Bletchley Park and Big Science: Industrialising the Secret War, 1939-1945

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ABSTRACT

During the Second World War, Bletchley Park, the headquarters of the Government Code and Cypher School, was the epicentre of a vast scientific enterprise which succeeded in reading enciphered Axis wireless traffic on an industrialised scale. Typically, this important intelligence agency has been depicted as a collegiate organisation with a clear Senior Common Room culture. This article argues that Bletchley Park is better understood as major mechanised, military orientated scientific enterprise with vast numbers of employees, a considerable budget and was subject to careful and professionally managed wartime media control which extended for many years into the post-war period. Each of these facets respectively represents each of the five 'M's of 'Big Science'. As such, the agency can in fact, be viewed and understood as an example of quasi-Big Science.

INTRODUCTION

Popular belief would have it that, during the Second World War, Britain's intelligence battle was won by a motley collection of eccentric mathematicians, chess players and crossword enthusiasts.[1] These individuals were plucked from their Cambridge University common-rooms, in the hope that assembling a sufficiently large pool of bright individuals (with "acrostic brains") and leaving them to muddle through the problem posed by the highly advanced mechanised cipher systems of the Axis powers could yield positive results.[2] By no small miracle, this was achieved. Men like Alan Turing, the archetypal wartime cryptanalyst, were able to break the seemingly unbreakable and solve the unsolvable.[3] They accomplished this through a mixture of profound intellectual ability, but

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[1] Christopher Moran, *Classified: Secrecy and the State in Modern Britain*, Cambridge: Cambridge University Press, 2013, p. 256; Taylor Downing, *Churchill's War Lab: Code-Breakers, Boffins and Innovators: The Mavericks Churchill Led to Victory,* London: Abacus, 2011, pp. 160-165.

[2] Ewen Montagu, *Beyond Top Secret U,* London: Corgi, 1977, 1979, p. 45. This image was primarily fostered by memoirists in the 1970s and 1980s, like Montagu. For an example, see: Peter Calvocoressi, *Top Secret Ultra,* London: Cassell, 1980.

[3] Given the centrality of his place within Bletchley Park "lore", Turing has been immortalised repeatedly by biographers and even on the Silver Screen. See: Andrew Hodges, *Alan Turing: The Enigma,* London: Burnett Books, 1983; Dermot Turing, *Prof: Alan Turing Decoded,* Stroud: The History Press, 2015. Other key figures have also been subjects of biographers, see: Robin Denniston, *Thirty Secret Years: A. G. Denniston's Work in Signals Intelligence 1914–1944,* Trowbridge: Polperro Heritage Press, 2007; Mavis Batey, *Dilly: The Man Who Broke Enigmas,* London:

also the development of mammoth, whirring machines – devices which would not be out of place in a W. Heath Robinson cartoon.[4] In doing so, not only did these slightly bedraggled and bespectacled boffins reduce the length of the war by no less than two years, their inventions also ushered in the information age.[5]

As with all such whimsical historical myths, the legend of Bletchley Park is based on at least some grains of truth. The Government Code and Cypher School (GC&CS), the agency whose headquarters were based at Bletchley Park during the Second World War, did indeed draw upon some of the finest, hand-picked minds from Britain's elite universities. Moreover, these men and women did indeed provide many of the breakthroughs (which did involve the development of new technologies) that facilitated the mass reading of Axis military and diplomatic wireless traffic. That much, at least, is true. However, this narrative, since rejected in academic investigations, obscures the industrial magnitude of the operation conducted in the pursuit of signals intelligence (SIGINT).[6] Though the agency did indeed initially resemble a militarised university senior common room, this organisational model did not long survive the pressures of total war.

While likening the agency to a factory, according to Jon Agar, by 1944 Bletchley Park had developed from its pre-war common room culture structure, into 'an industrialized enterprise: finely arranged division of labor, very high staff numbers, an emphasis on through-put, and innovative mechanization at bottlenecks.'[7] More recent studies by Christopher Grey and Andrew Sturdy, investigating the organisation and management of GC&CS, though suggesting that Bletchley Park's transformation was significantly more complex and less uniform that presented by Agar, concur that

Dialogue, 2009; Joel Greenberg, *Gordon Welchman: Bletchley Park's Architect of Ultra Intelligence,* London: Frontline Books, 2014.

[4] Indeed one set of machines built for Bletchley Park were named Heath Robinson Machines, precisely because they looked eerily similar the caricature devices depicted by the famous cartoonist.

[5] F. H. Hinsley, 'The Enigma of Ultra', *History Today*, 43 (1993), pp. 15-20.

[6] Christopher Grey, *Decoding Organization: Bletchley Park, Codebreaking and Organization Studies,* Cambridge: Cambridge University Press, 2012.

[7] Jon Agar, *The Government Machine: A Revolutionary History of the Computer*, Cambridge MA.: The MIT Press, pp. 203-209.

the industrialisation of the agency was highly significant.[8] This article builds on these findings arguing that, in fact, Bletchley Park represents not merely the birthplace of merely of mechanised espionage, but industrial scale espionage.

There were, of course, precursors to Bletchley Park. Of particular note was the War Trade Intelligence Department (WTID) during the First World War, tasked with collecting and disseminating information required to enforce Britain's blockade. In order to achieve this, the WTID produced and continually updated an index based on millions of intercepts. John Ferris, the official historian of GC&CS's successor, the Government Communications Headquarters, described this remarkable and vast data processing system as 'the triumph of data processing for intelligence in the age of the card index.' Similarly, Ferris also singles out the size and the scale of the British cable censorship operation of the First World War, which read 80 million cables. Similarly, in terms of manpower, the censorship operation peaked at 802 staff in 1918 and the WTID some 333. Hugely significant in terms of the scale of data collected and processed, these systems were not industrial, neither in terms of the mechanisation of data processing nor the manpower requirements which went with it.[9] Meanwhile, sizably staffed organisations though they were, both were dwarfed by GC&CS at its 1944 height during the Second World War. It was the advent of wide-spread machine encryption during the inter-war period that necessitated an industrial, mechanised response by practitioners of SIGINT, it was at Bletchley Park that this response first emerged.

This is important in that it suggests routes for intelligence historians to contextualise historical intelligence activities within wider debates regarding the history of science and technology in the twentieth century. The historian of science and technology, David Edgerton, has observed, contrary

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[8] See Dominique Pestre and John Krige, 'Some Thoughts on the Early History of CERN', in Peter Galison and Bruce Hevly (eds.), *Big Science: The Growth of Large-Scale Research* (Stanford: Stanford University Press, 1992), pp. 78-99. This chapter is one of a number of important essays in an important collection reconfiguring scholarly understanding of Big Science.

