards. These technical systems were on show as the highest achievements of the early Victorian machine tool industry.[14]

Two salient features of these displays mattered for Babbage's own project. First, the systematisation of machine tool production was highly charged politically. Second, this process demanded the reorganisation of the productive body and of the visible space in which it performed. The preeminent example was provided at Portsmouth, the very earliest site at which the automatic machine tool system was implemented. Between 1795 and 1807 the entire system of production of pulley blocks for the Royal Navy was overhauled. Traditionally this production had relied on specialised crafts in woodworking and milling highly resistant to line management and control. Military force was used to discipline the work force in the face of mass protests against changing this craft culture. As historians Carolyn Cooper and Peter Linebaugh have explained, the new production line system destroyed and reorganized every feature of production. Pulley blocks were standardised and marked to prevent traditional forms of recompense in kind, practices which were now condemned as theft. Standardised machinists replaced specialist craftsmen. Wood was replaced by steam-driven, all-metal machinery and separate artisan tasks embodied in purpose-built lathes and clamps. The protagonists of this reorganisation were also the protagonists of much wider social change. The system was developed by Samuel Bentham, the inspector of naval works, who in collaboration with his brother Jeremy had already introduced an identical system of surveillance in Russian

13. Babbage, *Passages from the Life of a Philosopher* (London, 1864), p. 17. See also pp. 365–67, 425–57, and Hyman, *Charles Babbage*, p.175.

14. Quoted in Hyman, *Charles Babbage*, p. 192. For the 'block mill as tourist attraction', see Carolyn Cooper, 'The Portsmouth System of Manufacture', *Technology and Culture* 25 (Apr. 1984): 213. For Watkins's models, see Francis Watkins, letter to Babbage, 15 Jan. 1834, British Library, Add. MSS 37188, fol. 160.

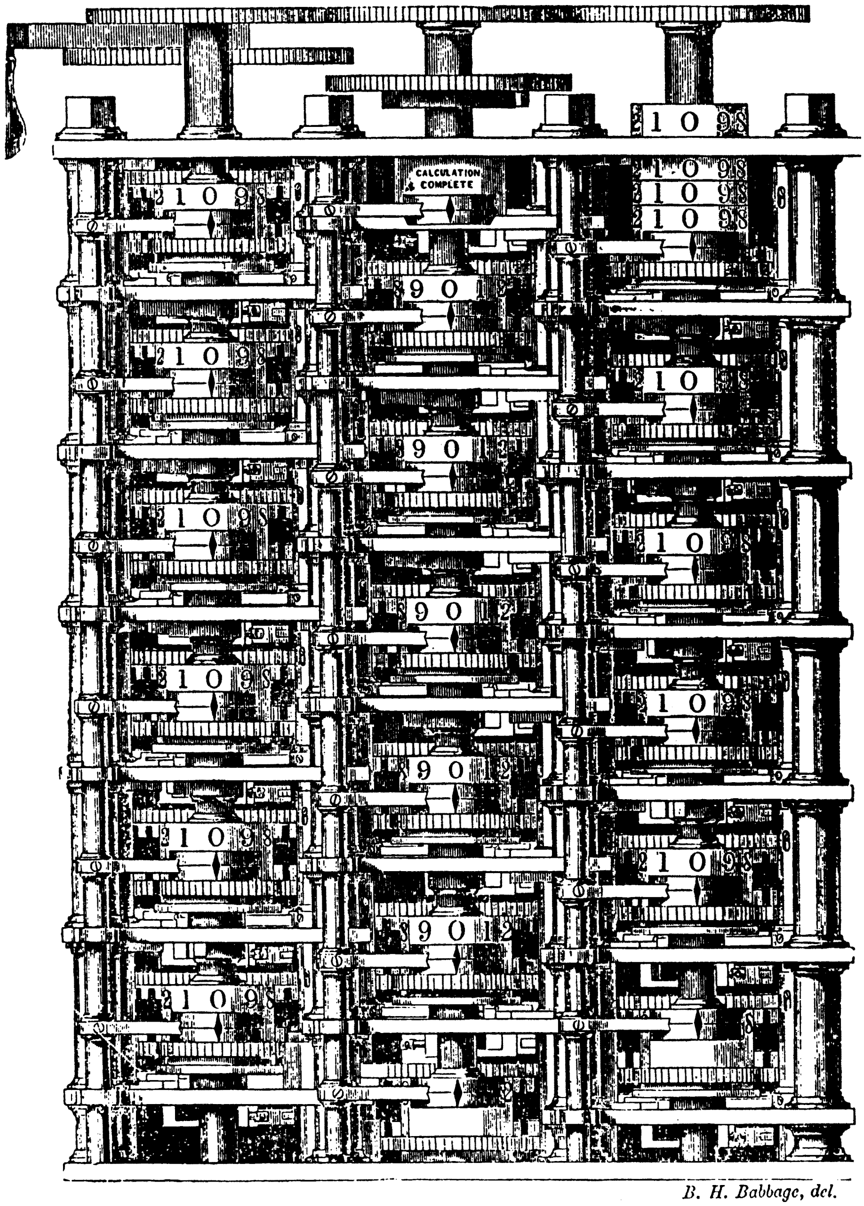


FIG. 3.—A small portion of Babbage's Difference Engine No. 1. Frontispiece from Babbage, *Passages from the Life of a Philosopher* (Longman, 1864); rpt. as vol. 11 of *The Works of Charles Babbage.*

woodworking schemes in the early 1780s, a scheme soon to be known as the Panopticon. The engineering works were laid out by Marc Brunel and implemented by his close ally Maudslay. These were the men who introduced Clement to Babbage and the men who made this system of inspection, regulation, and line production a visible exemplar of rational management.[15]

