‘Research is the Door to Tomorrow’: the Post Office Engineering Research Station, Dollis Hill, 1933–1958

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AT&T	American Telephone and Telegraph Company
BBC	British Broadcasting Corporation
BSA	Bulk Supply Agreement
BM&A	Brent Museum and Archives
BTA	BT Archives
COTC	Canadian Overseas Telecommunications Corporation
COI	Central Office of Information
CSDIC	Combined Services Detail Interrogation Centre
DSIR	Department of Scientific and Industrial Research
GC&CS	Government Code and Cypher School (1919–1946)
GCHQ	Government Communications Headquarters (1946–present)
GPO	General Post Office
IEE	Institution of Electrical Engineers
IWM	Imperial War Museum
LGC	Laboratory of the Government Chemist
MOI	Ministry of Information
NPL	National Physical Laboratory
PMA	Postal Museum Archives
PMG	Postmaster General
POB	Post Office Board
POW	Prisoner of War
POEEJ	Post Office Electrical Engineers' Journal
PRD	Public Relations Department
R&D	Research and Development
SCM	Science Museum
STD	Subscriber Trunk Dialling
TAT-1	Transatlantic Telephone Cable No. 1
TNA	The National Archives
TRE	Telecommunications Research Establishment

Abstract

The Post Office Engineering Research Station in Dollis Hill, North West London, was Britain's leading establishment for communications research in the mid-twentieth century. This thesis provides the first detailed study of the Research Station from its official opening in 1933 to 1958, the year senior staff of the General Post Office (GPO) decided to relocate the site. Following a chronological structure, I trace the development of Dollis Hill, its research activities and institutional culture. I reveal the aims and ambitions of senior Post Office staff in the context of the broader themes of this period, changing government policies, the wartime mobilisation of science and shifting attitudes to state-sponsored science. Two research questions guide this study: how did a civil state institution like the GPO use a technological research facility to further political and bureaucratic goals, and how did the staff at Dollis Hill negotiate boundaries and priorities between civilian and military requirements while working within governmental and industrial networks? In addressing these questions this thesis contributes to scholarship on, the history of state enterprise, state-funded research and development (R&D), conceptions of modernity and engineering culture.

Dollis Hill was a unique establishment not accounted for by the patterns described in existing literature on state, academic or industrial research. I show that this uniqueness was shaped by being part of the Post Office, itself an anomalous component of the British state as an income-generating government department. The Post Office's public identity as a customer service provider, offering largely familiar postal, banking, telegraph, telephone and counter services, meant that its role in the national research culture was easily overlooked. Many of these services relied on technologies developed at the Research Station. I demonstrate that the value of Dollis Hill as an anomalous research establishment lay in its freedom and flexibility of organisation and purpose to support the aims of patrons beyond the Post Office. Both its concrete achievements, in the form of new equipment and techniques, and its visions for future developments were key factors in securing and maintaining patronage at a time when government policies hindered Post Office aims and ambitions, to develop and improve public communication services. I show that national defence requirements had a far greater influence on the direction of Dollis Hill's research activities than contemporary descriptions portray.

This thesis is based principally on the archival holdings of BT (formally British Telecom) Archives and the archives held by the Postal Museum, including scientific and technical reports, board minutes, photographs, publicity material, publications and newspaper cuttings. Other resources include government files held by the National Archives and oral histories collected by the Brent Museum in Willesden, London, the Imperial War Museum and Science Museum.

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Copyright

Dedication

This thesis is dedicated to Jeff Hughes (1965–2018) without whom this project would not have been possible. Jeff's passion for the history of science and technology impacted many lives, especially mine. As a third-year physics undergraduate my world was changed by attending Jeff's 'The Nuclear Age' course, putting me on the path to where I am today. For that, I am eternally grateful.

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This project was funded by the Arts and Humanities Research Council, as a collaborative partnership between the University of Manchester and the Science Museum Group in conjunction with BT Archives. During the researching and writing of this thesis, I have received the support and mentorship of many people, far more than can be named here. Special thanks first and foremost to my supervisory team. Jeff Hughes, whose enthusiasm for the project was invaluable. Tilly Blyth, who provided thoughtful comment on my research. I am immensely grateful to James Sumner for taking me on as a doctoral student and for making me a better historian. James' kindness and mentorship knows no bounds and I cannot express the debt of gratitude I owe to his support.

CHSTM has been an important part of my life since 2011 and although I have not spent a lot of time in Manchester during this project, I am always grateful to receive a warm welcome when I visit. In particular I would like to thank Simone Turchetti, Pratik Chakrabarti and Jane Gregory for their thoughtful comments and conversation on previous thesis drafts. Commissioned as one of three PhDs writing the history of research in the Post Office I am lucky to have shared this journey with the wonderfully supportive Alice Haigh (University of Leeds) and Jacob Ward (University College London), with whom I will always be one of the 'Dollis Hill three'. I am also grateful to their respective supervisors, Graeme Gooday and Jon Agar for their insightful comments and discussion.

My project would have been impossible without the support of many archivists and librarians. It has been a great pleasure and privilege to work alongside many knowledgeable and friendly people at BT Archives, my thanks to staff both past and present; David Hay, James Elder, Dave Shawyer, Keith Lovell, Vicky Rea and Anne Archer. I am also grateful to the staff at the Postal Museum and Archive, Brent Museum and Archive and the National Archives. A note of thanks to Colin Whitlum of the BT Retired Staff Society for his help in sharing our project among his members to identify ex-Dollis Hill staff.

Whilst working on this project, I have had the privilege of working alongside wonderfully supportive and inspiring colleagues at the Science Museum and Imperial War Museum. While there are countless to mention, particular thanks go to, Katy Barrett, Abbie MacKinnon, Laura Humphreys, John Liffen, Ali Boyle, Adam Boal, Rupert Cole, Margaux Wong, Richard Dunn, Robert Bud, David Rooney, Elizabeth Bruton, Bergit Arends, Doug Millard, Tim Boon, Andrew Nahum, Emily Tan and Georgia Metcalf.

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I would like to acknowledge the amazing support of my friends and family, who happily accepted that every conversation would begin with the newest findings from my PhD research. Special thanks to my best friend Lily for always being there for a tea and a chat. I would not have been able to undertake (nor complete) this thesis without the love and support of my parents Deborah and Richard. Finally, I would like to thank Liam whose patience, love and understanding has been immense. I could not have done this without you.

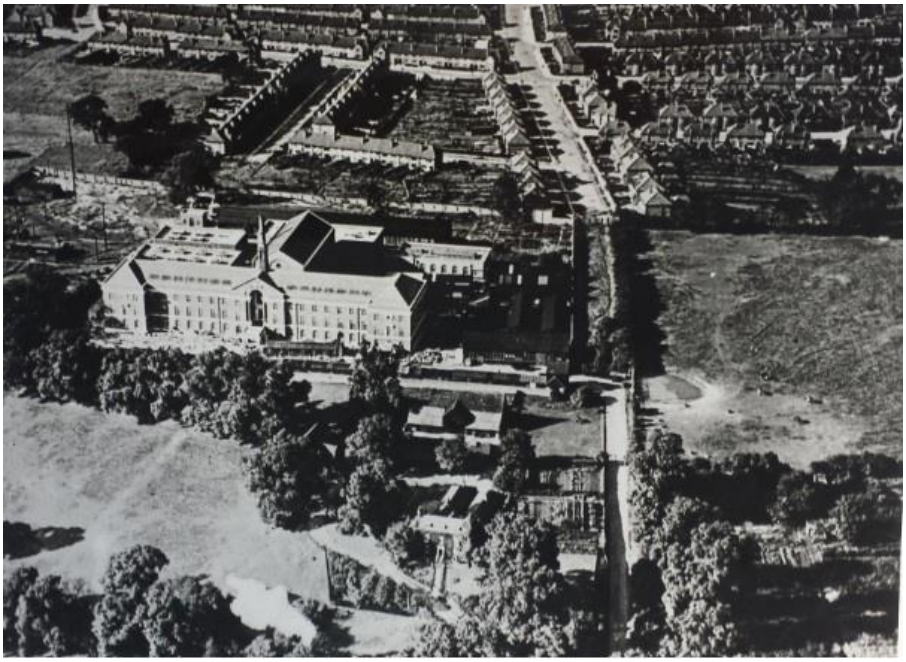

Figure 1 Aerial photograph of the Post Office Research Station at Dollis Hill, London, c. 1932.[1]

Figure 2 Photograph of the Main Research Building, Post Office Research Station, 1935.[2]

[1] BTA: TCE 361/ARC 1278 Aerial photograph of the Post Office Research Station at Dollis Hill, London, c. 1932.

[2] BTA: TCB 473/P 782 Dollis Hill Research Station,1935.

Introduction

> One of the most vital functions of [the Engineering] department is research. In the improvement and elaboration of communication services it is not content with the discoveries of outside scientists and foreign administrations. At Dollis Hill, in the north-west of London, it has its own research station and here Post Office engineers live constantly and excitingly on the very edge of knowledge.[1]
>
> E. T. Crutchley, *GPO, English Institutions* (Cambridge: Cambridge University Press, 1938)

This thesis provides the first detailed study of the Post Office Engineering Research Station at Dollis Hill between 1933 and 1958, expanding scholarship on twentieth-century British research and development (R&D), science-state relations, and the growth of telecommunication networks (Figure 1 and Figure 2 above). Over this period, the Post Office cemented its place in British life, expanding mail and telephone services over which it had a monopoly and branching out into new services, including personal savings and the popular Premium Bonds. The Research Station at Dollis Hill expanded from an institution of around one hundred staff – testing, calibrating and improving equipment in newly constructed laboratories and converted ex-army huts – to 1,337 scientists and engineers undertaking a vast range of pure and applied research in a severely congested site. I account for this growth through the ambitions of senior staff, the Research Station's demonstrable value to wider government aims and its projection by the Post Office as a symbol of modernity.

My work goes beyond an institutional history of the site, to explore how research at Dollis Hill shaped and was shaped by government policies, the wartime mobilisation of science and changing perceptions of state-funded science and engineering. To do so I address two research questions: firstly, how did a civil state institution like the General Post Office (GPO) use a technological research facility to further its political and bureaucratic goals? Secondly, how did staff at Dollis Hill negotiate boundaries and priorities between civilian and military requirements while working within governmental and industrial networks? To answer these questions I analyse

[1] E. T. Crutchley, *GPO, English Institutions* (Cambridge: Cambridge University Press, 1938), p. 181.

engineering and scientific knowledge and practices in context; focusing on the people, activities and places involved. Emphasis is placed upon the relationships between Dollis Hill, the Post Office, manufacturers of telecommunications equipment and wider government; the classification of military and civilian research; and how research activities were used by the Post Office to influence public opinion.

Planning for a Post Office Research Station can be traced back to 1914 when the Postmaster General Charles Hobhouse inspected the laboratories used by the GPO Research Department in London. The merger between the Post Office and National Telephone Company in 1912 had led to the establishment of a new internal branch, the Research Section. The combined staff placed an enormous strain on the limited laboratory space at GPO West and King Edward Buildings in London.[2] After his visit, Hobhouse agreed that the research department needed its own permanent facility to support Post Office services, including research into telephone lines, telegraph apparatus and other postal technologies.

A rural area of North West London called Dollis Hill was identified as a suitable site to build a research station. Away from the city, where the high cost of land would have prevented a central London location, this suburb offered the ideal environment for research activities: protected from traffic vibration and acoustic and electro-magnetic disturbances. Plans were put on hold with the outbreak of the Frist World War in 1914 as the Post Office redirected its attention to support the war effort. This conflict highlighted the strategic value of telecommunication technologies as telephone and telegraph networks were expanded across the country and mainland Europe. This also gave further impetus to the Post Office to establish a new Research Station. In 1920 the Treasury authorised the purchase of eight acres of land on the Dollis Hill site. The first researchers moved in the following year and were housed in temporary ex-army huts which had been converted into laboratories, workshops and offices. The site grew rapidly during the 1920s with the erection of permanent buildings designed in collaboration between the Post Office and Office of Works.

[2] Bertram Cohen, 'Research in the Post Office', *Journal of the Institution of Electrical Engineers'*, 75.452 (1934), 133-151 (p. 133).

Since 1921, Dollis Hill housed the Research Branch and the Radio Branch's research section; two parts of the Engineer-in-Chief's Office which sat within the Engineering Department. The focus of this thesis is the Research Branch, but occasionally I consider the work of the Radio Branch at Dollis Hill to inform issues which affected the whole site. The Engineer-in-Chief's Office consisted of several other Branches which were responsible for maintenance, testing and development but did not have a research function.[3] Although the Research Branch was restructured several times between 1933 and 1958 and new studies were introduced, research consistently fell into the following areas; signalling apparatus and circuits, telegraphs, cable research, telephone apparatus, telephone lines and transmission (including 'trunk' – long-distance – circuits), materials (physics, chemistry and metallurgy), and systems for postal activities. The Radio Branch was responsible for expanding, managing and developing radio equipment, installing receivers and transmitters, microwave communication, and helping to introduce television. Its activities were also regional, including the Rugby and Criggion Radio Stations as well as smaller sites.

This PhD is one of three AHRC funded Collaborative Doctoral Awards in partnership with BT Archives and the Science Museum. Each project is hosted by a different university and divided chronologically. Alice Haigh, based at the University of Leeds, has focused on the early years of the Post Office Research Branch. Starting in 1909, Haigh shows how the First World War motivated senior Post Office staff to construct a permanent Research Station and traces why the Dollis Hill site was selected.[4] Based at University College London, Jacob Ward's project takes a broader view of the role of information and control at the Post Office in the post-war period, focusing on the Organisation and Methods Department. Within his thesis, Ward shows the dispersal of Civil Service departments away from London and Post Office requirements meant a new home was selected for the Research Station at Martlesham Heath, Suffolk in

[3] See Appendix 1, Branches of the Engineer-in-Chief's Office, Engineering Department, 1957.

[4] Alice Haigh, 'To Strive, To Seek, To Find', The origins and establishment of the British Post Office Engineering Research Station at Dollis Hill, 1908-1938' (unpublished PhD thesis, University of Leeds, (ongoing)).

1964.[5] My thesis sits in-between Haigh and Ward's work, starting in 1933, the year Dollis Hill and its research activities became part of the Post Office publicity drive. It ends in 1958 when it was formally recognised that Dollis Hill was no longer suitable for the work of the Research Branch and relocation plans were initiated.

The Research Station was one part of the Post Office, the income-generating government department responsible for maintaining and providing the nation's telecommunication services.[6] Post Office ambitions to improve and expand its services were hampered by the short-term fiscal policies of its funding department, the Treasury. Although governments changed, Treasury attitudes remained consistent across the period – that the telephone was not a necessity and Post Office capital was a means to aid macroeconomic needs. While this impeded the Post Office's ability to install tried and tested technologies, Treasury funds were more forthcoming for research which promised British innovation and new export markets. Within this environment, I show that Dollis Hill became an important means by which the Post Office could progress in some of its long term aims when encumbered by government policy and bureaucracy.

I demonstrate that Dollis Hill played an integral role in sustaining the relationship between Post Office and telecommunications manufacturers. Not having a manufacturing arm, the Post Office relied on private firms to mass-produce equipment for its networks. This meant the Post Office held a unique position as both a gatekeeper to industry, controlling what equipment could be introduced into its networks, and as the industry's largest customer. As the source of equipment standards (which firms had to meet), new knowledge and patents (which industry could access through agreements with the Post Office), and the place where devices designed by industry were tested and approved for use in the network, the Research Station was a tool the Post Office used to strengthen its position in this relationship. The benefits gained from the Research Station became increasingly important post-

[5] Jacob Ward, 'Information and Control: Inventing the Communications Revolution in Post-War Britain' (unpublished PhD thesis, University College London, 2017).

[6] Since 1914 the Post Office held the monopoly over Britain's telecommunications apart from in Hull where the telephone service was established by a municipally owned corporation.

war, when government policies encouraging export markets weakened the Post Office's influence over manufacturers who made telecommunications equipment.

Government research establishments shaped British science and industry, yet Dollis Hill and similar institutions have received little scholarly attention. Historians tend to focus on the same, small number of establishments, including the National Physical Laboratory (NPL), the Government Code and Cypher School wartime station Bletchley Park, and the Atomic Weapons Research Establishment.[7] This thesis shows that Dollis Hill is worthy of the same level of examination for its role in developing technologies which profoundly shaped British culture and society. Here, I present original research for the critical period of its existence when Dollis Hill faced competing pressures to deliver technologies for a public service and support national defence policy. As the Research Station was a R&D facility within a government department, one might expect it to have shared experiences with other civil research sites. However, I show that Dollis Hill sits outside existing narratives of state, academic and industrial research.

The closest comparator to Dollis Hill is the NPL, founded in 1900 as Britain's first standards and testing laboratory. Both establishments played a role in setting scientific standards and supporting private industry, but with differing motivations. The NPL was created to undertake scientific research to meet the needs of industry, whereas research at Dollis Hill was intended to reduce costs and improve services managed by the Post Office. The NPL generated its income by conducting research for industry, while the Post Office recouped its spending through selling public services. Benefits gained by industry from activities at Dollis Hill were reabsorbed into the Post Office through the purchase of equipment. The NPL established a model of state-funded R&D establishment which was replicated across other laboratories controlled by the

[7] Margaret Gowing, *Britain and Atomic Energy, 1935-45* (London: Macmillan, 1964); Russell Moseley, 'The Origins and Early Years of the National Physical Laboratory: A Chapter in the Pre-history of British Science Policy', *Minerva*, 16.2 (1978) 222-250; Edward Pyatt, *The National Physical Laboratory A History* (Bristol: Adam Hilger, 1992); Laura Arnold, *Britain and the H-bomb* (Basingstoke: Palgrave Macmillan, 2001); Jack Copeland, ed. *Colossus: The secrets of Bletchley Park's codebreaking computers* (Oxford: Oxford University Press, 2006); Christopher Smith, *The Hidden History of Bletchley Park* (Basingstoke: Palgrave MacMillan, 2015).

Department of Scientific and Industrial Research (DSIR). Dollis Hill remains anomalous, not fitting into a defined model but sharing characteristics with them all: military establishments (including secrecy and compartmentalisation of information); private firms (as research was driven by Post Office business needs); and, post-war, university laboratories (when Post Office staff aspired to a more academic research culture).

I show that the Dollis Hill site and its research activities were used as symbols of Post Office modernity to gain support from industry, government and the public. Emerging as part of the widespread reinvention of the Post Office during the 1930s, representations of the Research Station increasingly became the only means by which the department could defend itself from criticisms of obsolescence and inefficiency. The Post Office sought to associate the work of the Research Station with wider recognisable images of scientific and technological culture, highlighted in the above quote by E. T. Crutchley, Head of the Public Relations Department. Using the Research Station, the Post Office aligned itself with and shaped visions of the future. This ethos was reflected on the site itself with 'Research is the Door to Tomorrow' embossed above its entrance. However, as this thesis demonstrates the projection of high-technology futures was often at odds with what the Post Office could realistically achieve.

The purpose of Dollis Hill was publicly presented, by the Post Office, as undertaking research to maintain and improve the efficiency of its services. However, defence requirements had a far greater influence on the Research Station's work than contemporary descriptions portray. I extend the work of Haigh, who identified the role that the military played in shaping the research culture at Dollis Hill after the First World War, to show that this continued into the 1950s. The Research Station's unique identity was used by senior Post Office staff to navigate between military and civilian requirements. I trace how this flexibility was advantageous to the Post Office as it could associate itself with the needs of the state to further departmental aims, but at times the expectation that Dollis Hill would support the wider government's defence and civil agenda distracted from Post Office needs. Whilst Dollis Hill operated in a state which was guided by both warfarist and welfarist priorities, as David Edgerton suggests, its research cannot be exclusively characterised by either, yet was integral to

both.[8] This suggests a limitation of Edgerton's argument that Britain can be understood by considering the influences of the 'warfare state' and 'welfare state' as these categories can become indistinguishable at the institutional level.

This thesis demonstrates the important, if underexplored, role of Civil Service engineers in shaping British technology and culture. Led by the hierarchical nature of the business archive, I have focused on the research aims and aspirations of the Engineer-in-Chief (head of the Post Office Engineering Department) and the Staff Engineer in charge of Dollis Hill (from 1946 known as Controller of Research).[9] However, where possible, I include the voices of those in positions representative of the workforce. By considering the actions of Research Station staff, this project is an opportunity to provide a new perspective on histories of Colossus, the codebreaking computer designed by Post Office engineer Tommy Flowers, built at Dollis Hill and used most notably at Bletchley Park during the Second World War. The immense scholarly attention given to Bletchley Park has skewed our understanding of both Flowers' and the wider Dollis Hill staff's contribution to the wartime state. This is reassessed by placing Dollis Hill at the centre of the Colossus development. This project has revealed that Colossus was one of many projects which sought to gain the Research Station and the Post Office benefits by aligning with wider government aims.

[8] David Edgerton, *Warfare State: Britain 1920–1970* (Cambridge: Cambridge University Press, 2005).

[9] See Appendix 2: Senior roles in the Post Office and Government, 1933-1958 and Appendix 3: Biographies of senior Post Office engineering staff.

Definition of terms

I use the terms ‘Research Station’ and ‘Dollis Hill’ interchangeably with reference to the whole site and its activities. ‘Research Branch’ and ‘Radio Branch’ are referred to separately.

While Dollis Hill was undertaking research, development and testing, all activity at the Research Station was described as ‘research’, a term I use throughout this thesis.

Throughout the thesis I use the actors’ terms to describe the workforce. The ‘major ranks’, sometimes referred to as ‘professional grades’, included the Staff Engineer, Assistant Staff Engineer, Executive Engineer, Assistant Engineers, Chemists and Physicists, Assistant Chemists and Physicists, Chief Inspectors and Inspectors. Skilled Workmen, Female Assistants, telephonists and labourers were referred to as ‘minor staff’.

General Post Office, or ‘GPO’, was the formal name for the government department but it was more commonly referred to as the ‘Post Office’, which is the term I have chosen to throughout.

Literature review

This study is an opportunity to write the first history of the Post Office Research Station. To contextualise the development of this R&D establishment I have consulted a wide range of literature to chart the social, cultural and political changes that saw a shift in priorities for state-funded science. As this thesis touches on several themes, drawn from disparate academic fields, I have considered the existing literature thematically. From the broadest relevant analytical framework to the most detailed historiography on the Post Office literature is reviewed as follows: geographies of science; conceptions of modernity; science, military and the state; models of research establishments; engineering culture; and Dollis Hill and the Post Office. By considering Dollis Hill within the context of these themes, I will demonstrate that a research institution history can be a lens through which to critique how knowledge is shaped and disseminated, influenced and was influenced by external factors and advance our understand of twentieth century R&D.

Throughout the thesis I broadly follow constructivist science and technology studies methodologies – reflecting influential STS literature.[10] Thomas Hughes' theory of sociotechnical systems is particularly pertinent as I consider how Post Office infrastructure and equipment was socially constructed by key actors: government officials, Post Office staff, representatives of industry, patrons and associates.[11] By tracing the motivations of different actors the interpretive flexibility of what Post Office research is, can and should be doing is revealed.[12] This concept – where a technical artefact can simultaneously have different meanings and interpretations to

[10] Trevor Pinch and Wiebe E. Bijker, 'The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other', *Social Studies of Science*, 14 (1984), 399-441; Wiebe E. Bijker, Thomas P. Hughes, Trevor Pinch, ed. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: MIT Press, 1987); Ronald Kline and Trevor Pinch, 'Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States, *Technology and Culture*, 37 (1996), 763-795; Donald MacKenzie and Judy Wajcman ed. *The Social Shaping of Technology, second edition* (Milton Keynes: Open University Press, 1999); Nelly Oudshoorn and Trevor Pinch, ed. *How Users Matter: The Co-Construction of Users and Technology* (Cambridge, MA; London: MIT Press, 2003).

[11] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: John Hopkins University Press, 1983).

[12] Pinch and Bijker, 'The Social Construction of Facts'; Wiebe E. Bijker, *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change* (Cambridge, MA; London: MIT Press, 1997), pp. 76-77.

different actors – is useful in understanding how senior Post Office staff demonstrated Dollis Hill's usefulness to influential stakeholders whilst also supporting departmental aims and ambitions.

Geographies of science

Since the late 1980s, scholars from history of science, sociology and geography have considered how specific sites have influenced the production of scientific knowledge.[13] These have ranged from more traditional locations, such as laboratories, museums and scientific societies, to informal sites like the pub and the field. This approach demonstrates that the location of scientific work influences the validity of knowledge and socially determines who can be engaged in scientific enterprise.[14] Particularly relevant to my study is how laboratories construct, shape and disseminate scientific knowledge. Steven Shapin's work on the place of experiment has shown how laboratories became authoritative sites in the construction of scientific knowledge in seventeenth-century England.[15] At this time, the acceptance of new knowledge depended on the respectability of the witness and only those considered appropriate (elite gentleman), were invited into the laboratory. In modern laboratories, Robert Kohler argues that the credibility of science depends on its 'placelessness' created by removing all environmental context. With laboratory standardisation, experiments can

[13] Steven Shapin, 'The House of Experiment in Seventeenth-Century England', *Isis*, 79.3 (1988), 373-404; Anne Secord, 'Science in the pub: artisan botanists in early nineteenth-century Lancashire', *History of Science*, 32 (1994), 269-315; Owen Hannaway, 'Laboratory design and the aim of science: Andreas Libavius versus Tycho Brahe', *Isis*, 77.4, (1986), 584-610; Peter Galison, 'Bubble chambers and the experimental workplace', in *Observation, Experiment, and Hypothesis in Modern Physical Science*, ed. by Peter Achinstein and Owen Hannaway (Cambridge, MA: MIT Press, 1985), pp. 309-373; David Livingstone, 'Landscapes of Knowledge' in *Geographies of Science*, ed. by Peter Meusburger, David Livingston, and Heike Jöns (Dordrecht; London: Springer, 2010), pp. 3-22.

[14] Simon Schaffer, 'Physics laboratories and the Victorian country house', in *Making Space for Science: Territorial Themes in the Shaping of Knowledge*, ed. by Jon Agar and Crosbie Smith (Basingstoke: Palgrave Macmillan, 1998), pp. 149-180; Robert Kohler, *Landscapes and Labscapes: Exploring the Lab-Field Border in Biology*, (Chicago: The University of Chicago Press, 2002); Simon Naylor, 'Introduction: Historical Geographies of Science – Places, Contexts, Cartographies', *The British Journal for the History of Science (BJHS)*, 38.1 (2005), 1-12.

[15] Steven Shapin, 'The House of Experiment in Seventeenth-Century England', Isis, 79.3 (1988), 373-404.

be replicated under near identical conditions, shaping the image of laboratories as 'objective' spaces.[16]

Throughout this thesis I consider how the physical site of the Research Station shaped the type of research undertaken by Post Office staff. I also explore how the Research Station was used to shape public opinions of the Post Office. My approach draws inspiration from Thomas Gieryn's argument that, despite being structurally fixed, buildings stabilise imperfectly and that, 'they are forever objects of (re)interpretation, narration and representation'.[17] Gieryn has developed an analysis of reading laboratories as text, arguing that the architecture of a site shapes the building's identity and its occupants.

Looking specifically at industrial laboratories Scott Knowles and Stuart Leslie have applied Gieryn's approach to understand the post-war industrial laboratory architecture of some of America's largest private firms. They argue that the buildings of General Motors, IBM and AT&T represented a change in corporate research strategy which was inspired by university campuses and a move towards more fundamental research.[18] The authors show how these sites, opened in the late 1950s and 1960s, were designed to project corporate prestige but failed to fully support research activities by isolating and preventing interdisciplinary collaboration.[19] This is also observed by Albena Yaneva who suggests that until the 1960s laboratories were designed to control the interactions between scientists from different specialisms.[20] Where possible I have looked at how social clubs influenced the culture of the Research Station, expanding the work of scholars who have considered how informal

[16] Robert Kohler, 'Place and practice in field biology', *History of Science*, 40.2 (2002), 189-210 (p. 191).

[17] Thomas Gieryn, 'What Buildings Do', *Theory and Society*, 31.1 (2002). 35-74 (p. 35).

[18] Scott G. Knowles and Stuart W. Leslie, '"Industrial Versailles" Eero Saarinen's Corporate Campuses for GM, IBM, and AT&T', *Isis*, 92.1 (2001) 1-33 (p. 1,2, 22 and 33).

[19] Ibid.

[20] Albena Yaneva, 'Is the Atrium More Important than the Lab? Designer Buildings for New Cultures of Creativity', in *Geographies of Science, Knowledge and Space*, *Vol. 3*, ed. by Peter Meusburger, et. al. (Dordrecht: Springer, 2010), pp. 139-150 (p. 141).

spaces (atriums, communal spaces and cafeterias) created new environments for staff interactions and opportunities for knowledge transfer.[21]

Sophie Forgan has shown in her work on the architecture of nineteenth century scientific societies that credibility and authority was reinforced by the structure and design of buildings. They were designed to claim institutional respectability, establishing a corporate identity and to demarcate different types of learned spaces.[22] Though built in the twentieth century, the Post Office Research Station follows this pattern; the Main Research Building, highly visible atop Gladstone Park, acted as a façade to the rest of the site. In Chapter 1, I show how the exterior became symbolic of Post Office modernity, with photographs appearing in the press and on official publicity posters. This extends Julian Holder and Elizabeth McKeller's analysis of Neo-Georgian architecture, of which Dollis Hill is an example, emerging as the 'architecture of the state' in the interwar period; which was designed to instil authority but also used by the Post Office to shape opinions of scientific research.[23]

Conceptions of modernity

In this section I review how scholars have discussed conceptions of modernity, focusing on its relations to the function and aesthetics of the Post Office during this period. The Post Office was responsible for developing, installing and managing telecommunications systems, such as the telephone and telegraph, which allowed almost instantaneous communication over vast distances, across Britain and the world. These services can be understood as infrastructures which, Paul Edwards argues,

[21] Yaneva, p. 143; Thomas Gieryn, 'Biotechnology's Private Parts (and Some Public Ones)', *Making Space for Science*, ed. by Agar and Smith, pp. 281-312; Martina Merz '"Nobody Can Force You When You Are Across the Ocean" – Face to Face and E-Mail Exchanges Between Theoretical Physicists', *Making Space for Science*, ed. by Agar and Smith, pp. 313-329.