[9] John Ferris, *Issues in British and American Signals Intelligence, 1919-1932*, United States Cryptologic History, Special Series, vol. 11, 2015, pp. 9-10. Available online: https://www.nsa.gov/Portals/70/documents/about/cryptologic-heritage/historical-figures-publications/publications/misc/issues-in-british-and-american-signals-intelligence-1919-1932.pdf (accessed: 15 July 2019).

to declinist mythologies, that 'The United Kingdom was long distinctive in its approach to warfighting, opting for machines over men. … The warfare state was always strong, and at the core of the state, and shaped the United Kingdom, the rest of the empire and much of the world so as to emerge victorious, with allies, in two world wars.'[10] Clearly, Bletchley Park, which successfully mechanised the management, analysis and distribution of vast quantities of data, reflects the truth of Edgerton's observation. The agency was a key example, after initial teething problems, of investing in machines, to equip a relatively small number of fighting men with the key military advantage: foreknowledge. This fits a wider pattern of investing in innovative British SIGINT strategies, as earlier examples such as censorship and the WTID show. The pressures of war saw GC&CS's leaders rapidly opt, in a not always smooth and in an often *ad hoc* process, to adapt and evolve the agency. It was this evolution which saw GC&CS emerge into Agar's 'industrialized enterprise'. By contrast, in the United States of America, SIGINT work lagged behind in terms of industrialisation and mechanisation. As Colin Burke notes, 'from World War I to the tense days of the Cold War the US Army and Navy's cryptanalysts labored to keep up with, let alone get ahead of, the state of the art in technology, science and mathematics.'[11]

This article seeks to stimulate debate by suggesting that Bletchley Park can, in fact, helpfully be thought of as a mid-twentieth century example of a quasi- "Big Science" project.[12] By viewing Bletchley Park through such a prism, it is possible to reach a more accurate understanding of the agency than offered in previous studies by historians of science and technology and intelligence historians. Moreover, investigating the agency as a quasi-Big Science enterprise demands asking hitherto rarely explored questions, not least how the operation was financed.

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[10] David Edgerton, *The Rise and Fall of the British Nation: A Twentieth Century History*, e-book, London: Penguin, 2018, p. 32.

[11] Colin Burke, 'Automating American Cryptanalysis 1930-1945: Marvellous Machines, a Bit Too Late', in David Alverez (ed.), *Allied and Axis Signals Intelligence in World War II*, London: Frank Cass Publishers, 1999.

[12] Some other historians have made this claim, see: Subrata Dasgupta, *It Began With Babbage: The Genesis of Computer Science,* Oxford: Oxford University Press, 2014, p. 57.

BIG SCIENCE

The term Big Science was first coined in 1961 by the American nuclear physicist Alvin M. Weinberg, in an article in *Science*, where he bemoaned the parlous influence of vast scientific projects on the ability of the lone scientist to conduct individual, independent research.[13] The concept was further developed two years later by the historian of science, Derek J. de Solla Price, in his landmark study *Little Science, Big Science*.[14] The central thesis of the model is that, prior to the Second World War, the vast majority of scientific research had been conducted by individuals typically working alone or in small units. However, the Second World War, often called the "Physicists' War", changed all of that. The requirements of the war, unparalleled in its scope and immorality, had led its major belligerents to invest vast sums of money, materiel, manpower and expertise into vast scientific weapons projects – the Manhattan Project being *the* original Big Science project.[15] The hope was that these endeavours might produce weapons and technologies which would offer a decisive advantage in the conflict. For instance, in Germany, Wernher von Braun headed a project awarded as much as RM 2 billion to develop rockets which could rain death on the Nazis' opponents.[16] Meanwhile, the United States of America invested an unprecedented $2 billion and employed 130,000 individuals in the Manhattan Project.[17]

These kinds of projects, with their vast budgets, huge numbers of employees and hulking machines, set a new standard for scientific research and development which continued into the Cold War. In order to remain ahead, the two great superpowers channelled resources into both theoretical and practical projects. It was hoped that such investment would garner either a military advantage or the reward of cultural soft power generated by unveiling major new scientific discoveries. Thus, Big

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[13] Alvin M. Weinberg, 'Impact of large-scale science on the United States', *Science* (1961), pp. 161-164.
[14] Derek J. de Solla Price, *Little Science, Big Science,* New York: Columbia University Press, 1963.
[15] James H. Capshew and Karen A. Rader, 'Big Science: Price to the Present', *Osiris* (1993) 7, pp. 3-25.
[16] Gerard DeGroot, *Dark Side of the Moon: The Magnificent Madness of the American Lunar Quest,* London: Jonathan Cape, 2007, p. 18.
[17] Jeff Hughes, *The Manhattan Project: Big Science and the Atom Bomb,* Duxford: Icon Books, 2002, p. 9.

Science was characterised by five major components, known as the five 'M's: Money, and lots of it; Manpower, in huge numbers; Machines, of vast scale; a Military or national security purpose; and tight Media control and management.[18] Clearly, the Manhattan Project, the largest and most expensive of the Second World War, had each of the first four of the 'M's in spades. Less obvious is the 'Media' element; the project was a closely guarded secret until 1945.[19] Nevertheless, after the bombings of Hiroshima and Nagasaki, it was subject to careful media management.[20]

Of course, the concept of Big Science has not gone without significant challenge and reconfiguration.[21] Historians of science have rightly pointed out that large scientific projects, exhibiting at least some of the 'M's, existed before the Second World War and that the precursors of Big Science have a very long heritage.[22] Charles Babbage's work in the Nineteenth Century, designing and constructing calculating machines built to produce accurate mathematical tables, for example, racked up a princely sum (provided by the British state) of £17,000 between 1823 and 1842.[23] Meanwhile, other vast projects, which did not necessarily exhibit all the 'M's, have since been developed and understood as examples of Big Science; the European Organization for Nuclear Research (CERN), with its limited military application and international, pan-European backing, being an example. Unsurprisingly given its roots, a problem with the term is that it has primarily been applied to large scale physics projects; as such, the history of Big Science has in fact largely been the history of Big Physics.[24] Indeed, even by the 1990s this association remained clearly prevalent. For instance, a 1994 report for the Department of Trade and Industry, concerning the attitude of British industry to Big Science, though providing nods to other forms of science such as

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[18] Capshew and Rader, op. cit. (11) p. 4.
[19] Often without success: Nigel West, *Mortal Crimes: The Greatest Theft in History: Soviet Penetration of the Manhattan Project*, New York, NY: Enigma Books, 2004.
[20] Jon Agar, *Science in the Twentieth Century and Beyond,* Cambridge: Polity, 2012, p.330.
[21] For an important series of essays see: Galison and Bruce (eds), *Big Science.*
[22] Mary Jo Nye, *Before Big Science: The Pursuit of Modern Chemistry and Physics, 1800-1940,* Cambridge MA.: Harvard University Press, 1996, pp. xiii-xviii.
[23] Martin Campbell-Kelly, *The Computer Age,* Hove: Wayland Publishers, 1978, pp. 40-41.
[24] Catherine Westfall, 'Rethinking Big Science: Modest, Mezzo, Grand Science and the Development of the Bevalac, 1971–1993', *Isis*, (2003) 94, pp. 30-56, 30-31.

pharmaceutical research, primarily focussed on high energy physics, space and large telescopes.[25]

Yet even so, Big Science, if instead viewed as an analytic framework, remains a valuable tool in considering several important scientific projects in the Second World War and beyond. This is in-spite of the caveat that, as Elena Aronova has pointed out, 'the categories we typically use to characterize science during the Cold War were themselves products of Cold War science.'[26] It is undeniable that the pressures of the Second World War and the cultural and scientific arms races of the Cold War saw the development of huge projects, complete with increasingly enormous machines, which could only be funded and manned through national and even international science budgets. It is the argument of this article that the framework can also be interestingly applied to Bletchley Park. Over the course of the Second World War, GC&CS developed each of the five 'M's and rapidly expanded beyond the Senior Common Room ethos which has come to define how it is typically framed in the British cultural memory of the war. The military purpose and application of reading Axis wireless signals is obvious, already well explored and requires little comment here.[27] On the other hand, Bletchley Park's relationship with the other four 'M's are less well understood.

