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Defiance to compliance: Visions of the computer in postwar Britain

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In a climate of profound uncertainty over Britain's postwar status, some industrialists and policymakers sought solace in a 'defiant modernist' aesthetic, proposing radical technological transformations to circumvent economic constraints. The British computer industry, which briefly challenged that of the USA for technological sophistication, presents a revealing instance of this approach and its limitations. Early promoters, notably Vivian Bowden of Ferranti, shrewdly laid the rhetorical groundwork to position the new machines as the natural outcome of a uniquely British technological trajectory. Into the 1960s, however, their agenda was disrupted not only by economic realities, but also by the increasing importance of software and compatible systems as opposed to individual machines, and by growing public and industrial familiarity with computing in general. Promoters sought new points of differentiation, but had made little headway when a combination of national policy changes, growing market dominance by US-based corporations, and Anglo-French rapprochement rendered the British national exception largely unworkable. Its powerful rhetorical appeal, however, ensured that it never entirely disappeared.

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'Programming is a particularly British skill. In fact, we invented it'. Thus spoke the narrator of an influential 1978 BBC documentary on the challenges of the information age.[1] The claim drew on a received understanding that Britain possessed a unique national technological style, capable of almost miraculous innovations to leapfrog economic and social obstacles. Though the documentary's central message was that policymakers in government and industry were doing alarmingly little about the global rise of the silicon chip, it held out a hope that native ingenuity, if properly supported, would meet the challenge. This message drew strongly on rhetorical approaches which had come together around the promotion of electronic computers in the 1950s, but whose roots lay in the nineteenth-century era of industrial heroism.

Authors in the history of computing, and in history and social studies of technology more generally, have emphasised the importance of marketing in shaping the desires and choices of users, and indeed in creating a user base in the first place.[2] My concern here is not only with promotional material, but with the kinds of consciousness-raising and policy advocacy that underlay promoters' opportunities to achieve particular effects – especially, with how received versions of technological history helped to make contingent courses of action appear natural and inevitable.[3] Most important was the notion of a great national exception in scientific and technological innovation, often couched in terms of defiance in the face of adversity. Britain, the message ran, had weathered the greatest of storms, and could now rise again to challenge the world.

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The British exception was real enough at one level: the United Kingdom is famously anomalous in the history of postwar technical endeavour, particularly as regards its relationship with the United States.[4] In rebuilding their shattered scientific infrastructure, most of the nations of Western Europe drew heavily on reconstruction aid co-ordinated through the United States' Marshall Plan, which fostered a co-operative international culture under tacit American leadership. Britain's position at the end of the Second World War was unique: uninvaded, with a functioning and in some ways highly advanced military-scientific-industrial complex, and yet with tracts of its urban-industrial landscape bombed to rubble; victorious, but bankrupt. By 1947 it was obvious that Britain could not expect the bloc-leading status then emerging for the USA and USSR, yet the prospect of a long-lasting sphere of influence, based on what remained of the British Empire, remained in serious contention for a time.[5] The only nation in a roughly comparable position was France, humbled by defeat and itself undergoing a traumatic period of national soul-searching. With fewer global options, however, France gradually vested its status claims in a project to assume leadership of a Western European economic federation. This policy specifically necessitated the exclusion of Britain, for fear of an anglophone hegemony directed by the USA.[6]

If not a superpower, or peripheral, or federally integrated, what *was* Britain to be? Into the 1950s, as severe material shortages abated and policymakers found time to struggle with this question, some saw answers in technology. Electronic computing, alongside aerospace and the nuclear, played an important role in this vision. Total war had left Britain distinctively strong in the conceptual and engineering skills required; indeed, for the first half of the 1950s, it was internationally conceivable that the USA and Britain would share dominance of the field. This perception was a valuable promotional device in itself, and remained so for some time after it ceased to reflect reality. Early computing promoters, notably Vivian Bowden of the engineering firm Ferranti, worked hard to lay a rhetorical groundwork which positioned the new machines as the natural outcome of a uniquely British technological trajectory.

This positioning was disrupted, however, by the very fact of growing familiarity with computers in the 1960s, and by the changing balance between hardware and software concerns. Defiant and exceptionalist rhetoric worked best when 'the computer' itself was a novel artefact, especially insofar as it could stand as a visual icon. As corporate buyers came to view it more as a mundane necessity, promoters turned to software to seek new points of differentiation. They had made little headway, however, before a combination of changes in national policy, growing market dominance by US-based corporations, and Anglo-French rapprochement rendered the British national exception largely unworkable. Its powerful rhetorical appeal, however, ensured that it never entirely disappeared, and was duly reincarnated in the 1980s era of mass personal computing.

The rhetoric of British exceptionalism

The Second World War had hugely expanded Britain's research base in electronics, signalling and data processing. The vast operation to decrypt enemy signals, headquartered at Bletchley Park, had pioneered reprogrammable computing machines which read digital data from paper tapes and operated on it at high speed using thermionic valves. Radar research, meanwhile, had inspired the use of cathode ray tubes as a potentially much more flexible data store. After the War, multiple groups at British universities, at government installations, and in industry began working towards fast, all-electronic installations.[7] 'Electronic brains', as journalists dubbed the new machines, drew considerable public interest from 1946 onwards. A continuing policy of stringent national security meant that elements of the wartime experience, including the existence of the Bletchley Park machines, remained highly secret, and so early British accounts tended to be framed with reference to American developments, in particular the ENIAC project at the University of Pennsylvania.[8]

From the outset, however, a combative strain appeared, as when Sir Charles G. Darwin, of the UK's National Physical Laboratory (NPL), outlined plans for a faster and more streamlined machine, leaving the Americans to pay 'the penalty of starting first'. All such machines, he stated, owed their conceptual foundations to pre-War work by 'a young Cambridge mathematician, by name Turing', who was now leading development of the NPL computer.[9] Setbacks in this particular project meant that the claim for Alan Turing as the fundamental originator of the computer was seldom repeated in this period (it was to resurface, with ever-growing prominence, decades later).[10] As the British computing community underwent what appeared to be a mysteriously rapid flowering of practical expertise, however, projects emerged to support multiple further assertions of British origination and leadership.

In 1947, J. Lyons and Company, Britain's leading catering firm, sent two senior managers to the USA to investigate American systems of office management. Their bald conclusion was that established practice could teach them nothing: 'We did not find any firm which has developed on so broad a front as Lyons, most offices only having tackled a limited number of office problems without having surveyed the whole field'. Physical layouts – notably including that of the Pentagon – were poor, and development plans conservative, tending blindly to ignore the potential of rapid electronic processing. Far more exciting was the extensive American work on digital computing, but this was still largely uncommercialised.[11] Learning that there were British efforts in the same direction, the Lyons managers fostered a partnership with researchers at the University of Cambridge to develop the Lyons Electronic Office (LEO), which automated the bulk of the firm's payroll, stock control and valuation tasks across 1951–54, placing it at the forefront of international developments in this field. Lyons then formed a subsidiary to market LEO equipment to other businesses, stressing its business context as a unique guarantee of user-focused design.[12]

A similar story played out in parallel at Ferranti, the commercial electrical and defence contracting group, which in 1948 sent a representative, Dietrich Prinz, to the USA to assess the state of the art in digital computing. Prinz's American hosts, according to company legend, wondered 'why he had come there, since the most advanced work was being done on Ferranti's doorstep at Manchester University', where the cathode ray tube storage system had become the basis for a prototype computer.[13] Collaboration between Ferranti and the University was fostered by the National Research Development Corporation (NRDC), a government agency set up in 1949 to promote the commercial exploitation of British inventions. The result was an upgraded specification, the Ferranti Mark 1, designed to be marketed for volume production. The first machine was delivered to the University in February 1951, a transaction later interpreted as the first-ever commercial sale of a computer.[14] Lord Halsbury, Director of the NRDC, lauded the Ferranti machine as 'the most powerful of its kind in the world', and stressed that the American data-processing giant, International Business Machines (IBM), was dependent on the Manchester cathode ray tube store, used under licence, for its own machines.[15] To the most optimistic, it appeared that Britain might actually achieve long-term leadership over a new and fast-growing industrial sector.