Samuel Bentham and his colleagues made Portsmouth dockyard a site of 'incessant work' and then turned it into a tourist attraction. The Portsmouth team argued that public visibility could be an invaluable aspect of their industrial reformation. Bentham 'considered it highly conducive to the hastening of the introduction of a general System of machinery that public opinion should be obtained in its favour, and that this was likely to be more surely effected by a display of well arranged machines'. So from the 1810s the block machinery became a common resort for interested visitors. The new system of technological repression can be taken as exemplary of the emergence of the wage form and of the productive labourer. A guidebook to the dockyard commented that 'on entering the block mill, the spectator is struck with the multiplicity of its movements and the rapidity of its operations'.[16] The impersonal pronouns in this account are eloquent. To see the automatic world as a system, it was important not to see the work force's culture.

The London machine shows of the Difference Engine and the Portsmouth lathes were designed to win income and teach important lessons to a wide range of publics. This was not an audience which knew exactly what it wanted and certainly not an audience that obviously wanted exactitude. Babbage reckoned that automatic systems should yield specific truths about the relation among intelligence, work, and mechanism. These truths were by no means self-evident or uncontroversial, especially during the machine-breaking protests which raged during the struggle for Reform. Babbage's lessons hinged on the proper ownership of machinery and thus, in the jargon of his favourite science, the source of productive value. The rights of the workers to the whole value of their labour informed much of the radical protest of these key years. Who should 'own' these machines? Whose labour did they embody? Reformist journalists were persistently struck by 'the systematic way in which the people proceeded', while the 'people' themselves protested against the campaigns 'to make us tools' or 'machines'. These issues made urgent

15. See Cooper, 'The Portsmouth System of Manufacture', and Peter Linebaugh, 'Ships and Chips: Technological Repression and the Origin of the Wage', *The London Hanged: Crime and Civil Society in the Eighteenth Century* (Harmondsworth, 1991), pp. 371–401.

16. Quoted in Cooper, 'The Portsmouth System of Manufacture', pp. 213, 214. See also Linebaugh, *The London Hanged,* pp. 399–401.

the problem of the source and ownership of the skills embodied in machines confessedly designed to perform mental work.[17]

Working-class interests appealed to traditional custom in which skill was recognized as a property inherent in the persons of the workers themselves. Skill was reckoned to be scarcely communicable outside carefully controlled milieux which were designed to remain opaque to the surveillance of managers and inspectors. Thus attempts by observers such as Babbage to gather intelligence about machines and the work force were politically controversial. In contrast to the traditional model, philosophers of machinery promoted an account of rational valuation, attempting to render the labour process transparent and skills rather easily measurable in the marketplace of wage labour. These are the early nineteenth-century English conflicts which, following E. P. Thompson, we now typically associate with political economic campaigns against the Corn Laws and the customary moral economy of the grain rioters, where economic rationality fought with traditional forms of exchange, or, following Michel Foucault, with Benthamite strategies for the surveillance of the body in the illuminated spaces of the Panopticon. Babbage's campaigns for machine intelligence take their place alongside these more familiar strategies for the reconfiguration of the productive body.[18]

In this context, the faculties of memory and foresight with which Babbage sought to endow the Analytical Engine also characterize his self-presentation as the unique author of the machine. They *embodied* his control over the engine while they *disembodied* the skills and camouflaged the work force on which it depended. He explained his view of the property of skill involved in the calculating engines in an appeal regarding their future to the Duke of Wellington in late 1834. 'My right to dispose, as I will, of such inventions cannot be contested; it is more sacred in its nature than any hereditary or acquired property, for they are the absolute creations of my own mind'.[19] This remarkable declaration followed a decade of strife with Clement, the brilliant (but here characteristically unnamed) engineer on whose work so much of the engine's development depended. When the project was inaugurated Babbage had to work out whether the design was in 'such a form that its execution [might be] within the reach of a skilful workman'. This in turn prompted his imme-

17. Quoted in E. P. Thompson, *The Making of the English Working Class* (Harmondsworth, 1968), pp. 889, 915. See also John Rule, *The Labouring Classes in Early Industrial England, 1750–1850* (London, 1986), pp. 357–63.

18. See Thompson, 'The Moral Economy of the English Crowd in the Eighteenth Century', *Past and Present* 50 (Feb. 1971): 76–136 and *Customs in Common* (New York, 1991), pp. 184–351; Foucault, *Discipline and Punish,* pp. 133–338 and 'The Eye of Power', *Michel Foucault: Power/Knowledge,* trans. Colin Gordon et al., ed. Gordon (New York, 1980), pp. 146–65. For customary skill, see Rule, 'The Property of Skill in the Period of Manufacture', in *The Historical Meanings of Work,* ed. Patrick Joyce (Cambridge, 1987), pp. 99–118.