In addition to reconsidering the status of the agency, viewing Bletchley Park through the prism of Big Science also invites investigation into aspects of the agency's operation which have been awarded surprisingly little attention. Significantly, very little is known about the financial cost of the wartime development of the agency. The financial aspect of GC&CS's activities, save important work by work Eunan O'Haplin, has been almost entirely hitherto unconsidered.[28] This is, perhaps, explained by the patchy, partial and deliberately misleading nature of the extant financial records

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[25] Segal Quince Wicksteed, *Preliminary Study of the Attitude of UK Industry to Big Science: a report to the Department of Trade and Industry* (1994).

[26] Elena Aronova, 'Big Science and "Big Science Studies" in the United States and the Soviet Union during the Cold War', in Naomi Oreskes and John Krige (eds.), *Science and Technology in the Global Cold War,* Cambridge MA.: The MIT Press, 2014, p. 393; Agar, *Science in the Twentieth Century*, p. 331.

[27] For excellent studies of the military impact of wartime cryptanalysis see: Ralph Bennett, *Behind the Battle: Intelligence in the War with Germany, 1939–1945*, rev edn, London: Pimlico, 1999; F. H. Hinsley, *et al.*, *British Intelligence in the Second World War*, 5 vols., London: HMSO, 1979–1990.

[28] Eunan O'Haplin, 'Financing British Intelligence: the Evidence up to 1945', in K.G. Robertson (ed.), *British and American Approaches to Intelligence,* Basingstoke: Macmillan, 1987.

available, which render any attempt to accurately ascertain the agency's budget impossible.

As such, even with the additional research outlined here, it is feasible only to provide a partial glimpse into the agency's finances. It has, however, proven possible to locate some illustrative figures which provide some, very limited, further indication regarding the order of magnitude of the agency's wartime budget. Of course, the scale of financial investment in GC&CS is significant in understanding the trajectory of the agency, but more importantly still the willingness of the organisation's managers to both seek and spend large sums money on scientific research and development further highlights the changing culture of the organisation. Meanwhile, ever more substantial sums invested in GC&CS demonstrate an increasingly favourable attitude among Whitehall mandarins, ministers and senior military officials towards the potential for technology in espionage work.

First however, a central issue to briefly address is the sheer scale of Britain's information war. Typically, Bletchley Park is held-up as *the* British cipher cracking operation. This is misleading, as noted, Bletchley Park was in fact the head-quarters of a larger agency, with other subsidiary establishments located off-site. Moreover, the agency itself was one major constituent part of a larger process. The GC&CS's central task was to analyse the communications traffic of foreign powers, if necessary strip those messages of protective ciphers, and to forward useful information to relevant ministries and military commands. Yet, the actual process of collecting these messages, a vast, expensive and technically sophisticated process, was not handled by the agency directly, but rather by the 'Y Service'.[29] The Y Service, a multi-agency and multi-ministry operation, ran the global network of listening and direction finding stations, in close liaison with GC&CS. An umbilical cord, primarily comprised of teleprinters and dispatch riders on motorcycles, connected Bletchley Park to these stations. To provide an indication of the scale of the interception operation,

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[29] For a full discussion of the relationship between GC&CS and the Y Service, see: Kenneth Macksey, *The Searchers: Radio Intercept in Two World Wars,* London: Cassell, 2013.

it is worth noting that one the largest intercept stations, Beaumanor, utilised 196 radio sets and employed some 1,300 operators. The Y Service as a whole employed approximately 10,000 people.[30] Though this article is concerned primarily with Bletchley Park and GC&CS, the central role it played within the wider SIGINT network should be kept in mind.

MACHINES

The interception of Axis wireless traffic was clearly no small endeavour, yet it was only the beginning of the operation; the next step, which was where GC&CS came in, was to convert the messages into plain text. The most important intellectual breakthrough by GC&CS, in this arena at least, came before the outbreak of the war in 1939. During the inter-war period Germany had invested in, and continued to develop, a new type of cipher system to protect its military and diplomatic wireless traffic – the famous Enigma family of cipher machines. Despite some triumphs against an early variant of this system, that used by Franco's forces in the Spanish Civil War, GC&CS had virtually no success attacking messages enciphered by advanced military grade versions of the machines utilised by the German military. By 1939, they had largely given up. The secret internal history of the agency, penned by Francis 'Frank' Birch and written in the years immediately after the war, recorded the prevailing pre-war view: if Enigma were 'readable at all, [it] might call for elaborate apparatus which had not yet been designed.'[31] This realisation, confirmed later that year when it transpired that Polish cryptanalysts had been (temporarily) successful in utilising just such a mechanised approach, would fundamentally change the focus of the agency.

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[30] Greenberg, *Gordon Welchman*, pp. 19-20.

[31] Frank Birch, *The Official History of British Sigint, 1914-1945*, vol. 1 (part 1), John Jackson (ed.), Milton Keynes: The Military Press, 2004, p. 20. This now published volume is based on the internal histories of the agency entitled 'A History of British Sigint, 1914-1945' filed under HW 43 /1 and the National Archives, Kew (TNA).

Prior to the Second World War the British intelligence community placed a premium on social status, gentlemanly credentials and the school tie.[32] In this world, which during the interwar period was beset by retrenchment, fulltime scientific and technical expertise was an unaffordable luxury. For example, in the early 1920s, when scientific support was required by MI6, it was farmed out to external consultants.[33] In this respect, the GC&CS was little different and had placed considerable store in the recruitment of gentleman scholars, often with backgrounds in the humanities – individuals who were good with words, who understood language and letter frequencies. These types of individuals, usually linguists, historians and classicists, had proven remarkably adept cryptanalysts during the First World War. Yet the mechanised ciphers developed during the inter-war period required a different skill-set to crack and, from at least 1929, the agency began to recruit mathematicians.[34] This proved a fruitful strategy. A number of the mathematicians recruited, including the famous logician Alan Turing and the Cambridge geometrist Gordon Welchman, were interested by machines and the possibilities in cryptanalysis which technology presented. On the outbreak of war, Turing set about designing electro-mechanical devices, dubbed "Bombe machines", with which to attack Enigma ciphers. His initial design was soon improved by Welchman.[35]

The machines were large brass cabinets, over six feet high, five feet wide and two foot deep, containing around 10 miles of wire, a million soldered connections and fronted by dozens of rotating drums.[36] A contract was drawn up with the British Tabulating Machine Company (BTM) to build the machines and the first prototype arrived at Bletchley Park in May 1940. This speedy start should not, however, be taken as an indication that the Bombe machine proposal received universal

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[32] Juliette Pattinson, 'The twilight war: gender and espionage in Britain, 1900-1950', in Simona Sharoni, Julia Welland, Linda Steiner, Jennifer Pedersen (eds.), *Handbook on Gender and War*, Cheltenham: Edward Elgar Publishing, 2016, p. 70.