Such developments fitted in very neatly with broader attempts to promote British science and industry as uniquely placed to respond to the challenges of the postwar world. Robert Bud has identified a rhetoric of *defiant modernism*, founded on a belief in

> a new sense of technocratic competence in a country whose empire was vanishing. In addition to the [atomic] bomb and penicillin, in an era of national consensus, everyone knew that 'we' had invented radar, atomic power, the jet engine and of course the Spitfire. From the 1950s their sequels would be electrical generation through nuclear power stations of which Britain boasted the world's first; Comet, the world's first civilian jet airliner; and *Bluebird*, the world's fastest land vehicle.[16]

The roots of this picture lay, of course, among the more straightforwardly triumphal narratives which had intertwined heroic accounts of Industrial Revolution and global Empire from around the mid-nineteenth century.[17] In later decades, as Britain had manifestly been overtaken as an industrial world power in many sectors by Germany and the USA, the gospel of technological excellence as a national peculiarity had survived as part of a diagnosis sometimes known as the 'British problem': the nation's inventive genius, supposedly, was persistently frustrated by an equally exceptional curse of incompetence in volume production, fiscal management and marketing, the radical opportunities implied by British research being routinely 'stolen' by commercially savvy foreigners.[18]

Such nationally deterministic tales, as historians have repeatedly pointed out, bear little relation to the realities of technological or economic change.[19] They are revealing, however, as fables which resonate with particular audiences, and can serve the ends of certain interest groups.[20] To the defiant modernist, the crucial merit of asserting a national exception was to offer a path to optimism without complacency. If Britain's inventiveness was intrinsic, and if its manufacturing woes were due to contingent factors capable of remedy (as must be the case, given the evidence of past glories), then it must be possible to restore the country's fortunes in the face of economic collapse – not by imitating foreign competitors, but by finding radical transformations to reassert British superiority. If Britain could not match American standards of material wealth (and few, in the age of austerity, seriously felt it could), it could instead dominate alternative, and perhaps more valuable indices of progress: the egalitarian social mission, the conquest of disease, the automation of drudge work, or the creation of sublime technical artefacts which would push the limits of human endeavour.

This was clearly not a recipe to inspire universal confidence: indeed, the logic of defiance was never general in British policy thinking. It sat in particularly uncomfortable tension with the drive for 'productivity' associated with Sir Stafford Cripps, Chancellor of the Exchequer from 1947 to 1950. Openly tied to Marshall Plan aid, the campaign sought to improve output of such prosaic goods as the world (but specifically the dollar area) wanted. By its nature, productivity implied comparability with American norms, its success defined by such metrics as rising coal and steel tonnage and a falling dollar gap.[21] As Britain did not have the high wage costs or labour shortages seen in the USA, the productivity lobby was sceptical as to the likely return from investing in high-technology automation.

But if 'productivity' was pragmatic, it was also prosaic, implied job losses, and offered no path out of long-term subordination to the USA. Defiance, which appealed strongly both to popular and to some policy-making audiences at all points on the political spectrum,[22] was at least as influential in determining British technology policy from the late 1940s to the early 60s. Rhetoric for public consumption, of course, could be bolder than practical commitments in this direction; and it is important to remember that visions of British world ascendancy were still a mainstream current in popular culture. From 1950, the comic paper *Eagle* drew a huge audience (overwhelmingly male, largely pre-adolescent, and blissfully unconcerned with the dollar gap) with tales of Dan Dare, Chief Pilot of the Interplanet Space Fleet, a global agency headquartered somewhere off the north-west coast of England and dominated by British military and scientific expertise.[23] Conceived by a Church of England vicar as an alternative to 'nastily over-violent' American imports, *Eagle* blended straightforward escapism with information features emphasising national technological prowess, offering technically detailed cutaway illustrations of current and historical projects such as the London Underground, 'a modern British coal mine' or 'HMS *Vanguard*: the Empire's mightiest battleship'.[24]

British exceptionalism was not altogether exceptional: Gabrielle Hecht has charted how a comparable ethic emerged in France, where the venerable stock image of the elite engineer, combining flair, efficiency and service to the nation, fed into a postwar programme which made nuclear capability, in both civil power and defence, the totem of resurgent French global status.[25] The British national narrative, however, differed from the French in emphasis and background: while the laboratories of continental Europe were still rebuilding, Britain's research base had not only survived, but in many sectors had grown substantially during the War, and had been harnessed closely to the cause of national survival. The legacy of pre-war 'air-mindedness' and airborne colonialism, combined with vivid recollections of the Battle of Britain, prompted a particular focus on aerospace technology, while the story of radar, as much as that of penicillin, brought home to general audiences the connection between science and salvation.[26]

Thus, an approach which arose during Clement Attlee's reforming Labour administration of 1945–1951, and drew some of its rhetorical force from the welfare-socialist vision of a planned better world,[27] also featured a substantial military dimension, seen most obviously in the decision to charter an independent British atomic bomb. With no prospect of American technological support following the stringently isolationist McMahon Act of 1946, Britain's leaders were willing to pay dearly for a device with, as Foreign Secretary Ernest Bevin memorably put it, 'a bloody Union Jack flying on top of it', as the price of maintaining influence in US foreign policy.[28] The succession of Conservative administrations which followed to 1964 made nuclear and aerospace visions – both military and civil – dominant in the articulation of British technological status. Notwithstanding a thaw in Anglo-American nuclear relations, another process of costly independent development played out for the far more powerful hydrogen bomb, which Britain achieved in 1957.[29] Atomic and hydrogen bombs were routinely carried by the gargantuan jet bombers of the 'V-force', long-distance craft notionally intended to penetrate deep into Soviet airspace.[30]

These projects' need for extensive and often high-speed calculation work meant that the electronic computer was often portrayed as an 'indispensable adjunct to the atomic age', as the pioneering researcher Andrew Booth put it in a 1958 radio broadcast: alongside nuclear energy, Booth singled out the computer's application in the structural engineering behind such defiant showpieces as the Comet jetliner and the Royal Yacht *Britannia*.[31] Similarly, Sir John Cockcroft, the most high-profile atomic physicist of his generation, summarised the activities which had inspired the digital computer's growth by pointing to (in that order) the hydrogen bomb, civil nuclear reactors, particle accelerators, accounting and management, aviation testing, and guided missile telemetry.[32] A parallel strain of rhetoric, however, focused on the computer as an advanced technology in its own right. Across the 1950s, its promoters developed various ways of harnessing exceptionalist logic to their cause.

Making British computers, and making computers British

Rewriting the rules of the game may bring crucial opportunities, yet always creates at least one crucial problem: the need to explain. Ferranti, in commercialising the Mark 1 computer, found itself with neither competitors nor custom; news articles on electronic computers still generally positioned them in terms of scientific achievement, with little to connect them to the data-processing needs of manufacturing or commerce.[33] Ferranti's initial search for an audience included a contribution to the quintessential expression of the defiant-modernist ethic, the 1951 Festival of Britain, intended as a showcase of British ingenuity, an affirmation of postwar social progress, and a morale-boosting prospectus of life in the post-austerity world. One element of the Festival was an Exhibition of Science at the Science Museum in South Kensington, London. Ostensibly, the Exhibition focused on fundamental concepts, but links to the new narrative of British productive success were obvious in its chief theme, 'Inside the Atom'.[34] Ferranti had hoped to display a version of the commercial Mark 1 machine at the Exhibition, but this proved impossible in the four months available.

The engineers instead concocted a technically simple but robust single-purpose machine, Nimrod, which challenged members of the audience to play a version of the ancient turn-taking game of Nim. Nimrod certainly struck a defiant note. Its display cabinet, twelve feet (3.65 m) wide and nine feet (2.75 m) tall, was designed purely for visual impact: the electronics inside occupied only a hundredth of the total volume. Accentuated by a raised podium, it dominated the final room of the Exhibition.[35] Ferranti's attempt to use the machine as an accessible introduction to the nature of automated computing in general, however, was less successful. This relied on a short booklet, offered for sale, which explained basic computing concepts in terms of the differences between Nimrod and the general-purpose Ferranti Mark 1. A fully functional computer, it explained, was more than a calculator: it resembled a 'calculating organization', with machines needing to be 'taught' various routines.[36] The engineers found, however, that the ominous 'electronic brain' (as Nimrod was described in the Exhibition's official guidebook) was rather a distraction from the concepts that would need to underpin the growth of commercial electronic data-processing.[37]

The need to reach out more specifically to potential buyers was clear to Vivian Bowden, a former radar engineer, who found himself as de facto chief salesman for the new Ferranti computer in 1951. To support his efforts, Bowden compiled a book-length, semi-popular introduction, published in 1953 as *Faster Than Thought*, a title borrowed from the Nimrod booklet. The American computer scientist Edmund Berkeley had produced a similar introduction in 1949, but it had not been widely promoted in the UK: Bowden knew he had a unique opportunity to shape long-term beliefs about information-processing technology through accounts of its uses, history and future. Whereas Berkeley had co-opted the default journalistic discourse with the arresting title *Giant Brains, or, Machines That Think*, Bowden dismissed the 'brain' analogy as a counterproductive distraction in his opening paragraph.[38] He proceeded, with similar stylistic economy, to ground the digital computer in a history of science and industry familiar and palatable to British audiences.