[22] Sophie Forgan, 'Context, Image and Function: A Preliminary Enquiry into the Architecture of Scientific Societies', *BJHS*, 19.1 (1986) 89-113 (pp. 100 and 110).

[23] Julian Holder and Elizabeth McKellar, 'Introduction: reappraising the Neo-Georgian', in *Neo-Georgian Architecture 1880-1970: a reappraisal*, ed. by Julian Holder and Elizabeth McKellar (Swindon: Historic England, 2016), pp. 1-12 (p. 8).

shape and are shaped by the condition of modernity. They are, Edwards says, the 'connective tissues and the circulatory systems of modernity'.[24]

Telecommunication systems and their compression of time and space have been analysed by scholars for their role in shaping people's concepts and experiences of modernity.[25] Marxist economic geographer David Harvey has termed this alteration 'time-space compression', which occurs following changes in technological systems, including telecommunications. For Harvey, the increasingly rapid circulation of information, capital and goods, disrupts and disorientates the norm; from social and cultural life to political-economic practices.[26] In applying Harvey's theories to the Post Office, design historian Yasuko Suga Ida argues that the Post Office possessed the 'practical conditions of "modernity"'.[27] She continues to suggest that, through its monopoly of telecommunications services, modern society would not exist without the Post Office.[28] Building on Suga Ida's work I show that Dollis Hill was instrumental in creating this society, both as the location of advancing communication technologies and through its public projection shaping perceptions that the Post Office was modern.

Despite having the traits of twentieth century modernity, the Post Office had to explicitly promote this notion as it relied on public investment in its services. This supports Bernhard Rieger's argument in his study of Britain and Germany in the interwar period that the success of a technology depended in part on gaining cultural support for the new inventions.[29] Although Rieger focuses on large scale 'modern wonders', including aviation, transatlantic passenger ships and film technologies, and

[24] Paul Edwards, 'Infrastructure and Modernity: Force, Time, and Social Organization' in the History of Sociotechnical Systems', in *Modernity and Technology*, ed. by Thomas J. Misa, Philip Brey and Andrew Feenberg (Cambridge MA; London: MIT Press, 2003) pp. 185-225 (p. 185).

[25] Stephen Kern, *The Culture of Time and Space 1880-1918* (Cambridge Massachusetts: Harvard University Press, 1983); Lorenzo Simpson, *Technology, Time and the Conversations of Modernity* (New York, London: Routledge, 1995).

[26] David Harvey, *The Condition of Postmodernity: an enquiry into the Origins of Cultural Change* (Oxford: Blackwell Publishers, 1990).

[27] Yasuko Suga Ida, 'Image Politics of the State: Visual Publicity of the General Post Office in inter-war Britain' (unpublished PhD thesis, V&A and Royal College of Art, 1998), p. 13.

[28] Ibid., p. 14.

[29] Bernhard Rieger, *Technology and the Culture of Modernity in Britain and Germany, 1890-1945* (Cambridge: Cambridge University Press, 2005), p. 5.

the public nervousness surrounding them, I show that this also applies to telecommunications by considering the Post Office's use of mass publicity and public relations. I show that, between the 1930s and 1950s, the Post Office used highly visible artefacts, from cable ships to computers, as tokens of the invisible infrastructure it managed.

Historians have looked at the influences which shaped the presentation of Post Office modernity. Scott Anthony has shown the important influence of Stephen Tallents in modernising the Post Office as the department's first Public Relations Officer.[30] Tallents shaped a modern aesthetic by commissioning contemporary artists to design publicity material. As marketing historians have shown, this was not a new strategy, but it was the first time a government department engaged with techniques commonly used by private firms. In Britain, the use of advertising material visualised the commercial strategies of private companies in the interwar period, for example London Transport and Shell-Mex.[31] The Post Office adopted the same approach as it became more commercially minded and, like private firms, had a role in shaping public perceptions of modernity. This extends Terry Smith's argument that industry, art and design normalised modernity in America in the 1920s and 1930s by showing the same occurred in Britain.[32]

Several scholars have explored how Post Office modernity was shaped by and communicated through publicity campaigns. Michael Heller argues the Post Office's broad use of publicity material, including advertising, films and posters, associated the telephone with modernity, technology, art and culture.[33] Focusing on the intersection of corporate identity, advertising and state patronage of art and design, Suga Ida

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[30] Scott Anthony, *Public Relations and the Making of Modern Britain: Stephen Tallents and the birth of a progressive media profession* (Manchester: University of Manchester Press, 2012).

[31] Richard A. Hawkins, 'Marketing history in Britain: From the ancient to internet era', in *The Routledge Companion to Marketing History*, ed. by D. G. Brian Jones and Mark Tadajewski (London: Routledge, 2016), pp. 315-332 (p. 324); John Hewitt, 'The 'Nature' and 'Art' of Shell Advertising in the Early 1930s', *Journal of Design History*, 5.2 (1992), 121-139.

[32] Terry Smith, *Making the Modern: Industry, Art, and Design in America* (University of Chicago Press, 1993).

[33] Michael Heller, 'The development of integrated marketing communications at the British General Post Office, 1931-39', *Business History*, 58.7 (2016) 1034-1054 (p. 1039).

argues that the Post Office publicised its modernity through the use of modern design.[34] Post Office modernity was also projected in films, with the GPO Film Unit receiving much attention from film historians because of its connection with John Grierson and the Documentary Film movement.[35] Timothy Boon considers how the GPO Film Unit represented Post Office communication systems, telephones and telegraphs as world transforming technologies. Boon analyses the 1933 film *Coming of the Dial*, released to introduce automated telephone exchanges, and focuses on how Post Office documentary films represented wider social change shaped by scientific modernity.[36] In Chapter 1, I extend Boon's examination of *Coming of the Dial*, by considering how Dollis Hill is represented and interpreted in the film, to support my argument that the Research Station became an important symbol of Post Office reinvention during the 1930s.

Existing studies of Post Office publicity focus firmly on the 1930s, and do not extend into the post-war period when the British technological aesthetic began to exhibit a strain Robert Bud has identified as 'defiant modernism'.[37] In Chapter 4 I show that, unlike other prestige science projects whose visual icons came to represent British technological enthusiasm throughout the 1950s and 1960s, the Post Office's contribution to 'defiant modernism' was through infrastructure. Invisible to many, its promotion posed a unique challenge, creatively met by the Post Office while working within government restrictions on the department's publicity activities. Whilst many promotional platforms disappeared, the launch of new services because increasingly important: these were the physical manifestations of the activities and outputs of Dollis Hill. Not only was much Post Office work invisible to the public but, especially

[34] Suga Ida, p. 15.

[35] David Matless, 'Accents of Landscape in GPO Country: *The Horsey Mail*, 1938', *Twentieth Century British History*, 23.1 (2012) 57-79; *The Projection of Britain: A History of the GPO Film Unit* ed. by Anthony Scott and James Mansell (London: British Film Institute, 2011); Paul Swann, *The British Documentary Film Movement, 1926-1946* (Cambridge: Cambridge University Press, 1989), Paul Swann, 'John Grierson and the GPO Film Unit, 1933-1939', *Historical Journal of Film, Radio and Television*, 3.1 (1983) 19-34.

[36] Timothy Boon, 'Old Industry, New Science? The GPO Film Unit Between Palaeotechnology and Neotechnology', in *The Projection of Britain*, ed. by Scott and Mansell, pp. 28-35.

[37] Robert Bud, 'Penicillin and the new Elizabethans', *BJHS*, 31.3 (1998) pp. (305-333) p. 312.

during the war, much of the Research Station's output was secret, supporting the Service departments.

Science, the military and the state

Throughout this thesis I trace how staff in the Post Office and Dollis Hill negotiated the boundaries and priorities between civilian and military requirements. It is useful, therefore, to briefly discuss the wider literature on the relationship between science, military and the state during this period. The work of David Edgerton is especially relevant to my study. Edgerton challenges declinist views that R&D was underdeveloped and poorly funded, arguing that Britain was as much of a 'warfare state' as a 'welfare state' between 1920 and 1970. He defines the components of the warfare state as including traditional military professionals but also a large scientific and technical core with strong industry links forming a formidable 'military-industrial-scientific complex'.[38]

By comparing warfare and welfare spending Edgerton shows that the state was far more invested in military R&D than previously thought, spending was growing rather than declining and, significantly, the military were the largest investors in R&D during this period.[39] Edgerton highlights that the Ministry of Supply, the coordination department for the armed forces, was the most influential government R&D agency in the post-war period, funding more civilian research than the scientific research councils and spending more in private industry than industry did on its own R&D.[40] While Dollis Hill existed in the warfare and welfare state, I show that it did not belong to either, instead navigating between the two to further Post Office aims. This highlights the limitations of the warfare and welfare dichotomy when describing how an institution shaped twentieth-century research.

[38] David Edgerton, *Warfare State: Britain, 1920-1970* (Cambridge: Cambridge University Press, 2006), p. 1 and 9.

[39] Ibid.; C. Barnett, *The Lost Victory: British Dreams, British Realities 1945-1950* (London: Macmillan, 1995).

[40] David Edgerton, 'Whatever happened to the British warfare state? The Ministry of Supply, 1945-1951', in *Labour Governments and Private Industry: The Experience of 1945-1951*, ed. by H. Mercer, N. Rollings and J. D. Tomlinson (Edinburgh: Edinburgh University Press, 1992), pp. 91-116 (p. 102).

There is a consensus amongst scholars that the Second World War had a dramatic impact on the funding, organisation and direction of British science.[41] Hilary Rose and Steven Rose identified three themes which emerged during the conflict; the establishment of centralised bodies of scientific decision making, the approval of secret projects without parliamentary scrutiny and a decision to maintain wartime structures after the war.[42] Building on the work of Rose and Rose, Jon Agar has identified three characteristics of wartime research. Firstly, it was directed towards goal-orientated projects, such as nuclear physics and radar. Secondly, these projects benefitted from more equipment, capital and personnel than pre-war programmes. Thirdly, there was a shift in the place and organisation of projects creating new networks between government, university and military sites and staff which shaped post-war practices.[43] By considering how this changing landscape affected the Post Office I show, that due to the actions of senior staff, Dollis Hill adopted the identity of a military establishment to play an important role in the wartime state, not currently recognised in scholarship.

Military patronage remained an important feature of science in Britain during the Cold War.[44] Some areas of scientific enquiry which promised military or strategic returns gained more support than others. For example, Sam Robinson shows how oceanography research benefitted from increased geopolitical interest in surveillance and national security.[45] Scholars have shown that scientists were not simply directed by military need but had agency, actively shaping the expectations of their funders to gain support for their own ambitions.[46] This is demonstrated by Néstor Herran who

[41] Hilary Rose and Steven Rose, *Science and Society* (Harmondsworth: The Penguin Press, 1969); Jon Agar and Jeff Hughes, 'Open Systems in a Closed World: Group and Airborne Radar in the UK, 1945-1990', in *Cold War, Hot Science: Applied Research in Britain's Defence Laboratories, 1945-1990*, ed. by Robert Bud and Philip Gummett (London: Science Museum, 2002) pp. 219-250;

[42] Rose and Rose, p. 59.

[43] Jon Agar, *Science and Spectacle: The work of Jodrell Bank in post-war British culture* (Amsterdam: Routledge, 1998), p. 6.

[44] Robert Bud and Philip Gummett, *Cold War, Hot Science: Applied Research in Britain's Defence Laboratories, 1945-1990* (London: Science Museum, 2002).

[45] Sam Robinson, *Ocean Science and the British Cold War* (Basingstoke: Palgrave Macmillan, 2018), p. 18.

[46] Daniel Kevles, 'Cold War and Hot Physics: Science, Security and the American State, 1945-56', *Historical Studies in the Physical and Biological Sciences*, 20.2 (1990) 239-264; Simone Turchetti and

traced how isotope research grew at the Atomic Energy Research Establishment, Harwell, after Henry Seligman, Head of the Division, argued that it would support the wider nuclear programme.[47] As Sally Horrocks has shown, Britain's defence programme had a dramatic impact on the landscape of industrial R&D. Private firms which could obviously support military aims, or could be seen to, benefitted from government defence contracts.[48] Across Chapters 3 and 4 I show how national defence requirements continued to impact Post Office operations and dominate Dollis Hill research. Military work was formally brought into the Research Station as a strategy to avoid losing staff and to provide access to limited materials.

Models of research establishments

Scholars who have looked at the different models of research establishments which emerged in the nineteenth and twentieth centuries have identified different types of research laboratory which commonly fall into one of these categories: state funded civil and military sites, industrial and universities, the last two either private or state funded.[49] Studies have shown that these sites did not develop in isolation. Instead, they were linked through networks of knowledge exchange and collaboration. Arjan van Rooij has argued that these relationships make it hard to distinguish certain

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Peder Roberts, 'Introduction' in, *The Surveillance Imperative: the Geosciences and the Cold War*, ed. by Simone Turchetti and Peder Roberts (New York: Palgrave, 2014), pp. 1-19 (p. 9); Naomi Oreskes, 'Introduction', in *Science and Technology in the Global Cold War*, ed. by Naomi Oreskes and John Krige (Cambridge, MA: MIT Press, 2014), pp. 1-10 (p. 6).

[47] Néstor Herran, 'Spreading nucleonics: the Isotope School at the Atomic Energy Research Establishment, 1951-67', *BJHS*, 39.4 (2006) 569-586 (p. 575).

[48] Sally Horrocks, 'Enthusiasm Constrained? British Industrial R&D and the Transition from War to Peace, 1942-1951', *Business History*, 41.3 (1999a), 42-63.

[49] Robert Clayton and Joan Algar, *The GEC Research Laboratories, 1919-1984* (London: Peregrinus in association with the Science Museum, 1989); David Edgerton and Sally Horrocks, 'T. S. Ashton Prize Essay for 1991-2: British Industrial Research and Development before 1945', *The Economic History Review, New Series*, 47.2 (May 1994), 213-238; Robert Fox and Anna Guagnini, *Laboratories, Workshops, and Sites: Concepts and Practices of Research in Industrial Europe, 1800-1914* (Berkeley: Office for History of Science and Technology, University of California, 1999); F. Kees Boersma, "Structural Ways to Embed a Research Laboratory into the Company: A Comparison between Philips and General Electric, 1900-1940', *History and Technology*, 19.2 (2003), 109-126; Graeme Gooday, 'Placing or Replacing the Laboratory in the History of Science?', *Isis*, 99.4 (2008) 783-795; Benoît Godin and Désirée Schauz, 'The changing identity of research: A cultural and conceptual history', *History of Science*, 54.3 (2016), 276-306.

laboratories as private or public.[50] The Post Office Research Station is a hybrid as it depended on profits from selling its services, some developed in collaboration with private firms, as well as receiving funding from the Treasury as a government department.

In aiming to move the focus of scholarship away from academic and private R&D laboratories van Rooij suggests that twentieth century laboratories in the Western world can be understood as eight distinct types based on three factors; the type of knowledge production, its orientation and its ownership. These are university laboratory, works laboratory, laboratory company, internal government laboratory, regulative government laboratory, R&D laboratory, normative government laboratory and research associations.[51] Whilst mindful that van Rooji does not suggest this analysis should be used to classify individual laboratories or research establishments, the large and varied amount of work carried out at Dollis Hill would allow us to mark at least three of these categories. The first is an internal government laboratory which emerged to enable the internal function of a government department, in this case the Post Office, and which focuses on testing and quality control. The second, regulative government laboratory, used testing to control society, so defining and enforcing standards relating to national and international telecommunication. Finally, normative government laboratory, which was designed to produce knowledge to support policy goals in the Dollis Hill case, and to undertake research which made industry more competitive on the export market. The only point when van Rooji discusses laboratories which have multiple characteristics is in the case of standard laboratories, such as the NPL and the United States Bureau of Standards, which border on regulative and normative types. Throughout, the wide range and remit of science and technology at Dollis Hill was part of an effort to ensure continued patronage and custom from a variety of private, public, military and civil sources.

[50] Arjan van Rooij, 'Knowledge, money and data: an integrated account of the evolution of eight types of laboratory', *BJHS*, 44.3 (2011) 427-448 (p.429).

[51] Ibid., p. 433.

Historians have shown the influence of specialist bodies and powerful networks of individuals in the development and sponsorship of research establishments. Edward Pyatt has shown how the formation of the National Physical Laboratory (NPL) was shaped by the Royal Society and British Association campaigning for a national laboratory and the perception that Britain's industrial strength was falling behind Germany and the United States.[52] A cross between university and industrial laboratories, supported by public and private funds, the NPL was a new form of research establishment which became the model for later government institutions.[53] Russell Moseley argues that NPL staff, including many eminent scientists and Fellows of the Royal Society, forged the laboratory's reputation as a major scientific institution – important for industry, government and the scientific community.[54] In her study of the Department of Scientific and Industrial Research (DSIR) run Building Research Station, Anne Elizabeth Beesley shows that during the interwar period science policy was shaped by a small number of individuals who moved in the same social circles including civil servants, research council secretaries and members of the Royal Society.[55] I also consider the networks of influence which shaped the development of the Research Station by tracing the ways senior Post Office staff navigated the R&D landscape, through government committees and strengthening ties with influential patrons.

Whilst Research establishments may appear to fall into a category of 'pure', 'applied' or 'fundamental' research, scholars have shown that these terms emerged to serve specific purposes and hold many definitions.[56] For example, Sabine Clarke has revealed

[52] Edward Pyatt, *The National Physical Laboratory A History* (Bristol: Adam Hilger, 1992) p. 81.

[53] Stephen Thomas Keith, 'The Role of Government Research Establishment: A Study of the Concept of Public Patronage for Applied Research and Development' (unpublished PhD thesis, Aston University, 1982), p. 1.

[54] Russell Moseley, 'Science, Government & Industrial Research: the Origins & Development of the National Physical Laboratory, 1900-1975' (unpublished PhD thesis, University of Sussex, 1976), p. 4.

[55] Anne Elizabeth Beesley, 'Strategic Change in a Government Laboratory: The Case of the Building Research Establishment' (unpublished PhD thesis, University of Manchester, 2000), p. 51.

[56] Robert Bud, '"Applied Science" in Nineteenth-Century Britain: Public Discourse and the Creation of Meaning, 1817-1876', *History and Technology*, 20.1-2 (2014), 3-36; Graeme Gooday, '"Vague and Artificial": The Historically Elusive Distinction between Pure and Applied Science', *Isis*, 103.3 (2012), 546-554; Ronald Kline 'Constructing "Technology" as "Applied Science": Public Rhetoric of Scientists and Engineers in the United States, 1880-1945', *Isis*, 86.2 (1995), 194-221.

how the DSIR used 'fundamental research' as a rhetorical device to gain patronage from influential stakeholders.[57] Although the Research Station was consistently described by senior Post Office staff as being a site of applied research, the application of this research was left strategically fluid to respond to changing government agendas. Whether it was during war or peace, the activities at Dollis Hill were aligned with national priorities to gain prestige and patronage from wider government and industry.

One factor which has been used by scholars to explore the development of a research establishment is to trace how they are financed. In studying the DSIR, Stephen Keith shows that there was a tension between the aims of institution and its funding body, the Treasury.[58] Institution Directors wanted to focus on long-term research of a general nature but faced pressure from the Treasury which wanted to see a financial return from short-term research which industry paid to access. This debate is explored further in Moseley's study of the NPL in which he shows that during the interwar period the laboratory's research programme was restricted by what the Treasury thought they should be working on.[59] Whilst, similarly, the Treasury had a stronghold over the Post Office and its development of the communications network, I show that Dollis Hill became a means by which the department could meet some of its wider aims. The Research Station retained Treasury support by Post Office staff promising cost saving technologies which had the potential to support export markets.

There has not been much systematic examination of state funded research establishments compared to universities and commercial laboratories. Recently there has been some revised attention on DSIR funded research stations: both Justine Cook's thesis on the scientific governance of British roads and their users and Georgina Lockton's doctoral study on 1960s and 1970s British road safety focus on the Road

[57] Sabine Clarke, 'Pure Science with a Practical Aim: The Meanings of Fundamental Research in Britain, circa 1916-1950', *Isis*, 101.2 (2010), 285-311 (p. 288).

[58] Stephen Thomas Keith, 'The Role of Government Research Establishment: A Study of the Concept of Public Patronage for Applied Research and Development' (unpublished PhD thesis, University of Aston in Birmingham, 1982), p. 1.

[59] Moseley, 'Science, Government & Industrial Research', p. 220.

Research Laboratory.[60] Studies have tended to concentrate on a small group of laboratories, most commonly the NPL, Bletchley Park and the Atomic Weapons Research Establishments. In the case of Bletchley Park its trajectory from an anomalous secret to an incredibly well-publicised site has shaped the available literature on topics indirectly connected to it, of which Dollis Hill is an example. This is explored in Chapter 2, where I discuss the construction of the codebreaking machine, Colossus. By placing this development in the wider context of the Dollis Hill wartime activities, I show that this was one of many projects being pursued in order to gain prestige, an interpretation currently omitted in current literature which discusses Colossus from the perspective of Bletchley Park.[61] While the impact of war on research was discussed in the previous section, there is still much to know about the military and defence laboratories, which, as David Edgerton has shown, dominated state funded research.

Throughout this thesis I show how Dollis Hill was used by the Post Office to defend its monopoly over the nation's telecommunications. Whilst scholars have looked at how the Post Office operated as a business (discussed in a later section) no-one has considered what role the Research Station played. The development of research in American industrial laboratories provides a useful comparator to the Post Office case.[62] Most pertinent is Bell Laboratories, known as Bell Labs, the R&D section of the American Telephone and Telegraph Company (AT&T). Kenneth Lipartito shows that AT&T had a wider influence on Britain as during the period under review politicians and Post Office staff looked to AT&T as a model to develop telecommunication policy.[63] Louis Galambos explores how Theodore Vail, CEO of AT&T between 1907 and

[60] Justine Cook, 'Constructing Britain's Road Network: The Scientific Governance of British Roads and Their Users, 1900-1963' (unpublished PhD thesis, University of Kent, 2018); Georgia Lockton, 'Road safety in 1960s Britain' (unpublished PhD thesis, University of Leicester, ongoing).

[61] Andrew Hodges, *Alan Turing: The Enigma* (London: Vintage Books, 2014) p. 336; Jack Copeland, ed. *Colossus: The secrets of Bletchley Park's codebreaking computers* (Oxford: Oxford University Press, 2006); Paul Gannon, *Colossus: Bletchley Park's Greatest Secret* (London: Atlantic Books, 2006), p. 257.

[62] Jon Gertner, *The Idea Factory: Bell Labs and the Great Age of America Innovation* (New York: Penguin, 2012), p. 2.

[63] Kenneth Lipartito, 'Failure to Communicate: British Telecommunications and the American Model', in *Americanization and its Limits: Reworking US Technology and Management in Post-war Europe and Japan*, ed. by Jonathan Zeitlin and Gary Herrigel (Oxford: Oxford University Press, 2004), pp. 153-179.

1919 directed the innovation of the Modern Bell System. Rather than focusing on the technology produced by Bell System, Galambos explores the management of the organisation.[64] This approach sheds light on how the corporation worked with scientific and engineering professionals.[65]

Standardisation and control were central to Vail's strategy and under his leadership Bell Systems became one of the most technically advanced companies in the United States. Andrew Russell has shown the lengths AT&T went to maintain control over the standards of equipment. After discovering customers were using iron washers instead of coins in telephone boxes and calculating the large costs required to make changes to the slot mechanism, AT&T successfully persuaded washer manufacturers to revise their standards.[66] Leonard Reich has studied the emergence of industrial research in America by comparing Bell Laboratories to General Electric, the two largest electrical firms in the early twentieth century. Although the two companies developed different attitudes to the application of industrial research they did so for the same reason; to control technologies of immediate commercial concern.[67] While not being defined as private industry, Dollis Hill held many of these characteristics, including obtaining patents, and it significantly shaped the activities of manufacturers of telecommunications equipment by setting standards, testing products and defining what could be introduced in the Post Office network.

[64] Louis Galambos 'Theodore N Vail and the Role of Innovation in the Modern Bell System', *The Buisness History Review*, 66.1 (1992), 95-126 (p.98).

[65] Ibid., p.125.

[66] Andrew Russell, *Open Standards and the Digital Age: History, Ideology, and Networks* (Cambridge: Cambridge University Press, 2014), p. 124.

[67] Leonard Reich, *The Making of American Industrial Research: Science and Business at GE and Bell, 1876-1926* (Cambridge: Cambridge University Press, 1985), p. 241.

Engineering culture

While there were many career scientist and engineers working in government and research establishments little is known about their motivations, working cultures and career development. Alexandros-Panagiotis Oikonomou has shown that their role in shaping scientific policy has often been overlooked by histories of state science.[68] In contrast, the role of scientific advisors to government has been scrutinised, focusing on individuals such as Henry Tizard, Solly Zuckerman, C. P. Snow and scientists in advisory committees and bodies.[69] Many of these individuals have written themselves into history, demonstrated by the various books about the role of science during the Second World War authored by the scientists involved.[70] Although these publications grab the public imagination more than official histories, they project a specific agenda for self-promotion and tend to avoid discussing the less glamorous details about the management of research.

Sally Horrocks and Tom Lean have highlighted some of the reasons why government engineers and technicians are hard to trace historically noting that they rarely leave material records in archives, write reminiscences and few receive obituaries.[71] Like Horrocks and Lean, I have found oral histories a valuable source to understand more about the experiences of Dollis Hill staff which are not reflected in departmental archives. In studying the rise of large corporations in America from the late nineteenth century, David F. Noble has made an important contribution to scholarship on engineers and engineering. Noble demonstrates that engineers played a dual role as agents of corporate capitalism and modern technologies by controlling the technical

[68] Alexandros-Panagiotis Oikonomous, 'The Hidden Persuaders: Government Scientists and Defence in Post-war Britain' (unpublished PhD thesis, Imperial College, London, 2011).

[69] Jon Agar and Brian Balmer, 'British scientists and the Cold War: The Defence Research Policy Committee and information networks, 1947-1963', *Historical Studies in the Physical and Biological Sciences*, 28.2 (1998) 209-252.

[70] R. V. Jones, *Most Secret War* (London: Hamish Hamilton, 1978); A. P. Rowe, *One Story of Radar* (Cambridge: Cambridge University Press, 1948); Robert Watson-Watt, *Three Steps to Victory* (London: Odhams Press, 1957); C. P. Snow, *The Two Cultures and the Scientific Revolution* (Cambridge: Cambridge University Press, 1962); Guy Ortolano, *The Two Cultures Controversy: Science, Literature and Cultural Politics in Postwar Britain* (Cambridge: Cambridge University Press, 2011).

[71] Sally Horrocks and Thomas Lean 'Doing it for Britain: science and service in oral history with government scientists', in *Scientific Governance in Britain, 1914-79*, ed. by Don Leggett and Charlotte Sleigh (Manchester: Manchester University Press, 2019) pp. 162-178 (p. 162).

means of production as corporate managers and educators in the late nineteenth and early twentieth centuries.[72] Noble's analysis is based on the development of private firms like AT&T, DuPont and General Electric. Engineers were a key part of British industry but were also hired in state funded establishments, a history yet to be written.

While archival records can be a limiting factor, Steven Shapin argues that the lack of attention given to technical staff in the making of scientific knowledge, 'reflects both historical and modern attitudes toward the value of skilled work'.[73] Building on Shapin's work, which focuses on the role of 'invisible technicians' in Robert Boyle's laboratory in the seventeenth century, Paul Forman shows that the notion that engineers were subservient to scientists was prevalent in the first half of the twentieth century.[74] In her work on technical careers at the National Institute of Medical Research (NIMR), Elizabeth Tansey has identified that, in the post-war period, technicians became less invisible and more respected for their individual skills, no longer working for scientists, but with them. Tansey's work reveals that the culture of the NIMR laboratory was shaped and maintained by the continuity of technicians who spent longer in their posts than scientists.[75] In Chapter 2, I explore how different working cultures led to friction between staff at Dollis Hill and Bletchley Park.

Oikonomous' study touches on a wider point that the self-promotion of individual contributions was not a common feature of the working culture of government establishments. When achievements were published, generally in specialist journals, the labour of invisible technicians was often not recognised. David Edgerton has gone some way to reflect the variety of scientific and engineering roles which shaped the wartime state. Edgerton points to the importance of the scientific civil servants who he

[72] David F. Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (Oxford: Oxford University Press, 1977), p. xxi and xxiii.

[73] Steven Shapin, 'The Invisible Technician', *American Scientist*, 77.6 (1989) 554-563 (p. 544).

[74] Paul Forman, 'The Primacy of Science in Modernity, of Technology in Postmodernity, and of Ideology in the History of Technology', *History and Technology*, 23.1-2 (2007) 1-152 (pp. 14-15).

[75] Elizabeth Tansey, 'Keeping the Culture Alive: The Laboratory Technicians in the mid-twentieth-century British medical research', *Notes and Records of The Royal Society of London (Notes Rec. R. Soc. Lond)*, 62 (2008) 77-95 (p. 91).

calls the 'the research corps' in terms both of their sheer numbers and type of work they performed.[76] He stresses that 'the distinctions between the research corps and the academics, between the researchers and the advisers, and different kinds of advisers are crucial'.[77] Despite highlighting the importance of expert staff in laboratories, this category of 'the research corps' is too broad to aid my analysis. For example, in reference to the increase in state sponsorship of R&D post-war Edgerton argues that 'much research was done in national establishments by hugely expanded state research corps'.[78] However, this expansion was not uniform, as the growth of R&D establishments meant there was competition between institutions over a limited workforce. As I show in Chapter 3, the inability to hire the desired staff, limited Post Office research plans.