19. Babbage, letter to Arthur Wellesley, 1st Duke of Wellington, 23 Dec. 1834, British Library, Add. MSS 40611, fol. 181.

diate examination 'in detail' of 'machinery of every kind'. Fights were endemic about Babbage's claims that the work force should submit to, and only needed slavishly to follow, his detailed recipe for the calculating engines and that any results of this labour would belong to Babbage himself.[20]

Babbage's specifications placed unprecedented demands on the capacities of the machine tool workshops and soon turned those workshops into revolutionary sites of innovation and training. An 1829 Royal Society report on the engine plans conceded that 'in all those parts of the Machine where the nicest precision is required, the wheelwork only brings them by a first approximation (though a very nice one), to their destined places: they are then settled into accurate adjustment by peculiar contrivances, which admit of no shake or latitude of any kind' (quoted in *M*, p. 86). The troublesome terms in these bland remarks by the gentlemen of science were the references to nice precision, accurate adjustment, and shake or latitude. What might seem to a savant matters of irrational judgment were the key aspects of the customary culture of the workshop. What might seem to the Royal Society and the Treasury to be worthless or exorbitant demands from the workshop staff would appear within the machine shop as legitimate and self-evident expectations of machinists' status. The fights between Clement and Babbage which raged between 1822 and 1834 testified to the fury and significance of these issues of control.

Two critical problems haunted the work on the calculating engines. First, the *place of skill* and the social and cognitive distance between designers, machinists, and draughtsmen were vital for the project's conduct. When Babbage set out on a European tour in 1828 he left Clement what he reckoned were 'sufficient drawings to enable his agents to proceed with the construction of the Difference Engine during his absence'(*M*, p. 81). Such written recipes soon proved hopelessly inadequate. Two years later, on his return, Babbage demanded that the engine construction site be moved from Clement's works in Lambeth to Babbage's own house in Marylebone. Clement demanded huge compensation, did not get it, and sacked his men. Jarvis, Clement's ex-draughtsman and the future codesigner of the Analytical Engine, explained to Babbage why it was important that work proceed 'under your immediate inspection': '*You* might be at once appealed to, whenever it was found very difficult to produce *nearly* [the desired] effect—which is a very common case in machinery'. The lesson is a familiar one. The production and reproduction of skills and material technology requires intense and immediate interaction in spaces specifically designed for the purpose. Such designs violated the conventions by which the machinists plied their trade.[21]

20. Babbage, 'The Science of Number Reduced to Mechanism', in *M*, p. 65.

21. C. G. Jarvis, letter to Babbage, quoted in Hyman, *Charles Babbage*, p. 131. See also James Nasmyth, *James Nasmyth, Engineer: An Autobiography*, ed. Samuel Smiles (London, 1883), p. 130. For the move to Marylebone, see Babbage, letter to Joseph Clement, 18 May

A second decisive problem for the engine project was therefore the issue of *ownership* and public knowledge. The costs of the work were traditionally in the hands of the engineer while his tools, in this case the lathes, planes, and vices, were always his own property. Thus the question of whether the Difference Engine was itself a tool became moot. From 1829 Babbage and Clement were in dispute about property and prices. Clement at once appealed to the customs of his craft: all the tools, especially the new self-acting lathes, belonged exclusively to him and he insisted on his right to make more calculating engines without Babbage's permission. Once again, Jarvis explained the point to the infuriated mathematician:

> It should be borne in mind that the inventor of a machine and the maker of it have two distinct ends to obtain. The object of the first is to make the machine as complete as possible. The object of the second—and we have no right to expect he will be influenced by any other feeling—is to gain as much as possible by making the machine, and it is in his interest to make it as complicated as possible.[22]

Babbage's characteristic solution was to propose the nationalisation of the engine, the tools, and the designs. He was pursuing what he reckoned was the practical logic of much of the machine tool industry. Outstanding initiatives, such as the development of precision tools at Greenwich Observatory and the installation of the Portsmouth block-making system, were state-funded projects, part of the activity of what has been labelled the 'fiscal-military state', involving large-scale military investment, a major financial bureaucracy, and commitment to the accumulation of quantitative information about civil society. Babbage's machine intelligence was designed to appeal to, and reinforce, these rather fragile interests.[23] In the Lambeth machine shops personal skill and thus individual property was at stake in every 'improved' design and workshop layout. Once the engine had been nationalised and shifted to Babbage's own workshop, it was proposed that Jarvis work there but remain under Clement's management. Clement refused the deal because 'my plan may be fol-

1832, British Library, Add. MSS 37186, fol. 400. For the machine tool culture, see K. R. Gilbert, 'Machine Tools', in *History of Technology*, ed. Charles Singer et al., 8 vols. (Oxford, 1954–84), 4:417–41, and A. E. Musson, 'Joseph Whitworth and the Growth of Mass-production Engineering', *Business History* 17 (July 1975): 109–49.

22. Jarvis, letter to Babbage, Feb. 1831, British Library Add. MSS 37185, fol. 419. See also Hyman, *Charles Babbage*, pp. 124, 128. The best discussion of the fight with Clement is William Ginn, *Philosophers and Artisans: The Relationship between Men of Science and Instrument Makers in London 1820–1860* (Ph.D. diss., University of Kent, 1991), pp. 157–69.