[33] Keith Jeffrey, *MI6: The History of the Secret Intelligence Service, 1909-1949,* London: Bloomsbury, 2010, p. 168.

[34] Alastair Denniston to C. E. D. Peters, 26 April 1932, TNA, HW 72/9.

[35] Gordon Welchman, *The Hut Six Story: Breaking the Enigma Codes,* Kidderminster: M&M Baldwin, 1982, 2014, p. 77.

[36] AP. Mahon, *The History of Hut Eight 1939 – 1945*, HW 25/2, TNA. This document is available online at, http://www.ellsbury.com/hut8/hut8-000.htm (accessed: 15 July 2019, p. 28.

acceptance. It was, in fact, subject to questions of cost and viability. Turing's ideas were, however, championed by some very senior figures, not least Edward Travis, the agency's second in command, and Frank Birch, a veteran cryptanalyst of the First World War.[37] With their support, whatever misgivings towards this novel technological approach that existed were overcome. As the internal history of Turing's section, Hut 8, explained:

> Unfortunately the bombe was an expensive apparatus and it was far from certain that it would work or, even if the bombe itself worked, that it would enable us to break Enigma. Its original production, and above all the acceptance of a scheme for large scale production, was the subject of long and bitter battles and Hut 8, and of course, Hut 6, owe very much to Commander Travis and to a lesser extent to Mr. Birch, for the energy and courage with which they sponsored its production.[38]

Moreover, despite the speedy start, new machines only arrived from the production line in limited numbers – still as few as six by late summer 1941.[39] These delays were the result of the sheer complexity of the devices which required significant time and rare expertise to construct.[40] The difficulties in procuring them in sufficient numbers resulted in a series of heated clashes within the agency, as the various sections of Bletchley Park competed for priority use of the few machines which had been delivered. These disputes significantly contributed to a near all-out bureaucratic civil war within the agency which, in 1942, toppled its chief Commander Alastair Denniston – and

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[37] Mahon, *The History of Hut Eight*, p. 14

[38] Mahon, *The History of Hut Eight*, p. 28. These reservations were a product of wider pessimism regarding Enigma and the utility of pouring resources into a potentially doomed project aimed at generating solutions. Frank Birch was informed at the beginning of the war that 'all German codes were unbreakable. I was told it wasn't worth while putting pundits onto them.' He complained, in a later letter to the head of the agency, Commander Alastair Denniston, that 'Defeatism at the beginning of the war to my mind, played a large part in delaying the breaking of codes.' Mahon, *The History of Hut Eight*, p. 14. Like Mahon, the cryptanalyst Hugh Alexander noted, in an internal history of work on the Naval Enigma, that Birch and Travis were instrumental in changing the agency's position. They were determined 'that the problem should be solved and it is to the pertinacity and force that, in utterly different ways, both of them showed that success was ultimately due.' See: C.H.O'D. Alexander, *Cryptographic History of Work on the German Naval Enigma* (no date, c. 1945), HW 25/1, TNA. This document is available online at, http://www.ellsbury.com/gne/gne-000.htm (accessed: 21 April 2019), pp. 20-21.

[39] Mahon, *The History of Hut Eight*, p. 29.

[40] Mahon, *The History of Hut Eight*, p. 29.

with him several of the agency's 'old guard', the veterans of the First World War and the inter-war period.[41]

The internal conflict hammered home the final nail in the coffin of the common-room culture which had dominated the agency before 1939, a transformation which was not lost on its managers.[42] It was replaced with a highly structured, carefully managed, factory orientated, information production line – which rapidly expanded over the course of the war.[43] This process of change and increased emphasis on technology was greatly assisted by an alliance forged with the American government, which began building machines at a fast pace. By 1945, the agency had access to 332 machines, over 100 of which were located in the USA and were generously time-shared with Bletchley.[44] Though among the most famous and significant of the agency's technologies, the Bombes were not the only machines developed for use at Bletchley Park.[45]

BTM also had another important role to play. In addition to working closely with the agency in the production of Bombe units, GC&CS also contracted the firm to operate a punch-card index section, utilising a wide array of tabulating machinery, to collect and collate the information acquired from deciphered Axis messages.[46] This was a vital section of the agency, the ability to break ciphers was often dependent on a process known as 'cribbing', which was to infer the partial content of a message, based on previous patterns, formats and wording of previous messages, for which a solution had already been found. Armed with this information, it was possible to extrapolate the keys to the ciphers. The result was that keeping a vast catalogue of all messages which had been sent before and was retrievable at short notice, was crucial to the agency's success. Not only was a central mechanised indexing section utilised, but other sections dealing with the messages of

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[41] Grey, *Decoding Organization*, pp.89-95.

[42] A.D.(Mech) [Gordon Welchman] to Director [Edward Travis], 10 July 1944, TNA, HW 62/6.

[43] 'Memorandum by Nigel De Grey', 17 August, 1949, TNA, HW 50/50.

[44] Alexander, *Cryptographic History*, p. 57.

[45] For a discussion of the agency's cipher-making machines see: John Ferris, *Intelligence and Strategy: Selected Essays,* Abingdon: Routledge, 2005, pp. 138-180; Christopher Smith, 'Bletchley Park and the Development of the Rockex Cipher Systems: Building a Technocratic Culture, 1941–1945', *War in History*, 24 (2), 2017.

[46] Martin Campbell-Kelly, *ICL: a business and technical history,* Oxford: Clarendon Press, 1989, pp. 120-123.

specific branches of the German state also kept their own indexes.[47] Mechanised information management was key to GC&CS's work, a fact reflected by the scale of the BTM tabulating section, which employed approximately 300 machine operators and a further 100 technicians to ensure the machines operated efficiently. Furthermore, some of the dozens of machines could process 300 punch-cards per-minute and required truckloads of punch cards to be delivered week in, week out.[48]

The agency was also heavily involved in the research and design of another set of vast devices, the Colossus machines – which were among the very first electronic programmable computers and stand as landmarks in the history of Computer Science.[49] The project to build these machines began in 1943, following the introduction of new and even more complex German cypher systems, produced by C. Lorenz AG, the Lorenz SZ-40 and SZ-42 machines. They were designed at the General Post Office's (GPO) Post Office Research Station at Dollis Hill in London, under a team led by Tommy Flowers one of the GPOs top telephone engineers, on the behalf of GC&CS. The machines were of staggering size and complexity, filling the entirety of a large room and comprised of over 1,500 electronic valves, and fed information via a photoelectric punched-tape reader which could manage an impressive 5,000 characters per-second. The design of the initial prototype machine was similarly speedy and was delivered to Bletchley Park after just 11 months of frantic work at Dollis Hill.[50] In total, ten of these machines were built, as well as a further 26 related machines, all attacking the same Axis cipher system.[51]

One particularly important type of 'big' mechanical devices, also utilised in this process, were the (Heath) "Robinson" machines. While the Colossus machines were utilised to help to establish the settings used by the Lorenz machines, the Robinson's were designed to strip the encrypted message

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[47] Grey, *Decoding Organization*, p. 216.