The stated goal of *Faster Than Thought* was 'to describe the development of computing machinery in England'.[39] Bowden drew material from twenty-three fellow contributors: all were based in the UK, either in university or governmental science establishments, or at the various Ferranti research divisions.[40] The eight scientific machines then established in the UK each received a chapter, with only a six-page comparative summary of "Computers in America", a deliberate skewing that unsurprisingly drew some comment from American readers.[41] Bowden also took care to colour his story by reference to established British historical landmarks: William the Conqueror's fiscal regime, the mathematics of Venn and Napier, the *Nautical Almanac*, and, indeed, the Festival of Britain. The University of Manchester computer's hooter did not merely play tunes: it played 'God Save the Queen'.

This strategy of mobilising history bears comparison with the aesthetic promoted by the French nuclear industry around the same time, as described by Gabrielle Hecht: the nation's past helped to legitimate modern developments, while its modernity helped to legitimate the nation.[42] Bowden's approach was tailored, of course, to the specifics of the British narrative, and this was most transparent in his claim that computers promised a 'second Industrial Revolution'.[43] This expression had been used rather differently a little earlier by the US cybernetician, Norbert Wiener, in urging a response to the potentially dehumanising effects of digital automation.[44] Bowden's usage was more literal and more positive, hammering home commonalities between automatic computing and the iconic British industrial culture which had reshaped global notions of manufacturing, communication and distance itself across the eighteenth and nineteenth centuries.[45]

Above all, both in *Faster Than Thought* and in Ferranti's contemporary trade catalogues, Bowden foregrounded one element of history: the mechanical calculating engines of the nineteenth-century mathematician and inventor, Charles Babbage, and the writings of Ada, Countess of Lovelace, his chief interpreter.[46] Interest in Babbage's projects had been reviving slowly since the 1930s, when they attracted the attention of the American designer Howard Aiken, responsible for one of the largest electromechanical computers.[47] Bowden first learned of Babbage through the mathematician Douglas Hartree, who played a key role in originating both the Manchester and Cambridge computer projects, and had emphasised conceptual similarities to Babbage's largely unbuilt specifications in some of the earliest published accounts of the new electronic machines.[48] Another eminent British computationalist, Leslie Comrie, had gone further, interpreting the government's 1830s refusal to underwrite the completion of Babbage's machines as a defining failure which 'cost Britain the leading place in the art of mechanical computing'.[49] This, of course, had the makings of a classic 'British problem' fable: a parliamentary speech supporting the creation of the National Research Development Corporation in 1948 ranked the episode – apparently still somewhat unfamiliar, as the name appears as 'Richard Babbage' in the official transcript – alongside the more entrenched historical exemplar of Britain's lost early lead in aniline dyestuffs.[50]

It was Bowden, however, who first brought depth to the portrayal of Babbage as a historical individual and emphasised the significance of Ada Lovelace, devoting most of a chapter to the (not always accurate) results of his original research. In doing so, he displayed a strategic concern with Britishness which set him apart from contemporaries such as the abovementioned pioneer Andrew Booth and his collaborator and wife Kathleen, who also produced an introductory study in 1953: in giving the customary chronology of technological development, the Booths' coverage reflected the balance of the existing survey literature, referring briefly to Babbage before shifting focus to the USA to discuss the rise of electronics.[51] Bowden, however, framed his introduction around a more essentialist understanding of the 'problem of computation' and the will to solve it. This enabled him to make Babbage's engines a necessary historical passage point without insisting the case for their direct influence on twentieth-century developments (which was, as studies of Aiken's work have revealed, slender).[52] Bowden simply took it as self-evident that Babbage deserved attention for the scale of his prescience and accomplishments, quietly de-emphasising the actual sequence of practical development. In Bowden's hands, an obviously American milestone, such as IBM's showpiece SSEC machine of 1948, could be reinterpreted as 'the first machine to have a conditional transfer of control instruction in the sense that Babbage and Lady Lovelace recommended'.[53]

Moreover, while acknowledging Babbage as an irascible character, imprudent in his dealings with the powerful – characteristics which became signature features of later biographies – Bowden took pains to stress that his hero was not himself an exemplar of the 'British problem'. Rather, he presented Babbage as an able political economist, a reforming technocrat, and a skilled consulting engineer – almost a mathematical twin of his friend and collaborator, Isambard Kingdom Brunel, whose gigantic engineering projects had inspired similar stock notions of heroic genius.[54] Irrespective of the success of Babbage's machines, 'the improvements which he effected in the art of machining and in machine shop practice more than justified the £17,000 which the British Government gave him'.[55]

Bowden's narrative was elaborated and adapted by later authors such as the journalist Maboth Moseley, who produced the first book-length biography of Babbage while editing the British trade periodical *Computer Survey*. Earlier, in 1961, she contributed a historical survey to a *Times* newspaper supplement on 'The computer in industry', aimed primarily at managers who might have a role in appropriation decisions. This text is remarkable in seeking to give the appearance of a comprehensive developmental chronology without ever straying from English soil. Where a typical account would have invoked Aiken and the ENIAC, charting the evolution from electromechanical to electronic systems, Moseley unapologetically signalled a 'gap' in the narrative, hinting vaguely at the upheavals of war to justify the picture of a self-contained, all-British development culture leaping into activity from a standing start in 1945.[56]

Few advocates went so far, but many were willing to assert that computing was a British invention, or at least a British-led enterprise. The abovementioned LEO, announced publicly in 1954, drew a welter of positive publicity focused on the novelty of its achievements in office automation.[57] Ferranti's brochures for its later machines unsurprisingly referred back to the technical and commercial 'firsts' of the 1951 machine, asserting a continuity of cutting-edge innovation.[58] Another British firm, Elliott, which had developed a series of defence computers around 1950 before expanding into commercial data processing, took a similar line with its 1960s marketing strapline: 'Pioneers of the first decade – now leaders of the second decade'.[59]

Exceptionalist appeals in computer marketing copy of this period operated at two levels: the approach pioneered by LEO, based on concrete claims about the manufacturer's unique appreciation of the audience's localised needs, and more nebulous assertions that a British development heritage must add up to something solid and effective. The computing division of English Electric, a conglomerate with wide-ranging electrical, locomotive and aviation interests, followed the LEO approach, trading on internal procurement of its own computers across its various divisions to guarantee a focus on 'user convenience'.[60] Unsurprisingly, application-focused copy sometimes had a strong flavour of the technological sublime: in 1955, when Ferranti promoted a new commercial machine, Pegasus, the list of sample applications consisted of weather forecasting, aircraft design, dam construction (emblematic of grand civil engineering), turbines, cotton ring-spinning (the last great hope for the revival of Britain's textile industry), and the payroll computations which the roaring new information economy would demand.[61]

It was in the nature of the industry, however, that the potential customer base was difficult to determine, and so some publicity was always cast in more noncommittal and evocative terms which often owed much to Bowden's mobilisation of history. A particularly striking example appears in a 1962 campaign for Elliott's 503 computer. Each advertisement showed the conventional hardware portrait dwarfed by a massive image of