23. For state standardisation, see Julian Hoppit, 'Reforming Britain's Weights and Measures, 1660–1824', *English Historical Review* (Jan. 1993): 82–104; for the fiscal-military state, see John Brewer, *The Sinews of Power: War, Money, and the English State* (London, 1989).

lowed without my being in any way a gainer', and Jarvis refused because he would not become 'party to my own degradation'. Babbage and his Royal Society allies judged this rational management, while the engineers often saw it as a challenge to their rights and skills.[24]

Babbage's early projects collapsed under the force of these challenges. But his campaign for machine intelligence and the automatic system successfully captured the interests of the engineering managers and their new system. The intelligence gathered for his work on manufacture offered important lessons about wage rates and skill patterns. First, the engineers were prepared to value the calculating engine project by raising the wages of workmen who had been involved in the scheme. Second, they were committed to the design of increasingly automated systems which would break down craft divisions and allow the employment of increasingly cheap hands and increasingly subordinate labour processes. In a telling annotation to his correspondence with Wellington, Babbage remarked that 'I have been informed by men who are now scattered about in our manufacturing districts, that they all get higher wages than their fellow workmen in consequence of having worked at that machine'. Babbage's informant was Richard Wright, first employed as Babbage's valet, then based near Maudslay in Lambeth, who toured the northern factories for Babbage's book and ended up in Manchester working for Joseph Whitworth, who had just left the Difference Engine project. 'There is much talk about the [calculating] Machine here', Wright told Babbage, 'so much so that a man who has worked at it has a greater chance of the best work and I am proud to say that I am getting more wages than any other workman in the Factory'. Wright offered himself to Babbage as a possible master engineer. He became a Smilesian paragon who reckoned that rational management and the careful surveillance of the division of labour provided the key to success in making the calculating engines. Wright explained to Babbage how the new system should work:

> The man you select for the workshop ought to be a good general workman both at Vice and Lathe for such a man can see by the way a man begins a job whether he will finish it in a workmanlike manner or not. Perhaps you are not quite aware that at Mr Clement's and most other Factories the work is divided into the branches Vice and Lathe, and in most cases the man who works at the one is nearly ignorant of the other. . . . He ought above all to have studied the dispositions of workmen so as to keep the workshop free from contention and disorder and the causes of the repeated failures of so much new Machinery for I am sure there is more failures through

24. Jarvis, letter to Babbage, quoted in Hyman, *Charles Babbage,* p. 132. See also Babbage, letter to Wellington, July 1834, in *M,* pp. 104–5.

> waste of labour and bad management than there is through bad schemes or any other cause.[25]

Wright's was the anonymous voice recorded in the pages of Babbage's *Economy of Machinery* and which this text helped make representative of the automatic system. In the philosophy of manufacture much was made of the highly personal skills embodied in the master engineers. In his travel notes for the engine survey, Babbage recorded that 'causes of failure' should be found by consulting a 'man of science on the principle' and 'a practical engineer on mechanical difficulties'. It was acknowledged, and celebrated, that manual dexterity remained a central attribute of 'the skilled workman'. Babbage reckoned that 'the first necessity' for his Difference Engine was 'to preserve the life of Mr Clement. . . . It would be extremely difficult if not impossible to find any other person of equal talent both as a draftsman and as a mechanician'. Engine masters became heroes. But, crucially, these virtues were to be increasingly vested in the standardised tool kit of the machine shops. No doubt this was why the authoritative scales and tools in use were so often fetishised. Maudslay's bench top scale was 'humourously called . . . "The Lord Chancellor"', while his colleagues boasted of 'the progeny of legitimate descendants' which they had produced.[26]

In industrialising Britain the systems these men helped forge were the sites of a new managerial and technical network, dependent as much on strenuous regulation of the labour process as on the development of new automatic machinery. In the process, craft customs were subverted and standardised, accurate production secured.[27] The managers of the most advanced workshops eventually became Babbage's closest allies and sources of intelligence and support. In his *Economy of Machinery* Babbage made much of the means through which the lathe would guarantee 'identity' and 'accuracy', and then accounted accuracy as an economy of time, since 'it would be *possible* for a very skilful workman, with files and polishing substances', to produce a perfect surface (*E*, pp. 66–67). So artisan skill could be transmuted into its wage equivalent. Babbage's friend the dissenting mathematician Augustus de Morgan brilliantly summarised the relation between the lathe, emblem of automatic skill, and Babbage, master of mechanical analysis, in a cartoon showing him at the lathe

25. Richard Wright, letters to Babbage, 18 June 1834 and 13 Jan. 1839, British Library, Add. MSS 37188, fol. 390 and Add. MSS 37191, fols. 99–100; compare Hyman, *Charles Babbage,* pp. 66, 107.

26. Babbage, 'Notes for Economy of Manufacture', University of Cambridge Library, Add. MSS 8705:25, p. 10; Babbage, 'Report on the Calculating Machine' (1830), British Library, Add. MSS 37185, fol. 264; and Nasmyth, *James Nasmyth, Engineer,* pp. 148–49, 179. Compare Ginn, *Philosophers and Artisans,* p. 167, on the uniqueness of artisan skill.

27. See John Foster, *Class Struggle and the Industrial Revolution: Early Industrial Capitalism in Three English Towns* (London, 1974), pp. 224–25, and Ian Inkster, *Science and Technology in History: An Approach to Industrial Development* (London, 1991), pp. 82–83.