[48] Ron Gibbons interview with the Bletchley Park Trust, in Dave Whitchurch (ed.), *Other People's Stories*, vol. 3, The Bletchley Park Trust Archive [BPTA], pp. 22-24

[49] B. Jack Copeland, 'Colossus and the Rise of the Modern Computer', in B. Jack Copeland, *Colossus: The Secrets of Bletchley Park's Codebreaking Computers,* Oxford: Oxford University Press, 2006, pp.101-115.

[50] Welchman, *Hut Six Story*, pp. 178-179.

[51] Paul Gannon, *Colossus: Bletchley Park's Greatest Secret,* London: Atlantic Books, 2006, p.239.

of its protecting cipher once the settings of the Lorenz machines had been established.[52] These machines were known as Tunny machines, but were also referred to as Robinson machines because of their physical appearance and size. Built within a metal frame, which resembled the dimensions of a double-bed, the machines contained numerous spinning wheels and pulleys, which shot streams of tape around the machine at speeds of up to 2,000 characters a second, it bore a striking similarity to W. Heath Robinson's cartoon devices – not least 'The Professor's Invention for Peeling Potatoes'.[53] The successes and emphasis of the agency had very much become wedded to, and revolved around, "Big" Machines.

(WO)MANPOWER

The problem with building so many machines was that somebody had to operate them. As with the labour-intensive task of machine construction, which was farmed out to carefully chosen commercial partners, the agency shopped around for suitable supplies of labour. The chief ports of call were the armed forces and the civil service, which had, in their ranks, an abundant supply of potential recruits. Moreover, the Admiralty, War Office, Air Ministry and Foreign Office, as the chief consumers of the agency's product, had a vested interest in supplying Bletchley with enough staff to ensure that military intelligence was churned out at a swift pace. The result was that by January 1945, 8,955 individuals worked at Bletchley Park and 5,599 were drawn from the military services.[54] The primary source of the agency's cryptanalytic machine operators was the Women's Royal Naval Service (WRNS). Weekly administrative returns, compiled by the agency from March 1942 onwards, provide detailed staff tallies. The number of Wrens working for the agency at that time stood at some 159. By 27 December 1942, this figure had risen to 613 and, by December 1943,

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[52] Ken Halton, 'The Tunny Machine', in F.H. Hinsley and Alan Stripp (eds), *Codebreakers: The Inside Story of Bletchley Park,* Oxford: Oxford University Press, 1993, 1994, p. 168.

[53] W. Heath Robinson, 'The Professor's Invention for Peeling Potatoes', in Norman Hunter, *The Incredible Adventures of Professor Branestawm*, London: Random House, 1933, 2013, p. 191.

[54] Kerry Johnson and John Gallehawk, *Figuring it out at Bletchley Park, 1939-1945,* Redditch: BookTower Publishing, 2007, p. 14.

to 1,874. At the peak of GC&CS's growth, in the winter of 1944, it employed some 2,546 women from the Royal Navy.[55]

But why did the agency require so many Wrens? The answer is simple: Bombes were highly labour intensive machines. Over a 24 hour period, no less than ten operators were required.[56] Given that by 1945 the agency had acquired 200 Bombe machines, it required over 2,000 staff to operate them. Moreover, several other labour intensive machines, including the Colossus Computers, were also operated by Wrens.[57] The increased number of machines and Wren operators facilitated the considerable and ever-escalating production of intelligence. This, in turn, led to increased staffing demands across a wide variety of sections within the agency. More cryptanalysts had to be recruited to supervise the Wrens, translators were required to convert the messages into English, caterers were needed to feed the additional staff, and a vast communications section was essential to distributing the huge quantities of intelligence the agency produced on a daily basis. The major source of communications equipment operators was, again, the women's branches of armed forces, specifically the Women's Auxiliary Air Force (WAAF). The result was that a similar trend can be observed in the agency's secondment of members of the WAAF. In March 1942, GC&CS had 162 WAAFs on its books. By the end of the year, that figure had increased to 400, and, by December 1944, there were 1,553.[58]

Of course, given the massive expansion of the agency's labour force, one of the major side effects was that the management of the agency was forced to adapt. As noted above, the introduction of machines and disputes regarding access to that equipment helped topple the leadership of the agency in 1942. The other major factor in play was the difficulty in accruing sufficient levels of manpower. Despite the significant headway made in this area, under the direction of Commander

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[55] Johnson and Gallehawk, *Figuring It Out*, pp. 40-43.
[56] [No Author Given] 'Locations and Numbers', 29 July 1942, TNA, HW 62/4.
[57] Christopher Smith, *The Hidden History of Bletchley Park: A Social and Organisational History,* Basingstoke: Palgrave Macmillan, 2015, pp. 79-80.
[58] Johnson and Gallehawk, pp. 48-50.

Alastair Denniston, who oversaw exponential staff growth, it was not enough. In a now infamous

episode in the agency's history, four of the leading cryptanalysts went over the heads of both

Dennison and the head of the Secret Intelligence Service (SIS), Sir Stewart Menzies, to complain

directly to the Prime Minister. Among their list of complaints was a the lack of female labour to

perform the essential auxiliary work of the agency. It was this damning indictment on the

managerial performance which the official historian of MI6, the late Keith Jeffrey, directly linked to

the collapse of Denniston's rule in February 1942.[59]

The battle to increase the influx of workers, typically women, to perform the auxiliary roles of the

agency, saw not just the fall of the old order, but also the partial demise of their systems of

management. The sections dealing with cryptanalysis and translation continued to cling on to the

collegiate managerial attitude which had dominated in the inter-war era, which was characterised by

meritocracy and the intellectual freedom to approach work in a scholarly fashion. Indeed, John

Cairncross, a Bletchley Park translator who also moonlighted as a Soviet agent secretly transmitting

GC&CS's product to Moscow, described the atmosphere of his section as 'an adolescent jocularity

which recalled college days.'[60] The new machine sections were not run in the same fashion. These

sections were instead operated as points on a factory-based production line and the staff were

treated as factory labourers on the shop-floor. This the agency made explicit. Indeed, senior agency

managers concluded that machine work, particularly the operation of communications equipment,

was so uninteresting that it was 'necessary to intervene and institute factory methods.'[61]

In addition to managerial practices of machine sections, the agency had increasingly come to

resemble a factory in terms of its structure, a point which has been made repeatedly by historians of

the agency. Indeed, R.A. Ratcliff described the wartime agency in these terms and attributed its

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[59] Jeffrey, *MI6*, pp. 745-746.