There is a growing literature on women in engineering, highlighting the roles of individuals, their working experiences and the connection between technological change and gender relations.[79] Studies have looked specifically at the development of professional societies in the shaping of women's engineering careers, for example the establishment of the Women's Engineering Society and its methods to encourage women into the profession.[80] While figures of female graduates highlight a gender gap in formal education, Ruth Oldenziel has shown that these statistics underestimate the numbers and methods by which women gained technical skills, missing the women who acquired knowledge informally through family firms or training on the job.[81] Both Patricia Fara and Elizabeth Bruton highlight the connection between women taking on

[76] Edgerton, *Warfare State*, pp. 143-144.

[77] Ibid., p. 165.

[78] Ibid., p. 104.

[79] Graeme Gooday, *Domesticating Electricity: Gender, Technology and Uncertainty* (London: Pickering & Chatto, 2008); Annie Canel, Ruth Oldenziel and Karin Zachmann ed., *Crossing Boundaries, Building Bridges: Comparing the History of Woman Engineers 1870-1990s* (Amsterdam: Harwood, 2000); Janet Abbate, *Recoding Gender: Women's Changing Participation in Computing* (Cambridge, MA: MIT Press, 2012); Mar Hicks, *Programmed Inequality: How Britain Discarded Women Technologists and Lost Its Edge in Computing* (Cambridge, MA: MIT Press, 2017).

[80] Carroll Pursell, '"Am I a Lady Engineer?" The Origins of the Women's Engineering Society in Britain, 1918-1940', *Technology and Culture*, 34.1 (1993) 78-97; Graeme Gooday and Emily Rees, 'Where are the Women in Engineering? A century-old story', *Newcomen Links*, 252 (2019) 12-14

[81] Ruth Oldenziel, *Making Technology Masculine: Men, Women, and Modern Machines in America, 1870-1945* (Amsterdam: Amsterdam University Press, 1999).

engineering roles during the First World War and the suffrage movement.[82] Looking at the employment of women in private industry, Horrocks has shown that while opportunities grew in the interwar years, their work was defined by perceptions of gendered skills and ability which, in turn changed the nature of what was considered men's work.[83]

Recently the role of women in telecommunications has received focused attention in a special issue of *Information and Culture* edited by Bruton and Mar Hicks.[84] Papers seek to understand the changing opportunities and careers available to women in the Post Office in the late nineteenth and early twentieth centuries. This thesis is an opportunity to go beyond the time period discussed in the special issue and build on the work of Mark Crowley who had published several works on the role of women in the Post Office during the Second World War.[85] Crowley shows that despite the immediate inequalities felt by female staff at the start of this conflict, their position improved as a result of organised women's groups, trade unions and unexpected opportunities for promotion.[86] Crowley's work is particularly relevant in Chapter 2, where I explore the changing demographic of staff at Dollis Hill during the war which included hiring women into technical roles for the first time. This expands on Crowley's case studies which concentrate on telephone engineers, telephonists and postwomen.

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[82] Patricia Fara, *A Lab of One's Own: Science and Suffrage in the First World War* (Oxford: Oxford University Press, 2018); Elizabeth Bruton, '"Uncertain at Present for Women, but May Increase": Opportunities for Women in Wireless Telegraphy during the First World War' *Information and Culture [Special Issue]*, 55.1 (2020), 51-74.

[83] Sally Horrocks, 'A promising pioneer profession? Women in industrial chemistry in inter-war Britain', *BJHS*, 33 (2000), 351-367.

[84] Elizabeth Bruton and Mar Hicks, 'A History of Women in British Telecommunications: Introducing a Special Issue', *Information & Culture [Special Issue]*, 55.1 (2020), 1-9.

Mark Crowley, 'Women Workers in the General Post Office, 1939-1945: Gender Conflict, or Political Emancipation?' (unpublished PhD thesis, Institute of Historical Research, University of London, 2010).

[86] Crowley, 'Women Workers in the General Post Office', p. 2.

The Post Office and Dollis Hill

Despite its role as one of nation's largest employers and its importance in shaping twentieth century culture and society, the Post Office has received little historiographic attention. Of the few publications, most are institutional studies concentrating on the development of the postal service, rather than telecommunications. Mark Daunton and Duncan Campbell-Smith have written authorised histories of the Post Office, focusing on the Royal Mail. These provide a rich source of information about the development of the postal services but do not offer much detail about the institution's engineering department or telecommunications. Daunton's work traces the development of the Post Office as a business from 1840 to 1969, when the post and telecommunications arms were separated.[87] Daunton's thematic structure is more focused on the developments of the nineteenth century, with little attention given to the twentieth. Unlike the Post Office's mail and financial services, telephone and telegraph research do not receive a dedicated chapter. Instead, they appear sporadically throughout. The Engineering Department is only mentioned in the context of wider organisational changes like the 1930s Bridgeman and Carpenter reviews, which contributed to a devolution of powers by introducing regional management.[88]

Unlike Daunton, Campbell-Smith provides more details about the Engineering Department including some of the Research Station activities. Two projects receive the most attention: first, the role of Dollis Hill staff in codebreaking activities during the War and, second, postal mechanisation. Whilst noting that, 'fresh from their wartime work for Bletchley Park, the scientists of Dollis Hill did not take long to identify the critical components of a fully automated letter-sorting system', Campbell-Smith makes no mention of how this experience influenced other post-war projects, such as the development of electronic exchanges.[89] As such, this work presents an uneven view of the Research Station's contribution to the Post Office. Nonetheless, the book

[87] Mark Daunton, *Royal Mail: The Post Office since 1840* (London: Athlone Press, 1985).

[88] Ibid., p. 299.

[89] Duncan Campbell-Smith, *Masters of the Post: The Authorized History of the Royal Mail* (London: Penguin Books, 2012), p. 396.

successfully traces the longer history of the organisation and includes observations of the nation's telephone habits.

Alan Clinton's comprehensive social history of the Post Office trade union leans towards the experiences of postal workers, including postmen, sorters and counter clerks, but does also mention telephonists and telegraphists.[90] Clinton provides a detailed historical review of grading, industrial relations, wage negotiations and an important overview of change in the Post Office. Key to his study are archives which trace the negotiations between employers and trade union representatives. Frank Bealey's history of the Post Office Engineering Union traces the development of unionisation within the telecommunications industry, the organisation of the Union and its work and pay campaigns.[91] This is a valuable source for understanding how trade union negotiations were shaped by political change. Bealey and Clinton's studies provide wider context to Chapter 2 where I discuss the introduction of women into engineering roles.

Business historians have used the Post Office as a case study to explore government relations and changes to the telecommunications industry. Douglas Pitt's organisational history of the telephone business is a valuable source in this canon. Pitt argues that the Post Office's expansionist aims were challenged by the Treasury and central government's restrictive spending during much of the twentieth century.[92] This thesis support Pitt's argument when considering the impact of this financial arrangement on the Post Office's broad aims to improve the telephone network. However, in Chapter 3, I show that this cannot be so easily applied to the Research Station, as Dollis Hill was comparatively well-funded when compared with other state R&D establishments. The Treasury approved new positions and supported the development of the site. The impact of this uneven support is discussed in Chapter 4,

[90] Alan Clinton, *Post Office Workers: A Trade Union and Social History* (London: George Allen & Unwin, 1984).

[91] Frank Bealey, *The Post Office Engineering Union: The History of the Post Office Engineers 1870-1970* (London: Bachman & Turner, 1976).

[92] Douglas Pitt, *The Telecommunications Function in the British Post Office: A Case Study of Bureaucratic Adoption* (Farnborough: Saxon House, 1980), p. 46.

when the underinvestment in infrastructure placed limitations on the introduction of new technology designed at the Research Station.

Mark Thatcher, addressing the influence of national politics on telecommunications policy, argues that, following civil service structures, the Post Office was hampered by not having technically trained administrators and Ministers in senior positions in the department.[93] While making this claim, Thatcher's study does not actually interrogate the influence of individuals from the Engineering Department in shaping Post Office developments. Instead he explores the friction between successive Postmaster Generals and other government officials. Peter Sutton has demonstrated the instrumental role of engineers in shaping and delivering the Post Office's postal mechanisation programme, in his study of the Letter Post Plan between 1969 and 1975. Notably, Sutton identified that senior engineers were responsible for training, financial modelling and negotiating with the unions as well as designing new types of equipment.[94] Sutton's study provides a rich insight into the ambitions of the Post Office and Engineering Department during his six-year period. My thesis contextualises Sutton's work by showing that engineers whose careers developed at Dollis Hill were key actors in the growth of Post Office technologies and services.

While Dollis Hill has not been the focus of historical study, its role in shaping telecommunications has been discussed by Post Office staff. The most informative, if short, account about the Research Station was published in the technical *Post Office Electrical Engineers' Journal* (POEEJ) in 1976. Written by a former Dollis Hill employee, F. E. Williams, the article covers a wide period of Post Office Research Station activities. Starting with the first dedicated experimental laboratory in 1904, Williams briefly describes the industrial and political motivations that led to the formation of the Research Station, the contribution made by Dollis Hill employees during the two World Wars and post-war, and finally the relocation of the Research Station to

[93] Mark Thatcher, *The Politics of Telecommunications: National Institutions, Coverage, and Change in Britain and France* (Oxford: Oxford University Press, 1999), p. 34.

[94] Peter Sutton, 'Technological Change and Industrial Relations in the British Postal Service, 1969-1975' (unpublished PhD thesis, King's College London, 2013), p. 13.

Martlesham Heath.[95] Williams' report depends strongly on contemporary accounts by Captain Bertram S. Cohen, the Staff Engineer in charge of Dollis Hill in the 1930s.[96] Even though these articles provide detailed information not found elsewhere, they are institutional histories written to promote the work of the Research Station and devoid of any controversy or conflict. Alice Haigh has started the process of revising this narrative in her thesis which traces the origins of the Research Station at Dollis Hill between 1908 and 1938.[97] I continue, by exploring how senior Post Office staff steered the Research Station through a tumultuous period of war and peace, and by showing that Dollis Hill had an increasingly significant role in the department's approach to achieving some of its aims and ambitions.

Sources

For this study, I undertook qualitative archival research to recover the history of Dollis Hill. Based in London, BT Archives (BTA) and the Postal Museum Archives (PMA) were the two most significant repositories. The contents of these collections were once held together but became separated following organisational changes within the Post Office. In general, BTA holds material relating to the history of telecommunications while records connected to postal operations are stored at the PMA. The two archives operate collaboratively, sharing information about each other's holdings on their catalogues.

Alongside legal requirements and compliance with the Freedom of Information Act and Public Records Act, the historical records within BTA are selected to 'provide a source of knowledge about past actions and decisions, which can inform decision making in the future'.[98] Despite such a collections policy, the files I consulted were

[95] F. E. Williams, 'The story of Dollis Hill'*, Post Office Electrical Engineers' Journal (POEEJ)*, 69.3 (October 1976) 140-145.

[96] B. S. Cohen, 'Research in the British Post Office', *Journal of the Institution of Electrical Engineer (J.I.E.E.),* 75.452, (1934), 133-151.

[97] Alice Haigh, 'To Strive, To Seek, To Find'.

[98] [Anon.], *BT Archives Collection Management Policy* (October 2015) 1-11 (p. 1) https://www.bt.com/about/bt/our-history/bt-archives/our-heritage-policies [accessed 1 September 2020].

archived when the Post Office was still a government department and while recording changes such as departmental restructures, or chronicling achievements through annual reports, the decisions behind such actions are often lacking. This thesis is largely built on documents held in the archive; the meetings of committees, annual reports and some correspondence between key individuals, although this was limited. Such sources present evidence for high-level decision making which influenced the development of Dollis Hill, but rarely reflect the working experiences of staff in the Research Station which can only be gleaned through rare oral histories and personal reminiscences. As such there are potentially important cases and perspectives which were not represented in the available source base.

Records that were most likely to be preserved are those that served administrative needs, and those providing justification for past decisions. This means it is possible that documents were retained, and others disposed of which presented the department as competent and capable, as evidenced by recent discoveries that past governments have intentionally mishandled or destroyed records which could cause political embarrassment.[99] However, whilst it is possible that the retained documents were selected to present the best possible picture of Post Office progression, the archives also reflect the fact that Post Office was open to public scrutiny in ways that private institutions were not. I have attempted to mitigate the limitations of utilising this source base by consulting archives which provide differing perspectives of Post Office actions and lived experiences of working at Dollis Hill. The holdings of other government departments (archived at The National Archives), journal archives, parliamentary debates, government committee minutes, newspaper archives and oral histories helped to contextualise how the Post Office was affected by the wider economic, social and political landscape, and provided a critical view of Dollis Hill's work.

This thesis has been shaped by the surviving archival record which, at times, has hindered focused research into the culture of the Research Station, hiring practices

[99] Ian Cobain, Owen Bowcott and Richard Norton-Taylor, 'Britain destroyed records of colonial crimes', *The Guardian*, 18 April 2012 https://www.theguardian.com/uk/2012/apr/18/britain-destroyed-records-colonial-crimes [accessed 1 September 2020].

and staff experiences. BTA have a wide range of holdings, and whilst there are rich sources on the Post Office unions and organisational change, material relating directly to Dollis Hill is unfortunately lacking. For example, the minutes of the Coordination and Development Committee which discussed the allocation of research resources for the Engineering Department are patchy, especially in the post-war years. The papers and minutes of the Post Office Board (POB) were useful in understanding the main aims and challenges facing the department and, whilst infrequent, differing opinions on the role of research appear. The Post Office commercial accounts and Engineer-in-Chief's report which were published annually (excluding the Second World War) provide useful facts and figures, including capital expenditure and rate of telephone exchange installations. From 1949, the Engineer-in-Chief's report includes a breakdown of R&D costs. Secrecy, a theme explored in the thesis, has also controlled what archives could be accessed. There were several POB papers which remained classified and, given their dates, were likely connected with Post Office Cold War planning. In February 2020, I was permitted to read a redacted version of the Research Station's Second World War 'War Diary' which became integral to Chapter 2.

Most records held by BTA associated with Dollis Hill are research reports, compiled by the Research and Radio Branches. There are hundreds of these reports, which identify the type of work being undertaken and occasionally who the work was for. While they demonstrate the breadth of research activity, these records do not explain how the Research Station undertook these projects and there is little context as to why they completed the enquiry. For my purposes, this information was just as important as the technical details of research activities. Some of these reports have provided valuable insights into the research culture at Dollis Hill, including visits to national and international telecommunication companies and summaries of conferences attended. These have been particularly useful in tracing the opportunities for female staff. The collection of reports surviving in the archive is not representative of the total range of projects, so quantitative research on these reports has not been possible.

I also consulted material published by the Post Office for internal communication held by BTA and PMA. These include Green Papers, introduced in the 1930s to describe departmental activities from the Savings Bank to the Engineering Department. In

contrast to the Green Papers, the Post Office Magazine was a more informal publication in which staff could contribute articles, share announcements and submit poems and cartoons. Michael Heller, a business and marketing scholar, has demonstrated the research value of in-house magazines to understanding organisational culture.[100] I assessed how Post Office staff described, discussed and reacted to technologies with their roots at Dollis Hill. I also looked at professional publications, including the Post Office Electrical Engineers' Journal (POEEJ) and Journal of the Institution of Electrical Engineering. These records provide an insight into Post Office culture, values and aspirations.

From the 1930s, the Post Office engaged in a range of promotional activities as the department went through a period of reinvention. This included posters, exhibitions, newspaper advertisements and films. Ludmilla Jordanova has highlighted that evaluation of whether audiences absorb messages of propaganda is not possible without qualitative analysis of their reactions.[101] Although these sources do not provide evidence of public perceptions of Post Office publicity, I have used them to consider how the Post Office saw itself and the methods by which it projected a specific narrative. Dollis Hill's activities were often reported on by journalists, and I have thus reviewed relevant newspaper, newsreel and specialist periodicals, such as *Nature*. Whilst reports were shaped by the political and social agendas of their media outlet, they provide evidence for how the Post Office was perceived externally. I have sourced this material using search terms in digital newspaper archives, but the identification of a book of press cuttings held at BT Archives provided a far richer collection of cuttings from now-defunct newspapers across Britain. Plans of the site which appeared in guides to the Research Station Open Days, which occurred roughly every four years, have been a means to trace changes to the physical site. It has not been possible to use Dollis Hill itself as source material, as most of the laboratories

[100] Michael Heller, 'British Company Magazines, 1878-1939: The origins and functions of house journals in large-scale organisations', *Media History*, 15.2 (2009), 143-166.

[101] Ludmilla Jordanova, *The Look of the Past: Visual and Material Evidence in Historical Practice* (Cambridge: Cambridge University Press, 2012), p. 167-168.

have been demolished. Only the Main Research Building remains and it has been converted into flats within a gated community.

I have used oral histories from several sources, which provide insights into the personal experiences of working at Dollis Hill absent from the archival record. Testimonies of some well-known staff, including Tommy Flowers, Allen Coombs and Stephanie 'Steve' Shirley, have been collected by the Imperial War Museum, Science Museum and British Library. I have also benefitted greatly from Brent Museum and Archive who curated an exhibition in the early 2000s called 'Speaking Clocks and Hiding Politicians: Dollis Hill Research Station'. Seven oral histories were recorded with retired staff for this project and these have been a valuable resource in understanding Dollis Hill's research culture. I am aware, however, that these recordings were made by historians and researchers with different agendas to my own and participants' responses are shaped by their line of questioning. I have attempted to identify other retired staff associated with Dollis Hill or those who had a friend or relative there. Unfortunately, this search did not prove fruitful.

Structure

This thesis is structured chronologically to trace how the Research Station was affected by the changing priorities of the Post Office and the state between 1933 and 1958. In Chapter 1, I demonstrate how Dollis Hill and its activities were used by the Post Office to justify its continued monopoly of the telephone service to the public, government and industry during the 1930s. Following criticisms from politicians and the public that the Post Office was inefficient and antiquated, the department launched a widespread publicity campaign to improve public relations and sell its services. I show that by embodying many of the characteristics the Post Office wanted to project, Dollis Hill was utilised as a symbol of prestige and modernity to fulfil departmental aims. This analysis builds on the work of scholars from art history, business and marketing and film studies who have explored the methods of the Post Office's organisational change. The campaign was successful in increasing applications for the telephone, but the Post Office struggled to meet the demand. As such, a gap emerged between the visions of

what technology could offer and the reality of accessing it. Whilst the Research Station's prestige was used to create a public image, prestige was also important for managers in the Engineering Department to establish Dollis Hill as experts in telecommunication research within, and to gain patronage from, professional networks, government, industry and international communication providers.

Chapter 2 provides a new perspective on the experiences of R&D establishments and the management of science and engineering during rearmament and the Second World War, 1934–1945. Given the strategic value of communication routes, the Post Office played an important role in supporting national defence by prioritising government telephone calls over civilian, installing new cables for military purposes and through staff, who left in their thousands to support the war effort. Whilst the Research Station was considered a site of expertise in some areas, notably telephone tapping, its authority was challenged by new and expanding R&D establishments managed or influenced by the Defence and Supply Ministries. Although collaboration between institutions was common, there was also competition over limited resources and prestige. As a government department, there was an expectation from across government that the Post Office would support the needs of the wartime state. However, I show that the transformation of Dollis Hill from a civilian site to a military establishment was also a strategy adopted by senior Post Office staff to safeguard its workforce and gain patronage.

In Chapter 3 I show that, having become a key component of the wartime state, the Research Station was expected to continue to meet military requirements in the post-war period, between 1946 and 1950. There was also the assumption, from the government and the public, that the Post Office would rebuild and advance technology for the civilian subscriber. I consider the impact of these competing pressures alongside the ambitions of senior staff at Dollis Hill to introduce a more scientific approach to research through projects of a long-term and fundamental nature and by hiring more academically qualified staff. The Post Office was in a unique position as a government department which was bound to the Treasury (the Post Office was forced to relinquish all profits to the Exchequer and then lobby for funding) but also invaluable to manufacturers of telecommunications equipment and key to national

defence. As such, I show that the Post Office and Dollis Hill were disadvantaged by policies designed to support post-war reconstruction. These included the export drive, which reduced the amount of material and equipment available for public services, and increases to the scientific workforce, which favoured R&D establishments and industry which supported military projects.

The final chapter, Chapter 4, covers the period 1951 to 1958 during which the Post Office struggled to deliver the overwhelming demands of the Cold War defence programme and a booming civilian service. Treasury cuts to nationalised industries, intended to improve the balance of payments, restricted Post Office purchasing power thus hindering plans to reduce the telephone waiting list and complete its mechanisation programme. In contrast, the Research Station benefited from the Conservative government's technological enthusiasm for new equipment which promised British prestige and goods for export. Dollis Hill became a means by which the Post Office could make progress on its long-term goals by aligning itself with national aims. I show that the successful application of Dollis Hill research in the installation of the first transatlantic telephone cable, the launch of Subscriber Trunk Dialling, which removed the need for a human operator when making calls, and the construction of ERNIE, the machine which generated Premium Bonds numbers, can be understood as examples of 'defiant modernism'.

This thesis provides a case study for broadening our understanding of state-sponsored science, charting how the Research Station shaped and was shaped by periods of peace and war. Although my project finishes in 1958, when it was formally recognised that Dollis Hill was restricting Post Office research, staff continued to work at the Research Station until 1975 when the Queen formally opened Martlesham Heath. The new site was a university inspired campus, reflecting modern aims for a modern Post Office. Whilst Dollis Hill had outlived its useful life, its ethos remained as research staff walked into Martlesham Heath beneath a sign which read 'Research is the Door to Tomorrow'.

Chapter 1: The Value of Prestige: Dollis Hill, modernity and the Post Office, 1933–1939

1.1 Introduction

Pathé News introduced the Post Office Research Station's formal opening to the nation on 23 October 1933 with the subtitle 'new wonder house of experiment and invention for the improvement of telephonic and telegraphic communication'.[1] The newsreel showed the speeches given by the Postmaster General Kingsley Wood and the Prime Minister Ramsey MacDonald intercut with shots of the Research Station, lingering on outside scenes of the grand Main Research Building and featuring a few seconds of engineers working in laboratories with whirring machinery testing wires and telephone dials. Paraded to the public as a new site of research, what this 'opening' concealed was the Research Station had, in fact, been in operation for twelve years and its staff had developed an international reputation in the art of communications. In this chapter I show how this event and other activities of the Research Station were successfully used by Post Office managers as part of a wider publicity campaign established in 1932 to project a modern, efficient and technologically progressive government department. This initiative was designed to challenge criticisms from the public, politicians and industry that the low uptake of Post Office services was because the department was inefficient and underdeveloped.

The campaign to modernise the Post Office fell within, and was shaped by, a period of major social, economic and political turbulence in Britain: financial depression, mass unemployment and the formation of successive National Governments.[2] Throughout,

[1] 'London. G.P.O.'s Research Station, New wonder house of experiment and invention for the improvement of telephonic and telegraphic communication, opened by the Prime Minister, 1933' (Pathé newsreel: 1933), British Pathé < https://www.britishpathe.com/video/g-p-os-research-station-aka-gpos-research-station/query/wonder+house> [accessed 20 Feb 2015].

[2] David Marquand, '(James) Ramsay MacDonald (1866-1937)', *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004) <https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-34704> [accessed 5 February 2020]; Michael Kitson, 'Britain's withdrawal from the gold standard', in *Routledge Handbook of Major Events in Economic History*, ed. by Randell Parker and Robert Whaples (London: Routledge, 2013), (pp. 127-137).

the government looked to reduce public spending and the wages of public sector workers to improve the economy. Whilst Britain's heavy industries, including coal mining, shipbuilding and textile manufacturing, which had performed well in the nineteenth century became increasingly uncompetitive in the world market, with the application of mass production and standardisation of parts, new industries grew, including motor cars, electrical goods and associated light industries. There was a market for these products as, despite mass unemployment, the middle-class population grew and encouraged by advertising, so did a culture of consumerism.[3]

While the telephone was both a product of booming industry and symbolic of modernity (offering new experiences of time and space) its adoption was slow. Several factors shaped this attitude, including a cultural aversion to the technology, its high tariff charges, and criticism of the Post Office in its management of the service.[4] This chapter will show how Dollis Hill and its research activities were represented by the Post Office as the antithesis of these criticisms, to defend the department's monopoly over communication services and build public trust. Important sources for this analysis are the representations of the Research Station in publicity materials which are explored in this chapter.[5]

Section 1.2 contextualises the position of the Post Office in the early 1930s to understand why Dollis Hill's image was being projected to the public at all. The first half, 1.2.1, traces how widespread criticism from the public, politicians and industry led to a government inquiry into the Post Office's management and organisation. Following the recommendations of the Bridgeman Committee, which called for greater

[3] Peter Scott, 'Marketing Mass Home Ownership and the Creation of the Modern Working-class Consumer in Inter-war Britain', *Business History*, 50.1 (2008), 4-25; Peter Scott and James Walker, 'Advertising, Promotion, and the Competitive Advantage of Interwar British Department Stores', *Economic History Review*, 63.4 (2010), 1105-28; Sue Bowden and Avner Offer, 'Household Appliances and the Use of Time: The United States and Britain Since the 1920s', *The Economic History Review, New Series*, 47.4 (1994), 725-748 (p. 743); Peter Gurney, 'Co-operation and the 'new consumerism' in interwar England', *Business History*, 56.6 (2012), 905-924; Roy Church, 'New Perspectives on the History of Products, Firms, Marketing, and Consumers in Britain and the United States Since the Mid-Nineteenth Century', *The Economic History Review, New Series*, 52.3 (1999), 405-435.

[4] Peter Scott, *The Market Makers: Creating Mass Markets for Consumer Durables in Inter-war Britain* (Oxford University Press, 2017).

[5] David Harvey, *The Condition of Postmodernity: an enquiry into the Origins of Cultural Change* (Oxford: Blackwell Publishers, 1990).

freedom for the Post Office from the Treasury to invest in new technologies, the department committed to change its negative image. Section 1.2.2 tracks the establishment of a Public Relations Department (PRD) by modernising Postmaster General, Kingsley Wood, which, under the pioneering leadership of Stephen Tallents, brought business marketing techniques into government for the first time. Keen to project the Post Office as an efficient, friendly and progressive organisation a nationwide publicity campaign was initiated which aimed to improve public image and encourage telephone use. The campaign used prestige, modernism, branding and revealed the hidden workings of the Post Office to achieve these goals.

In section 1.3, I show how despite being one of the less well-known parts of the Post Office, the Research Station and its activities became a central part of the department's publicity strategy by embodying many of the characterises the PRD was hoping to project. Through the official opening of the Research Station (more than a decade after it became operational) its representation in press reports, film, posters, and the promotion of new services and exhibitions, Dollis Hill and Post Office research were publicly projected as symbols of prestige. The Research Station was used to fulfil several Post Office ambitions; demonstrating modernity as a continuation of historic technological developments, showed the GPO's commitment to improving public services and saving money through cutting edge research, and built public trust by revealing behind the scenes of the government department. In section 1.3.6, I briefly discuss the success of the publicity campaign, showing that the number of telephone requests increased, but the Engineering Department struggled to meet demand.

Section 1.4 contrasts the way the reputation and image of the Research Station was used to shape public opinion with how it was used by managers in the Engineering Department to navigate professional networks, to gain patronage and further prestige. I emphasise the important role of Bertram Cohen, the Staff Engineer in charge of the Research Station, in promoting Dollis Hill by highlighting the cost benefit of research amidst the economic depression.[6] Also, nearing retirement, Cohen was keen to build

[6] See Appendix 3: Biographies of senior Post Office engineering staff and Appendix 4: Portraits of senior Post Office staff.

Dollis Hill's reputation to provide his own legacy.[7] Driven by the status of the Research Station, professionalisation became a priority with new research facilities, academic publications and further study prioritised for staff. The Research Station strengthened its role in national and international networks through collaborative transnational projects, undertaking contracted work for industry and defining global standards. Despite taking on some work to support the military services, during this period research at Dollis Hill was focused on meeting civilian services requirements. The impact of rearmament on the culture and management of the Research Station is discussed in Chapter 2.

1.2 Post Office goals and aims: from inefficient to forward-looking

By looking at the criticism of the Post Office and its plans for reform, this section will reveal the motivations behind the goals and aims of the department during this period and the means by which it hoped to achieve them. This understanding is necessary before exploring how the Research Station was used to further Post Office ambitions.

1.2.1 Reasons for reform

During the interwar period the Post Office became connected with the daily life of the nation in an increasing number of ways. It provided a wide range of services; some were directly relevant to the institution, such as telegraphs, banking and post, whilst for other services including the payment of pensions and issuing of new motor licences, it was considered the most convenient government machinery to deliver.[8] Despite the expansions of communication networks since the end of the First World War, including the installation of submarine telephone cables to Europe and the first transatlantic radiotelephone line in 1927 which connected Britain with 93% of the telephone subscribers in the world, and replacing open wire telephone lines with underground cables across the country, the Post Office's telephone service was heavily criticised by the public, politicians and in the press, accused of being underdeveloped

[7] Imperial War Museum (IWM): 18332, Flowers, Thomas Harold 'Tommy' (Oral History), 1998.