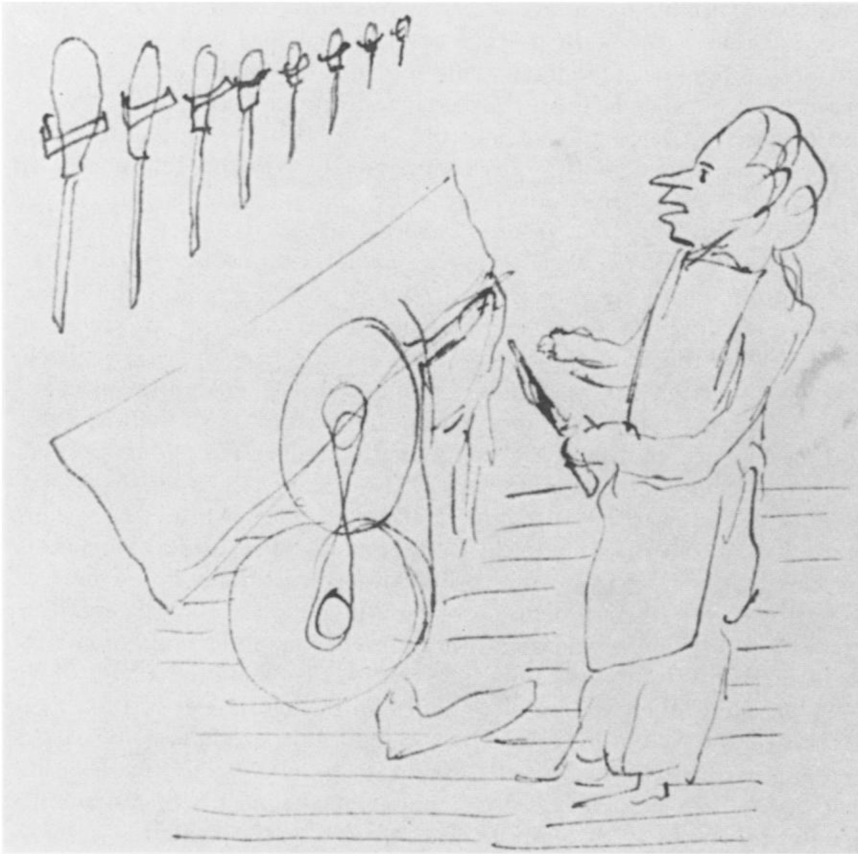


FIG. 4.—Cartoon by Augustus de Morgan of Babbage at a lathe, 21 Oct. 1839. From British Library, Add. MSS 37191, fol. 257.

armed only with a series of logarithmic functions (see fig. 4). On this showing mechanical analysis was just like the work of automated tools, but it also provided the key resource for managing the development of the new factory system.[28]

3. *From London to Manchester: Touring the Factory System*

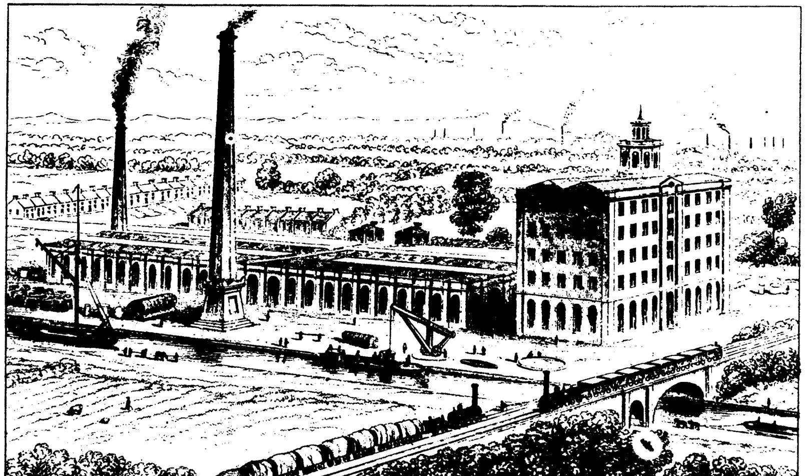
The factory system was first represented in a powerful series of journalistic reports in the 1830s and 1840s, of which Friedrich Engels's *The*

28. See Charles Holtzapffel, *Turning and Mechanical Manipulation*, 5 vols. (London, 1846–84), 2:984–91; Nasmyth, letter to Babbage, 22 June 1855; and Babbage, letter to Joseph Whitworth, July 1855, British Library, Add. MSS 37196, fols. 249, 366. The cartoon is in Augustus de Morgan, letter to Babbage, 21 Oct. 1839, British Library, Add. MSS 37191, fol. 257.

Condition of the Working Class in England is only the most notorious—though certainly one of the more perceptive. Babbage's work on political economy and on machine intelligence took its place in this genre of works which were both *products* of well-publicised tours of the workshops and also *producers* of intelligence about the factory system. Berg emphasises that 'the factory system itself was a term which frequently hid more than it revealed'.[29] Babbage's tours were no exception. His was one of the handbooks with which factory tourists were supplied. Other representative texts included *The Philosophy of Manufactures,* produced in 1835 by the Scottish consulting chemist Andrew Ure with the same publisher as Babbage's work, and reports on the Lancashire factories, produced in the 1840s by the Irish journalist William Cooke Taylor. In their well-marketed texts, the factory guides emphasised that inside the automatic system tourists would see those 'admirable adaptations of human skill and intelligence' by which 'we are giving to the present age its peculiar and wonderful characteristic, namely, the triumph of mind over matter'.[30] This triumph was at once a claim about the machine tool system, and thus the control of matter by human intelligence, and a claim about labour discipline, and thus the control of the work force by its masters. Ure stressed the relation between 'the automatic plan' and 'the equalization of labour'. 'The grand object therefore of the modern manufacturer is, through the union of capital and science, to reduce the task of his work-people to the exercise of vigilance and dexterity'. It was precisely for this reason that in his tours Ure judged the factory a form of laboratory, a potentially utopian site devoid of strife and replete with scientific truth. 'The science of the factory' was at once a means of disciplining labour and an object lesson in thermal physics 'better studied in a week's residence in Lancashire than in a session of any university in Europe' (see fig. 5). A Manchester guidebook explained that the self-acting principle applied to slide control in machine lathes 'is that which enables a child, *or the machine itself,* to operate on masses of metal, and to cut shavings off iron, as if it was deprived of all hardness, and so mathematically correct that even Euclid himself might be the workman!' (*MA*, pp. 217–18n). The tour guides agreed that accuracy was both demanded by, and a corrective to, labour resistance. 'The frequent and insufferable annoyances which