[60] John Cairncross, *The Enigma Spy: An Autobiography, the story of the man who changed the course of World War Two,* London, Century, 1997, p. 98.

[61] Quoted in Christopher Grey and Andrew Sturdy, 'A Chaos that Worked: Organizing Bletchley Park', *Public Policy and Administration* (2010) 25, pp. 47-66, 57.

success to both the centralisation of wartime cryptanalysis and to the building of an intelligence 'production line'.[62] As the organization theorist Christopher Grey has noted, the successful common-room culture, which continued to dominate the largely male and university graduate filled cryptanalytic sections, increasingly became run in conjunction with managerial techniques borrowed from the commercial and industrial world.[63] The incorporation of these new kinds of administration, with their emphasis on careful control and direction of labour, and corporate structures, were a feature of other Big Science projects.[64] Indeed, so significant was organisation and management to projects of this scale, it presents a further potential 'M': "Big Management".

The other key side effect of mass recruitment (to operate large numbers of complex machines, to fulfil bureaucratic tasks, to staff auxiliary roles and to provide labour for the core functions of the agency – cryptanalysis and translation of wireless messages) was that GC&CS expanded, beyond the facilities and space available at Bletchley Park. The Bletchley Park estate, in 1938, consisted of a modest mansion house and a few smaller buildings. Soon after GC&CS arrived, a building programme began which saw the construction of numerous prefabricated huts and later large concrete blocks, to house the expanding operation. By 1941, even this solution to the accommodation problem proved insufficient and the agency began requisitioning other sites – some many miles away. These satellite establishments, known as outstations, primarily housed the Bombe machines and their operators. Bletchley Park had rapidly become the hub of a far larger operation, with remote stations and many thousands of personnel, feeding information to and from Bletchley.[65] The agency was not merely 'Big' in terms of personnel, but also in terms of geographical sprawl.

MONEY

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[62] R. A. Ratcliff, *Delusions of Intelligence: Enigma, Ultra, and the End of Secure Ciphers,* Cambridge: Cambridge University Press, 2006, pp. 102-105.
[63] Grey, *Decoding Organization*, pp. 188-189.
[64] Audra J. Wolfe, *Competing with the Soviets: Science, Technology, and the State in Cold War America,* Baltimore MD.: John Hopkins University Press, 2013, pp. 48-53.
[65] Smith, *Hidden History*, pp. 17; 26-30.

According to Commander Alastair Denniston, the agency's head from 1919 to 1942, 'beyond a salary and accommodation vote GC and CS had no financial status', at that time it was, he further contended, 'an adopted child of the Foreign Office with no family rights, and the poor relation of the SIS, whose peacetime activities left little cash to spare.'

So, how much did all these machines, buildings and personnel, cost the British state? Unfortunately, this 'M', the amount of money the agency actually required, is impossible to establish at the time of writing. If the agency did, at any point, tabulate its full expenses, then that document has either been destroyed or is still awaiting discovery. In all likelihood, no such document ever existed. Staff salaries and wages were typically paid by the Whitehall ministry from which individual employees had been seconded. Those financial records which have survived are few and far between, they provide only a glimpse into GC&CS's wartime budget. For example, a few documents, such as those listing the water rates paid by the agency, are neatly filed away at the National Archives in Kew.[66] But such records reveal little about the true cost of the agency. As Eunan O'Halpin noted in 1987, in a short study of the financing of British intelligence, the material located 'facilitates a partial reconstruction of portions of the intelligence budget', very far from all of it.[67] In respects to GC&CS's finances, little has changed over the last three decades.

The best evidence available, in fact, comes from published parliamentary papers, which record the salaries openly paid to GC&CS's staff on the Foreign Office vote. In 1939, the agency's staff were paid some £348,878, by 1945, that tally increased to £1.4 million. In total, the Foreign Office paid some £6.6 million into the agency in salaries alone.[68] Yet this sum underestimates the Foreign Office's true contribution to the agency. For a start, these totals, with the exception of 1945, list only

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[66] W.H.W. Ridley to the Treasury Valuer, 23 July 1940, TNA, HW 64/42.
[67] O'Haplin, 'Financing British Intelligence: the Evidence up to 1945', p. 187.
[68] Civil Estimates and Estimates for Revenue Departments, *Parliamentary Papers* [PP], viii (1939-1940), p. 107; *PP,* vi.1 (1940-41), p. 195; *PP,* (1941-42) vi, p. 195; *PP* (1943-44) vi.1, p. 129; *PP,* (1944-45) viii.1, p. 138; *PP,* (1945-46) xvii.1, p. 160.

salaries other expenses do not appear in these tallies. The 1945 total, in addition to the £1.4 million

spent on salaries, also lists a further £1.04 million unaccounted for in the list of salaries.[69]

To add a layer of confusion, the internal records of the Foreign Office do not tally with those

supplied in the published Foreign Office vote. For example, Foreign Office documents state that in

the 1941-42 financial year, the ministry invested a total of £351,674, of which £207,569 was

salaries, significantly less than the £620,281 listed in public. Meanwhile, this internal tally covered

not just the salaries of the staff it supplied, but also additional expenses such as travel and catering

accumulated by its staff, communications costs, and "special services" such as the purchase of

communications equipment.[70] By 1945, internal documents suggest that the sum had increased

substantially, to more than £1.4 million, a tally confirmed by the salaries listed in the Foreign Office

vote.[71] Meanwhile, because of the agency's highly secret status, the financial dealings GC&CS had

with other ministries are extremely difficult to locate. This was no accident of bad accounting. In

1941, £18,429 was paid in salaries to technical staff seconded to GC&CS from the Post Office via

the Foreign Office. These funds were buried in Appendix F of the Post Office vote, under the

heading "free services rendered".[72] Clearly, any curious individual exploring the nation's finances

and who examined Appendix F would be none the wiser.

Other expenditure was also buried in the secret vote and channelled to GC&CS via SIS. In the year

1940-41, only a relatively modest £79,000 was derived from this source. However, as the official

historian of SIS notes, this was not to remain the case for long. Within three years, the amount of

SIS monies spent on GC&CS had increased many times over to £1.3 million, a figure broadly

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[69] *PP,* (1945-46) xvii.1, p. 160.

[70] 'Public Accounts Committee. March 2nd, 1943. Foreign Office Account 1941-42. Code and Cypher School', 2 March 1943, TNA, CAB 301/78.

[71] 'Government Code and Cypher School Provision in 1946 Estimates', 26 September 1945', TNA, CAB 301/78; *PP,* (1945-46) xvii.1, p. 160.

[72] 'Public Accounts Committee. March 2nd, 1943. Foreign Office Account 1941-42. Code and Cypher School', 2 March 1943, TNA, CAB 301/78.

similar to the salaries paid by the Foreign Office that year.[73] If the rate of investment from the Secret Vote increased in broadly similar increments to those of the Foreign Office, then the agency received at least as much as £5 million from this source over the course of the war.