[8] *Committee of Enquiry on the Post Office, 1932*, Cmd. 4149, (London: HMSO, 1932), p. 4

and expensive.[9] Whereas other consumer items, such as cars and radios had become more affordable during the 1920s, telephone charges had not. By 1929, Britain had around 4.3 telephones per 100 of the population, a density which put the country tenth in the world.[10]

The Post Office was blamed for the slow uptake of the telephone but the underlying reason was the result of the decisions made by its funding department, the Treasury, who sought to constrain its development as part of a wider strategy to cut public expenditure. Treasury control meant that, like other government infrastructure, the telephone service had been severely underinvested in since the end of the First World War.[11] Whilst the Treasury understood the telephone had the potential to be a profitable service for the Post Office, it did not consider the necessary upfront costs a good investment. That decision was shaped by the Treasury's longstanding opinion that the telephone was a business device, not a public necessity, and therefore low priority for capital expenditure.

Public perception also had a role to play in the slow spread of the telephone. Unlike in other areas of the world, the British public did not see the telephone as an essential item and domestic subscribers used it sparingly, for short conversations or emergencies.[12] With high charges per minute, the telephone was a luxury for the wealthiest in society. In contrast, countries and regions with higher penetration, including the USA, Germany and Scandinavia, had invested more in their telephone service and had actively encouraged a broad access to the telephone which meant they had higher penetration.[13]

With monopoly control over the nation's telephones, the Post Office received criticisms from manufacturers of telecommunications equipment that the department

[9] Ibid., p. 14; Scott, *The Market Makers*, p. 291.

[10] Ibid.; PMA: POST 108/5 Telephone Publicity Committee, minutes of meetings held 1931-1944, 'Post Office Telephones, 1930'.

[11] Scott, *The Market Makers*, p. 289.

[12] *Committee of Enquiry on the Post Office, 1932*, p. 13.

[13] Peter Scott, 'Still a niche communications medium: The diffusion and used of the telephone system in interwar Britain', *Business History*, 53.6 (2011) 801-820 (p. 804).

was not doing enough to encourage the expansion of its business. Following pressure from the Telephone Development Association (a lobbying body of equipment manufacturers who had been critical of the Post Office's failure to promote the telephone service since its establishment in 1924) the Postmaster General, Clement Attlee, formed the Telephone Publicity Committee in June 1931.[14] The TPC's objective was,

> to increase the number of telephones in use and the amount of use made of each telephone; in other words, to make the people of this country telephone-minded. We need to get into people's minds the idea that the telephone saves time, trouble and money; that it is indispensable in business and invaluable in the home.[15]

The Committee included experts in marketing from across industry, including Sir Francis Goodenough, Controller of the Gas Light and Coke Company, Sir Stephen Tallents from the Empire Marketing Board and advertising tycoon Sir William Crawford.[16] Despite the high calibre of advisors, economic depression delayed the introduction of a significant campaign.[17]

Criticism of Britain's low telephone diffusion rate, high call charges and accusations of a poorly run service resulted in a memorandum signed by 320 Members of Parliament in December 1931 asking the Prime Minister, Ramsey MacDonald, to appoint a committee to inquire into the status and organisation of the Post Office.[18] The task was passed to the recently appointed Postmaster General Kingsley Wood, who established the Bridgeman Committee, under the Chairmanship of Lord Bridgeman, a former Conservative Home Secretary.[19] The most pressing question for the Bridgeman

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[14] Ibid., p. 805.

[15] PMA: POST 108/5 Memorandum by Sir William Crawford, 6 July 1931.

[16] Heller, 'The development of Integrated marketing communications', p. 1039; Scott Anthony, *Public Relations and the Making of Modern Britain* (Manchester: Manchester University Press, 2012), p. 38.

[17] Howard Robinson, *The British Post Office: A History* (Princeton; Oxford: Princeton University Press, 1948).

[18] Campbell-Smith, p. 293

[19] G. C. Peden, 'Wood, Sir (Howard) Kingsley (1881-1943)', *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2011) <https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-37002> [accessed 5 Jan 2020].

Committee was whether the Post Office should continue to be treated as a government department under ministerial control or a large-scale business, driven by commercial considerations without government intervention, like American Telephone and Telegraph Company (AT&T) in the United States. There was no consensus on what changes should be made. Some MPs argued that the Post Office should be turned into a Public Utility Corporation, while others suggested a model like the Electricity Commission or British Broadcasting Corporation (BBC). The latter was endorsed by the BBC's Director General, John Reith, who argued that any public service should be removed from political control.[20] The Bridgeman Committee also reviewed the financial arrangement between the Post Office and the Treasury in which the Exchequer retained the whole of the Post Office's surplus and dealt with it as part of the national income.[21] MPs were concerned that this was hampering progress, preventing the Post Office from investing in new developments and undertaking long-term research to improve its services.[22]

Wood, who was against drastic reform of the Post Office, was relieved that his opinions aligned with findings of the Bridgeman Committee which concluded the root cause of the department's troubles was its direct financial dependence on the Treasury and over-centralisation of the administration.[23] The Committee argued against transferring the post, telephone or telegraph services into an independent corporation or public utility but did recommend giving the department greater freedom from the Exchequer. After some debate, the Government accepted these changes which were implemented throughout the decade. Instead of handing over its gross revenue, the Post Office Finance Act 1933 introduced a fixed annual contribution of £10.75m and half of any surplus over that amount to the Treasury.[24] The other half was retained by the Post Office in a separate fund which the department could use at its own discretion to invest in new services and research. However, the Post Office Fund, as it

[20] Ibid., p. 298.

[21] Crutchley, *GPO*, p. 220.

[22] *Committee of Enquiry on the Post Office, 1932*, p. 7; Campbell-Smith, p. 304.

[23] Ibid., p. 40.

[24] *Finance Act 1933*. (London: HMSO, 1933), http://www.legislation.gov.uk/ukpga/Geo5/23-24/19/enacted website [accessed 22 March 2020].

became known, was used to maintain the annual payment to the Treasury, so fluctuated depending on business.

Despite the aim to increase the Post Office's freedom, this was limited as large-scale capital expenditure still required Treasury approval. A Post Office Board was established to manage Post Office business under the chairmanship of the Postmaster General, with representatives from each sub-department. In 1934 a Director General role was created to ensure Board decisions made were implemented and provide continuity when the Postmaster General changed.[25] Furthermore, the launch of an active marketing policy to restore the public image of the Post Office and to encourage use of its services was a significant consequence of the Bridgeman Report.[26] It is during this time that we see Dollis Hill and its research activities pushed to the fore as the Post Office tried to change its much-maligned public image.

1.2.2 Changing the public image

Kingsley Wood was the force behind Post Office modernisation and was committed to improving the department's public reputation. Wood took a commercial approach and relaunched the Public Relations Department (PRD) which, unlike the TPC, had the expanded remit of being responsible for promoting all Post Office services. In 1933, Wood hired Stephen Tallents as Controller of Public Relations to oversee this revitalised department, a new role on the Post Office Board and the first in a government department.[27] Tallents was ideal for the Post Office after establishing his reputation as a pioneer of public relations as Secretary of the Empire Marketing Board (EMB). Founded in 1926 by the Dominions Office, the EMB promoted research into Empire food and production, marketed supplies and publicised imperial goods.[28] Tallents moved to the Post Office following the Treasury's decision to disband the EMB

[25] Peden, 'Wood, Sir (Howard) Kingsley'; See Appendix 5: Organisation of Post Office Headquarters, 1934.

[26] Crutchley, p. 200.

[27] Scott Anthony, *Public Relations*, p.101.

[28] Jonathan Woodham, 'Images of Africa and Design at the British Empire Exhibition between the Wars', *Journal of Design History*, 2.1 (1989), 15-33 (p. 21).

with the introduction of imperial preference tariffs.[29] Under Tallents' guidance the EMB adopted marketing techniques developed by commercial industry for public information messaging. This included posters, exhibitions and broadcasts, encouraging the public to buy Empire products.[30]

The PRD used many of the same promotional methods Tallents had developed at the EMB, but on a much greater scale. It also adopted advertising techniques which had developed alongside growing consumerism, designed to reflect consumer desires as well as shape them.[31] The primary aim of the PRD was to build good will with the public, as Tallents put it 'to make the Post Office 'alive' to the public; to present it as a National Institution – modern, up-to-date, in close touch with the community and inspired with a desire to serve'.[32] Gaining public support was also important in maintaining good relations with the Treasury, who still had power over the Post Office, despite changes to the funding model.[33] Selling services, like the telephone, was a secondary objective. In order to facilitate both, the PRD introduced two types of advertising. It was the first organisation to separate prestige advertising from selling advertising.[34] Prestige activities included redesigning interiors of public branches, updating stationery styles and commissioning a new logo from MacDonald Gill.[35] Gill was one of many contemporary artists and designers commissioned to produce

[29] Robert Self, 'Treasury Control and the Empire Marketing Board, The Rise and Fall of Non-Tariff Preference in Britain, 1924-1933', *Twentieth century British history*, 5.2 (1994), 153-182 (p. 172); Campbell-Smith, p. 305.

[30] Woodham, 'Images of Africa and Design', p.22; Tom Hulme, ''A Nation of Town Criers': Civic Publicity and Historical Pageantry in Interwar Britain', *Urban History*, 44.2 (2017), 270-292 (p. 276).

[31] Michael French, 'Modernity in British advertising: Selling Cocoa and Chocolate in the 1930s', *Journal of Historical Research in Marketing*, 9.4 (2017) 451-466 (p. 451); Robert Fitzgerald, 'Products, Firms and Consumption: Cadbury and the Development of Marketing, 1900-1939', *Business History*, 47.4 (2005), 511-531 (p. 524); John Hewitt, 'The 'Nature' and 'Art' of Shell Advertising in the Early 1930s', *Journal of Design History*, 5.2 (1992) 131-139 (p. 124).

[32] BTA: POST 33/4812 Sales Conference proceedings, 4-5 July 1934, Sir Stephen Tallents, 'The Post Office Publicity Programme'.

[33] Heller, 'The development of integrated marketing communications', p. 1040.

[34] Ibid., p. 1035.

[35] Campbell-Smith, p. 306.

striking, modern publicity material, a technique which had been used by the EMB, London Underground and Shell-Mex Ltd.[36]

The publicity strategy also focused on improving relations inside the Post Office and boosting staff morale. In March 1934, Post Office *Green Papers* were released to internally communicate the changes and progress made across its services.[37] The same year the more informal *Post Office Magazine* was launched giving 'the individual Post Office servant a sense of the larger activities of which his personal work was a part'.[38] Content included articles, notices, poems and illustrations submitted by Post Office staff. The idea of a magazine was borrowed from large commercial firms, who had introduced company magazines in the late-nineteenth century and by the 1930s were a familiar features, used to shape corporate identity and organisational culture.[39] These included Unilever, which had started an in-house magazine in the late nineteenth century, and railway companies, such as the Great Western and Southern, which had been publishing from the early twentieth century.[40] The *Post Office Magazine* was also sold to the public, in Post Office shops and at exhibitions, a strategy which accounted for 10% of its commercial sales.[41]

In response to previous criticism the PRD directed activities to encourage people to apply for the telephone. One of the first and most significant publicity drives was the 'Come on the Phone' campaign. It started in 1933 and culminated in a national 'Telephone Week' in October 1934. This celebrated the reduction of telephone rates and the introduction of a new range of coloured hand microphone sets. Like the earlier objective of the TPC, this campaign was designed to make the public more 'telephone minded' and borrowed from the model of the EMB's 1931 'Buy British' campaign.

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[36] Woodham, 'Images of Africa and Design', p. 21; Barnes, 'Ringing Another Empire Alive?', p. 65.

[37] PMA: POST 92 The Post Office Green Papers, 47 volumes released between 1934 and 1939.

[38] PMA: POST 33/5699 - 'Public Relations Committee Notes form the Reviews of the Tallents (1935) and Crutchley (1936) meetings', S. Tallents, 'Report of Committee of Enquiry into Post Office publicity, 1935'.

[39] Michael Heller, 'British Company Magazines, 1878-1939: the origins and functions of house journals in large-scale organisations', *Media History*, 15.2 (2009), 143-166 (p. 143).

[40] Kevin Ruck and Heather Yaxley, 'Tracking the rise and rise of internal communication from the 1980s', *Conference: International History of Public Relations Conferences*, (2013), 1-19 (p. 4).

[41] Suga Ida, 'Image Politics of the State', p. 132.

Publicity was designed to target all ages and genders and to advertise telephones as more than a business tool. Everyone was considered a possible or, in the case of children, a future customer. This was achieved through 'pop-up' shops in London and across the regions attracting tens of thousands of visitors, 270,000 posters were produced and a special film was shown in over 745 cinemas across the country (Figure 3 below).[42]

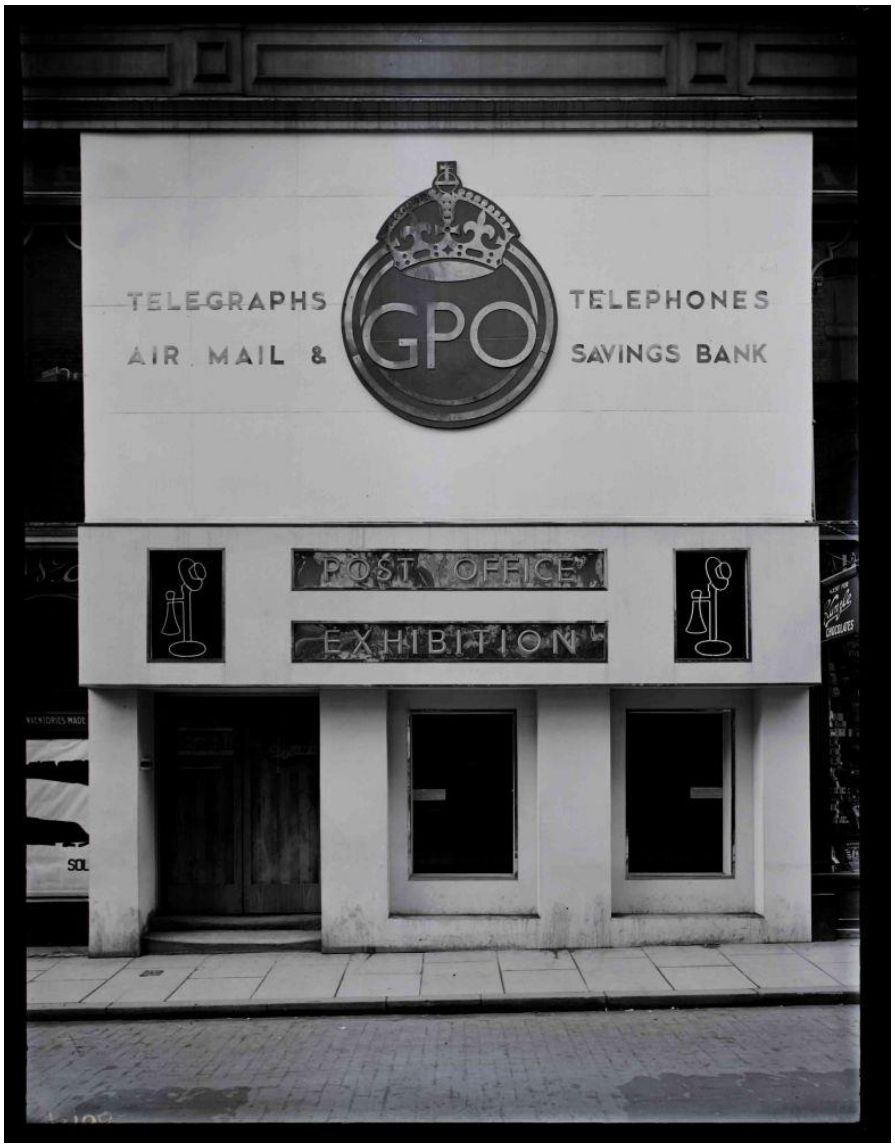

Figure 3 Post Office publicity shop and exhibition, Scarborough, showing MacDonald Gill new GPO logo, 9 October 1934.[43]

[42] PMA: POST 108/5 Minutes of the 22nd meeting of the Publicity Committee, 4 October 1934; Anthony, *Public Relations*, p. 103.

[43] BTA:: TCB 417/E 9069, Scarborough publicity shop, 9 October 1934

With much of the Post Office's telephone service hidden from view, the PRD chose to use highly visible artefacts to present as icons of the invisible infrastructure. Reflecting an appetite for public spectacle, *Monarch* (the largest cable ship in the world owned by the Post Office) was moored on the Thames for the first time. At the inauguration, London's Lord Mayor told Kingsley Wood that the ship would 'give a great many Londoners a new conception of the remarkable organisation behind the scenes on which the telephone service depends'.[44] The campaign was considered a major success generating over 7,000 newspaper column inches and thousands of telephone orders.[45] Not only did the 'Come on the Phone' campaign generate sales it also associated the telephone (and thereby the Post Office) as an instrument of modernity, a device which was shaped by scientific research, collapsed time and space, and a necessary instrument for the modern home. The following sections show how 'research' became an established feature of the Post Office's publicity, used to project a modern organisation at the forefront of science, for both commercial and reputational gain.

1.3 Research Station and Public Relations

In this section I show how, having many characteristics which the wider Post Office wanted to project, the Research Station became a central part of the PRD's publicity strategy. Dollis Hill could show the scale of the unseen work that went into technologies of the Post Office services, to challenge views of government departments as inefficient. Outputs from the Research Station promised to reduce costs and provide better services, countering criticism that Post Office services were underdeveloped and expensive. Research at the site already had the attributes of being forward looking, progressive and modern, all the features the publicity campaign was seeking to align with the Post Office.

[44] 'Telephone Week Inaugurated, 1934' (Pathé newsreels, 1934), British Pathé < https://www.britishpathe.com/video/telephone-week-inaugurated/query/telephone+week+inaugurated> [accessed 5 February 2020].

[45] PMA: POST 108/5, Minutes of the 23rd meeting of the Publicity Committee, 19 November 1934.

1.3.1 The official opening of the Research Station

The Post Office Research Station, Dollis Hill, was formally opened by the Prime Minister Ramsey MacDonald on the 23 October 1933 with additional speeches from Wood and Bertram Cohen (the Staff Engineer in charge of the site). This was an interesting time to host a grand opening considering that the site had been staffed since 1921 and already had an international reputation. Whilst plans for a permanent Research Station had been agreed in 1924 and although several buildings had been constructed the site was not complete by the time of its official opening. The External Plant, Tea Room and Plating and Spraying Blocks were outstanding, and staff were still working in converted ex-army huts. Justification for the timing of this event does not survive in the archives, but in the context of contemporary public relations activities the Post Office was pursuing, it seems likely that this was part of the wider strategy connected to the 'Come on the Phone' campaign launched earlier that year. This is further evidenced in the speeches as MacDonald incorrectly claimed that Wood was responsible for the realisation of the Research Station, omitting Dollis Hill's longer history (Figure 4 below).[46]

[46] BTA: TCB 211/20 Extracts from newspapers, 1933: Randolph Churchill, 'New P.O. Research Palace Opened', *Daily Mail* (24 October 1933).

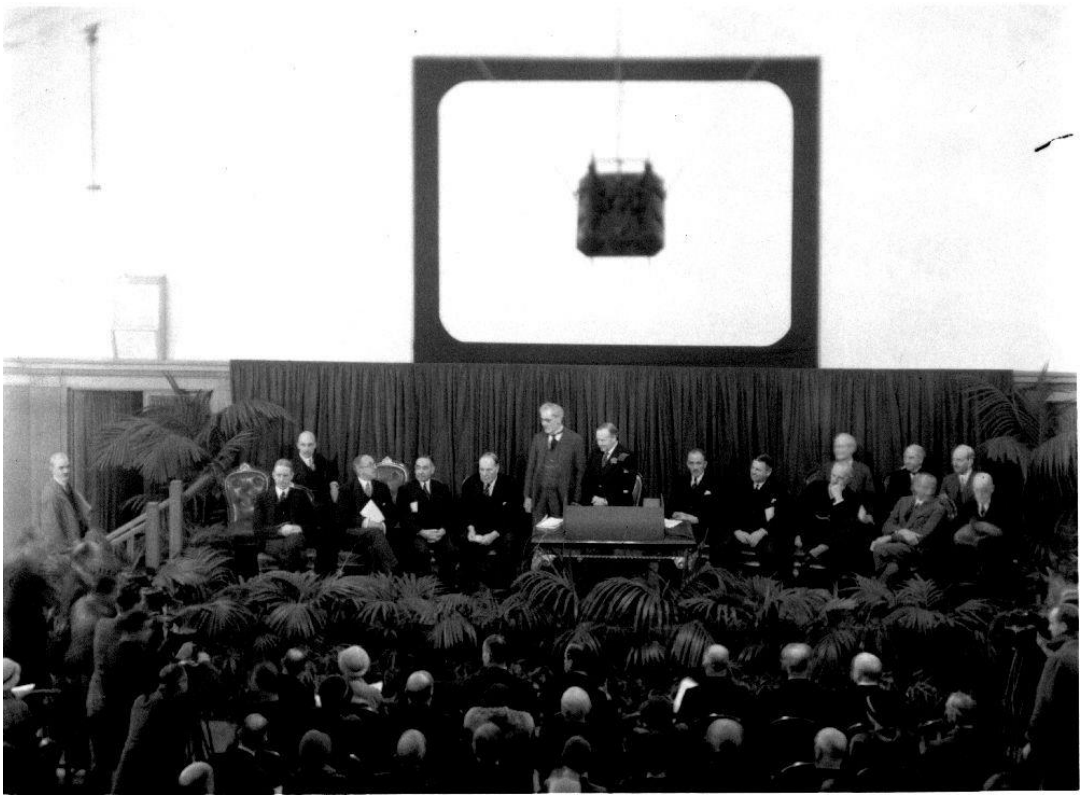

Figure 4 Research Station opening ceremony in the lecture hall, Dollis Hill, 1933.[47]

With the Research Station largely unknown to the public before this, the opening represented an opportunity for the Post Office to reframe its image. As a site of technological and scientific activities, Dollis Hill spoke to several narratives the PRD wanted to project: a site of prestige, forward looking and modern. Displays of staff diligently undertaking research were used to illustrate the department's commitment to improving services and making systems more efficient. This was directly referenced in MacDonald's speech 'some… might be affected by the erroneous belief that a Government department was always a slack affair. He hoped before they left that building that idea would have been killed'.[48]

The opening was an occasion for MacDonald to use a technological establishment to promote the government and Britain at a time of serious economic issues and mass

[47] BTA: TCE 361/ARC 341 Opening of Dollis Hill Research Station, London, Prime Minister Ramsay MacDonald standing, 22 October 1933.

[48] Ibid., 'Post Office Research', *Times*, (24 October 1933).

unemployment.[49] This was part of a wider strategy of aligning himself with celebrations of sciences. For example, he attended the Michael Faraday centenary celebrations in 1931, an event, which, as Frank James has shown, attached Faraday iconography to contemporary priorities.[50] MacDonald also visited the Fuel Research Station in 1935 where he shared hopes that new uses for coal would support jobs in the depressed areas.[51] The Research Station could be used to evidence his personal views that industrial research was a means of raising the standard of living for the whole nation.[52] In his youth MacDonald had shown an interest in science and technology and having studied at Birkbeck Literary and Scientific Institution he had contemplated a scientific career.[53]

At the opening of the Research Station seventy-seven exhibits were displayed to show the breadth of the research undertaken at Dollis Hill and the productivity of the Post Office.[54] The centrepiece was the telephone and the exhibit showed how it worked, its composition of components and its materials, and rigorous testing measures. The life-testing laboratory was used to promote the durability of Post Office products, illustrating Dollis Hill's commitment to perfecting equipment and advertising them as sensible investments, worth their high initial cost. Presentations from the Training School showed the rigorous training which Post Office engineers received in the maintenance of exchanges and overhead cables.

Over 600 guests were invited from industry, universities and government. The list of attendees provides an insight into the networks the Post Office engineering department were part of and the reputation of technological research in the Post Office. The guests included the Chairman of the General Electric Company, the

[49] Richard Arman Gregory, 'James Ramsey MacDonald, 1866-1937', *Obituary Notices Fellow Royal Society Obituary Notices*, 2 (January 1939), 475-482.

[50] Frank James, 'The Janus face of modernity: Michael Faraday in the twentieth century', *BJHS*, 41.4 (2008), 477-516.

[51] 'News in a Nutshell, Mr MacDonald at Greenwich Fuel Research Station, 1935' (Pathé newsreels, 1935), British Pathé <https://www.britishpathe.com/video/news-in-a-nutshell-aka-mr-macdonald-at-greenwich/query/research+station> [accessed 15 Feb 2020].

[52] Gregory, 'James Ramsey MacDonald', pp. 475-482.

[53] Ibid.

[54] BTA: Undocumented File, Dollis Hill Opening Booklet, 1933.

President of the Institution of Civil Engineers, the Director of NPL and the Chairman of the BBC.[55] The prestige of the guest list and the pageantry of the event ensured press attendance, the vehicle by which Post Office messages were communicated to the public. To the Post Office's advantage in obtaining press attention was the emergence of scientific journalism as a distinct profession, reflecting an appetite for media platforms to report on scientific feats and inventions.[56]

The opening resulted in a 'good deal' of newspaper and newsreel publicity, shown in cinemas.[57] A review of press coverage around the opening shows that the Research Station was described in ways that supported the Post Office's objectives, in terms of its spectacle, its commitment to perfecting the telephone and the financial investment made towards improving the public service. Examples include *The News Chronicle* which described Dollis Hill as 'home of the bright young scientists and inventors who spend their days bending over delicate machinery devised to bring every department of the GPO up to date'.[58] The *Daily Mail*'s report on the event had the title ,'New P.O. Research Palace Opened, Best in the World, Millions Saved'.[59]

Press reports often highlighted features that reflected concepts of modernity, in which normal perspectives of time and space were manipulated. This included anechoic laboratories where the human voice was analysed; equipment that howled at telephone receivers subjecting equipment to years of use in weeks; artificial fogs created in cabinets for testing metals in different environments; and models of telegraph poles which were subjected to artificial lightning.[60] For example, the *Daily Mirror* ran a headline that said 'Time Really Flies at the G.P.O.! Where 10 Years Pass in 10 Weeks', and its reporter described these 'eerie' environments. Another claimed:

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[55] BTA: TCB 211/20 *Willesden Chronicle*, 27 October 1933.

[56] Jeff Hughes, 'Insects or neutrons? Science news values in interwar Britain', in *Journalism, Science and Society: Science Communication Between News and Public Relations* ed. by Martin Bauer and Massimiano Bucchi (London: Routledge, 2008), pp. 11-20 (p. 11).

[57] PMA: POST 108/5 General Publicity Progress Report, 16 November 1933.

[58] BTA: TCB 211/21 'Room Lined with Cotton Wool: Scientists of the GPO', *News Chronicle*, (16 October 1933).

[59] Ibid., Randolph Churchill, 'New P.O. Research Palace Opened', *Daily Mail*, (24 October 1933)

[60] Ibid., 'Room Lined with Cotton Wool: Scientists of the GPO', *News Chronicle*, (16 October 1933).

'Einstein should develop a new theory about this building, for in many of the rooms present time is non-existent'.[61]

Such press attention did not feature the names of Research Station employees apart from Bertram Cohen instead, staff were described as a mass of anonymous experts, working tirelessly to perfect the telephone. This description supported Post Office aims, showing the dedication of its employees to improve the public service. This reflected an interwar period shift from scientific enquiry being understood as the act of a lone inventor to one of large scale, collective activity.[62] Inspired by the phrases above the Main Research Building doors a 1935 report on the Station described the engravings as 'a fine motto and perhaps we can pay no finer compliment to the two hundred workers there than to say that they are living up to it'.[63] Another report referred to the Station as 'a colony of workers tirelessly experimenting'.[64] Despite not receiving attention publicly, Dollis Hill's staff were active in widening professional and academic networks.

Many newspaper articles close with an economic justification for the Station's research, listing large sums of money that this work had saved the country. These figures are likely to have been disseminated by the Post Office and served to justify the construction and expansion of a research station during a time of economic crisis. Investment in the Research Station was reported on as finances well spent: the *Manchester Guardian* highlighted 'four successful bits of research brought about an annual saving of £190,000'. The *Sunday Express* reported the same figure, pairing it with the £150,000 annual cost to run Dollis Hill which, according to the journalist, demonstrated 'the value of the research work at the station'.[65] A *Daily Herald* reporter concluded 'I left Dollis Hill with the feeling that the Post Office is lucky in its enthusiasm and I also felt slightly less depressed by the thought that possibly a little of

[61] Ibid., Special Correspondent, 'Time Really Flies at the GPO', *Daily Mirror,* (24 October 1933).

[62] Marcel LaFollette, *Making Science our Own: Public Images of Science, 1910-1955* (Chicago: University of Chicago Press, 1990), p. 120.

[63] Callisthenes, 'Post Office Research', *The Times*, (30 July 1935).

[64] 'Speeding up Trunk Calls', *Daily Mail*, (26 July 1935), p. 7.

[65] BTA: TCB 211/21, Anon., 'Premier to see wonders of the G.P.O.', *Sunday Express*, (22 October 1933).

one's income tax trickles into this endeavour, which at least does something to show for it'.[66] The Post Office's aim to present economic advantage and research excellence through the opening ceremony had succeeded in influencing the popular press. I will explore the impact on the public in 1.3.6.

1.3.2 Posters

More than any other medium, posters captured and projected Post Office modernity. Working with contemporary artists such as Vanessa Bell and Pat Keely, the Post Office commissioned hundreds of designs over the 1930s. The Post Office followed several companies, including the 'Big Four' railway companies, Shell-Mex and BP, in adopting the medium to promote activities.[67] Tallents had commissioned artists to design posters for the Empire Marketing Board and Frank Pick used them to modernise the London Underground. The Post Office took advice from a Poster Committee, established to recommend suitable artists in 1931 as part of the first wave of publicity.[68] This high-powered group included Kenneth Clark, Director of the National Gallery and Keeper of the King's Pictures; Clive Bell, the well-known writer on art and literature and husband of Vanessa and J. L. Beddington, Publicity Officer for Shell-Mex. The EMB had similarly brought together experts from public and private spheres to advise on publicity design.