29. Berg, *The Age of Manufactures 1700–1820* (London, 1985), p. 229. For factory tourism, see Steven Marcus, *Engels, Manchester, and the Working Class* (New York, 1985), pp. 30–66, and Francis D. Klingender, *Art and the Industrial Revolution* (London, 1972), pp. 109–17.

30. *Manchester as It Is; or Notices of the Institutions, Manufactures, Commerce, Railways, etc., of the Metropolis of Manufactures* (1839; Manchester, 1971), p. 271n; hereafter abbreviated *MA*. For Manchester and machine tools, see Musson, 'Joseph Whitworth and the Growth of Mass-production Engineering', p. 113. For Chartist demonstrations in Manchester, see Dorothy Thompson, *The Chartists: Popular Politics in the Industrial Revolution* (Aldershot, 1984), pp. 57–76, and Nasmyth, *James Nasmyth, Engineer,* pp. 222–28. Ure's personal connexion with Babbage is revealed in George Evans, letter to Babbage, 16 Feb. 1835, British Library, Add. MSS 37189, fol. 17, where Ure asks to see the Difference Engine in person.



MANCHESTER

AS IT IS:

OR, NOTICES OF THE INSTITUTIONS, MANUFACTURES,
COMMERCE, RAILWAYS, ETC.

OF THE

METROPOLIS OF MANUFACTURES:

INTERSPERSED WITH MUCH VALUABLE INFORMATION USEFUL FOR

THE RESIDENT AND STRANGER.

WITH NUMEROUS STEEL ENGRAVINGS, AND A MAP.

Manchester:

PRINTED AND PUBLISHED BY LOVE AND BARTON:

LONDON: W. S. ORR AND CO., AND

BALL, ARNOLD, AND CO.

1839.

FIG. 5.—Frontispiece and title page from *Manchester as It Is; or Notices of the Institutions, Manufactures, Commerce, Railways, etc., of the Metropolis of Manufactures* (1839; Manchester, 1971).

engineers have experienced from trades unions' produced 'those admirable contrivances which are enabling mechanicians to perform such wonders in overcoming the resistance of the material world' (*MA*, p. 33).[31] In their accounts of this resistance, a characteristic series of themes was developed in the literature of factory tourism. The apparently overwhelming power of the works should rightly be understood as labour discipline within a system of division and coordination producing geometrical precision out of mere manual skill in despite of proletarian resistance.

Even if the factory were the consequence of the adoption of the automatic system, it was still necessary but difficult to represent the inmates of the factory as themselves possessed of intelligence. The puzzle of the thinking machine was the very stuff of this debate. No doubt this was why the images of the modern Prometheus and of Athena springing fully clad from the mind of Zeus were so common in tourists' analyses. Had not Mary Shelley, in 1818, subtitled her *Frankenstein* the *modern Prometheus*?[32] Defining the *site* of intelligence was a key political task. Critics reiterated their suspicion that automatic machinery and factory discipline mechanized the proletariat. Cooke Taylor addressed the puzzle directly: 'I am willing to confess that the mechanical processes which require a continuous and unvarying repetition of the same operation . . . have a tendency to degrade the workman into an automaton'. He conceded that 'there is a tendency in the use of machinery to materialize the thoughts'. But in drawing a picture of the balance between the necessary division of labour and the combination of tasks required within the factory system, he insisted that 'such combination requires no small exercise of mind and no conceivable adaptation of wood and iron will produce a machine that can think'.[33]

There was thus an unresolved contradiction between stress on the subordination and thus mechanization of workers' intelligence and on the coordination and thus cerebration of their labour. A notorious example appeared in Ure's attempts to define the term *factory*. On the very same page of his *Philosophy of Manufactures* he defined the factory *both* as 'a vast automaton, composed of various mechanical and intellectual

31. Andrew Ure, *The Philosophy of Manufactures* (London, 1835), pp. 21, 20–21, 25. On Manchester strikes and technical innovation in 1837, compare William Pole, with Sir William Fairbairn, *The Life of Sir William Fairbairn* (London, 1877), p. 163. Further evidence is available in *Technology and Toil in Nineteenth-Century Britain,* ed. Berg (London, 1979), especially p. 159.

32. For this debate, see Tine Bruland, 'Industrial Conflict as a Source of Technical Innovation: Three Cases', *Economy and Society* 11 (May 1982): 91–121, and William Lazonick, 'Industrial Relations and Technical Change: The Case of the Self-acting Mule', *Cambridge Journal of Economics* 3 (Sept. 1979): 231–62. For the Promethean and Athenian images, see Ure, *Philosophy of Manufactures,* p. 367.