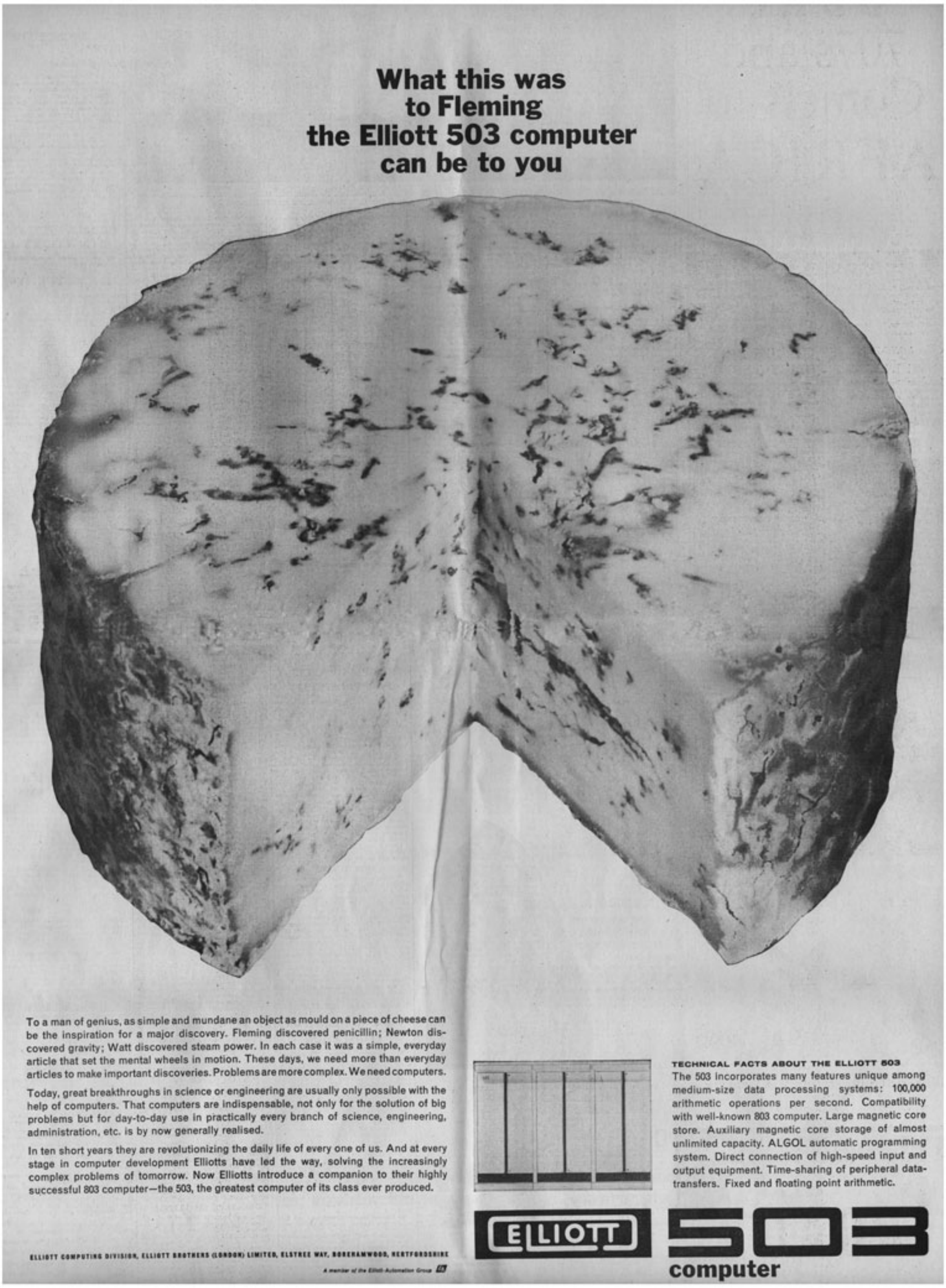

Figure 1. Elliott 503 display advertisement, Times, 11 October 1962.

an everyday object: an apple, a kettle, or a cheese (Figure 1).[62] As the supporting copy explained:

> To a man of genius, as simple and mundane an object as mould on a piece of cheese can be the inspiration for a major discovery. Fleming discovered penicillin; Newton discovered gravity; Watt discovered steam power. In each case it was a simple, everyday article that set the mental wheels in motion. These days, we need more than everyday articles to make important discoveries. Problems are more complex. We need computers.

In a few simple stock images, the campaign brought together the common context reaching from the Industrial Revolution to present-day informatics, the exceptional culture of inventive flair, the crucial role of the brilliant individual, and the ability of computing power to transcend conventional economic logic. The computer's past and present were British; its future could remain so – at least rhetorically.

The strongest of all appeals to the national technodream in computing, however, came with the Atlas project, developed by the University of Manchester and Ferranti with another electronics firm, Plessey, between 1958 and 1962. Atlas was specifically conceived to be the most powerful computer in the world, recapturing and cementing the legacy of the Manchester partnership's postwar lead, as the promotional literature made clear. 'A thousand times faster than the world's first commercial computer, also pioneered by Ferranti, Atlas will be a research weapon of incalculable power in the hands of great nations and great enterprises alike'.[63] The unmistakeable figurative connection to the transformative properties of nuclear technology was made literal a few years later when a second-generation Atlas was commissioned for the Atomic Weapons Research Establishment at Aldermaston.

In charting the rhetoric of the British computer industry, it is important not to lose sight of the reality, from which it was increasingly divorced.[64] Despite their early technical lead, Ferranti and its competitors never became major exporters of computing machines, and by the late 1950s American firms, led by IBM, had cut heavily into Britain's domestic market. Such was the overall growth of that market, however, that firms which were now in relative decline could still claim strong expansion in terms of absolute numbers of machines sold. As the British industry matured, it promoted bullish messages through co-ordinated efforts such as the British Electronic Computer Exhibition, held annually at London's Olympia exhibition centre. In the popular science periodical *New Scientist*, Nigel Calder (in later years, perhaps the most high-profile science journalist in Britain) went so far as to claim that the Exhibition's inaugural year of 1958 was the year in which in which the British industry became 'something much more than a novelty', buttressing his point with a typically selective potted biography of the computer which began with Babbage and ended with LEO.[65]

By the mid-1960s, however, marketers and industry advocates were increasingly abandoning the idea of a national exception. This was not a simple consequence of the continued growth of American imports, but resulted largely from two concurrent and fundamental changes in the market, to be addressed in the next two sections. On the technical side, the nature of what it meant to 'computerise' now had less to do with the individual, idiosyncratic and visible artefacts which suited defiant and exceptionalist narratives. At the level of national policy, meanwhile, grand defiant visions had fallen out of favour, replaced by an ethic which saw modernisation in terms of conformity to international (that is, in most cases, American-led) agendas.

Systems, standardisation and software

Defiant modernism thrived on visual aesthetics. The Vulcan bomber, the Jodrell Bank radio telescope, and the reactors at Calder Hall and Windscale were among the iconic technological artefacts whose modernity seemed to be embedded in their unfamiliar physical forms. At the outset, electronic computers were cast in a similar mould, seldom described without accompanying photographs. The nine-foot-tall Nimrod, as we have seen, was a product of the need for visual impact, while the rats'-nest wiring of development machines had an eccentric allure of its own. Corporate display involved a rather different visual language of showpiece presentation, clean modernist lines and 'futuristic' accessories. As LEO had demonstrated, novel settings or applications added to the appeal. In 1961, for instance, Barclays Bank captured useful column inches and bolstered its modernising reputation by opening Britain's first computing centre for banking, using hardware from the British firm EMI. The super-powerful Atlas was presented in similar style, a room-sized array of uniform cabinets picked out against a stark, white-tiled floor.[66]

Across the sixties, however, the novelty of new hardware wore off as installations multiplied, costs and prestige declined, and some business purchasers positively favoured familiarity and interoperability over innovation. In 1966, the chairman of Williams Deacon's Bank told shareholders that the adoption of a new computer 'hardly justifies particular comment', but the firm's choice of system was symptomatic of an important wider change.[67] In 1964, IBM, now vigorously active in many European markets, had announced System/360, a fully compatible 'family' of computers aimed at a wide range of markets. The promotional approach was simple, stressing low entry costs, flexibility, and (supposed) ease of programming.[68] System/360 quickly approached the status of an industry standard in the global market, and American competitors began to offer 'clone' models, similarly designed and partially interoperable.[69]

Such changes were part of a broader shift in the shape of the computer industry and its promotional endeavours, as programming, software services and eventually software products eclipsed hardware as a focus for investment and market comparison.[70] Historically, British innovations in formalising, supervising and understanding the instruction of machines had been at least as significant as hardware achievements. The Cambridge group, led by Maurice Wilkes, enjoyed high esteem among American and European computer scientists for developing the immensely valuable principle of the pre-prepared subroutine library and for producing, in 1951, the first textbook on programming; the Manchester group had produced the first 'Autocodes', high-level programming specifications which could be compiled automatically into machine instructions.[71] Britain's software production culture in the 1960s was innovative and entrepreneurial, though it was inevitably much smaller than an American industry, which swelled to globally exceptional proportions through a series of huge, mostly defence-oriented government projects.[72]

Creating a space for programming in the grand national narrative had been one of Vivian Bowden's priorities in *Faster Than Thought* – hence his relentless championing of the conceptual achievements of Charles Babbage, and in particular of the discussion of applications by Ada Lovelace, whose portrait he included as a frontis illustration (this coverage was, in later years, the foundation of the distinctly ahistorical depiction of Lovelace as the 'first computer programmer'). Yet the problem which Ferranti had encountered at the Festival of Britain remained obstinate: programming concepts, unlike hardware visions, did not pass readily to non-specialist audiences. There was a fundamental tension, moreover, between the very universality of these concepts and the idea of a national exception.