Posters were divided into two main classes: selling/advertising posters and prestige posters. The former targeted the Post Office services, facilities and rate reductions. The latter were intended for the decoration of public and private Post Office offices. In 1934, posters were specifically designed to appeal to schools, covering themes about the history and development of communications. Educational material was a vehicle to bring the Post Office brand into the classroom. The initial distribution of these posters came from the list of 25,000 schools that were previously served by the EMB scheme

[66] BTA: TCB 211/20 H. V. Morton, 'H. V. Morton Discovers the C.I.D. of the G.P.O.', *Daily Herald*, (13 January 1933).

[67] Paul Rennie, *GPO: Design Posters* (Suffolk: ACC Art Books, 2011), p.7.

[68] PMA: POST 33/5253, Post Office service publicity: poster work, 1934-1938, Col. Crutchley to Director General, 15 October 1937.

and other schools were invited to apply.[69] By January 1937, 28,000 schools were receiving posters sets, representing around 75% of the total number of elementary, primary and secondary schools in the United Kingdom.[70] Schools could also apply for a telephone demonstration set, which explained how it worked and how to use it in an attempt to make children more 'telephone minded' and encourage their future custom.[71] These were designed by the engineers at Dollis Hill and produced by the Telephone Branch. By March 1933, 120 sets were in circulation.[72]

The Post Office Research Station appeared in series of prestige posters released in 1937, the first set to depict Post Office buildings.[73] The Poster Advisory Group commissioned Fred Taylor, a designer specialising in architectural scenes, whose unique style was a familiar feature of London North Eastern Railway and London Underground advertising.[74] The coloured poster (Figure 5, seen in monochrome below) shows a serene scene of the front of the Main Research Building completed four years prior, with three smartly dressed men and a car by the entrance. This may have been familiar to some of the public as the design reflects a similar view which appeared in photographs in newspapers. The poster was part one of a set of four showing different Post Office locations each by a different artist. The other three were 'Mount Pleasant Packet Sorting Machine' by Michael Ross, 'Rugby Wireless Station' by Norman Howard and a 'Coast Wireless Station' by Graham Sutherland. Each poster shared a view of the Post Office normally hidden from public view. This appears to be a specific marketing strategy to make the Post Office come alive to the public by showing unfamiliar

[69] PMA: POST 108/6 Post Office Publicity Committee, minutes of meetings held 1934, PC/14 Post Office Publicity Committee General Publicity: Progress Report, 11. General Posters 3 March 1934.

[70] PMA: POST 108/9 Post Office Publicity Committee, minutes of meetings held 1936-1937, PC/123 19 January 1937 Progress Report; in 1935 there were 35,966 elementary, primary and secondary schools in the UK, Paul Bolton, 'Education: Historical statistics, Standard Note: SN/SG/4252', *House of Commons Library*, (2012) 1-20 (pp. 15-16) <www.parliament.uk/briefing-papers/sn04252.pdf> [accessed 10 April 2020]

[71] PMA: POST 92/1502 The Post Office Green Papers. Number 8: Public Office Publicity, Stephen Tallents, p. 21.

[72] PMA: POST 108/5 Minutes of the 11tt meeting of the Publicity Committee, 16 February 1933; Ibid. Minutes of the 12th meeting of the Publicity Committee, 30 March 1933.

[73] PMA: POST 33/5253, Post Office service publicity: poster work, 1934-1938, minutes of the 11th meeting of the Poster Advisory Group, 23 September 1937.

[74] Beverley Cole and Richard Durack*, Railway Posters 1923-1947: From the Collection of the National Railway Museum* (London: Laurence King Publishing, 1992), p. 16.

environments, revealing the variety of work that went on behind the scenes. Another example is the poster entitled 'Submarine Cable' designed by Rosemary and Clifford Ellis which shows a repaired cable being lowered to the seabed.

Figure 5 'Post Office Engineering Research Station, London', Fred Taylor, 1934, GPO poster.[75]

With the aim of presenting a more personal Post Office, posters of industrial settings often included people. This is seen in 'International Telephone Exchange' by John Cooper, depicting rows of telephonists managing calls. Another piece by Cooper, 'Wireless Station at Rugby', shows a Post Office engineer working in a modern setting, a man in a white coat attending technical equipment. This type of imagery was familiar in America at the time, as popular culture increasingly linked social progress to science.[76] Scientists were stereotyped as men in white coats and the image commonly appeared in adverts for scientific products in popular magazines.[77] Figure 6 shows a

[75] BTA: TCB 437/P 2424, *Post Office Engineering Research Station, London', Fred Taylor, 1934*PRD Poster 217 (in monochrome).

[76] Marcel LaFollette, *Making Science our Own: Public Images of Science, 1910-1955* (Chicago: University of Chicago Press, 1990), p. 112.

[77] Ibid., p. 75.

1930s AT&T advert utilising the same image of engineers diligently attending equipment with the caption 'the steady scientific progress of the Bell Laboratories shows in the ever-increasing quality and scope of your telephone service'.[78]

THE STEADY SCIENTIFIC PROGRESS OF THE BELL LABORATORIES SHOWS IN THE EVER-INCREASING QUALITY AND SCOPE OF YOUR TELEPHONE SERVICE

To clear all barriers for the human voice

An Advertisement of the American Telephone and Telegraph Company

BELL TELEPHONE LABORATORIES, Incorporated, is the scene of a progressive conquest of natural forces that aims to let you speak clearly, quickly and cheaply to any one, anywhere in the land and even to distant countries. More than 5000 scientists and assistants are busy there and elsewhere in the Bell System studying the problems of sound transmission. Its work is the growing foundation of the telephone art; and it has, besides, helped to make possible the radio, sound pictures and special apparatus for the medical profession.

Among its achievements are the underground cables which make city telephone service possible, better and faster long distance service, service to ships at sea, and to millions of telephones beyond the seas. The steady scientific progress of the Bell Laboratories shows in the ever-increasing quality and scope of your telephone service. Its new developments in every type of equipment clarify and speed up your telephone talks and give you more and better service at low rates. Every advance it makes is available throughout the Bell System.

The Bell System is an American institution owned by more than 500,000 stockholders. It places before you the benefits of its technical achievements and the coordinated efforts of more than 400,000 trained workers. It accepts its responsibility to further the development and welfare of the nation by furnishing the public the best of telephone service at the least cost consistent with financial safety.

Figure 6 Bell Laboratories advertising AT&T Co. c. 1930s.[79]

[78] 'Bell Laboratories are the subject of this 1930s ad.' Dennis Markham's Classic Rotary Phones <http://www.classicrotaryphones.com/ad_bell-barriers-1930_big.jpg> [accessed 14 March 2020]

[79] Bell Laboratories are the subject of this 1930s ad.' Dennis Markham's Classic Rotary Phones <http://www.classicrotaryphones.com/ad_bell-barriers-1930_big.jpg> [accessed 14 March 2020]

The Post Office represented itself as part of a longer history of technical development, presenting the department as a continuous extension of social good and using the projection of continuity to justify its modernity.[80] This publicity technique was also used by the electricity industry: scientists and engineers in the interwar period promoted electrification in a manner which Frank James describes as 'Janus-faced'.[81] Historical progression was communicated through sets of posters, which acted as a storyboard. This is seen clearly in the first set of pictorial posters by John Armstrong showing the historical progress of postal delivery and released in 1935.[82]

John Armstrong's series (Figure 7 below) presents the Post Office as the modern-day incarnation of Pheidippides, the legendary ancient Greek runner who delivered the news of the Greeks victory over Persia in the Battle of Marathon. This affiliation is continued in the next two posters of 'The King's Messenger, 1482' used by Edward IV in the Anglo-Scottish war and of the first Post Office Mail Coach from 1784.[83] The final image in the series is called 'Royal Mail 1935' and shows a figure riding a motorbike zooming past a scene of houses and a mail box. This form of boosterism was common in the interwar period with a resurgence of pageantry, a form of historical celebration which became popular in the Edwardian period, and increased focus on civic promotion.[84] Erin Beeston has shown how, following the amalgamation of the private railways into four large companies in 1923, the 'Big Four' were quick to use public displays and pageantry to construct a narrative of their role in the history of railway progress.[85]

[80] Rennie, *GPO: Design Posters*, p.18; Suga Ida. 'Image Politics and the State', p. 116-117.

[81] Frank James, 'Presidential address, The Janus face of modernity: Michael Faraday in the twentieth century', *BSHS*, 41.4 (2008), 477-516 (p. 477, p. 513).

[82] PMA: POST 108/7 Post Office Publicity Committee, minutes of meeting held in 1935, PC/70 - PO Publicity Committee General Publicity Progress Report, 4 March.1935.

[83] Jiazhu Hu, 'Messengers in Later Medieval England' (unpublished PhD thesis, University of St. Andrews, 2017), p. 24.

[84] Hulme, ''A Nation of Town Criers'', p. 276.

[85] Erin Beeston, 'Spaces of Industrial Heritage: a history of uses, perceptions and the re-making of Liverpool Road Station, Manchester' (unpublished PhD thesis, University of Manchester, 2020), p. 74 and 78.

Figure 7 Series of four Post Office posters by John Armstrong, 1935.[86]

The PRD associated the Post Office with efficiency and progression through images of science and technology. Providing striking and unfamiliar sights, Dollis Hill and the research activities of the wider Post Office were used to show a forward looking, efficient and modern department to audiences across the country, enabled through the widespread poster campaign. Unusual and surprising images of research activities appeared across other mediums as demonstrated in the next sections.

[86] PMA: clockwise from top left: POST 109/171. Pheidippides 490 B.C., POST 110/2484 The King's Messenger A.D. 1482, POST 120/4130 Mail Coach A.D. 1784, POST 110/2486 Royal Mail A.D. 1935, posters by John Armstrong, 1935.

1.3.3 Research on film

By the 1930s film had become a mass medium and an ideal method of communicating government messages and advertising goods. During the interwar period the cinema became an important leisure activity and attracted audiences from across society. Films were projected as part of a continuous programme, including news reel, advertising, featurettes and feature documentaries.[87] Two thousand new cinemas were built between 1926 and 1939 and the number of weekly attendees increased from 17.4 million in 1934 to 19 million in 1939.[88]

Film became an important and well-funded part of Post Office public relations. When Tallents joined the Post Office in 1933 he brought the EMB Film Unit with him, renamed the GPO Film Unit under the control of John Grierson. Grierson, recognised by contemporaries as a pioneer of documentary film making, brought with him the desire to make public information films distinct from propaganda. [89] Tallents ensured that Grierson was protected from political scrutiny and received generous financial backing through his relationship with Kingsley Wood. [90] By 1939 the GPO Unit had produced more than thirty films, some of which were external commissions by organisations such as the BBC and the Ministry of Labour. From 1935, the Unit focused on Post Office subjects including the air mail service and stamps.[91] The central message was that the Post Office brought the nation together through modern communications, science and committed staff.

Timothy Boon has written about the rise of scientific documentary film in the interwar period and the GPO Film Unit. He argues that film was the perfect medium to capture

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[87] Ellen Reay, 'Glamour and comfort: Cinemagoing in the 1920s and 1930s', *Independent Cinema Office*, online https://www.independentcinemaoffice.org.uk/glamour-and-comfort-cinemagoing-in-the-1920s-and-1930s/, [accessed 14 April 2020]

[88] Laura Beers, 'Education or manipulation? Labour, Democracy and the Popular Press in Interwar Britain', *Journal of British Studies*, 48.1 (2009), 129-152 (p. 130); Peter Miskell, 'Seduced by the Silver Screen: Film Addicts, Critics and Cinema Regulation in Britain in the 1930s and 1940s', *Business History*, 47.3 (2005), 433-448 (p. 436).

[89] Anthony, 'An introduction to the GPO Film Unit', p. 4.

[90] Ibid., p. 6.

[91] Paul Swann, 'John Grierson and the GPO Film Unit, 1933-1939', *Historical Journal of Film, Radio and Television*, 3.1 (2006) 19-34 (p. 25).

the growing industry of applied science.[92] This is reflected in the Unit's first film 'The Coming of the Dial' showing the development of the automatic telephone exchange, from the Research Station experiments to telephonists being replaced by switching equipment. The fourteen-minute film starts with a voiceover, framing staff at Dollis Hill as the force behind Post Office modernisation, aligned with other types of industrial scientists:

> Research, the creative power behind the modern world, building the future in the laboratory. The industrial chemist, determining a carbon percentage for a safety steel; the physicist, analysing colour light-rays for signal lenses; the plant breeder, pollinating selected grasses for mountain pastures: these men are applying the laws of science to everyday problems, and research into the behaviour of electromagnets has revolutionised the telephone system and introduced the dial. In the laboratories of Dollis Hill, they are testing specimen telephones for the dial system.[93]

This is narrated over a scene of abstract shapes, mirrors and shadows produced by one of Laszlo Moholy-Nagy's kinetic sculptures. Moholy-Nagy's involvement in the film shows that the GPO Film Unit was engaging with wider discussions about the role of art and science in shaping the modern world, encouraged by figures such as crystallographer J. D. Bernal and constructivist artist Naum Gabo.[94] However, it is unlikely this was appreciated by the target audiences of this and other GPO films as most were sent to schools or displayed at exhibitions rather than distributed at cinemas. This might have been due to the cost of cinema advertising, or the lengths of the films which sometimes ran to thirty minutes.

The Research Station provided the backdrop to a film that was distributed in cinemas made by Pathé News for newsreel. Recorded in 1932, "Treating 'em Rough!' shows several life-testing devices in use by Dollis Hill staff. This type of work was the Post

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[92] Timothy Boon, 'Old Industry, New Science? The GPO Film Unit Between Palaeotechnology and Neotechnology', in *The Projection of Britain. A History of the GPO Film Unit*, ed. by Scott Anthony and James Mansell (London: British Film Institute, 2011), (pp. 28-35) p 31.

[93] BTA: FILM/1188, *The Coming of the Dial*, dir. by Stuart Legg (GPO Film Unit, 1933), https://bt.kuluvalley.com/view/IpB2QHdGcri#/.

[94] Ben Nicholson, Naum Gabo and John Lesile, ed. *Circle: International Survey of Constructivist Art* (London: Faber & Faber, 1937); Ian Blatchford and Tilly Blyth, *The Art of Innovation: From Enlightenment to Dark Matter* (London: Bantam Press, 2019), p. 193.

Office's most obvious use of research to promote its products, demonstrating the care and commitment of its staff to develop the best equipment for the public. One testing device, 'Galloping Gus' features in the newsreel film dropping a telephone receiver multiple times to replicate the misuse of the handset and to test the magnets inside after impact. This piece of equipment, named after the galloping-horse-like noise generated by the impact of the handset on the wooden base, was used by the Post Office in a range of advertising material. It was exhibited at the Ideal Home Exhibition, Olympia in 1932, in the film 'The Coming of the Dial' (1933) and in newspaper advertisements (Figure 8 below). It was also on display at the Dollis Hill grand opening where it was described by a journalist as an 'unexpected human touch on the part of the Post Office'.[95]

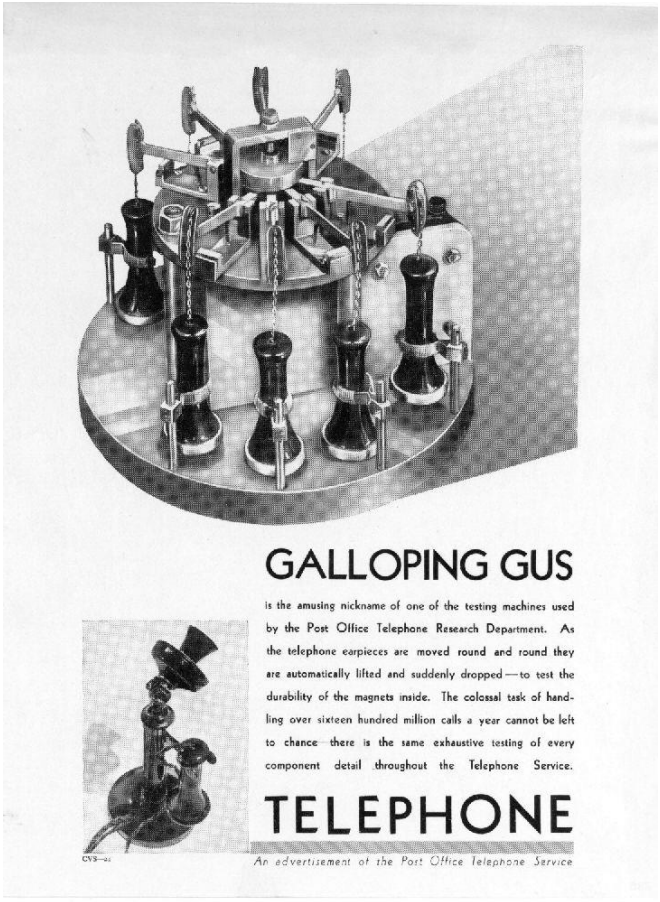

Figure 8 'Galloping Gus' newspaper advertisement, 1934.[96]

[95] 'PO Palace of Gadgets', *Aberdeen Press and Journal*, (24 October 1933), p. 4.

[96] BTA: TCB 699/1/28, 'Galloping Gus' proof of newspaper advertisement using the nickname given to a testing machine, 1934.

Film was the ideal medium to explain technological developments, able to communicate a narrative through a multi-sensory experience. Also capable of shifting views from big to small made it an ideal medium to capture the features of large technology and systems. The attributes of research were amplified through the experimental use of film techniques in the GPO Film Unit's output.

1.3.4 Selling new services

During the 1930s the Post Office introduced new services to meet public needs including the '999' emergency number, establishing a direct line to the police, ambulance and fire brigade, and the travelling Post Office, which brought postal services to rural areas.[97] These examples repurposed established technologies, but, others were the result of Dollis Hill research, a provenance which was emphasised as part of their promotion. An example includes an engaged number service, first announced in January 1933. This replaced a high-pitched buzzing noise, which informed automatic telephone subscribers of a failed connection, with a female voice saying 'number unobtainable' and 'number engaged'.[98] This appears to be the first automatic service introduced by the Post Office which used a human voice, recorded on to a film and distributed to telephone exchanges across the country. When a number was engaged a mechanism at the exchange automatically switched on a pinpoint of light which was directed onto a revolving drum carrying the film.

The device which delivered the number engaged service received attention when it was displayed at the Physical Society's Annual Exhibition at the College of Science, South Kensington. Newspaper articles noted that it had been developed at the Research Station and made it public that the female voice was a member of the Research Branch at Dollis Hill but did not reveal her name.[99] It was reported that she had become known as 'Tallulah of the Telephone', likely coined by the Publicity Department, who used alliterative titles for other publicity outputs, for example the

[97] David Matless, 'Accents of Landscape in GPO Country: The Horsey Mail, 1938', *Twentieth Century British History*, 23.1 (2012), 57-59 (p. 57).

[98] BTA: TCB 211/21, 'Filmed Voice to Say 'Number Engaged'', *Daily Herald*, (4 January 1933).

[99] BTA: TCB 211/21, Museum Correspondent, 'New Wonders of Science', *Observer*, (19 March 1934); 'Filmed Voice to Say 'Number Engaged'', *Daily Herald*, (4 January 1933).

1936 film 'Fairy of the Phone'.[100] Tallulah was revealed to be Helen Everett from Willesden with her portrait appearing in the *Star* and *Daily Sketch*, in March 1934, coinciding with the announcement that the service was being trialled in Folkestone.[101] Newspaper reports about Dollis Hill often showed men and women working in the laboratories, but Everett was the first to be named. The number engaged service received less publicity than commercial outputs.

In comparison the income generating service, the Speaking Clock, was heavily promoted. This was an accurate time service whereby a subscriber to an automatic exchange could dial T-I-M (numbers 8, 4, 6), and those who were connected to a manual exchange could ask the telephonist for 'TIME'.[102] This new service was developed in response to public demand and the success of a similar installation in Paris. Responsibility for designing this new equipment lay with the engineers at the Research Station and included technical developments in methods of recording sound on glass discs, read photoelectrically and controlled by a master pendulum.[103]

To build public interest in the new service, the Publicity Department constructed a competition to find 'The Girl with the Golden Voice' from their staff of telephonists to be the voice of the Speaking Clock. This was likely inspired by the increasing number of beauty pageants and newspaper run competitions which emerged during the interwar period to promote consumer products.[104] Telephonists across the country applied to be the voice of the new service. The final of the competition was held on the 21 June 1935 in King George V Hall. The Postmaster General took part in the ceremony which was filmed by the cinema newsreel companies; Gaumont British, Pathé News, Paramount and British Movietone News, and exhibited in cinemas countrywide. The BBC broadcast a special report on the final stage and on 24 June, the winner, Ethel

[100] BTA TCB 211/19, 'Filmed voice to say 'number engaged'', *Daily Herald*, (4 January 1933).

[101] BTA TCB 211/21, '"Engaged," she keeps saying, but she is not', *Star*, (9 March 1934); 'Girl who is always "Engaged"', *Daily Sketch*, (10 March 1934).

[102] BTA: TCB 422/8627 E.A. Speight, 'The Speaking Clock', (Post Office Engineering Department, March 1934), (pp. 1-74), p. 1.

[103] BTA: TCB 422/8627 The Speaking Clock, E.A. Speight, March 1934, p. 13.

[104] Rebecca Conway, 'Making the Mill Girl Modern?: Beauty, Industry, and the Popular Newspaper in 1930s' England', *Twentieth Century British History*, 24.4 (2013), 518-541.

Cain, appeared in a programme which was transmitted across the Empire.[105] One year after the winner was announced her voice recording of the Speaking Clock was installed in the Holborn Telephone Exchange and inaugurated by the Astronomer Royal on 24 July 1936.

Whilst the customer could hear a human voice, publicity showed that it was technology, designed at Dollis Hill, which supplied the service. In one Pathé News film entitled 'Time Please!', released in April 1938, the voiceover provided details on all aspects of the mechanism. It described the role of the glass discs, explained how a photoelectric cell reproduced the sound, showed the relays which ensured the sounds were transmitted in the correct sequence and highlighted the hourly check with Greenwich Mean Time.[106] As in other films and posters the accuracy of the clock, to a tenth of second, was a selling point.

Further selling of the Speaking Clock service anthropomorphised it as a cartoon figure with the tagline 'phone TIM for the right time' and appeared in newspaper advertisements (Figure 9 below).[107] Brand mascots were a familiar feature in commercial advertising, but were commonly human characters or animals, not technologies.[108] One exception to this rule was Mr Therm, a personification of a live gas flame designed by Eric Fraser and introduced by the Gas Light and Coke Company in 1931.[109] Despite the obvious promotional opportunities, during a period of anxieties around new machines replacing human workers, the public competitions and anthropomorphised character associated this new, automatic service with familiar human characteristics. In Chapter 4, I show that by the 1950s this strategy had become an established marketing technique in the Post Office to manage the integration of increasingly automatic technologies.

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[105] PMA: POST 108/7 PC/99 Progress Report, 20 July 1935.

[106] 'Time Please!', 1938 (Pathé newsreels, 1938), British Pathé, <https://www.britishpathe.com/video/time-please-2/query/time+please> [accessed 7 June 2018].

[107] BTA: TCE 361/ARC 1458, Proof of a Press advertisement for the Speaking Clock, 1936.

[108] Richard Hornsey, '"The Penguins Are Coming": Brand Mascots and Utopian Mass Consumption in Interwar Britain', *Journal of British Studies*, 57 (2018), 812-839 (p. 819).

[109] Anne Clendinning, *Demons of Domesticity: Women and the English Gas Industry, 1889-1939* (Routledge, 2017), pp. 233-235.

Figure 9 Newspaper advert for the Speaking Clock showing the character TIM, 1937.[110]

[110] BTA: TCB 699/2/32, 'This is the voice inside the clock that gives you seconds precisely', newspaper advertisement for the Speaking Clock, published in the Evening Standard, 5 February 1937).

Eighteen months after opening, the Speaking Clock had been called 22,000,000 times, representing a revenue of over £90,000.[111] Originally only available to London subscribers, the service was instantly popular and extended nationwide. The revenue provided around 0.3% of the total income made on telephones over the period.[112] The figure was used to publicise the value of Dollis Hill, reported by Tallents' successor E. T. Crutchley as being 'sufficient to pay for half the upkeep of the Research Station'.[113] TIM became synonymous with the telephone service. It was featured in Post Office exhibitions where items displayed in newsreel were also demonstrated live through public displays. I explore this marketing technique in the next section.

1.3.5 Research on display

Exhibitions were an important part of the Post Office Publicity Department's strategy. They brought the public face to face with the technologies they saw advertised in newspapers, films and posters, and, with a focus on display and design, projected a modern and futuristic service.[114] The rise in exhibition culture in the interwar period was invigorated by the popularity of the 1924 British Empire Exhibition in Wembley, London. This spectacular event was designed to promote goods from across Britain and the Empire, welcoming 27 million visitors during the first seven months.[115] By the 1930s, exhibitions were a familiar feature across Britain, used to boost trade and promote national pride.[116] Many combined entertainment with education, attracting a broad audience of individual adults and families.[117]

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[111] PMA: POST 108/11 Post Office Publicity Committee, minutes of meetings held 1939, PC/159 The Speaking Clock, January 1938.

[112] BTA: TCB 10/20 Post Office Commercial Accounts, 1937, p. 25

[113] Crutchley, p. 182.

[114] BTA: POST 108/5, Minutes of the Publicity Committee, 1933-1935, The artist Edward McKnight Kauffer was commissioned to design the Post Office stand at the British Industries Fair, 1934.

[115] Sarah Britton, ''Come and See the Empire by the All Red Route': Anti-Imperialism and Exhibitions in Interwar Britain', *History Workshop Journal*, 69 (Spring 2010), 68-89 (p. 69).

[116] Hulme, ''A Nation of Town Criers', p. 277; Peter Scott, 'Marketing mass home ownership and the creation of the modern working-class consumer in inter-war Britain', *Business History*, 50.1 (2008), 4-25 (p. 12).

[117] James Taylor, '"A Fascinating Show for John Citizen and his Wife": Advertising Exhibitions in Early Twentieth-Century London', *Journal of Society History*, 51.4 (2018) 899-927 (p. 901).

The Post Office first started investing in exhibitions when Kingsley Wood became Postmaster General and following the establishment of the Telephone Publicity Committee in 1931. Prior to this, the Post Office had participated in trade exhibitions, but only on a small scale as restrictions on publicity spending prevented exhibition space hire or costly well-designed displays.[118] Exhibitions became even more frequent after Tallents joined the Post Office and a permanent shop was opened on the Strand in London advertising the latest telephone equipment and promoting the Research Branch. Tens of exhibitions of different sizes took place all over the country during the 1930s (see example in Figure 10). For example, in 1934 the Post Office took part in the British Industries Fair, Radiolympia, Edinburgh Radio Exhibition and four Post Office specific exhibitions in Leeds, Liverpool, Nottingham and Scarborough.[119]

Figure 10 Post Office stand at the Ideal Home Exhibition, 1934.[120]

[118] Heller, 'The development of integrated marketing communications', p. 1038.

[119] BTA: TCB 417 E series negatives and prints 1934-1937 (9074, 9160, 9157, 9160, 8950, 9064).

[120] BTA: TCB 417/E 8879, Post Office stand at the Ideal Home Exhibition, 1934.

The Post Office commonly displayed and demonstrated equipment from Dollis Hill to show how research was lowering costs and expanding services (Figure 11 below). Devices were displayed at the *Daily Mail* Ideal Home Show, Olympia in May 1932, where the Post Office held one of the largest stands. The choice of event reflects the Post Office's ambition to reframe the telephone as a technology for the (ideal) home, not just businesses. Life-sized room sets showed the telephone in a range of environments; in a green-grocers shop with the tagline 'all up-to-date tradesman are on the telephone – telephone your orders', in the drawing room where 'the telephone is essential', and in the office 'not to be on the telephone is to be out of business'. These challenged the perception by the public and the Treasury that the telephone was not for widespread dissemination. Other examples of the extravagant exhibit included a replica rural automatic exchange, telephone kiosk, and picket fence and village backdrop. Great pains were taken to show the research that went into these telephones with technology from the Research Branch also on display. These included a cathode ray oscilloscope which showed the visitors voice frequencies on the screen, automatic and director telephone exchanges, and high-speed apparatus for handling telephone traffic. Press reported that:

> Demonstrating the amazing magnitude and complexity of the service, no phase of telegraphy or telephony will be overlooked. The first telephone and the most modern instrument will be shown. Secrets of the world-famous Post Office Engineering Research Section at Dollis Hill, N.W., will be revealed in detail.[121]

Channelling the imperial outlook of these exhibitions, the Post Office display reflected Britain's global power by allowing visitors to make a free call over the Radio and Continental Telephone Service to, South Africa, North and South America, most of Europe and Atlantic liners.'[122]

[121] [Anon.], 'Greatest Exhibition of the Secrets of the Post Office', *Daily Mail*, (29 May 1932), p. 9.

[122] The British Empire Exhibition, 1924 and Glasgow Empire Exhibition, 1938; 'Home Building in Many Lands', *Daily Mail,* (7 April 1932), p. 6.