33. William Cooke Taylor, *Notes of a Tour in the Manufacturing Districts of Lancashire,* 2d ed. (London, 1842), pp. 126, 139 and *Factories and the Factory System* (London, 1844), p. 3.

organs, . . . all of them being subordinated to a self-regulated moving force' and as 'the combined operation of many orders of work-people . . . in tending with assiduous skill a series of productive machines'.[34] Marx immediately picked up this striking contradiction between automatism and skill and associated it closely with Babbage's account of the division of labour in the machine system. 'These two descriptions [by Ure] are far from being identical. In one, the combined collective worker appears as the dominant subject [*übergreifendes Subjekt*], and the mechanical automaton as the object; in the other, the automaton itself is the subject, and the workers are merely conscious organs'(*C*, p. 544). The 'automatic workshop' posed in an unprecedentedly acute form the challenge of situating its intellectual and thus governing principle within the skilful work force, as Cooke Taylor hinted, within the managerial regime, as managers themselves so often claimed, or within the machines, as Ure and Babbage boasted.[35]

This problem of the geography of intelligence depended on the fetishisation of machines and the reification of the labour power exerted around them. Under the new orthodoxies of political economy, the surplus value extracted from the machines was the product of the intelligence of capital made real in the force of steam-driven engines. On this showing, intelligence itself was easily identified with just those qualities displayed by manufacturing capital and the subordinate 'servants of the machine', notably *foresight* and *vigilance*. As we have seen, these were also the virtues which Babbage reckoned made his engines think. The aim of this polemic was to make the identity of intelligence and capitalist machine management self-evident. Socialist, radical, and plebeian critics sought, in contrast, to make it nonsensical or disastrous. This made the problem of workers' intelligence vital in political debate. The pervasiveness of the language of machine intelligence was most marked in the more sophisticated socialist analyses, for in these texts claims for the liberation of the proletariat from the subordination of factory discipline simultaneously used, and assumed, the image of the human body as 'living machinery'. Engels reckoned that in Manchester the process which mechanized the very bodies and minds of the work force would also radicalize their politics *despite* the capitalists' power. Machine systems helped divide the body into specialised, monstrous capacities. 'No activity . . . claims the operative's thinking powers'. He straightforwardly rejected the meliorist claims of Cooke Taylor, Ure, and their colleagues that machine superintendence was a form of leisure. It was rather a form of tedium. 'The operative is condemned to let his physical and mental powers decay', Engels added; 'if the operatives have, nevertheless, not only rescued their

34. Ure, *Philosophy of Manufactures*, p. 13 and *MA*, p. 207.

35. Marx had already discussed Ure's *Philosophy of Manufactures* in *Poverty of Philosophy* (pp. 136–38) and in *Grundrisse* (p. 690), where it is linked with Babbage's *Economy of Machinery*.

intelligence but cultivated and sharpened it more than other working-men, they have found this possible only in rebellion against their fate and the bourgeoisie'.[36]

Such remarks indicate the need to legitimate the discourse on the factory system produced in the 1830s and 1840s and its polemical vocabulary of machine intelligence. The processes of automation and coordination which had spawned the factory system had made the problem of the place of intelligence urgent. Proponents of machinofacture reckoned that the factory system was evidently a consequence of intelligent reason and thus providential and virtuous. They situated this intelligence in the complex relation between the fixed capital of the steam-driven engines and the mental capital of the mill owners. The work force itself was only judged a producer of value to the extent that it matched precisely the capacities of the machines. The qualities attributed to this intelligence were just those required from this form of superintendence—anticipation and meticulous scrutiny. This was the definition of intelligence which Babbage embodied in his machines and the sense of intelligence which he reckoned those machines displayed. He even claimed that these were the virtues of divinity.

4. *From London to Paradise: The Apotheosis of Machine Intelligence*

It was, perhaps, inevitable that Babbage should ultimately teach the supreme value of machines possessed of foresight and memory by attributing these powers to the Deity. Natural theology was the indispensable medium through which early Victorian savants broadcast their messages. The dominant texts of this genre were the eight *Bridgewater Treatises* produced in the early 1830s by eminent divines and natural philosophers under the management of the Royal Society. The treatise produced by William Whewell, then mathematics tutor at Trinity College Cambridge, was among the most successful of these works and included a claim about the relation between mathematics, automatism, and atheism which Babbage decided he had to answer. His machine philosophy was here assailed from a perspective in complete contrast to that of the radical artisans. Whewell maintained a consistent hostility to the implications of mechanised analysis: 'We may thus . . . deny to the mechanical philosophers

36. Friedrich Engels, *The Condition of the Working Class in England*, ed. Eric Hobsbawm (London, 1969), pp. 204–5. For the connexion with intensification of labour, see Raphael Samuel, 'The Workshop of the World: Steam Power and Hand Technology in mid-Victorian Britain', *History Workshop Journal* 3 (Spring 1977): 6–72, esp. 40; and for the connexion with socialist analysis of skill, see Linebaugh, 'Labour History without the Labour Process: A Note on John Gast and His Times', *Social History* 7 (Oct. 1982): 319–28.

and mathematicians of recent times any authority with regard to their views of the administration of the universe'. Worse was to follow. Whewell brutally denied that mechanised analytical calculation was proper to the formation of the academic and clerical elite. In classical geometry 'we tread the ground ourselves at every step feeling ourselves firm', but in machine analysis 'we are carried along as in a rail-road carriage, entering it at one station, and coming out of it at another. . . . It is plain that the latter is not a mode of exercising our own locomotive powers. . . . It may be the best way for men of business to travel, but it cannot fitly be made a part of the gymnastics of education'.[37]