The challenge of adapting the established rhetorical framework is nicely illustrated in press advertisements for the strongest British competitor to System/360, the ICT 1900 series, whose development background was itself symptomatic of wider shifts. IBM was not the first firm to address the opportunities of a compatible system range: Ferranti had been working on a similar approach for some time, as had another British producer, ICT, and there was a growing sense that Britain could not sustain a large number of independent and uncoordinated development efforts. In 1963, ICT acquired Ferranti's commercial computing operations (the Ferranti parent organisation retaining its defence interests), and began to rationalise its development plans. In the wake of the System/360 announcement, ICT considered buying into a scheme by one of the US rivals, RCA, to produce IBM-compatible machines, but instead – for a combination of market and cultural reasons – threw its weight behind the 'British designed, British built' 1900 range, which in fact derived significantly from work by Ferranti's Canadian subsidiary.[73]

General press advertising from the year of launch shows an awkward modification of the conventional iconic hardware portrait (Figure 2), with the installation pushed to the rear of the shot to foreground an empty 'operator's chair'. This was an attempt to reflect the message of copy focused on the system's 'master program' – a forerunner of what would later be called an operating system – as a unique feature of interest. ICT also highlighted that it was relatively close to being able to fulfil orders; otherwise, the promotional pitch was essentially equivalent to IBM's. The appeal to the pioneering British track record survived only as a vestige, with a brief invocation of the technical 'lead' gained in the Ferranti era.[74]

Subsequent promotions did not repeat the attempt to focus on exceptional software innovation, and often featured no exceptionalist images at all. One series of 1966 was built around the theme of the hardware-software 'package deal', stressing '[g]etting the software right' as 'the biggest single problem manufacturers have – and a prime cause of installation delays'. There was no attempt to promote particular solutions to the problem, however: the advertisement merely pointed to the more than 400 items (a figure which was repeatedly revised upwards in later versions) in ICT's 'software library'.[75] The concern now was to avoid giving any impression that clients were committing to technologies or approaches which might not last. It was rare, for instance, for manufacturers to take sides on the competing merits of FORTRAN and ALGOL, the two high-level languages often identified, respectively, with 'American' and 'European' programming styles;[76] copy typically stressed that a given machine could use both, and sometimes other languages besides.

Another ICT campaign of the same period, intended to shore up confidence in the company among less technically informed buyers, was framed very much in terms of hardware installations, using the persona of an overworked delivery driver to reflect growing fulfilment of orders. Though software was deemed sufficiently familiar to provide the theme for one advertisement in the sequence (Figure 3), the tokenism is awkwardly apparent.[77] Britain should 'be proud of ICT', but was not directed to show pride in any particular design.

IBM's ever-growing transnational dominance, moreover, meant that considerations of nationality were often beside the point. Defiant modernists had construed success in terms of beating 'the Americans'; the simple goal of British producers was increasingly to survive against IBM. Since this was also the primary goal of IBM's American competitors, as Jeff Yost has pointed out, transatlantic collaboration was a natural prospect.[78] The period thus

Figure 2. ICT general press display advertisement promoting the 'Executive' program supervisory system, 1964.

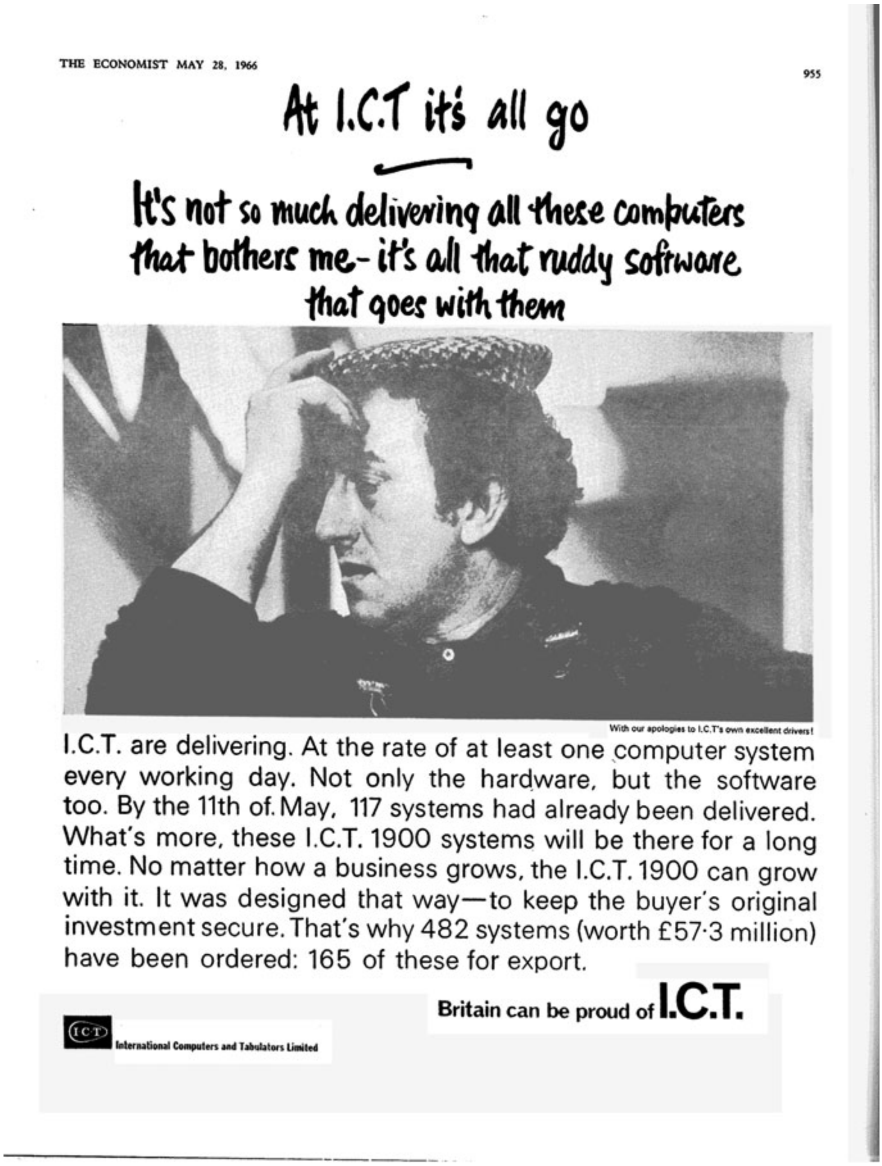

Figure 3. ICT general press advertisement emphasising sales of the 1900 system, 1966.

saw a bewildering array of negotiations involving ICT, Machines Bull of France, and the US firms Burroughs, Sperry Rand, RCA and General Electric.[79] English Electric's System 4 range, announced in 1965, derived its specification directly from RCA's System/360 clone; though much of the engineering design was British, the project was firmly inspired by the compatibility agenda.[80]