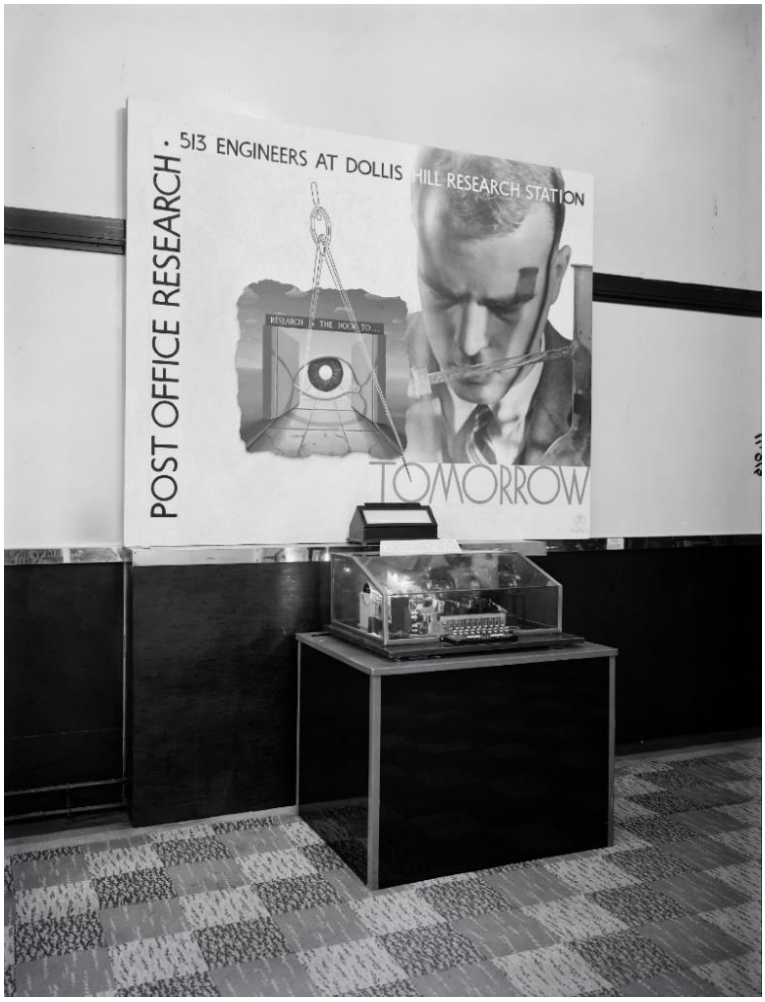

Figure 11 Research stand at the 'Post Office and the Community Exhibition', Armour House publicity shop, London, 1939.[123]

The same Dollis Hill devices appeared in exhibitions that targeted children, or as one Post Office official described them: 'the Post Office customer of tomorrow'.[124] Exhibitions for children had emerged in the interwar period, a time when the relationship between citizenship, education and creativity had a wide currency.[125] The Post Office's first Young Peoples' Telephone Exhibition took place at the Imperial Institute, South Kensington between 6 and 27 January 1932. Kingsley Wood ensured press attention at the opening by making a telephone call to Theodore G. Miller, Vice-

[123] BTA: TCB 417/E 11016: Post Office and the Community Exhibition, Armour House publicity shop, research display, 10 February 1939.

[124] BTA: E. C. Baker, 'Young People's Telephone Exhibition', POEEJ, Vol. 30, No. 1, (April 1937), (pp. 61-64), p. 61.

[125] Alice Kirke, 'Education in Interwar Rural England: Community, Schooling and Voluntarism' (unpublished PhD thesis, UCL Institute of Education, 2016), p. 222.

President of AT&T, in front of 500 specially invited children (Figure 12 below).[126] Wood told the young crowd that 'the times in many respects might be dark and depressing, but the exhibition would help them realize that they were living in an age of wonders and modern miracles', using the opportunity to align the Post Office with modernising wonders of science.[127]

Figure 12 Sir Kingsley Wood, Postmaster General at the opening of the Young People's Telephone Exhibition, South Kensington, January 1932.[128]

Unlike other children's exhibitions, including the Schoolboys Exhibition, the Post Office event was free and attracted sizable crowds. The second exhibition in London took place over the Christmas period 1936–1937, with 24,000 people attending its opening day.[129] Exhibitions incorporated models, dioramas and large-scale photographs to promote contemporary equipment and show the development of communication

[126] Anon., 'Children's World Talk', *Daily Mail*, (6 January 1932), p. 4.

[127] Anon., 'Children and the Telephone', *The Times*, (6 January 1932), p. 8.

[128] BTA: TCB 417/E 7725, group photograph including the Postmaster General Sir Howard Kingsley Wood, at Young People's Exhibition, 5 January 1932.

[129] Anon., '24,000 at Telephone Exhibition', *The Daily Telegraph* (London, England), (8 January 1932), p. 6.

technology. A familiar site in the Science Museum Children's gallery, working exhibitions were also an important feature of these events.[130] The 1936 exhibition included working teleprinter and stamp cancelling machines, placing a call to TIM and demonstrations of the 250,000 volt impulse generator which produced artificial lightening to test the safety of devices. These exhibits were displayed in the Research Branch section alongside a poster series by Eric Fraser showing the founders of modern communications; 'Wheatstone's Telegraph, 1858', 'Hertz Radio Set, 1886' and 'Graham Bell's Telephone, 1876'. Yet again publicity material, including equipment built by the Research Station, was used to situate the Post Office in a long history of world changing technical progress and as a department looking into the future.

1.3.6 Impact of publicity

The impact of the Post Office's new commitment to modernisation was recognised immediately. The public perception that the Post Office was inefficient changed rapidly with congratulatory articles appearing in newspapers and positive responses in Parliament. In December 1934 the Parliamentary Correspondent from *The Times* reported that 'today no Department stands higher with the House of Commons and the public, and the reason is not far to see in the considerable transformation of its outlook and methods'.[131] The Post Office Public Relations Department built on the success of 'Come on Phone' with a similar campaign 'Get the Telephone Habit' in 1935, during which the telegraph service also received publicity.[132] The six penny telegram was introduced to revive the loss making service but of equal impact was the promotion of 'greetings' and festive telegrams, designed to remove their association with bad news which emerged during the First World War.[133]

Public Relations continued after Wood and Tallents left the Post Office. In 1935, Wood was appointed Minster of Health in the new coalition government, under Stanley Baldwin. Tallents left shortly afterwards to join the BBC as Controller of Public

[130] Nielsen, ''What things mean in our daily lives', p. 514.

[131] Anon., 'The Modernized Post Office', *The Times*, (18 December 1934), p. 11

[132] Suga Ida, p. 198-199.

[133] Ibid.

Relations.[134] This move was likely connected to Wood's departure, having lost a close political ally who frequently defended the large sums spent on publicity in the Post Office, something which the next Postmaster General, George Tryon was more critical of, but continued to fund at high cost.[135] For example, the launch of the Empire Airmail Scheme in June 1937 was a large affair.[136] Further reductions in charges boosted sales with 439,000 telephone connections installed between April 1935 and March 1937 bringing the total to 2,850,000 installations across the country. More than 170,000 were added in eight months following the introduction of 50 free penny calls per quarter by Tryon in October 1936.[137]

While Wood and Tryon quoted figures of new telephone installations to elevate the Post Office in parliament, the Engineering Department struggled to keep up with the increased public demand.[138] Most concerning was the deteriorating speed at which new subscribers were being connected and the challenge to find suitable men to install the service. The number of telephone stations installed in 1933–34 was 88,000 and increased to 191,000 the following year. This growth in exchange lines was described as 'unprecedented' by the Post Office Board.[139] It was frequently reported that the Engineering Department was struggling to keep up with the demand as it started missing targets.

There are three possible reasons why this discord existed. Being the first organisation to undertake a public relations campaign of this nature, the Post Office Board was unable to predict how it would translate into actual numbers of requests for the telephone. Therefore, they would not know the resources needed to fulfil demand. Second, in order to get the staff needed to install new lines, lead in times were

[134] Anthony, *Public Relations*, p. 131.

[135] Scott Anthony, 'An introduction to the GPO Film Unit', in *Addressing the Nation, The GPO Film Unit Collection, Volume One* (London: British Film Institute, 2008), pp. 1-8 (p. 6); Campbell-Smith, p. 311.

[136] Heller, 'The development of integrated marketing communications', p. 1047.

[137] 'House of Commons Debate: Post Office and Telegraph (Money)', 11 June 1937, Hansard, vol. 324, cc. 2153-70, c.2153.

[138] PMA POST 69/5 Post Office Board 1936, POB 38(36) 'Review of Telephone Development', W.R.B. 8 October 1936.

[139] Ibid.

required for recruitment and training. Third, new connections would require an expansion of infrastructure, which would take time to install but required negotiation with the Treasury, which approved the Post Office's capital expenditure on an annual basis.

The Post Office publicity drive had wider implications than increasing the number of telephone subscribers. It also encouraged other government departments to invest in public relations. By 1937 there were publicity departments in the Air Ministry, Ministry of Health and Ministry of Labour.[140] The Post Office did, however, outspend these departments by thousands. For example, in 1937, the Post Office spent £85,000 on publicity while the second most well-funded department was the War Office with £32,335. The same year the budget for the GPO Film Unit alone was greater than the total spending of the Publicity Department of the Foreign Office.[141] In the next chapter we see how the Post Office publicity shaped state propaganda during war.

1.4 The wider role of prestige

Whilst the Research Station's status as a symbol of prestige for the Post Office was recent in publicity terms, its reputation was well-established amongst academic and industrial networks, nationally and internationally. One way the Post Office made use of this was strengthening its relationship with telecommunication manufacturers, on whom the department relied on for equipment. During the interwar period, the Post Office looked to justify its monopoly by demonstrating its value to private industry and did so through Bulk Supply Agreements (BSA) and co-ordinating committees. The first BSA was signed between the Post Office and the four largest manufactures to supply automatic exchange equipment in 1923, following the decision to adopt the Strowger electro-mechanical exchange as the national standard. The four were: Siemens Brothers, Automatic Electric Company, General Electric Company, Plessey and

[140] *Report from the Select Committee on Estimates, 1937-1938,* HC 158 (London: HMSO, 1938), p. 284.
[141] Ibid., p. 286.

Company and Standard Telephone and Cables Company. In 1927 Ericsson Telephones was added and the five became known as 'The Ring'.

Throughout the 1930s BSAs were agreed with The Ring for different technical components, from telephone cords to batteries, on five year contracts.[142] Mutually beneficial, BSAs meant the Post Office could ensure the standardisation of equipment across its network, reduce maintenance costs and receive discounts for bulk orders. Manufacturers were then able to pool patents and, with Post Office approval, organise the allocation of orders amongst themselves.[143] Orders were guaranteed as BSAs prevented the Post Office from buying products from firms outside the agreements. These relationships were strengthened further in 1933, through the establishment of the British Telephone Technical Development Committee (BTTDC) as a co-ordinating body to standardise new parts, coordinate development work and exchange technical ideas.[144] The reputation of Dollis Hill staff as experts in the telecommunications industry ensured the Post Office remained unchallenged in these forums, being the source of new patents, technical standards and where equipment was tested before being accepted into the network.

Whilst Dollis Hill was a tool for the Post Office to strengthen its hold over industry, Research Station staff had their own aims to build on their reputation as a site of research excellence by expanding their networks of influence. Prestige was a way staff at Dollis Hill could reassure external parties that they were at the forefront of knowledge and innovation. Aided in this task, the new buildings provided an air of authority and establishment with Neo-Georgian architecture (Figure 13 below). This style had been adopted in the interwar period by the state for government buildings and banks for this very purpose.[145] Sophie Forgan has shown the importance of built

[142] Scott, *Market Makers*, p. 294.

[143] Jill Hills, *Information Technology and Industrial Policy* (London: Croom Helm, 1984).

[144] Chris Harlow, *Innovation and Productivity: The First Thirty Years* (London: Allen and Unwin, 1977), p. 115.

[145] Julian Holder and Elizabeth McKellar, 'Introduction: reappraising the Neo-Georgian', in *Neo-Georgian Architecture 1880-1970: a reappraisal*, ed. by Julian Holder and Elizabeth McKellar (Swindon: Historic England, 2016), p. 8; Neil Burton, 'Banker's Georgian', in *Neo-Georgian Architecture 1880-1970,* ed. by Holder and McKellar, p. 112.

spaces and how scientific societies of the nineteenth century communicated their authority through them.[146] Considering this interpretation, the Research Station did more than provide improved working space for the staff it also sought to define its credibility (Figure 14 below). Architectural details including 'Research is the Door to Tomorrow' and 'To Strive, To Seek, To Find', engraved into the porte-cochere, communicated the ethos of the Research Station to staff and visitors. Furthermore, the inner décor of the Main Research Building, clad in materials from across the Empire and a checkerboard floor, conveyed the prestige and authority of an establishment already living this ethos. These details were often used by Cohen to impress both peers and the public.[147]

Figure 13 The Post Office Research Station, 1933.[148]

[146] Sophie Forgan, 'Context, Image and Function: A Preliminary Enquiry into the Architecture of Scientific Societies', *BJHS*, 19.1 (1986) 89-113 (pp. 111-112)

[147] Bertram Cohen, 'Research in the British Post Office', *Journal of the Institution of Electrical Engineers (IEE)*, 75:452 (1934), 133-151 (p.134).

[148] BTA: TCE 361/ARC 337, The Post Office Research Station, 1933.

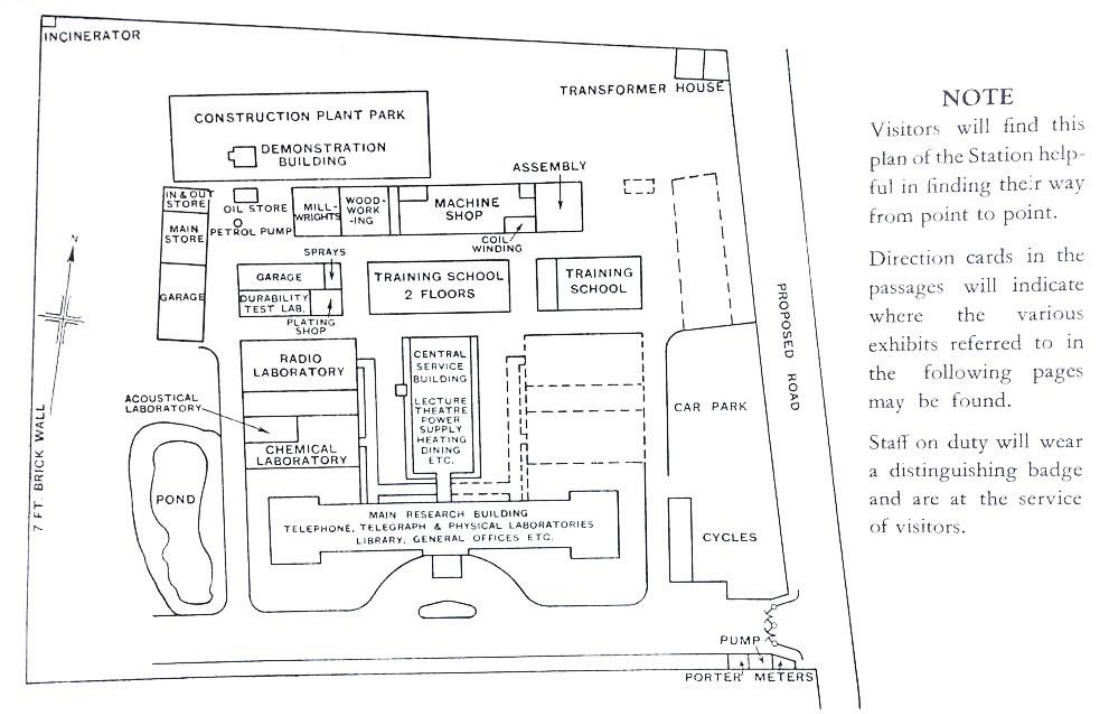

Figure 14 Plan of Research Station from opening ceremony programme, 1933.[149]

Cohen was instrumental in maintaining and developing Dollis Hill's network and prestige. His public appearances were focused on raising the profile of the Research Station, not explicitly the wider Post Office. Promoting Post Office research was also a means by which Cohen hoped to establish his own legacy, coming to the end of his professional life. According to staff member Tommy Flowers, Cohen was 'hoping to make a reputation for himself so was rather anxious to be in on anything that might bring him credit'.[150]

Cohen commonly used facts and figures to support his claims that 'the Research Section may be regarded as a highly successful business organisation paying a handsome profit'.[151] He was keen to highlight the financial benefit of Post Office research, emphasising that, unlike pure research, the value of applied research could be quantified. Cohen presented the Research Station in terms of costs saved and its value to professional engineering bodies, the Post Office staff and to the public,

[149] BTA: uncatalogued, Research Station opening ceremony programme, 1933.

[150] IWM: 18332, Flowers, Thomas Harold.

[151] Bertram Cohen, 'Engineering Research in the Post Office', *POEEJ*, 24.1 (1931), 6-16 (p. 16).

through articles in the popular press. In doing so he justified the worth and raised the prestige of Dollis Hill to public subscribers, taxpayers, the Post Office, political decision makers and industry. This was particularly important at a time of economic uncertainty and increased scrutiny on how public money was being spent. For example, in an article in the *Post Office Electrical Engineers Journal* Cohen argued that a third of the investigations undertaken at Dollis Hill led to an estimated annual saving of £150,000 to the Department through improved methods of maintenance or the introduction of new services.[152] Cohen travelled the county to extol the virtues of the Research Station. In a series of regional presentations given to branches of the Institution of Electrical Engineers, Cohen claimed that fourteen out of a total of 511 investigations undertaken between 1932 and 1933 had increased annual revenue or savings 'amounting to a sum more than double the total annual expenditure of research'.[153]

Cohen argued that new knowledge would create new products and described the Research Station as the place where the future was being trialled and developed. In 1932 he wrote an article in *The Telegraph* about world-wide telephony. He described 'carrier working', research into transatlantic telephone cable and London becoming the telephone centre of the world for long-distance connections through the international switchboard. Cohen projected:

> I foresee the time when the ordinary telephone instrument, as we know it to-day, will, in private rooms, be replaced by microphones incorporated in the furnishings, together with similarly concealed receivers which will emit high quality speech into the room at normal conversational levels.[154]

Cohen's use of language was not unique and during the interwar period 'applied science' was used to serve a variety of purposes; to explain new scientific wonders to the public, to promote technical institutions and project a modern Britain.[155] The way

[152] Ibid., p. 15.

[153] Cohen, 'Research in the Post Office', p. 138.

[154] B. S. Cohen, 'Calling the World by Telephone', *The Telegraph*, (30 September 1932), p. 12.

[155] Robert Bud, 'Modernity and the Ambivalent Significance of Applied Science: Motors, Wireless, Telephones and Poison Gas', in *Being Modern: The Cultural Impact of Science in the Early Twentieth Century*, ed. by Robert Bud, et. al. (London: UCL Press, 2018), pp. 95-129.

research was described, whether 'pure', 'fundamental' or 'applied', became important to gain state support. For example, Sabine Clarke has shown how the Department of Scientific and Industrial Research used the term 'fundamental research' to convince that their work aligned with patrons' needs.[156]

Professionalisation was an important signifier of prestige and staff were encouraged, and given opportunities to, advance the reputation of Dollis Hill through training. Increasing educational qualification of the staff was a means to demonstrate Post Office credibility and widen professional networks. Staff at the Research Station and the wider Engineering Department were given leave to attend night school and work towards City and Guild qualifications and several engineers at Dollis Hill were awarded degrees for their research. Training was an important element of the Engineering Department and ensured the staff had the same knowledge so they could transfer more easily around the country. In May 1931, the Training School buildings were completed, and the Research Station became home to the largest section of the Engineering Department's training school, which had smaller sites across the country.[157] The Post Office hoped that this facility would bring prestige shared by other, well recognised sites so that 'the station… might rank as an Engineering Training College on a par with the Naval Engineering Colleges and Military Training Colleges already in existence'.[158]

The Training School at Dollis Hill was well resourced with seventy-four staff and facilities to train up to 500 students at a time.[159] There was a construction park covering an area of 12,000 square feet which was a microcosm of all types of outdoor work, from pole climbing to working in manholes (Figure 15 below).[160] Most Post Office engineers from across the country spent some of their training at Dollis Hill. The standards of training were recognised by external bodies and staff from other

[156] Clarke, 'Pure Science with a Practical Aim', p. 288.

[157] Haigh, 'To Strive, To Seek, To Find', p. 116.

[158] W.T. Palmer and G. W. Hodge, 'Cable Instructional Courses held at Dollis Hill', *POEEJ*, 23 (1930), 142-143 (p. 143).

[159] Bertram Cohen, 'Research in the British Post Office', p. 137.

[160] Ibid.

government departments and overseas administrations spent time in the Training School. As such the training influenced engineering practice beyond the Post Office and Britain.

Figure 15 Construction Park at Post Office Research Station, Dollis Hill, 1936.[161]

As with other R&D sites, publication of research was encouraged to raise the status of staff and the reputation of the organisation. This technique was also adopted by industrial companies such as Metropolitan-Vickers and food manufacturers, Lyons and Rowntree.[162] At Dollis Hill, staff frequently published papers in the *Post Office Electrical Engineers Journal* and in other academic publications. Senior Post Office staff were members of professional bodies, such as the Institution of Electrical Engineering, and they also attended conferences such as those organised by the Institute of Physics discussing 'Vacuum Devices in Research and Industry' in March 1935 and 'Optical Devices in Research Industry' in March 1937. The presentation and discussion of papers brought together professionals from industry and academia.[163] This provided

[161] BTA: TCB 473/P 1135, Construction Park at Dollis Hill, 1936

[162] T. Cooper, 'The science-industry relationship: the case of electrical engineering in Manchester, 1914-1960' (unpublished PhD thesis, University of Manchester, 2003), p. 81; Sally Horrocks, 'Consuming Science: Science, Technology and Food in Britain' (unpublished PhD thesis, University of Manchester, 1993), p. 173.

[163] BTA: TCB 422/9802 Optical devices in Research and Industry, April 1937.

Dollis Hill with a stage for disseminating innovation beyond government, state-funded research organisations and industry.

Patents were another means by which Dollis Hill could demonstrate its innovation. Dollis Hill staff were encouraged to apply for patents for their inventions in their own name. Under the terms of employment any patent resulting from Dollis Hill research could be used by the Post Office and all other government departments. However, there was further benefit to the individuals and the Post Office as if a manufacturer wished to buy the patent, and the Engineering Department approved, both the inventor and the Post Office received the payment.[164] This operated on a sliding scale: if the sum was small the individual received most of the payment but for higher value patents, the Post Office retained nearly all the income generated by its sale.

Through the BTTDC and collaborating with other research establishments, Dollis Hill became embedded in a network of public, private and national organisations, where staff could further prestige by demonstrating their expertise. Whilst a large proportion of the work of the Research Branch was to carry out investigations for the wider Engineering Department, for example the causes of cable corrosion and disturbance on lines, this often involved testing and calibrating materials and equipment which had been manufactured by industry. 'The Ring' group of manufacturers made up the most of this work, but the branch also engaged with firms from across engineering including Bakelite Limited, Imperial Chemical Industries and Mullard Radio Valve Company. There was also close cooperation between the Research Branch and other research organisations including the British Non-Ferrous Metals Research Association, the British Electrical and Allied Industries Research Association and the Building Research Station. They frequently reviewed materials and checked results with many of the DSIR funded Research Associations including the National Physical Laboratory, especially in the work of frequency control and time keeping. Undertaking many short-term projects, the Research Branch produced hundreds of research reports which were shared amongst government departments. In 1937 alone the Research Branch

[164] *Fourth Report from the Select Committee on Estimates: The Post Office, Session 1950*, HC 130 (London: HSMO, 1950), p. 42.

completed around 500 separate investigations. Validating the sweeping claims to research eminence Cohen expressed through routine communications development.

Networks were created between Dollis Hill and international telecommunications companies through representing the Post Office in international forums. Being the telecommunications function of the state, the Post Office represented the government on regulatory bodies which standardised frequencies and planned the expansion of international communication infrastructures. Dollis Hill experts were often present in these forums to advocate for the adoption of British standards abroad. Meetings were arranged through the International Telecommunications Union which managed committees for telegraph, telephone and radio standards. On average there was at least one meeting a year which took place for several weeks in cities across the western world. In February 1936, London was the site for the meeting of the Comite Consultatif International Telephonique and featured a visit to Dollis Hill for delegates. The importance of these committees and networks led the Post Office Engineer-in-Chief, Albert George Lee, to enquire about the possibility of training engineers in other languages to support negotiations.[165]

Knowledge transfer between industry, academia and the Post Office was possible, in part, because of the workforce employed at Dollis Hill. By 1933, 112 qualified staff were in 'major ranks' which included Staff and Assistant Staff Engineers, Executive Engineers, Assistant Engineers, Chief Inspectors and Inspectors.[166] This was close to the same number of qualified staff working at the General Electric Company and higher than those employed in the R&D departments of some of Britain's largest firms, Metropolitan-Vickers, British Thomson-Houston and Dunlop.[167] Another 174 'minor staff', including Clerical Support, Skilled Workmen, Telephonists, and Labourers worked on site.[168] In comparison, most of the 190 staff employed at Dollis Hill in 1924

[165] BTA: TCB 371/43 Coordination and Development Committee, Minutes of the 94th Meeting, 15 July 1935.

[166] Bertram Cohen, 'Research in the Post Office', p. 137.

[167] David Edgerton and Sally Horrocks, 'T. S. Ashton Prize Essay for 1991-2: British Industrial Research and Development before 1945', *The Economic History Review, New Series*, 47.2 (May 1994), 213-238 (p. 223).

[168] Bertram Cohen, 'Research in the Post Office', p. 137.

were workshop fitters and tradesmen, and only thirty-eight were qualified engineers.[169] This change was an unexpected benefit from the economic crisis in the early 1930s when, in response to financial concerns, private industry restricted recruitment and the Post Office attracted highly qualified engineers and scientists facing unemployment.[170] It appears it was still benefitting from poor employment options in May 1936, with 800 men applying to Dollis Hill for thirty advertised Inspector roles. Scientific graduates were still in the minority with most Research Branch staff having trained as apprentices or entering as a Youth-in-Training.

Reflecting its growing expertise and widening specialisms, the Research Branch was reorganised in October 1936, subdividing seven technical groups in to eleven. The number of staff was also expanded with the introduction of a fourth Assistant Staff Engineer, a role below Cohen's.[171] The telephone instrument and local transmission research group continued to be one of the largest with fifty-three staff including twenty-nine Post Office staff and twenty-four telephonists on loan from the London Telephonist School.[172] The biggest change, however, was in the Materials and Special Measurement Group, which was separated into four separate sections under one Assistant Staff Engineer. This became the Chemical and Metallurgical Division, with seven staff, Physics with fifteen staff, Electrical with nine staff and Signalling Apparatus and Circuits, with thirty-three staff. A new group for 'Special Research', was established: although there is no detail of its function, it is likely it undertook investigations for outside bodies, civil or military.[173]

Research engineers kept abreast of international developments by visiting laboratories run by foreign telecommunication establishments. During the 1930s senior engineers from the Engineer-in-Chief's office, Research and other branches visited America,

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[169] Bertram Cohen, 'Engineering Research in the Post Office', *Telegraph and Telephone Journal*, 11.117 (1924), 46-49 (p. 46).

[170] BTA: POST 33/5487 Engineering Department, Research and Testing Branches, 1935-1944,'Staff Employed in Chemical Laboratories' Mr Barralet, Head of the Test Branch to Engineer-in-Chief, 31 January 1935; Brent Museum and Archives (BM&A): OH/3/6 Dr Arnold Lynch, Oral History, (2001-2002).

[171] BTA: TCB 371/43 Minutes of the 106th Meeting, 17 September 1936.

[172] TNA: T 162/696/5 Organisational Chart for the Post Office Research Branch, 1936.

[173] Ibid.

Germany, Denmark and Sweden. They observed that specialist staff were being recruited in Germany and saw new designs for telephone equipment in Scandinavia. They returned with detailed information about service costs and samples but also areas of research which might lead to competing patents. An important collaborator and competitor was Bell Laboratories, the research establishment for the American Telephone and Telegraph Company (AT&T). AT&T was the world's largest telecommunication company and responsible for building America's telephone networks and Bell Labs, as it was known, was responsible for developing telecommunication technology for AT&T as well as engaging in fundamental research.[174]

While AT&T and the Post Office were completely different business models, Dollis Hill and Bell Labs were both developing national communications technology and were undertaking fundamental research. There was a close connection between AT&T and the Post Office who developed and managed several international communication services which depended on collaborations between Dollis Hill and Bell Labs. Although the scale of the organisations differed dramatically (in 1924 Dollis Hill had thirty-eight qualified engineers compared to 4,000 at Bell Labs in 1925), there was close connection between them including sharing research findings.[175] While Dollis Hill and Bell Labs worked together to support the installation of the first transatlantic telephone service established by radio in 1927, at times collaboration was not forthcoming leaving the staff at Dollis Hill to solve problems alone.

Dollis Hill's expertise in quartz crystals illustrates the interplay between the Research Station, Post Office ambitions, international competition and industry. In 1935, international competition propelled the Post Office Engineering Department to match the United States' coaxial system which had 'reached a degree of development such that, it is understood, a working trial over a route approximately 100 miles in length

[174] [Anon.], 'Bell Laboratories', *Encyclopaedia Britannica*, <http://www.britannica.com/EBchecked/topic/59675/Bell-Laboratories>, [accessed 6 April 2014].

[175] [Anon.], 'History', *Nokia Bell Labs*, <https://www.bell-labs.com/about/history-bell-labs/#> [accessed 6 April 2014]; F. E. Williams, 'The story of Dollis Hill', *POEEJ*, 69.3 (1976) 140-145 (p. 141).

will be undertaken in the near future'.[176] An integral part of the new cable were quartz crystals which were used as a band-pass filter which created more telephone channels in the frequency spectrum than magnetic cores.[177] This cut costs for the Post Office as more telephone lines could be held on one cable, thus making the service more efficient.[178] The inability to access knowledge from Bell Labs directed Post Office research into new materials and equipment leading to the establishment of a separate Crystal Laboratory at Dollis Hill.[179] With no other company manipulating quartz for this purpose, Dollis Hill engineers became the country's largest manufacturers. The experience gained by the Post Office engineers was directed back to industry as the Crystal Laboratory shared the details of their methods, designs of the cutting machines and the production process with interested manufacturers.[180] The impact of this small team of Post Office engineers was felt across the British Empire, private manufacturers and other state departments.