These remarks were direct blows to Babbage's programme. He called the reply to Whewell he produced in 1837 the *Ninth Bridgewater Treatise* and labelled it 'a fragment'. It amounted to a confession of his faith that the established intellectual order was incompetent, dangerous, and innumerate. Babbage had shown that memory and foresight were the two features of intelligence represented in his machines. He now showed that these features of machine intelligence were all that was needed to understand and model the rule of God, whether based on the miraculous work of the Supreme Intelligence or on His promise of an afterlife. Foresight could be shown to be responsible for all apparently miraculous and specially providential events in nature. Throughout the 1830s Babbage regaled his guests with a portentous party trick. He could set the machine to print a series of integers from unity to one million. Any observer of the machine's output would assume that this series would continue indefinitely. But the initial setting of the machine could be adjusted so that at a certain point the machine would advance in steps of ten thousand. An indefinite number of different rules might be programmed this way. To the observer, each discontinuity would seem to be a 'miracle', an event unpredictable from the apparent lawlike course of the machine. Yet in fact the manager of the system would have given it foresight.[38] His onlookers, Charles Darwin among them, were almost always impressed. Visitors 'went to see the thinking machine (for such it seems)' and were treated to Babbage's miraculous show of apparently sudden breaks in its output. 'There was a sublimity in the views thus opened of the ultimate results of intellectual power', one onlooker reported. A few streets away, Darwin learnt his lesson and set out to use Babbage's system as an analogue for the origin of species by natural law

37. William Whewell, *Astronomy and General Physics Considered with Reference to Natural Theology* (London, 1834), p. 334 and *Of a Liberal Education in General* (London, 1845), pp. 40–41. See also Richard Yeo, 'William Whewell, Natural Theology and the Philosophy of Science in mid-Nineteenth-century Britain', *Annals of Science* 36 (Sept. 1979): 493–516, and Walter F. Cannon, 'The Problem of Miracles in the 1830s', *Victorian Studies* 4 (Sept. 1960): 5–32.

38. See Babbage, *Ninth Bridgewater Treatise,* 2d ed. (London, 1838), pp. 32–43.

without divine intervention. Here, then, was the natural equivalent of the systematic gaze. In answer to Whewell's boast that only induction might reveal the divine plan of the world and that machine analysis could never do so, Babbage countered that the world could be represented as an automatic array only visible as a system from the point of view of its manager. The world system was a macroscopic version of a factory, the philosophy of machinery was the true path to faith, and the calculating engines' power of 'volition and thought' revealed to all.[39]

Babbage was not content with making mechanisable foresight responsible for all apparently miraculous and specially providential events. Mechanisable memory was to be associated with the doctrine of a future state of rewards and punishments. 'We must possess the memory of what we did during our existence in order to give them those characteristics. In fact, memory seems to be the only faculty which must of necessity be preserved in order to render a future state possible'. With this model Babbage managed to show that just those features of intelligence displayed in his machine were also required for rational religion. Without memory, there could be no heaven or hell and, without foresight, no providence.[40] The apotheosis of the intelligent machine was an integral part of Babbage's ambitious programme. This programme has been used here to illuminate the complex character of systematic vision in the Industrial Revolution. In the *Ninth Bridgewater Treatise,* the system was coextensive with the universe, and Babbage explained that its order and logic would only be visible from a privileged point of view. In his surveys of the factories and workshops, Babbage set out to reveal the systematic character of the machine economy by pointing out the rationale of the production, distribution, and deployment of power in the workshops of industrial Britain. In his project to build intelligent calculating engines, he attempted to represent himself as the intellectual manager of the complex labour relations of the machine tool industry, disastrously initially, and then as part of his overall vision of a newly rational system of automatic precision engineering. In the setting of early Victorian society, the connexions between these worlds cannot be seen as merely metaphorical. These techniques helped make a new social order and a new form of knowledge. The systematic gaze was designed to produce the rational order it purported to discover. This is to place Babbage's project alongside those of Bentham, whose panoptic schemes have been associated with the production of the docile body, and of Samuel Smiles, whose ha-

39. Lady Byron, letter to William King, 21 June 1833, quoted in Doris Langley Moore, *Ada Countess of Lovelace: Byron's Legitimate Daughter* (New York, 1977), pp. 43–44. Darwin's use of Babbage's argument is discussed in Desmond and James Moore, *Darwin* (New York, 1991), pp. 212–28.

40. Babbage, *Passages in the Life of a Philosopher,* p.405 and see *Ninth Bridgewater Treatise,* pp. 108–19.

giographies cleverly connected the self-fashioning of the Victorian engineers with the transformations they wrought on the material world.[41] Under Babbage's productive gaze, the powers of the body were rendered mechanical and thus profitable, or wasteful and thus consigned to oblivion.

41. See Foucault, 'The Eye of Power'. For Smiles on self-fashioning and system building, see Thomas Parke Hughes, introduction, in Smiles, *Selections from Lives of the Engineers* (Cambridge, Mass. 1966), pp. 9–25. For a brilliant analysis of the politics of the productive body, see Catherine Gallagher, 'The Body versus the Social Body in Thomas Malthus and Henry Mayhew', in *The Making of the Modern Body,* ed. Gallagher and Thomas Laqueur (Berkeley, 1987), pp. 83–106.