Only at the most superficial level did Britain's commercial computer offering remain exceptionalist, as the surviving firms regularly invoked their 'all-British' ownership and production. The increasing hollowness of this appeal in the mature computer market is perfectly illustrated by the fact that 'American' competitors were almost equally capable of accentuating British elements in their design, manufacture and use – the most convincing being IBM, which by now had extensive experience in foregrounding the local character of its operations right across Europe, and which was careful to make sure that British press coverage mentioned the input of the firm's UK laboratories in projects such as System/360.[81] Nationality, in fact, mattered far less to most buyers in this period than compatibility, pricing, and above all reliability – not only of the equipment, but of the suppliers behind it. From the early 1960s, as the numerous British suppliers struggled to maintain sales, much of their effort was diverted into convincing customers that they were not about to leave the market.[82]

The defiant vision of technocratic resurgence, we should note, remained part of the backdrop of wider national culture throughout these changes. Many Britons' first explicit experience of the hardware/software distinction must have come with a 1966 episode of the popular science-fiction adventure serial, *Doctor Who*. The megalomaniac computer which served as central menace was already a genre convention, but the means of salvation were novel: the Doctor neither out-thinks nor out-guns the machine himself, but reprograms one of its own weapons, a robot tank, to destroy it. The relevant scene was presumably scripted to address varying audience awareness, with the Doctor first stating that he has 'made an important readjustment to aid and change the purpose of this machine', then that it 'will carry out a special program that I've fed into it'.[83] The confrontation takes place in the real-world setting of the Post Office Tower (constructed 1961–1965), simultaneously a microwave aerial hub and an icon of modernist design. The computer, Wotan, a product of British engineering, is described as the 'most advanced' in the world (as, albeit briefly, had been the Ferranti Atlas four years earlier); before its unfortunate malfunction, Wotan was intended to serve, in an echo of the Dan Dare world order, as the 'central intelligence' for lesser machines around the globe. Already by this point, however, government policy had turned in a direction which no longer endorsed the aspirations behind these visions.

'White heat' and the toolroom agenda

Conceived under Labour, but chiefly shaped by the long arc of Conservative administrations after 1951, the defiant-modernist technodream was swiftly abandoned as Labour returned to power under Harold Wilson in 1964. Wilson was elected as a moderniser, and is popularly remembered as a technocrat who spoke of a new Britain 'forged in the white heat of [scientific] revolution'; yet what at first glance looks like a reaffirmation of the defiant agenda was, in intent and execution, something very different. Wilson considered the 'white heat' of technical and attendant social change not as something to be generated anew, but as an established global phenomenon demanding urgent action which must be unashamedly reactive.[84] This meant the scrapping of large and prestigious projects commissioned in the Conservative era, particularly in defence aerospace.

Wilson's alternative vision was that Britain's 'underused talent' would provide 'not the workshop of the world; that is no longer our role – but the pilot plant, the toolroom of the world'.[85] There would be no more Atlases. Computers would remain valued, but their task must now be to support the internationally valuable 'bridgehead' industries of machine tools, electronics and telecommunications.[86] Defiance, in other words, was off the agenda: something more like the Cripps productivity drive, with its inbuilt submission to American industrial norms, would dominate the Wilson period. Technology was ever more important, but it was no longer a magic bullet to change the rules of the game.

A high-profile variation on this theme came from Sir Leon Bagrit, managing director of the Elliott group, by then known as Elliott-Automation. 'Automation' was Bagrit's term for a proposed large-scale reform of technology policy involving extensive systems analysis to achieve much faster and more efficient production whilst eliminating drudge manual work, and blending advanced expertise in hardware and software. Bagrit's frame of reference was firmly international; his particular strategy for Elliott was to licence the use of key American innovations piecemeal, quietly putting together the means to dominate particular niches in overseas markets.[87]

In 1964, the BBC chose Bagrit to deliver the annual Reith Lectures, a broadcast series usually presented by a leading cultural or scientific commentator and intended to promote national attention to an issue of current concern. Couched in terms of what needed to be done at the national level, Bagrit's rhetoric at one level recalled the defiance of the immediate postwar: he spoke of a grand and distinctive social reform, with widespread mass education in both sciences and the humanities, which need not be beholden to American (or Soviet) norms, and might even put the iconic but stuttering Welfare State back on track. On the other hand, Bagrit's proposals to 'modernize' industry were couched very firmly in follow-the-leader terms. To fail to emulate international (and chiefly American) currents 'would have been suicidal'; the creation of a Ministry of Technology to implement Wilson's agenda represented an acknowledgment 'that time is not on our side'. New technologies remained the key to restoring fortunes, but only insofar as they could cut the time required to 'catch up with a technological lead'.[88]

Even before the 'white heat' reorientation, the UK producers had revised their goals from taking over the world, to staying in the domestic market: indeed, by 1964, three of them (GEC, EMI and Marconi) had abandoned it altogether. The transfer of Ferranti's commercial computers to ICT, and a merger of the LEO and English Electric computer interests in 1963, were steps in a process of industry consolidation which the Ministry of Technology pushed vehemently towards to its logical conclusion. By 1968, most of Britain's established computer manufacturing interests lay within a single conglomerate, International Computers Limited (ICL), which was dubbed a 'national flagship', a name intended to connote an export-focused strategy.[89]

This trend was international. In 1967, the French journalist Jean-Jacques Servan-Schreiber published his book-length manifesto, *Le Défi Américain* ('The American Challenge'), a bestseller across Europe. Servan-Schreiber rehearsed a version of the decline argument: Europe must integrate and mobilise its technological efforts or face wholesale American control of the European economy. Computerisation, along American lines, was crucial to this vision.[90] The text cited Harold Wilson approvingly and subscribed firmly to the 'toolroom' ethic, with no glimmer of the defiant technological trajectory. Servan-Schreiber stressed that American and European industrial cultures were thoroughly comparable; that performing the comparison clearly affirmed American superiority; and that Europeans must, therefore, reshape their own production urgently, or face American investors reshaping it on their own terms. Echoing the 'white heat' transformation, French national policy shifted significantly towards this vision in 1969, as the presidency passed from Charles de Gaulle, architect of defiant *grandeur*, to the more pragmatic Georges Pompidou.[91] The fading of the French national exception contributed directly to that of the British, as France permitted the UK's accession to the European Economic Community in 1973.

A similar diagnosis was fostered by the Organisation for Economic Co-operation and Development (OECD), which had grown out of the Marshall Plan collaboration, and which produced a series of comparative international quantitative studies around 1966–68 under the umbrella title ‘Gaps in technology’.[92] The investigation concluded that Britain remained in the global game – just about:

> [I]n 1967 there were no more than two companies making a broad range of computers outside the United States without the help of an American manufacturing licence: the first is [ICL] in the United Kingdom… and the second is Fujitsu in Japan. No European or Japanese firm is in a position to grant a licence to the United States.[93]

Moreover, while the Japanese star might be rising, the UK’s was falling: the report bracketed Britain alongside France and Germany in a systematic pattern of management decisions which, it concluded, ignored the market for commercial applications, in stark contrast to the USA in general and IBM in particular. Close co-operation between manufacturers and clients, institutionalised through the IBM user group SHARE and its various imitators, appeared as a factor; so, of course, did the USA’s gargantuan defence procurement, against which no degree of native ingenuity could possibly avail.[94]

Inevitably, the government-sponsored process which created ICL had become known as ‘Americanisation’.[95] The aim, now, was not to defy US corporate culture with new modes of doing things, but to create a large-scale entity able to contribute to the prevailing hegemony – although, over the long term, ICL was to be largely frustrated even in this.[96] The same was true, we must note, of some of IBM’s US competitors. The most successful of those which endured, CDC and DEC, did so by specialising their efforts into the profitable niches of, respectively, supercomputers and minicomputers.[97] This looked like a promising approach for British innovation. In the mid-1960s, indeed, the Ministry of Technology fostered several non-ICL firms producing minicomputers; all were soon eclipsed by DEC and other US producers, and retreated to localised supply arrangements which amounted to niches within a niche. This eclipse, however, was not a re-run of the loss of the first computer market, but a direct and largely foreseen consequence of Wilson’s ‘toolroom of the world’ agenda. In permitting US suppliers to take a large share of the market, government met its higher priorities of computerising various industries to ensure competitiveness on other fronts.[98] The isolated pursuit of any one sector, be it aerospace or computing, had disappeared with the defiant agenda.