The quartz expertise of Dollis Hill staff led to the establishment of new relationships between the Research Station and the military when it was realised that crystals could be used to control the frequencies of radio transmitters and receivers.[181] By 1936 the Post Office was the only reliable source of crystals to meet the needs of the Admiralty and Air Force and became their main supplier.[182] Crystals were requested in their thousands, with the Admiralty ordering 2000 between November 1937 and June 1938 and the War Office requesting 800 in March 1938.[183] This was one of several examples of Dollis Hill staff supporting military projects. In Chapter 2 we see the wider impact of

[176] PMA: POST 69/2, Post Office Board 1935 - 1(35) – 'Carrier Current Development', A.G.L. 19 January 1935.

[177] John Bray, *Innovation and the Communications Revolution: From the Victorian Pioneers to Broadband Internet* (London: Institution of Electrical Engineers, 2002), p. 118 and 120.

[178] Ibid., p. 118.

[179] BTA: TCB 135/2 The Engineer-in-Chief's Annual Report, 1936-37, A. G. Lee.

[180] C. F. Booth and C. F. Sayers, 'The production of quartz resonators for the London-Birmingham Coaxial Cable System', *POEEJ*, 32.1 (1939), 88-93 (p. 93).

[181] R. J. Thompson, 'The development of the quartz crystal oscillator industry of World War II, *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*, 52.5 (2005), 694-697 (p. 694).

[182] BTA: TCB 371/43 Minutes of the 106th Minutes, 17 September 1936

[183] BTA: TCB 371/43 Minutes of the 120th Meeting, 29 November 1937; Ibid., Minutes of the 123rd Meeting, 7 March 1938; Ibid., Minutes of the 126th Meeting, 13 June 1938.

rearmament on the Research Station but important to this chapter is the observation that the Research Station was considered by the military as a location for communications expertise. Gaining prestige was a driver in the actions of the Research Station during this period obtained through professionalisation and building networks. This led to staff undertaking work for patrons sitting outside the immediate telecommunications industry.

1.5 Conclusion

In this chapter we have seen the modes by which the Research Station was used to justify the Post Office's continued monopoly of the communication services, to the public, government and industry. This was a critical time for the Post Office: having held the telephone monopoly since 1912 it needed to demonstrate that progress was being made. Although steps had been taken in the standardisation of systems, much of this work would have been invisible, and as with most large technical systems, the benefits to the end user may not be seen until the entire network achieved the same standard. The Post Office needed greater transparency over the efforts employed and the path of progression with the telephone service in their hands, if they were to convince all it should remain that way. The Research Station was the perfect vehicle to show the hidden efforts in producing the technology in the telephone network and where the source of innovation in the service would come from.

The goals of the Post Office during this period were both reactive and proactive. Reactively they looked to change a public image that had been marred by widespread criticism, and proactively they looked towards research to make services cheaper and more efficient. Key actors during this period harnessed concepts of prestige and modernity to increase their standing in their relative fields. Kingsley Wood improved his own political standing by not just improving the public image of the Post Office but also creating elements which could also be attached to the wider government machinery. Stephen Tallents took strategies developed during his time at EMB and applied them on a much larger scale, developing public relations as a marketing strategy. Cohen increased the profile of the Research Station, gaining access to larger

networks and elevating the credibility of Post Office research, leaving a lasting legacy in the process. The leadership and strategies utilised created a strong cohesive vision of the future for the Post Office, strengthening both its brand and identity, not just to the public but also for the workers within.

Images of the site, research, work and engineers of Dollis Hill were key elements in an organisation wide publicity campaign by the Post Office centred around concepts of modernity and prestige. Through the presentation of research and the role of Dollis Hill as the promise of future technology, the Post Office was able to project its history as part of a continuity of progress into the future to imbue the features of modernity on to the current Post Office. The campaign used the past (world and Post Office history), present (Dollis Hill reputation and expanded views of behind the scenes) and the future (technological promise) to transfer prestige and modernity to the current organisation. Similarly, it expanded telephone subscribers by appealing to past users (good for business), potential present users (selling the telephone as a domestic tool for the modern home) and future users (targeting children). As Yasuko Suga Ida has argued: 'it is significant that the GPO used historical references to justify its modernity. Instead of rejecting history to proclaim modernity, it assumed that historical continuity produced the present, and that modernity rested on developments from the past'.[184]

Themes emerging in this chapter continue throughout this thesis. The nature of the telephone and the expansion to new users was not easily or quickly scalable. Whilst the Post Office had successfully utilised advertising, exhibitions and press attention to portray itself as a rapidly improving service at the forefront of technological research, a gap began to emerge between the promise of the services, and the reality that they may not be as readily available as advertised. This tension between these visions and realities will be explored further in chapters 3 and 4. Another discord that emerged during this period is how the Research Station and its activities were presented publicly and what was omitted from that image. To the public, the resources of the Research Station were dedicated to improving the public telephone service. However, by the end of the 1930s it was increasingly directing its resources to military need. The

[184] Suga Ida, p. 167.

next chapter explores this final point, tracing the impact of rearmament and the Second World War on the Research Station, to show how Dollis Hill adapted its identity – to that of a military establishment – to further the Post Office's goals in the wartime state.

Chapter 2: Dollis Hill Went to War: Preparation and Adaptation, 1934–1945

2.1 Introduction

This chapter explores how Dollis Hill became an integral part of the wartime state as its identity shifted from being a predominately civilian research establishment to operating as a mainly military site. A key actor in this chapter is Gordon Radley, who was promoted to Staff Engineer in charge of Dollis Hill on 1 January 1939. Like Cohen before him, Radley was Dollis Hill's main advocate during the period, driving the relationship of the Research Station with the government and other stakeholders in the rearmament programme and the Second World War. In this chapter I show this was driven as much by the desire to gain patronage, resources and prestige from military departments as out of a sense of duty to the nation. I will also demonstrate that Radley was motivated by the conviction that Post Office expertise was unsurpassed by any other research group in a wide range of areas.

It is through Dollis Hill's relationship with Bletchley Park, the main wartime station of the Government Code and Cypher School (GC&CS), that anything is more widely known about its work during the war. Most writing focuses on the Research Station's role in codebreaking by building the first purpose-built programmable computer, Colossus. Several books have been written about Colossus, and while some feature the experiences of the engineers who built it, most scholars have situated its history within a narrative about Bletchley Park.[1] However, codebreaking was not just about computing power; the challenge of intercepting and breaking enemy messages was a collaborative activity, bringing together several government and military organisations. The Post Office was a constant presence in these activities from installing new interception transmitters and receivers, to laying cables through which these

[1] Jack Copeland, ed. *Colossus: The secrets of Bletchley Park's codebreaking computers* (Oxford: Oxford University Press, 2006); Paul Gannon, *Colossus: Bletchley Park's Greatest Secret* (London: Atlantic Books, 2006); Christopher Grey, *Decoding Organisation: Bletchley Park, Codebreaking and Organization Studies* (Cambridge: Cambridge University Press, 2013); Christopher Smith, *The Hidden History of Bletchley Park* (Basingstoke: Palgrave MacMillan).

scrambled messages were directed to cryptographers. Part of a national information system, the researchers at Dollis Hill developed physical infrastructure to transport, visualise, intercept and decode information. Therefore, this chapter will provide a clearer picture of the period by adding the perspective of the Post Office and its Research Station during the war.

Histories of science during the war have focused on the methods by which establishment academic scientists became embedded within the wartime state through advisory bodies and gaining political favour. Examples include the Committee for the Scientific Survey of Air Defence, also known as the Tizard Committee, named after its chair and rector of Imperial University Henry Tizard, which championed the development of radar; the influence of the Royal Society through the Scientific Advisory Committee to the War Cabinet; and Frederick Lindemann, Churchill's confidant and first government scientific advisor.[2] This chapter provides an alternative history of state-funded wartime research by considering how Dollis Hill navigated the wartime state with fewer ties to the higher echelons of government. Rather than focusing on the details of specific technologies built at Dollis Hill, this chapter is interested in the organisational conditions by which Post Office staff ended up developing these devices, thereby taking a sociotechnical systems approach.[3]

A key factor in shaping the Post Office's wartime experience was that its efforts were not classified as essential war work for the first two years of the conflict. This made it harder for the Research Station compared with other R&D establishments run by the Service and Supply Ministries to obtain supplies to develop communication networks for the military, to hire suitable staff and gain patronage and prestige. Another factor which sets the Post Office apart from other organisations was that it remained bound

[2] Agar, *Science and Spectacle*; Edgerton, *Warfare State;* James Goodchild, 'The evolving role of the Chief Scientific Adviser to the Cabinet, 1940-71, in *Scientific governance in Britain, 1914*-79, ed. by Don Leggett and Charlotte Sleigh (Manchester: University of Manchester Press, 2016). G. J. Piller 'Tizard, Sir Henry Thomas (1885-1959)', *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004) https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-36528?rskey=390yfE&result=2 [accessed 30 August 2020].

[3] Thomas Hughes, 'The Evolution of Large Technological Systems' in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* ed. by W. Bijker, T. Hughes, and T. Pinch (Cambridge, MA; London: MIT Press, 1989), pp. 45-76.

to the decisions of the Treasury, rather than being taken over by a military department. The Post Office was further limited by the reversal of the Bridgeman recommendation for a Post Office surplus fund, with all profits during its suspension returning to the Exchequer. Finally, unlike the powerful role Kingsley Wood played as Postmaster General during the 1930s and his favoured status in government, the position would be used by Prime Ministers during the war as means to distance themselves from unpopular ministers.[4]

Section 2.2 shows there was a significant culture of war preparation which permeated throughout the Post Office. Whilst the Post Office made adjustments, there was little support from the Treasury or the military who saw the department as a means to achieve their respective goals of reducing expenditure and increasing preparedness. Research at Dollis Hill was steadily directed to meet the growing requests of the Armed Forces and staff were seconded to other R&D establishments. Faced with the threat of further staff losses, Radley advertised Dollis Hill's availability to defence organisations, thus being seen to support the government, and better embedding the Research Station into the wartime state while also protecting his resources. The Post Office's control of Dollis Hill was challenged by the government's decision to use the site as a refuge for Whitehall Departments at risk from aerial attack. This included the construction of an alternative Cabinet War Room, PADDOCK. Despite becoming redundant as the risk of air raids faded, the Post Office was restricted from accessing this much-needed space.

Section 2.3 shows that the Post Office was faced with competing demands throughout the Second World War. The mass publicity drive of the 1930s had dramatically increased the number of new telephone subscribers and led to a significant waiting list. The Post Office thereby became a victim of its own success and struggled to keep

[4] John Ramsden, 'Morrison, William Shepherd, first Viscount Dunrossil (1893-1961)', *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004) < https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-35123> [accessed 4 January 2020]; S. J. Ball, 'Crookshank, Harry Frederick Comfort (1893-1961)' *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004) < https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-32641> [accessed 4 January 2020].

up with the number of installations required. Public communications were downgraded as networks were redirected to support the military and staff were dispersed to other government departments. With finite resources and pressure to expand infrastructure for defence, the Post Office had to discourage subscribers from using the telephone and sending telegrams. Using publicity material, the Post Office hoped to deter the public from its services whilst also projecting a specific narrative of the department's contribution to war. The main impact of the war at Dollis Hill was the immediate loss of a quarter of the workforce. However, for the staff that remained, little changed for the first seven months of the conflict. This was not because the Research Station was not supporting the war effort, rather that the staff who were working on military projects during rearmament continued to and the requests from the Post Office involved the same activities as before the war, such as testing and calibration.

Section 2.4 shows how, in spite of having much less authority than R&D sites run by the Service and Supply Ministries, Radley positioned Dollis Hill as a site of unique value to the wartime state. Dollis Hill became part of a network of research establishments which had been expanded or conceived for the war. Post Office engineers worked with these sites at different levels, sitting on committees, undertaking collaborative projects with, and completing work for, different organisations. With limited resources and several R&D establishments working on similar projects there was as much competition as collaboration. Section 2.5 builds on this argument by showing that Radley was most successful at selling Post Office expertise to military departments without their own research establishments, such as those connected with human intelligence gathering. In contrast, the Research Branch found it harder to influence established R&D sites as shown in its support of codebreaking activities at Bletchley Park.

Section 2.6 shows that as the activities at Dollis Hill were not initially considered essential war work, Radley struggled to maintain the desired workforce. Not only did Dollis Hill lose staff, it also struggled to replace them as suitably qualified staff were more attracted to work in military R&D establishments. Like other wartime departments, the Post Office sought to improve its labour shortage by employing

women. Despite replicating gender-based pay practices seen across the wartime state, the Post Office encouraged the development of their female staff. By describing the experience of Female Assistants in the Engineering Department and more specifically Dollis Hill, where women joined scientific ranks for the first time, this section provides greater context to the work of historian Mark Crowley, who has produced the most detailed studies of women in the Post Office during war.[5]

Section 2.7 shows the introduction of compartmentalisation, a familiar feature of wartime management which restricted access to information, had a significant impact on Dollis Hill culture.[6] Much of the work had, in the interest of security, been so sub-divided that its application was not recognisable by the officers engaged. This led Head of Research, Dr Radley to comment in 1942 that 'never has there been a time when so many knew so little about so much'.[7] Although easy to introduce through the pre-war structure of the Research Branch, it led to dissatisfaction amongst the staff, frustrated at not knowing how they were supporting the war effort. By the end of the war senior staff at Dollis Hill had firmly established themselves as a source of expertise at designing and constructing equipment to solve specific military problems, such as codebreaking and listening-in. However, these activities were not shared as part of the internal narrative of the Research Branch so few of the staff knew of their significant contribution.

In the conclusion I discuss how the Post Office created a specific narrative of its wartime activities to different audiences, both inside the Research Station and to the wider public. The presentation of research remained key to projecting the prestige of the Post Office and while much of the activities at Dollis Hill were heavily censored, the Research Station provided a whole chapter in the commemorative pamphlet 'The Post Office went to War'. Secrecy would continue to shape the perception of Dollis Hill in

[5] Mark Crowley, 'Women Workers in the General Post Office, 1939-1945: Gender Conflict, or Political Emancipation?' (unpublished PhD thesis, Institute of Historical Research, University of London, 2010)

[6] Jeff Hughes, *The Manhattan Project: Big Science and the Atom Bomb* (Cambridge: Icon Books, 2002).

[7] PMA: POST 56/138 Engineer-in-Chief's Office War Diary, March 1942, p. 11.

the post-war period, as the Official Secrets Act prevented the small number of staff who were aware of the true nature of their work from sharing it wider.

Throughout I will, where appropriate, compare the experiences at Dollis Hill with those at other military and government establishments, in particular the National Physical Laboratory (NPL), the radiolocation laboratory, Telecommunications Research Establishment (TRE) and Bletchley Park. While Dollis Hill shared features in common with these and other R&D establishments, including compartmentalisation, the expansion of staff and the appointment of female labour, there were experiences which were unique to the Research Station. The latter include adopting a military culture while remaining a civil department and moving from seemingly an open institution to a closed one. I will conclude that in spite of significant changes to staff and management of the site Dollis Hill retained a distinct Post Office autonomy, due in a large part to the efforts of Radley.

2.2 Preparing for war

While improving the public image and developing new services for the civilian subscriber throughout the 1930s (as seen in Chapter 1), the Post Office was heavily involved in planning for a future war. Plans were drawn up as early as 1930 but intensified four years later when widespread rearmament began. The government considered the Post Office a strategically important department (an opinion shaped by its contribution during the First World War) and provided limited financial assistance to help with war planning. However, from 1935 the Treasury became increasingly reluctant to increase capital spending on war preparations for the Post Office, preferring to focus funds on military departments.[8] Nonetheless, senior staff in the Post Office were aware of the delicate balance they would have to strike, and were proactive in their own war plans which considered both civilian and military needs. The Director General, Thomas Gardiner, was an influential force in pre-war planning having witnessed the disruption caused by the previous conflict, in which a third of Post Office

[8] Mark Crowley, 'Technological change and the Post Office communications in Britain, 1918-1945', *History and Technology*, 32:4 (2016) 382-408 (p. 390).

staff were mobilised and new military communication networks were in high demand. Another important figure was Sir Stanley Angwin, appointed Deputy Engineer-in-Chief in 1935 and promoted to Engineer-in-Chief in July 1939. According to Radley '[Angwin's] wide knowledge of military requirements enabled him to be of exceptional assistance to the fighting services: he knew and helped to find the kind of equipment and the kind of engineers they needed'.[9] Radley readied Dollis Hill for war, both meeting the needs of the Service Ministries while also taking steps to safeguard Post Office priorities.

Gardiner and Angwin's war plans meant a culture of war readiness was felt throughout the Post Office, in every branch of the department. Planning fell into three parts: 'to meet the expected shortage of man power and changes in working conditions, to meet the circumstances of physical damage to buildings, plant and records, and to meet the additional demands on man power and plant arising from new or extended activities undertaken by the Post Office as a result of the outbreak of war'.[10] As such plans were established to relocate staff, work and records in case buildings were damaged or equipment destroyed by attack and essential engineering supplies were stockpiled. During rearmament several public telephone and telegraph circuits were diverted to the war departments and new communication routes were established. Duplicate cables were installed to critical exchanges: in London these were run through freshly dug deep tunnels under the city.[11] It was agreed that, depending on the route, between one fifth and two-thirds of the trunk network would be diverted to the military services on the outbreak of war.[12] As predicted the reallocation of resources had an impact on public services and by May 1938 the steady expansion of the

[9] Gordon Radley, 'Angwin, Sir (Arthur) Stanley (1883-1959)', *Oxford Dictionary of National Biography*, (Oxford: Oxford University Press, 2004), <https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-30421> [accessed 5 January 2020].

[10] PMA: POST 56/22 'An account of the work of the Post Office during the Second World War' by Sir Thomas Gardiner, Director General of the Post Office, 1936-1945, p. 1.

[11] Campbell-Smith, *Masters of the Post*, p. 236.

[12] PMA: POST 56/22 'Post Office during the Second World War', Gardiner, p. 17.

country's civil telephone network was being significantly held back by the 'work of meeting the telephone requirements of the defence network'.[13]

With its long connection with Service departments, tracing back to the First World War, Post Office research staff were recognised as sources of communications expertise by the military.[14] Whilst there is no evidence of work being declined or the details of contract agreements between Dollis Hill and external government departments, it is clear that Post Office staff saw themselves being at the centre of this work and did everything they could to meet the needs of the military. As we have already seen in Chapter 1 staff supported the fighting services by supplying quartz crystals for radio transmitters and receivers, but rearmament had a much deeper impact on the Research Station. The requirement to expand the communication systems for defence as well as maintaining the public network was put under pressure as material stocks were prioritised for military use. As a result, the Research Branch had to advance its research into alternatives for lead, copper and other raw materials.[15] This was not easy, as researchers relied on material samples being provided from manufacturers who were also working on rearmament projects. Investigations into rubber substitutes for lead in cables were delayed as it proved impossible to obtain samples from Imperial Chemical Industries (ICI).[16]

Dollis Hill was approached to support projects which built on peacetime knowledge relating to transporting, visualising and processing information. For example, in 1937 the Research Station was asked by the Commander in Chief of Fighter Command and A. P. Rowe, Superintendent of Bawdsey Research Station, to develop and construct equipment in connection with defence against air attack. This led to several novel devices including illuminated maps used to trace enemy planes and direct air raid warnings. Dollis Hill staff also installed extra telephone and telegraph circuits on strategic routes and improved army signals systems and equipment. This was in

[13] PMA: POST 69/9 Post Office Board 1938: Post Office Board Meeting, 8 November 1938.

[14] Haigh, 'To Strive, To Seek, To Find'.

[15] BTA: TCB 135/5 Engineer-in-Chief's Annual Report, 1939-1946; BTA: TCB 371/43 Minutes of the 114th Meeting, 24 May 1937.

[16] BTA: TCB 371/43 Minutes of the 114th Meeting, 24 May 1937.

addition to the work of the wider Engineering Department which was involved in protecting other routes for the fighting services. By July 1939, forty members of the Research Branch were fully committed to problems connected with national defence for the War Office, Air Ministry, RAF, Home Office and Royal Engineers and Signals Board. This equated to about 10% of the Research Branch, with the rest continuing to support day-to-day activities of the Post Office including developing new equipment for telephone subscribers.

In preparation for war Radley streamlined the structure of the Research Branch. The Signalling, Telegraph, Carrier and Voice-Frequency Groups were kept in their entirety and absorbed most of the staff from the other sections from which a small nucleus was kept. Informed by the type of work that had been requested during the First World War, Radley kept a small group from the Local Transmission and Acoustic Groups to attack problems relating to the location of enemies by sound and the development of special telephones for use in aircraft. A couple of staff were retained from the Chemical and Metallurgical Group to support work from the Research Department at Woolwich. Despite dispersing most of the Physics group Radley recommended keeping three Executive Engineers, L. E. Ryall, B. M. Hadfield and E. A. Speight in post with a few staff because of 'their exceptional ability for devising apparatus to meet novel requirements'.[17] Radley argued that the Workshop be retained in its entirety because it had been shown to be faster at constructing new or semi-experimental equipment than outside manufacturers.[18]

Not being classified as an essential wartime occupation put Post Office staff at risk of being called up, including those at Dollis Hill whose specialist skills were much desired by other departments. Given his seniority, Radley would have been aware of war plans that stipulated that 16,000 Post Office engineers were to be released to the services and passed directly into signals units on the outbreak of war.[19] This included 25% of

[17] BTA: TCB 4764/16 Second World War Diary of the Post Office Research Station, Dollis Hill, letter from Radley to Angwin, 11 July 1939.

[18] Ibid.

[19] PMA: POST 56/22 'Post Office during the Second World War', Gardiner, p. 44.

the Research Branch.[20] Writing to Engineer-in-Chief, Stanley Angwin, in July 1939, Radley suggested that 'despite the contact already existing it would be advantageous if the availability of Dollis Hill as a station at which wartime experiment work could be carried out and apparatus rapidly constructed, were made better known'.[21] While the archival record cannot say whether this led to an influx of requests, it is clear that Radley consciously presented the Research Station as a facility which could offer relief to the experimental establishments of the Fighting Services, through the transfer of additional work, or as insurance in case a site was put out of action from attack.[22]

It is clear that the Research Station was already willing to support the war effort by accepting a range of projects, but Radley's desire to play a more active role in national defence efforts may also have been a tactic to maintain staffing levels. Senior staff had already been seconded away from Dollis Hill and although some posts were backfilled, others were not. For example Executive Engineer E. J. C. Dixon who was loaned to the Air Ministry in 1936 for two years was subsequently permanently transferred in April 1939.[23] A similar approach was adopted by the Executive Committee of the National Physical Laboratory who encouraged the laboratory to take on extra work to retain skilled staff who were at risk of being transferred.[24] Radley justified the claim that 'it appears essential in the national interests that the branch should be maintained as a unit', by arguing that the training and experience of his staff meant they were well-placed to speedily tackle problems which might arise during the war.[25]

As part of national defence measures Dollis Hill became a physical refuge for Whitehall Departments. In the event of extensive air raid damage to Whitehall, space was reserved for a skeleton organisation of the Admiralty to move into Dollis Hill which could immediately take over the naval control of the war. Under the command of Vice Admiral Sir Charles Kennedy-Purvis, a party moved onto the site on the 25 August 1939

[20] BTA: 4764/16 'Note of the wartime work of the Research Branch', William Radley, 1 March 1941.

[21] BTA: 4764/16 Radley to Angwin, 11 July 1939.

[22] Ibid.

[23] BTA: POST 33/3073 J. A. C. Robertson, Treasury to Mr Scholes, Post Office.

[24] Russell Moseley, 'Science, Government & Industrial Research: the Origins & Development of the National Physical Laboratory, 1900-1975' (unpublished PhD thesis, University of Sussex, 1976), p. 261.

[25] BTA: 4764/16 Radley to Angwin, 11 July 1939.

taking over seven rooms in the General Research Building and three lecture rooms and the main lecture theatre in the Central Services Building. This caused major disruption to the Research Station as 205 students from the Training School were sent back to their districts to free up laboratory space. This action also removed them completely from the two buildings 'in view of the secret nature of the Admiralty occupation'.[26] Two days before war was declared arrangements were made to relocate a large part of the Research Station in case temporary accommodation was needed for a further evacuation of Whitehall. Although this was not required, the plans, which instructed staff to vacate their offices at short notice, reveal that military needs were of a greater priority than the Post Office's. Most of the Admiralty left Dollis Hill three months later as stipulated in the pre-war plans leaving a small group working out of three rooms.

The Post Office's control over the Dollis Hill site was further challenged by the construction of a 'citadel' for the War Cabinet. The threat of aerial bombardment led to the excavation of tunnels and shelters across Britain. In 1937 a committee, under the direction of Sir James Rae, recommended the 'citadel scheme' to relocate key wartime ministries to suburban London.[27] Three sites were chosen in North West London at existing government facilities: citadels were built for the Admiralty in the Admiralty Chart Depot in Cricklewood; the Air Ministry at a HMSO Factory in Harrow; and stand-by Cabinet War Rooms at Dollis Hill. The citadel at Dollis Hill was called Cabinet War Rooms 2 (with the original Cabinet War Rooms located in a basement under the Treasury) but was more commonly known as PADDOCK (likely named after the nearby Paddock Road).[28]

Work started on PADDOCK at the beginning of 1939 and was completed by June the following year, being immediately taken over by a skeleton staff. Built forty feet underground beneath a single-story administrative building, the citadel had 59 rooms

[26] BTA: 4764/16 Second World War Diary of the Post Office Research Station, Dollis Hill (Diary Entry), 26 August 1939.

[27] TNA: CAB 21/1068 Emergency War Headquarters at PADDOCK, 1938-1945, 'Emergency War Headquarters – Accommodation in the North West Suburbs', E.E.B., 7 November 1940.

[28] Duncan Campbell, *War Plan UK* (London: Paladin Books, 1983), p 167.

split across three floors.[29] Rooms were allocated to the War Cabinet Minister, War Office, Secretary of Station, Government Headquarters Liaison and Signals Section, Map Room and BBC, with space for Post Office staff to run the telephone exchanges.[30] The military presence was not just contained underground: the War Cabinet took other rooms in the Research Station. Although access to the citadel was restricted, there was little separation between the Dollis Hill and PADDOCK staff with both sharing on-site facilities including the Post Office canteen.[31] There was also close connection between the skeleton staff working at PADDOCK and the Admiralty citadel as they shared accommodation in nearby buildings called Neville's Court.

The citadel had an impact on the duties of Research Station staff who became responsible for maintaining the telecommunication systems installed within PADDOCK. This covered a wide range of communication technologies, from a Map Room to scrambler telephones. Any problems relating to the telephone equipment were directed to the Post Office Telecommunications Department (War Group) based in the Radio Block. Seven teleprinters were installed in PADDOCK which were tested daily, and all faults were directed to the Defence Telecommunications Network based in the Research Station. The Research Branch was responsible for the maintenance of wire broadcasting equipment which they had supplied. PADDOCK was a secret installation within a non-secret site, which caused complications. This included its postal address which, for a time, was 'Basement Accommodation, C.O. Post Office Research Station' but was criticised as 'it gives away the fact that some kind of dug-out is involved'.[32] The address was eventually changed to be the same as the Research Station.[33]

While reportedly costing the government £250,000 to build and absorbing Post Office resources, PADDOCK was never required to fulfil its intention. Only two War Cabinet meetings took place at the citadel on the 3 October 1940 and the 10 March 1941, their

[29] Kenneth Valentine, 'Willesden at War: The Secret Citadels of World War Two, Vol 2' (London: K. J. Valentine, 1995); TNA: CAB 21/1068 Office of Works to L.F. Burgis, 8 November 1938.

[30] TNA: CAB 21/1068 Arrangements at PADDOCK.

[31] Ibid., Accommodation in the North West Suburbs, E.E.B. 7 November 1940.

[32] Ibid., Letter to Major Rawlins, 25 March 1941.

[33] Ibid., Arrangements at PADDOCK.

main purpose to ensure it was fit for purpose. Not particularly taken with the site, in October 1940 Winston Churchill wrote 'the War Cabinet cannot live and work there for weeks on end… PADDOCK should be treated as a last resort'.[34] As a result, with Churchill's preference being the Cabinet War Rooms in Whitehall, the number of guards monitoring PADDOCK was reduced from forty to half a dozen. By 1943, the site was downgraded by the Cabinet Office from a 'vulnerable point' to 'no more than a reserve office for our non-essential staff'.[35] At that stage only a small number of staff were working in the site including the Dominion exchange which was staffed day and night.

If Cabinet were not to make use of the site, Radley was keen to access the available accommodation at PADDOCK to manage the congestion in other parts of the Research Station. Alongside being a crucial site for government departments, Dollis Hill also become home to several strategically important branches of the Post Office, including the War Section and Lines Section of the Engineering Department.[36] This put pressure on the site as the increasing number of Post Office staff struggled for accommodation. The Post Office first contacted the Cabinet Office in January 1941 requesting to commandeer some of the rooms in PADDOCK. But the appeal was not met until November 1943 and only on the condition that the available rooms could be vacated within forty-eight hours if required.[37] The citadel proved ideal for research which relied on a constant environment and did not need natural light, including growing crystals.