Other staffing, equipment and building costs are even more difficult to establish. Even such little evidence as is available is insufficient to begin making useful estimates. For instance, the agency helpfully provided pay scales for female members of the armed services: a Wren in early 1942 earned 1 shilling and 8 pence per day, a Leading Wren's wage was 3 shillings 3 pence, and so on up the ranks.[74] However, while the numbers of individuals employed by the agency from the WRNS are available after March 1942, the specific military ranks of these individuals are not. As such, this evidence cannot be utilised to gauge the true cost in wages accumulated by the agency with even remote accuracy.

Fortunately, the expenditure generated in constructing Bletchley Park's famous machines offers historians some small respite. The project to design the first Bombe machine was awarded a budget of £100,000.[75] Once production was up and running, the BTM quoted a charge of £7,500 per unit.[76] Given that approximately 200 Bombe machines were built for the agency, it is clear that the project cost at least £1.6 million. These were also far from the only machines that the agency bought from BTM and, in July 1944, Gordon Welchman revealed that the agency's purchases from the firm had reached nearly £3 million.[77] At least $1 million worth of this equipment was supplied to GC&CS from the United States, as part of the Lend-Lease programme.[78] Nevertheless, once again, this tally underestimates the true expenditure on technology. Machine production continued rapidly during the remainder of the war and the agency had significant dealings with other contractors – for which

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[73] Grey, *Decoding Organization*, p. 53.

[74] 'Rates of Pay (For Provisional Assessment) for Mobile Women Serving with the Women's Forces', [no date, though almost certainly written between December 1941 and January 1942], TNA, HW 64/67.

[75] Michael Smith, *Station X: The Codebreakers of Bletchley Park,* London: Pan Macmillan, 2004, p. 60.

[76] Baillie to [Edward] Travis, 2 December 1940, TNA, HW 62/4.

[77] A.D.(Mech) [Gordon Welchman] to Director [Edward Travis], 10 July 1944, TNA, HW 62/6.

[78] D.D.(S) [Edward Travis] to D.N.I. [Director of Naval Intelligence, Edmund Rushbrooke], 11 January 1944, TNA, HW 62/6.

few financial records have yet emerged.

After the end of the war, the process of hiding the money trail continued with the development of other secret technologies created to fight the information war, which was by then already a central element of the Cold War. British and American cryptanalysts turned their attentions to the Soviet Union and their cryptographers had already begun the process of improving their own communications security. GC&CS was at the forefront of those efforts. One of the most important technologies which GC&CS had a hand in building was the Rockex family of cipher systems, created as a replacement for Britain's existing cipher technology which was based on Enigma.[79] These machines, designed by the Canadian electrical engineer and GC&CS consultant, Professor Benjamin de Forest 'Pat' Bayly, during the war, provided a revolutionary approach to cipher making and would remain in service in British embassies until at least the 1970s. The financing of their production was a particularly complex task. The job of building the machines was given to the Radio Security Service, which proved a costly business – approximately £1 million each year, by 1951. The monies for this operation were accrued from four different Whitehall Departments, some of the funds were placed in public bank accounts. Others were paid directly into the private bank account of the service's chief, Brigadier Richard Gambier-Parry. It was a system described by one Treasury official as an 'auditor's nightmare'.[80]

Given that GC&CS's expenses, as well as those of sister agencies working on a co-operative basis with GC&CS, were so well hidden and that the figures available are at best fragmentary, it is impossible to usefully speculate the true expenditure of the agency. Nevertheless, despite the very limited evidence available, there is certainly enough to demonstrate that the operation was vast, rapidly expanding and hugely expensive. Even the near £12 million outlined above (excluding the money spent on Rockex and the extrapolated monies derived from the secret vote), a fraction of the

[79] Smith, 'Bletchley Park and the Development of the Rockex Cipher Systems'.
[80] Unknown [illegible signature] to Sir Edward Bridges, 17 July 1951, TNA, T 220/1444.

agency's actual cost, was a vast sum of money. Of course, nowhere near as vast a sum as the $2 billion invested in contemporaneous Manhattan Project. However such international comparisons generate more difficulties than they resolve. The complexities of exchange rates and, far more crucially, the difference in the size and emphasis of the respective economies, renders such comparisons more problematic than useful – what was 'big money' in Whitehall would not necessarily have been deemed as extravagant in Washington. A more telling point of comparison is Whitehall's investment in other military production programmes. An individual Spitfire cost a mere £9,000.[81] The cost of building a King George V-class battleship, a total of five of which were launched during the conflict, was £7,393,134. In short, even the incomplete financial figures for GC&CS, were approaching the cost of two of the Royal Navy's largest and most expensive battleships.[82]

MEDIA

Media management, the final 'M', is among the most celebrated of Bletchley Park's facets. Not only was the agency able to remain secret during the war, but its wartime existence and work remained a closely guarded secret until 1974 – under the code name 'Ultra'.[83] This required considerable media and information management during these decades of silence, but also careful handling once the secret was finally released to the public. As noted above, this even involved careful creative accounting to prevent any "following of the money". The reason for the secrecy surrounding the agency and its work was simple: the methods and mechanisms designed to crack machine generated ciphers were fragile. As Gordon Welchman pointed out in 1944, 'our specialised machinery has only just been adequate for the problems. Small improvements in the enemy's

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[81] John Nichol, *Spitfire: A Very British Love Story*, London: Simon and Schuster, 2018, p.53.
[82] R. A. Burt, British *Battleships 1919-1945: New Revised Edition*, Kindle edition, Barnsley: Seaforth, 1993, Kindle location 9205.
[83] Christopher Andrew, *Secret Service: The Making of the British Intelligence Community,* London: Septre, 1985, p. 628.

machines and methods could and may yet defeat us.'[84] If the Axis powers were to have gained wind of the wholesale industrialised efforts to read their wireless traffic, then they would have undoubtedly modified their systems accordingly. During the war, this meant that the number of individuals 'in' on the operation was tightly controlled and information within the agency was compartmentalised. Information was distributed on a need-to-know basis because people could not divulge secrets they did not possess.[85] The staff of Hut 3, the section tasked with translating, interpreting and distributing information derived from Heer and Luftwaffe traffic, were restricted from Hut 6 – the section charged with decrypting the materials passed to Hut 3 for translation and analysis.[86]

Employees were also subject to severe security restrictions, constant reminders regarding the dangers of 'careless talk', and dire warnings regarding the fate that would befall transgressors.[87] Unsurprisingly, the agency also kept the local press at arm's length. In the late 1930s, when GC&CS first acquired Bletchley Park, press enquiries to the government were met by enigmatic tall-tales to keep the waters thoroughly muddied.[88] This policy continued during the war. When two bombs fell on the site and a local journalist attempted to report on the situation, he was unceremoniously marched from the premises.[89]

Equally controlled was the dissemination of Bletchley's product and those "in the know" were kept to a bare minimum. By April 1940, as few as 30 officers outside of the agency, and its sister agency SIS, had been 'indoctrinated' into the true origin of material produced by GC&CS. Meanwhile, 'essential information for indispensable users' was distributed via SIS. This was achieved by

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[84] A.D.(Mech) [Gordon Welchman] to Director [Edward Travis], 10 July 1944, TNA, HW 62/6.