Conclusion

The information theorist Nelson Blachman used an interesting form of words in setting out a market report on European computing for American colleagues in 1961. ‘In at least one respect,’ he wrote, ‘Britain is the world’s leader in the computer field; the first stored-program electronic digital computer… was put into operation in June 1949 in the University Mathematical Laboratory, Cambridge’.[99] The two senses in which a nation might ‘lead’ – initial inventive milestones, or productive dominance – were, on the face of it, obviously distinct. A key part of the rhetorical recipe laid down by Bowden, however, was that the distinction was unnatural, a product of short-term and remediable adversity; leadership on all fronts was the natural consequence of the national industrial context and spirit, as illustrated by colourful lessons from history. More rigorous historical examination has tended rather to endorse the broad conclusion reached in the abovementioned OECD reports: the odds were stacked strongly against British producers from the outset, to a degree that was not initially apparent, for reasons that boil down chiefly to the rank impossibility of out-spending the US defence budget.[100]

The Wilson-era toolroom agenda, though, never entirely extinguished the appeal of the national technological exception as a rallying-point for action. Hence, a quarter-century after *Faster Than Thought*, the glib invocation of computer programming as 'a particularly British skill' mentioned in the opening to this article. While indicting traditional industry for ruinous complacency, the documentary held up the example of Logica, a British software company successfully exporting its brainpower to the US financial sector, as an exemplar of how disaster might yet be turned to triumph. Exercising considerable dramatic licence, the narrative paints software development as a novel – and hence transformative – enterprise in which 'we are world leaders', quietly eliding the vastly greater size of the US industry (and, indeed, the fact that Logica's startup had been partly funded by PRC, a veteran US software contractor). The comment that the British 'invented programming' is offered with no explanation whatsoever, as a simple given. (The implied reference was conceivably to the work of the Wilkes group at Cambridge, but more probably to some version of the Babbage/Lovelace legend, as laid down by Bowden, which featured prominently in popular introductions to computing from around this time.)

In the 1980s, the picture was greatly complicated by several factors: the entrenchment of the USA's own complacency/decline narrative, the bold rhetorical challenge of the Japanese 'Fifth Generation' programme, and the rise of mass personal computing.[101] This last, in particular, was attended in the United Kingdom by what looked remarkably like an attempt to revive the defiant ethic in national policy. Damaged, post-industrial regions of Britain were earmarked for regeneration through the transformative power of 'information technology', schools were given incentives to buy computers on the assumption of intrinsic educational value, and Prime Minister Margaret Thatcher, in a meticulously staged photo-opportunity, presented her Japanese opposite number with a small, inexpensive – and wilfully incompatible – Sinclair microcomputer, designed in Cambridge, assembled in Dundee, and putatively exported across the world.[102] One recent appraisal suggests that the policies of this era had a significant effect in building expertise and entrepreneurial activity in the UK.[103] In the past few years, the personal computing culture of the 1980s has itself become a rallying-point for advocates in education and industry, with tangible results including the reorientation of the schools computing curriculum to favour closer engagement with programming concepts.[104] The national exception, then, may ultimately be more than a myth.

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Notes

1. *Horizon:* "Now the Chips are Down", BBC2, transmitted 31 March 1978. The background to this broadcast is surveyed briefly in Blyth, "Computing for the Masses?"
2. Aspray and Beaver, "Marketing the Monster"; Tweedale, "Marketing in the Second Industrial Revolution"; Pinch, "Giving Birth to New Users."
3. Colin Divall, adopting an expression from Martin Reuss, has addressed similar narratives around transport and personal mobility as "techno-tales": Divall, "Mobilizing the History of Technology."
4. Krige, *American Hegemony*, 38–39.

5. Gallagher, "Decline, Revival and Fall", 144; cf. Hennessy, *Never Again*, 224.
6. For France's deep ambivalence towards the American element of the emerging Western Alliance, see Kuisel, *Seducing the French*.
7. These developments have been covered in numerous general histories of the computer; the most convenient starting point is Williams, *History of Computing Technology*, 323–346. For the mobilisation of the scientific war effort into postwar research more generally, see Sanderson, *Universities and British Industry*, 339–359.
8. "An Electronic Brain", *Times*, 1 November 1946, 2. For the American journalistic interpretation of ENIAC, which set a pattern for the British, see Martin, "Awesome Thinking Machine", 124–126.
9. Quoted in "Did You Hear That?", *Listener*, 14 November 1946, 663. Cf. "A New Electronic 'Brain': Britain Goes One Better", *Manchester Guardian*, 7 November 1946, 8.
10. Hodges, *Alan Turing*, xvi–xix, 530–534.
11. Report of visit of T.R. Thompson and O.W. Standingford to USA, 1947, quoted in Caminer et al., *User-Driven Innovation*, 16.
12. Lavington, *Early British Computers*; Campbell-Kelly, *ICL*; Hendry, *Innovating for Failure*; Bird, *LEO*.
13. This incident was recollected by Eric Grundy, the senior Ferranti manager responsible for Prinz's mission: see Kilburn and Piggott, "Frederic Calland Williams", 593.
14. Lavington, *History of Manchester Computers*, 5–27; Tweedale, "Marketing in the Second Industrial Revolution", 98–99; Hendry, *Innovating for Failure*, 7–22.
15. Earl of Halsbury, "The Work of the National Research Development Corporation", *Journal of the Royal Society of Arts*, 13 June 1952, 510–526, on 514.
16. Bud, "Penicillin and the New Elizabethans", quotation on 312.
17. For instance: Ure, *Cotton Manufacture*; Smiles, *Self-Help*.
18. Hendry, *Innovating for Failure*, discusses this stance and cites a range of policy literature from the 1950s onward which (without necessarily using the term 'British problem') bases its analysis on the same characteristic set of assumptions.
19. Coleman, "Gentlemen and players"; Collins and Robbins, *British Culture and Economic Decline*.
20. The historian of technology David Edgerton has been particularly influential in tracing appeals to the "British problem" since the 1980s to the tendencies of New Right historians keen to promote an easily digested morality tale of decline through soft-hearted complacency: see his *Science, Technology and the British Industrial "Decline"* and *Warfare State*.
21. Carew, "Anglo-American Council"; Tiratsoo and Tomlinson, "Gospel of Productivity."
22. Bud, "Penicillin and the New Elizabethans", 312–313.
23. Dan Dare and Britain's postwar design and production culture in defiant-modernist context were extensively explored in the 2008 (London) Science Museum exhibit, "Dan Dare and the Birth of Hi-Tech Britain", support materials for which may be found at http://www.sciencemuseum.org.uk/onlinestuff/stories/dan_dare.aspx, accessed 1 February 2014. Quotation: Morris, *Best of Eagle*.
24. Listing at http://owww.brookes.ac.uk/cgi-bin/social/psych/searchdata.pl, accessed 1 February 2014. A representative sample of 1950s and 60s illustrations may be found in Tatarsky, *Eagle Annual of the Cutaways*.
25. Hecht, *Radiance of France*.
26. Edgerton, *England and the Aeroplane*; Hennessy, *Never Again*, 109; Bud, *Penicillin: Triumph and Tragedy*, 73; and cf. the various contributions to Bud and Gummett, *Cold War, Hot Science*.
27. On Britain as a social model, see Ellwood, *Rebuilding Europe*, 141–143.
28. Bevin used this phrase at the October 1946 Cabinet committee meeting which affirmed the decision, according to a 1980 recollection by another attendee, Michael Perrin. See Hennessy, *Never Again*, 268.
29. Arnold, *Britain and the H-Bomb*. On the carrying-through of status claims from the atomic bomb to the hydrogen bomb decision, see Hennessy, *Having It So Good*, 328–331.
30. Nahum, "Royal Aircraft Establishment."
31. Booth, "Future of computers."
32. Cockcroft, "Science and technology in industry."
33. Tweedale, "Marketing in the Second Industrial Revolution", presents a more detailed study of Ferranti's promotional endeavours.

34. Forgan, “Festivals of Science”; Forgan, “Everything is Made of Atoms”. “Inside the atom” was used as the title for press display advertising: for instance, *Daily Mirror*, 12 July 1951, 10.
35. Stuart-Williams, “Ferranti Nimrod”; Bennett, “Autobiographical Snippets.” Nimrod’s scale and positioning relative to the Exhibition as a whole can be judged from a contemporary plan view, “The Way to Go Round the Exhibition of Science”, reproduced online at http://www.wellcomecollection.org/full-image.aspx?page=1137&image=exhibition-of-science-map, accessed 1 February 2014.
36. “Faster than Thought: the Ferranti Nimrod”, 14–15.
37. Bennett, “Autobiographical Snippets”; Bronowski, *Exhibition of Science*; Cobb, “1951 Exhibition of Science.”
38. Bowden, *Faster Than Thought*, vii. Leading promoters of computing had objected to the “brain” metaphor from the time of its creation, although Alan Turing’s famous contribution of 1950 had prompted more serious examination of the possibility that machine processing might be brainlike: see Priestley, *Science of Operations,* 145–153. Most specialists would have agreed, however, with Bowden’s emphasis that the practically available computers of 1953 were not “thinking machines” but fast processors for simple data operations.
39. Bowden, *Faster Than Thought*, 173. Bowden’s statement conflates England with the UK: Ferranti’s avionics division in Edinburgh was among the contributors.
40. One contributor, Raymond Stuart-Williams, had moved to RCA in the US by the time of publication.
41. Buchholz, “Faster Than Thought.”
42. Hecht, *Radiance of France*, 42.
43. Bowden, *Faster Than Thought*, x.
44. Wiener, *Cybernetics*, 37; Wiener, *Human Use of Human Beings*, 164–189. The unrelated sense of the term “Second Industrial Revolution” which is more familiar today, invoking the chemical and electrical rise of Germany and the USA in the late nineteenth century, was not well established until the 1960s.
45. Bowden’s rhetoric is addressed briefly in Tweedale, “Marketing in the Second Industrial Revolution”. For the rhetorical legacy of eighteenth- and nineteenth-century technology in Britain see MacLeod, *Heroes of Invention*; Marsden and Smith, *Engineering Empires*.
46. Bowden, *Faster Than Thought*, 6–31; “Ferranti: the Manchester Electronic Computer.” The material on Babbage was repeated in subsequent and more detailed brochures.
47. Cohen, *Howard Aiken*, 61–66.
48. Correspondence between Bowden and Brian Randell, March 1972, University of Manchester Archives, BVB/1/82, folder 2; interview with Douglas Hartree, *Science Survey*, BBC Home Service (radio), 11 December 1946; Hartree, *Calculating Instruments*, 69–73.
49. Comrie, “Babbage’s Dream Comes True.”
50. Speech of Viscount Hall, Development of Inventions Bill, second reading in the Lords, Hansard: HL Deb, 29 April 1948, vol. 155, cc. 568–573. “Richard” was corrected to “Charles” in newspaper accounts of this speech.
51. Booth and Booth, *Automatic Digital Calculators*.
52. Cohen, *Howard Aiken*, 66–72.
53. Bowden, *Faster Than Thought*, 175.
54. MacLeod, *Heroes of Invention*, 210–211.
55. Bowden, *Faster Than Thought*, xii.
56. Moseley, “Babbage’s Dreams”; cf. Moseley, *Irascible Genius*.
57. LEO 1950s press cuttings file, UK National Archive for the History of Computing, University of Manchester, NAHC/LEO/D6. See also Lean, “Mechanical Brains”, 183–185.
58. For instance, “Ferranti Computing Systems Atlas.”
59. “503 Ultra High Speed Digital Computer.”
60. “KDF-9 Very High Speed Data Processing System.”
61. “Main Points of the Ferranti Pegasus Computer”, 7.
62. *Times*, 10 October 1962, 7; 11 October, 7; 12 October, 7.
63. *Times*, 22 September 1961, 9.
64. The eclipse of the British computer industry has attracted much historical discussion from various perspectives. Good starting points include Campbell-Kelly, *ICL*; Hendry, “Innovating

for Failure"; Flamm, *Creating the Computer*; Tweedale, "Marketing in the Second Industrial Revolution."
65. Calder, "Development and Uses of Digital Computers."
66. The early, exposed Manchester computer assembly was the subject of a memorable panoramic photograph: Agar, "Digital Patina." For corporate display, see Martin, "Centring the Computer", which discusses the Barclays installation on 72–80. For the rhetoric around Atlas see, for instance, "Ferranti Computing Systems Atlas."
67. Williams Deacon's Annual Report, 1966, quoted in *Times*, 21 January 1966, 17.
68. For example: *Times*, 24 November 1964, 7.
69. Ceruzzi, *Modern Computing*, 144–171.
70. For this shift in the context of American-led international developments, see Ensmenger, *Computer Boys*; Campbell-Kelly, *Airline Reservations*.
71. Campbell-Kelly, "Wilkes, Wheeler and Gill"; Campbell-Kelly, "Programming the Mark I." See also Campbell-Kelly's "Development of Computer Programming" for a useful survey of British activity in this period.
72. Campbell-Kelly, *Airline Reservations*, 75–79.
73. Campbell-Kelly, "ICL and the Evolution", 402–406; "A British Attack on the Computer Market", *Guardian*, 29 September 1964, 14. The "British designed" strapline appeared in display advertising around the time of the announcement: for instance, *Times*, 24 March 1964, 5.
74. *New Scientist*, 22 October 1964, 228.
75. "ICT Datagram No. 1: software" (display advertising), *Economist*, 26 February 1966, 53; "With every ICT 1900 Series computer … " (display advertising), *Economist*, 23 April 1966, 108. By June, the library had reached 634 items.
76. The dichotomy is discussed (as rhetorical construct, rather than fact) in Nofre, "Unraveling Algol". The Elliott 503 advertisement discussed above is unusual in promoting ALGOL, which Elliott engineers had recently selected in place of a proposed machine-specific language.
77. *Economist*, 28 May 1966, 39.
78. Yost, "Appropriation and Independence."
79. Campbell-Kelly, *ICL*, 206–214.
80. Campbell-Kelly, *ICL*, 242–244.
81. Kelly, *British Computer Industry*, 58; Martin, "Centring the Computer", 170; Schlombs, "Engineering International Expansion"; Paju, "Many Levels of IBM Operations"; and see for instance "IBM: Leader in the Field of Electronics", *Times*, 19 May 1964, 18.
82. Martin, "Centring the Computer", 174–175.
83. *Doctor Who*, "The War Machines", episode 4, BBC1, broadcast 16 July 1966; quoted from DVD release: BBC Video, 2008. See also Lean, "Mechanical Brains", 189–90.
84. "Labour's Plan for Science", quotation on 7; Coopey, "White Heat", and see also Tony Benn's recollections in Coopey, "Ministry of Technology", 128–129.
85. Speech to the National Press Club, Washington DC, April 1963, quoted in Edgerton, "'White Heat' Revisited", 58.
86. Edgerton, "'White Heat' Revisited", 67.
87. Lavington, *Moving Targets*, 201–213.
88. Transcripts of Bagrit's Reith Lectures are available via http://www.bbc.co.uk/radio4/features/the-reith-lectures/transcripts/1960/#y1964. Accessed 28 December 2014.
89. Campbell-Kelly, *ICL*, 245–264; Coopey, "Empire and Technology", 149–156.
90. Servan-Schreiber, *American Challenge*, 134–142.
91. Hecht, *Radiance of France*, 118, 272.
92. Godin, "Emergence", 686; Godin, "Technological Gaps", 10–17.
93. Jéquier, "Technological Gaps", 31.
94. Jéquier, "Technological Gaps", 35–37.
95. Robert Reid, "Rhetoric of Americanisation."
96. Hicks, "Compiling Inequalities", 243–249.
97. Yost, *Computer Industry*, 79–80.
98. Hamilton, "Despite Best Intentions", 81–104.
99. Blachman, "State of Digital Computer Technology", 265.
100. Flamm, *Creating the Computer*, 136–149; Tweedale, "Marketing in the Second Industrial Revolution."

101. Collins, "American Enterprise", shows the American decline narrative to have been built on the model of the British, whilst presenting it as a minority strain in 1980s American policy thinking. For the *défi japonais*, see Feigenbaum and McCorduck, *Fifth Generation*.
102. Skinner, "Technology, Consumption and the Future"; Haddon, "Home Computer"; Selwyn, "Learning to Love the Micro"; Lean, "Making of the Micro".
103. Blyth, "Computing for the Masses?"
104. Computing At School, "Computing in the National Curriculum", 31–32; Solon, "Raspberry Pi's Eben Upton."

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