[85] Grey, *Decoding Organization*, p. 230.

[86] Birch, *The Official History of British Sigint, 1914-1945*, vol. 1 (part 1), pp. 41-42.

[87] AD(S) [Nigel de Grey], 'Confidential', 22 September 1943, TNA, HW 64/16; Denniston, 'All Heads of Sections', 7 January 1942, TNA, HW 64/16; Travis [DD(S)] 'Serial Order No. 21', 30 April 1942, TNA, HW 64/16.

[88] *North Bucks Times and County Observer*, 7 June 1938, p. 4;.*North Bucks Times and County Observer*, 28 June 1938, p. 4; *The Bucks Standard*, 4 June 1938, p. 3.

[89] Ron Staniford, 'Conscientious Objector', in Robert Cook (ed.), *Bletchley Voices: Recollections of Local People,* Stroud: Chalford, 1998, p. 93.

disguising decrypts to 'resemble agents' reports and prefixed "CX" (conventionally denoting such sources) would be issued via SIS to the appropriate "country" sections of the War Office and Air Ministry intelligence'.[90] Some of the copious high-grade intelligence that the British government had acquired was attributed to a "super-spy" code-named 'Boniface'. Boniface was alleged to have worked at the highest levels of the German state, feeding information to Britain – but he did not exist.[91] Despite these precautions, William Berry (Viscount Camrose), the proprietor of *The Daily Telegraph* among other titles, still managed to get wind of what was really going on (that Boniface did not exist and that the super-spy was a cover for a vast code-cracking operation) and it was only Berry's discretion (and presumably some panicked appeals to his patriotism) that kept Bletchley's work out of the papers.[92]

One of the stranger references to Bletchley Park in the media appeared in the February 1945 edition of the magazine, *CHESS*. It transpired that the University of Oxford chess team had been defeated 8-4 by a Bletchley Park team. That the Oxford team had been defeated is not odd – as is well known, Bletchley Park's staff team for the match included some of the best players in Britain. A team photograph, complete with a list of names, was published by *CHESS*. Followers of the game might have been intrigued why its luminaries, including Hugh Alexander and Harry Golembek, both of whom had represented England at the Buenos Aries Olympiad, and the Scottish players, Nicholas Anthony Perkins and J.M. Aitken, were all playing for a team based in an obscure Buckinghamshire railway town.[93]

The existence of Ultra remained among Britain's most closely guarded secrets, for no less than 29 years after the war, until the British government (which by then was struggling to keep a lid on the

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[90] Birch, *The Official History of British Sigint, 1914-1945*, vol. 1 (part 1), p. 42.
[91] Ratcliff, *Delusions of Intelligence,* pp. 113-114.
[92] John Colville, *The Fringes of Power: Downing Street Diaries, 1939-1945,* London: Hodder and Straughton, 1985, p. 422.
[93] Alan McGowan, 'Codebreakers at Bletchley, Scottish chess players at Bletchley ', *Scottish Chess* 198, June 2005. Available online: https://www.chessscotland.com/documents/history/CodebreakersBletchley.htm (accessed: 15 July 2019).

situation[94]) gave the retired intelligence officer F. W. Winterbotham permission to pen and publish a memoir on the subject.[95] As Christopher Andrew has pointed out, the secrecy that had remained in place for so long was, in no small part, the result of the traditions and long-established security culture of the intelligence community.[96] Even after Ultra became public, many documents and technical details remained withheld – locked away in closed, secret archives.[97]

CONCLUSION

Bletchley Park has been described by *IQ*, the "tech culture" magazine of the computer giant Intel, as "perhaps the birthplace of Big Data".[98] It was not. Even in the world of British intelligence, GC&CS was not the first organisation to deal in vast quantities of data. Clearly, censorship and the efforts of the WTID offer important precursors to the challenges posed by SIGINT during the Second World War. The problems of mass data posed by collecting, reading and indexing intercepted cables were made abundantly clear, as was the solution: systematic data processing. However, they lacked at least two of the 'M's which would necessarily be required by GC&CS during the Second World War: Machines and Manpower. These were necessitated by the additional problems posed by the mechanisation of cryptography in an age of increasingly mass communication. Rather, Bletchley Park was a mid-twentieth-century manifestation, or quasi-manifestation, of Big Science. By 1940, Bletchley Park was already the home of big and extravagantly expensive machines; its military purpose was a carefully managed state secret subject to media blackout and control, and its staff numbers had already swelled to a little under 3,800 by the end of March 1943 – the same month that the Manhattan Project's Los Alamos had opened its doors.

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[94] David Hooper, *Official Secrets: The Use and Abuse of the Act,* Sevenoaks: Coronet, 1987, 1988, pp. 247-248.

[95] F. W. Winterbotham, *The Ultra Secret,* London: 1974, 2000.

[96] Christopher Andrew, 'Codebreaking and Signals Intelligence', in Christopher Andrew (ed.), *Codebreaking and Signals Intelligence,* London: Frank Cass, 1986, pp. 1-2.

[97] For a full discussion of this topic see: Moran, *Classified*, pp. 273-280 and Hooper, *Official Secrets: The Use and Abuse of the Act,* Sevenoaks: Coronet, 1987, 1988, pp. 247-248.

[98] *IQ by Intel*, 'Bletchley Park, Intel and the Data that Changed the Course of History', http://iq.intel.co.uk/bletchley-park-intel-and-the-data-that-changed-the-course-of-history/ (accessed: 13 April 2016).

Applying the Big Science model to GC&CS serves two useful purposes. First, it presents Bletchley Park as it actually was, or at least would become over the course of the war – a major, military-orientated, state-funded, scientific establishment which industrialised espionage and information warfare. The whimsical narratives which have emerged in the national imagination, fed by Hollywood, novelists, journalists and television producers, have obscured the historical realities of the agency. Second, Bletchley Park clearly incorporated the five key facets of Big Science. As such, the agency can be usefully studied by intelligence historians, not merely as a key organisation in espionage history, but also be usefully linked to the wider contexts of British national, and indeed, international, "ways of war". It was an enterprise, extravagantly funded by the British state, which, rather than expending resources to place additional fighting men on battlefields, sought instead to arm with information those the state already had.

The long-term legacies of Big Science at Bletchley Park are as profound as those of the Manhattan Project and von Braun's rockets. The latter two led to the development the most fearful weapons of the Cold War; intercontinental ballistic missiles tipped with nuclear warheads, but, as a side effect, the Space Race as well. Bletchley Park, on the other hand, was a silent and unrecognised yet vital mile-stone in the development of the modern computer age. The machines built at Bletchley Park had a profound impact on those who contributed to designing them.[99] These individuals, not least Alan Turing, would go on to help make the modern world as we know it today. Though the Manhattan Project would rapidly come to dwarf Bletchley Park in terms of scale and remains *the* Big Science project, the latter was a clear and undeniable *proto*-example of wartime Big Science and should be understood by intelligence historians in such terms.

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[99] Copeland, *Colossus*, pp. 108-115.