The Post Office was considered a means by which the government could meet their wartime needs, as highlighted by the installation of PADDOCK at Dollis Hill and denial of Radley's request to make use of the nearly redundant site. While Gardiner, Angwin and Radley did their best to prepare the Post Office and Dollis Hill for war, they were not fully in control of the implementation of their plans. Treasury control of expenditure placed financial limits on what infrastructure could be safeguarded for

[34] Quoted in Nick McCamley, *Cold War Secret Nuclear Bunkers: The Passive Defence of the Western World During the Cold War* (Barnsley: Pen and Sword, 2013).

[35] TNA: CAB 21/1068 Letter to the Secretary of the Cabinet Office, 16 November 1943.

[36] John Bray, The Communications Miracle (New York: Plenum Press, 1995), p. 42.

[37] TNA: CAB 21/1068 J.D. Winnifrith to Colonel Ives, 25 November 1943.

war. Despite taking steps to safeguard the Post Office, management did not foresee the almost immediate impact of the conflict on staff numbers and demand for its services. Yet further demands and limitations as war progressed stretched the site even further.

2.3 Wartime changes

Post Office war plans were instigated on 3 September 1939 following Britain's declaration of war against Nazi Germany. Immediately almost a quarter of the long-distance trunk capacity was switched over to government departments and the public service was downgraded.[38] Demands from the Armed Forces placed huge pressure across all parts of the Post Office. This situation was exacerbated as staff were reallocated to temporary accommodation away from the city, including the Savings Bank and clerical departments who moved to Harrogate and Morecambe. Even more impactful was the loss of 9% of the total Post Office staff as 25,000 reservists were immediately dispersed.[39] Around 4,000 joined the Royal Engineers Postal Services and the rest, mostly from the Engineering Department, joined the Royal Signals Corp.[40]

The only way the Post Office could comfortably support military requirements was for the public to reduce their use of its services. Having successfully promoted Post Office services in the interwar years, the organisation faced another publicity challenge this time to actively discourage subscribers, asking them to telephone and telegraph less so that lines could be prioritised for military communication. Unlike food rationing and blackouts which were regulated by the wartime government, this was left to the Post Office who hoped to manage public behaviour through market intervention. One technique designed to dissuade customers from using the telephone was by increasing charges. In October 1939, the Post Office abolished the popular shilling trunk call, which encouraged so many to get on the telephone, and replaced it with the full day rate. However, this did little to deter customers. Gardiner commented that higher

[38] Campbell-Smith, p. 327.

[39] PMA: POST 56/22, 'Post Office during the Second World War', Gardiner, p. 48.

[40] Ibid.

charges 'seemed merely to sharpen the public appetite for one of the few things on which they could spend money without stint'.[41] The change was very unpopular and following pressure from the public the shilling rate was reintroduced in February 1940, resulting in a 75% increase in calls.[42] This was only managed by the recruitment of additional telephonists and installation of new circuits, further redirecting resource away from government needs.

Most of the Post Office Public Relations Department (PRD), which had grown in strength during the 1930s, was absorbed into the Ministry of Information (MoI), the central government department responsible for publicity and propaganda in Britain during the war. The MoI used the familiar publicity tools of posters and, after assimilating the GPO Film Unit, propaganda films. Posters were widely used in MoI campaigns to maintain morale and influence opinion. They covered a range of themes, from encouraging conscription and growing their own food, to demonising the enemy and discouraging 'careless talk'.[43] These were designed to be distinct from other government departments through the use of contemporary artists, a unique typographical style and by including slogans aimed to evoke an immediate public reaction, either encouraging collective sacrifice or providing reassurance.[44]

The much-depleted PRD worked alongside the MoI, repurposing the marketing skills developed during the interwar period to dissuade the public from making telephone calls. One series of posters used slogans to appeal to the public to 'telephone less' and 'think twice before making any trunk call'.[45] Others featured an anthropomorphised telephone with a helmet and bayonet with the tagline 'I am on war work'. Posters showed female telephonists connecting calls to the Army, Navy and Air Force. These were intended to discourage the public from using lines which were needed for military communication, but they also framed the Post Office as an integral service on

[41] Ibid., p. 20.

[42] Mark Crowley, 'Technological Change', p. 395.

[43] Richard Slocombe, *British Posters of the Second World War* (London: Imperial War Museum, 2013).

[44] Rebecca Mary Lewis, 'The Planning, Design and Reception of British Home Front Propaganda Posters of the Second World War' (unpublished PhD thesis, University College, Winchester, 2004), p. 100.

[45] PMA: POST 110/4392 'Stop! Think twice before making any trunk calls', 1944; PMA: POST 110/4393 'Telephone Less', 1944.

the same standing as the Armed Forces. The poster 'Unseen but Unceasing' uses the same approach, reminding the public that the Post Office was also working on activities which were not visible but integral to ensure the communication routes of the nation were maintained (Figure 16-18, collection of wartime posters below).

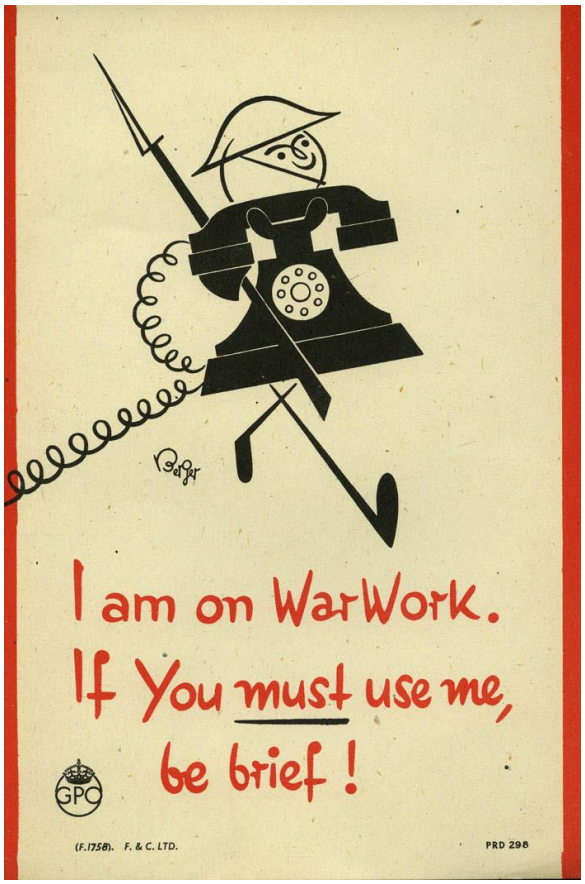

Figure 16 'I'm on War Work', by Oscar Berger, April 1943 (left).[46]

Figure 17 'we're in it together', F. H. K. Henrion, 1943 (top right).

Figure 18 'Wireless War: Post Office Engineers and Operators are in the forefront of radio developments', by Pat Keely, 1943 (bottom right).

The Post Office promoted its wartime contribution using images of technologies. Posters encouraging civilians to invest their money with the Post Office Savings Bank were accompanied by images of warships, heavy industry and soldiers in action, with the slogan 'make your money provide the driving power'. A few posters remained

[46] IWM: Art.IWM PST 4039, 'Wireless War', by Pat Keely, 1943; IWM: Art.IWM PST 3680: 'we're in it together', F. H. K. Henrion, 1943; PMA: POST 110/4384, 'I'm on War Work', by Oscar Berger, PRD 298, April 1943, Second World War poster.

purely promotional in line with the department's pre-war prestige scheme. One example is 'Wireless War' by Pat Keely which shows a Post Office telephonist surrounded by, and directing technologies used by the Air Force, Navy and Army. Its only ambition is to promote the Post Office's developments in radio. As in the case of telephony, these and other measures did not reduce public use of subscriber services; for example, telegraph traffic increased by 45% during the war.[47] But if the activities of the PRD had any practical outcome was to further imbed in the public's mind that the Post Office was an integral part of the war effort.

The site itself was changed as steps were taken to disguise the Research Station from aerial attack. North West London was at risk from bombing campaigns as it was not far from the capital and home to several manufacturers and warehouses. The Research Station was cloaked in camouflage netting covered in leaves, feathers and asbestos shapes, a Home Guard was present on the site and the staff prepared for an attack on the station with mock raids. Research Station staff also volunteered to be part of the Fire Watch who plotted the trajectories of flying bombs from the roof of the station and were part of a communication network linking other factories in the immediate area. This was quite a contrast to how the Post Office had presented the Research Station only a few years earlier when its location was widely published and it attracted visitors from all over the world, including staff from foreign administrations who, from 1939, became Britain's enemies. This was not unique to the Post Office and other sites, famous locations, factories and local landmarks used camouflage to minimise the ease of visual confirmation from the air.

The experience of war at Dollis Hill depended on the seniority and specialisms of the staff. The type of work being undertaken by the Research Station did not immediately change and there was little impact on the day to day activities for many of its engineers and scientists (see Table 1, below). There were several factors which shaped this situation: one is that the staff who had supported defence projects during the rearmament period continued to work on similar tasks under new wartime conditions. Most of the requests came from the other branches in the Engineer-in-Chief's Office,

[47] Campbell-Smith, p. 335.

rather than the military, which involved familiar duties such as calibration and testing. Of the new requests that were submitted by the Fighting Services, many of them involved a level of security which meant only a small team of staff were allocated to the task.

Category of work:	July 1939	February 1943	February 1944	1945
Work for the Armed Forces	9%	55%	67%	50%
Development and provision of circuits for service operational use		20%		
Security Services – SIGINT and HUMIT		25%	33%	50%
Work for the wider GPO	91%			

Table 1 Research Branch (Dollis Hill) resource assignment (%), by category of work and date, 1939–1945.[48]

Requests for support happened almost instantly. Two days after war was declared, Radley was asked by the Military Intelligence Department of the War Office to install concealed microphones in the Tower of London. These were used to gather information by covertly listening-in to conversations between German Prisoners of War. As I show later, requests of this kind continued throughout the war as the Research Branch became more skilled in designing and installing bugging equipment. Of equal urgency was the need for additional telegraph and telephone circuits to be installed on strategically important communication routes, either by radio or through new or established cable routes. Initially these concentrated around Scapa Flow and the neighbouring Scottish islands, but as the war developed would include links to Holland and France, avoiding any territories occupied by German troops.[49] The installation of new communication routes was normally a routine job undertaken by other parts of the Engineering Department. However, as these circuits were described by Radley as requiring 'special treatment', the necessary equipment was assembled at

[48] BTA: 4764/16 Radley to Angwin, 11 July 1939: BTA: TCB 135/5 Engineer-in-Chief's Annual Report, 1939-1946, p. 48; BTA: TCB 371/43 Minutes of the 147th Meeting, 25 Feb 1944: PMA: POST 69/28 Post Office Board, 1946 'Engineering Research', Angwin, 27 March 1946, p. 3.

[49] BTA: 4764/16 Diary Entry 31 May 1940.

Dollis Hill and installed by members of the Research Branch, who travelled around Britain and in some cases to mainland Europe.[50]

Another reason why the military did not absorb more of the Research Station's resources in the first year of the war was because, unlike the First World War, there were other new and expanded institutions which could undertake similar research. The Armed Forces had heavily increased their funding of R&D in the interwar period, spending several times more than civilian establishments. By 1932, the War Office was responsible for ten R&D sites, four were under the control of the Air Ministry and the Admiralty had twelve.[51] As well as controlling their own establishments, they also sponsored R&D in the private industry. Rearmament prompted further investment and new sites, for example the Air Ministry Research Establishment which moved to Bawdsey Manor in Suffolk in 1936 to develop radar for air defence. The Army research establishments were taken over by the Ministry of Supply, founded in 1939, to sit alongside its duties to take care of army supplies and raw material controls.

Aside from the work, some elements of the Research Station culture continued as before the war. The Horticultural Society, the oldest at the station, maintained their monthly committee meetings and AGMs throughout the conflict, encouraging the mutual exchange of plants, updating the lending library and organising shows.[52] Despite losing a couple of members to the Armed Forces, the committee remained reasonably constant throughout the war; for example Tommy Flowers was nominated as Chairman in 1940 and remained in post for three years in spite of his Top Secret work for GC&CS. It appears that the society stayed popular as the total membership increased from 126 in 1939 to 256 by the end of 1944, roughly a sixth of the total workforce of the Research Station.[53] On advice from Radley, only a couple of the seasonal shows were cancelled, including Autumn 1939 and Summer 1944.[54] There were also triumphs as despite the ongoing conflict the committee convinced Radley to

[50] Ibid., 18 June 1940; Ibid., 31 May 1941.

[51] Edgerton, *Warfare State*, p. 120.

[52] BTA: TCB 546/1 'Horticultural Society, Rules'.

[53] Ibid., Minutes of the AGM meeting, 5 December 1939 and 1 December 1944.

[54] Ibid., Minutes of Meeting, 5 September 1939 and 11 July 1944.

convert some of the neighbouring farmland into allotments and introduce an irrigation system. Clubs like these brought together staff from across the site with membership open to the Research Branch, Radio Branch and Training School. So, despite being heavily separated by their work duties, staff could still interact in these informal spaces.

2.4 Navigating the wartime state

Although all government departments were working towards Britain's success in the war, Dollis Hill was also competing with other R&D establishments and industry for space, resources, prestige and patronage from key stakeholders, or as Radley described them 'customers'.[55] Radley used every opportunity to promote Dollis Hill driven by his belief that his staff were better engineers than those in other research establishments. This attitude was not unfounded as the Research Station was approached by outside bodies because of the expertise they had demonstrated before the war. However, following rearmament Dollis Hill became one of several R&D sites working on communications technologies, the majority of whom were managed by one of the Fighting Services or Supply Ministries. Researchers and scientists in these establishments had greater opportunity to influence key wartime individuals than the Post Office who answered to the Treasury.

Nevertheless, individuals had significant influence on the wartime state through their roles on committees and advisory bodies. Angwin sat on several bodies including chairing the technical sub-committee of the Imperial Communication Committee to manage the equipment owned by Cable and Wireless and establish relay stations where strategically needed. As Vice-President (1939–1942) and then President (1943–44) of the Institution of Electrical Engineers, Angwin was part of a wide network of engineers across government and private industry. Radley influenced the direction of wartime research through his involvement on several inter-service committees including the Radio Components Research and Development Committee,

[55] BTA: 4764/16 'Appreciation of wartime work of the Research Branch Staff', W. G. Radley, 31 May 1945.

Communications Committee and as Chairman of both the Magnetic Materials Panel and the Electro-Acoustics Sub-Committee.[56] Britain relied heavily on imports which became harder to obtain with U-boat attacks sinking convoys and fighting in exporting countries which resulted in increasing the costs of those stocks that were available.[57] Raw materials and equipment were of great strategic importance during the war, so committees established priority lists of materials and introduced mechanisms for sharing expertise.[58] These groups brought together representatives from the Admiralty, War Office, Air Ministry, Ministry of Supply, Ministry of Aircraft Production and the Post Office. In many cases Post Office officials were also representing the BBC, Railways and manufacturing. [59] This was, in part, to manage relationships with private firms who were party to Exchange Equipment and Telephone Apparatus agreements and to safeguard the Post Office's contractual obligations to them.[60] Practically these committees collected information on a specific issue across the country, established priority lists and directed research.

The Post Office struggled to access many hard to source materials, such as iron, tin, and rubber which were integral to communication devices. As a result, the Chemistry Group of the Research Station undertook work on behalf of contractors and Supply Ministries to find natural and synthetic substitutes. For example, shortages of rubber and silk directed research into alternative dielectrics and the lack of tin in circulation affected the composition of solders.[61] In order to avoid duplication of research the Post Office worked with the Royal Aircraft Establishment at Farnborough to investigate replacement materials for electrical cables and wires. The Research Station also

[56] TNA: T 162/696/5 Post Office Engineering Department Research Section Staff, D. J. Lidbury to R. J. P. Harvey, 29 July 1944.

[57] Peter Thorsheim, *Waste into Weapons: Recycling in Britain during the Second World War* (Cambridge: Cambridge University Press, 2015), p. 2.

[58] David Edgerton, 'Controlling Resources: coal, iron and oil in the Second World War', in *The Cambridge History of the Second World War, Volume 3: Total War: Economy, Society and Culture*, ed. by Michael Geyer and Adam Tooze (Cambridge: Cambridge University Press, 2015), pp. 122-148 (p. 123).

[59] PMA: POST 69/15 Post Office Board 1942, B.P. 12(42) 'Stores and Equipment Supply Position', Angwin, 30 March 1942.

[60] PMA: POST 69/13 Post Office Board 1941, B.P. 18(41) 'Review of Expenditure since the outbreak of war', G. I., 1 July 1941.

[61] PMA: POST 69/15 Stores and Equipment Supply.

worked with industry to develop and test substitute materials. It collaborated with Pye Radio on the problem of impregnation of cellulose acetate for a substitute for silk needed to cover wires.[62] In other cases, production techniques were developed which used fewer precious materials. Tin became scarce after the Japanese invasion of Malaya which led to a new method of soldering joints that used three quarters of the normal amount. By March 1942, Angwin reported that substitutes may have to be found for every electrical purpose.[63]

One committee that directed research at Dollis Hill was the Iron Dust Advisory Committee: iron dust was a key material in the construction of inductors, an important element of telecommunication equipment used in carrier and radio-frequency devices. Inductors were composed of a core of compressed magnetic powder surrounded by a coil. At the time, the most suitable core was made by the carbonyl process and before the war Germany was the biggest exporter of the component. Little stock piling had been undertaken and by 1941 Britain had worked its way through most of its resources. The Committee was established under the Ministry of Supply and took control of the remaining store and prioritised how it was used. The Post Office was represented on the Committee and contributed to the review of the characteristics of powders that were available in Britain at the time.[64] In 1943, this culminated in a new factory to manufacture carbonyl powders under the management of the Ministry of Supply with advice from Research Station staff.[65]

Some projects enabled the Post Office to have access to material stocks which would otherwise been unobtainable. Engineers in the Radio Branch at Dollis Hill were responsible for designing and installing Masked Beacons 'Meacons' during the early stages of the war.[66] These were developed to interfere with radio navigation systems which guided enemy bombers to their targets. The theory, developed by Post Office

[62] PMA: POST 56/138, Engineer-in-Chief's Office War Diary, July 1942.

[63] Ibid., March 1942.

[64] BTA: TCB 422/12162 C. E. Richards, A. C. Lynch, 'Magnetic Properties and the Development of Carbonyl Iron Powders', 1941-1940.

[65] BTA: TCB 135/5 Engineer-in-Chief's Annual Report, 1939-1946, p. 50.

[66] James Goodchild, 'R.V. Jones and the Birth of Scientific Intelligence' (unpublished PhD thesis, University of Exeter, 2013), p. 156.

engineer Jim Merriman, was to create an interference pattern by intercepting the radio navigation signal at one location in the UK, transmitting it over a distance of coaxial cable and retransmitting it, therefore creating an interference pattern which would disguise the actual target.[67] The first Meacon became operational in July 1940 under the control of the RAF 80 Group.[68] The system took advantage of the German's dependence on Medium Wave Direction Finding which led to thirty-eight Meacons being deployed between Norway and Bordeaux.[69] Dollis Hill engineer John Bray described the experience of working on the project as one of unlimited resource stating that 'whatever we wanted was available before we finished asking for it… we had clearly defined objectives and almost unlimited powers to command and control'.[70] This was a most unusual experience for Dollis Hill staff, used to working to tight budgets with limited space and resources. Other projects were delayed or abandoned when it was difficult to access the materials required. For example, in October 1941 work was 'seriously delayed' on the installation of privacy units for Air Ministry teleprinter circuits.[71]

Confidential demonstrations of new technology were common during the war and gave Post Office staff an opportunity to promote their solutions to certain problems and prove their abilities to influential audiences. This did not always mean displaying a finished device. A mutual interest in infra-red signalling between the Research Branch, who were developing a portable optical telephone link for secret communications, and the Admiralty, who were in charge of infra-red research for all three fighting services, resulted in a demonstration at Dollis Hill where representatives from the Admiralty, the Ministry of Supply and Royal Engineers & Signals Board were shown an experimental set up.[72] Received well by these external parties, selected staff in the

[67] Ibid., p. 45.

[68] L. R. Harris, 'Post Office Engineers in World War II', *The Journal of the Communications Network*, 5.1 (2006) 17-29 (p. 20).

[69] Ibid.

[70] Bray, *The Communications Miracle*, p. 45.

[71] BTA: 4764/16 Diary Entry 26 October 1941.

[72] BTA: TCB 422/9769 'Design of an Experimental Portable Optical Telephone Link, 1939'; Jones, *Most Secret War*.

Research Branch were asked to redirect their attention towards making their equipment smaller and lighter.[73]

Demonstrations strengthened ties across the military-industrial-academic network, especially with projects which were collaborative in nature. Dollis Hill was one of several organisations developing equipment to detect buried delayed action bombs.[74] Post Office staff worked with institutions with whom they already had a connection including the NPL and the electrical firm British Thomson-Houston, but for the first time also collaborated with esteemed academic scientists who had influence across the wartime state. This included University of Cambridge physicist William Lawrence Bragg and the physicist Edward Andrade from University College London who was an advisor to the Ministry of Supply.[75] Radley and Bragg continued to collaborate on other projects of mutual interest including research into the carbonyl process and electro-acoustic equipment.

Unlike the presentation of Dollis Hill in histories of Bletchley Park, which give the impression that the Post Office had to fight for influence against more favoured organisations, I have shown that the Research Branch, through its role in wartime committees and its professional relationships, was dominant and unchallenged in many areas. Nonetheless, Radley was still keen to diversify the type of projects being undertaken by the Research Station on behalf of the wartime state.

2.5 Selling expertise

Radley's concern to position Dollis Hill as a key part of the warfare state was evident in his selling of Post Office expertise. This was demonstrated in the project to construct a codebreaking device for Bletchley Park in connection with the Enigma machine used by the German military. Two factors made it challenging for Radley to promote Dollis Hill's technological solutions to Bletchley Park. Firstly, as Christopher Smith's work

[73] BTA: 4764/16 Diary Entry 25 July 1940.

[74] Ibid., 30 August 1940.

[75] Ibid., 2 October 1940.

suggests, managers at Bletchley Park were unreceptive to technological innovation and mechanisation which was the opposite of Post Office attitudes.[76] Secondly, there was also a clash of personalities between personnel from the two research establishments which was likely connected to their different working cultures. Bletchley Park operated on a hierarchy correlating to academic aptitude, which meant senior staff were less likely to have dealt with engineers as equals. With Dollis Hill being predominately engineers, many of whom had started their technical education as apprentices, they were less used to working with academics from different social and educational backgrounds.

In February 1942, the British government became aware that the German administration was using 4-wheel Enigma machine to cipher messages. This was a more complex version of the 3-wheel Enigma which had been broken using an electro-mechanical device called the Bombe designed by Alan Turing and installed at Bletchley Park in March 1940. Commander Edward Travis, the Head of Bletchley Park, requested Post Office assistance. This could have been regarded as a step highlighting that the team at Bletchley Park regarded the Post Office as an equal. However, while Radley visited Bletchley Park on the 24 February, shortly after the first intercept of this new code, he was critical that the assistance of the Post Office had not been consulted sooner.[77] Several devices were proposed, including an adapted Bombe with two attachments, a commutator and electronic valve sensing unit. The commutator, codename 'Cobra' was built by a team at TRE under the direction of physicist Charles Wynn-Williams, but, there were competing ideas about how best to construct the sensing unit.[78] Harold 'Doc' Keen from the manufacturer British Tabulating Machines (BTM) who built the original Bombe, proposed a relay-sensing electro-mechanical system which had Wynn-Williams' support, and Tommy Flowers suggested a scheme which used valves.[79]

[76] Smith, *The Hidden History of Bletchley Park*, p. 164.

[77] BTA: 4764/16 Diary Entry 7 March 1942.

[78] TNA: HW 62/5 'Notes on the Bombe Position', W.G. Welchman to Commander Travis, 6 April 1943.

[79] Gannon, *Colossus*, p. 249.

Radley gained support from Travis for the Dollis Hill design of sensing unit by reframing the debate as one for which Post Office expertise was most suitable. This is demonstrated in a letter from Radley in which he wrote 'in conversation you have from time to time generously indicated that you regarded Flowers and myself as your technical advisers with regard to the use of telephone switching equipment'.[80] This approach proved successful as following a meeting in Westminster in December 1942, Radley convinced Travis to agree to the Post Office constructing seventy-two sensing units to their design, as a back up to the Wynn-Williams devices, even though there was no guarantee they would be used.[81] This positioning was criticised by Gordon Welchman, Head of Hut 6 at Bletchley Park and responsible for breaking Enigma ciphers, who wrote of his concerns to Alister Denniston, Travis' equivalent in charge of the civil wing of the GC&CS. In the letter Welchman complained that 'for a long time I have been worried about Commander Travis' apparent attitude to BTM and have wondered how much influence Dr Radley was exerting in the background… in particular his insistence of keeping Dollis Hill happy, without apparently worrying about the feelings of BTM has put me in a difficult position'.[82] He continued to argue that this situation had arisen because Radley 'had the reputation of Dollis Hill in mind and that he has been acting as a salesman'.[83]

Accusations of technical incompetence were used by Bletchley Park and Dollis Hill to dismiss opposing sensing unit designs. Writing to Denniston again, Welchman criticised Flowers' working methods 'Dr Wynn-Williams has found it difficult to get on with the Dollis Hill people, and feels that Mr Flowers' idea of co-operation is to run things himself', and his engineering abilities, claiming that '[Flowers] was probably very good at his ordinary work, and also very good at designing apparatus for a definite problem that he can understand', and believing this task to be beyond his capabilities, 'I have found him very slow at grasping the complications of our work and his mind seems to

[80] TNA: HW 62/5 W.G. Radley to Travis, 2 March 1943.

[81] BTA: 4764/16 Diary Entry 16 December 1942.

[82] TNA HW 62/5 Welchman to Alistair Denniston, 4 June 1943.

[83] Ibid.

be altogether inflexible'.[84] Equally, the Post Office were highly critical of the other team's work, especially that of BTM, and reportedly 'attacked Keen, both as to his competence as an engineer and as to the actual Relay System which he has designed'.[85] Frustrations over the delays to the project led Flowers to argue that 'it was a scandal that after fifteen months BTM had not got a machine running'.[86]

Despite Welchman arguing that '[the] influence of Dr Radley and Mr Flowers must be completely removed [from the Bombe project]', with Travis' support the Post Office was approached again to support another problem.[87] This related to the decryption of intercepted teleprinter messages, given the name 'Tunny' by Bletchley Park, encrypted on a twelve-wheel Lorentz cipher machine. Much more secure than the Enigma code, Tunny was used to send messages between the German high command. This challenge, also involving Wynn-Williams, was to construct an electronic counting device to be used on the Heath Robinson, the first machine designed to break the Tunny messages.[88] The Heath Robinson worked but suffered from technical issues including trouble sustaining the synchronisation of two teleprinter tapes at high speed, required for the statistical method used to identify five wheel settings of the cipher.[89] It was also slow, taking several hours to resolve one message.[90]

Yet again Flowers caused friction by suggesting replacing the Heath Robinson with a fully electronic machine in which the information of one of the tapes would be generated internally, removing the synchronisation problem and speeding up the process. Flowers recounted that his suggestion was met with 'incredulity' by senior staff at TRE and Bletchley who did not believe his design would work and if it did, it would take too long to construct.[91] Their main concern was that Flowers' machine

[84] Ibid.

[85] Ibid., 'Memorandum of Meeting with Dr Radley – Fish and Counting Machines (Mr Newman)', Alistair Denniston, 29 May 1943.

[86] Ibid., Welchman to Denniston, 4 June 1943.

[87] Ibid.

[88] Gannon, *Colossus*, p. 253.

[89] Jack Copeland, 'Machine against Machine', in *Colossus* ed. by Copeland, pp. 81-94 (p. 82).

[90] Gannon, *Colossus*, p. 253.

[91] Copeland, 'Machine against Machine', p. 91; IWM: 18332, Flowers, Thomas (Oral History), 1998.

relied on thousands of high-speed valves which were considered temperamental.[92] However, through his work designing electronic exchanges before the war, Flowers knew they could be efficient if they were left on and never switched off. [93]

In defence of Post Office skills and knowledge, and with no guarantee Bletchley Park would accept the machine, Radley provided Flowers with staff, funding and privileged access to the workshops at Dollis Hill, enabling a prototype to be built in ten months.[94] A successful demonstration of the machine at Dollis Hill in November 1943 changed the opinions of Bletchley Park staff. Vindicated, Post Office staff delivered 'Colossus', as it became known, to Bletchley Park on 18 January 1944.[95] Radley was right to describe the equipment as a 'major development, the comparison being made between a message tape and a pattern set up by an electronic commutator' as it ran fifteen times faster than the Heath Robinson.[96] Colossus immediately doubled the codebreaker's output and in March Bletchley Park ordered more to be built.[97] Radley's gamble was justified when, following the delivery of Colossus II to Bletchley Park in June 1944, the Research Branch was authorised an expenditure of £80,000 to build further Colossi and associated codebreaking machines (Figure 19 below).[98] This was a sizable figure, equivalent to 11% of the total annual expenditure of the DSIR that year, which funded 2,471 staff across twelve research establishments.[99]

[92] SCM: MS/0129/17, A. W. M. Coombs, Pioneers of Computing.

[93] IWM: 18332, Flowers (Oral History).

[94] Ibid.

[95] SCM: L2019-562, Tommy Flowers Diary, 18 January 1944.

[96] BTA: 4764/16 Diary Entry 30 January 1944; Copeland 'Machine against Machine', p. 92.

[97] TNA: HW 62/6 H. L. Ismay to Angwin, 15 March 1944.

[98] BTA: 4764/16 Diary Entry 1 June 1944.

[99] *DSIR Report for the Year 1947-8 with a review of the years 1938-48*, Cmnd. 7761 (London: HMSO, 1949), p. 7.

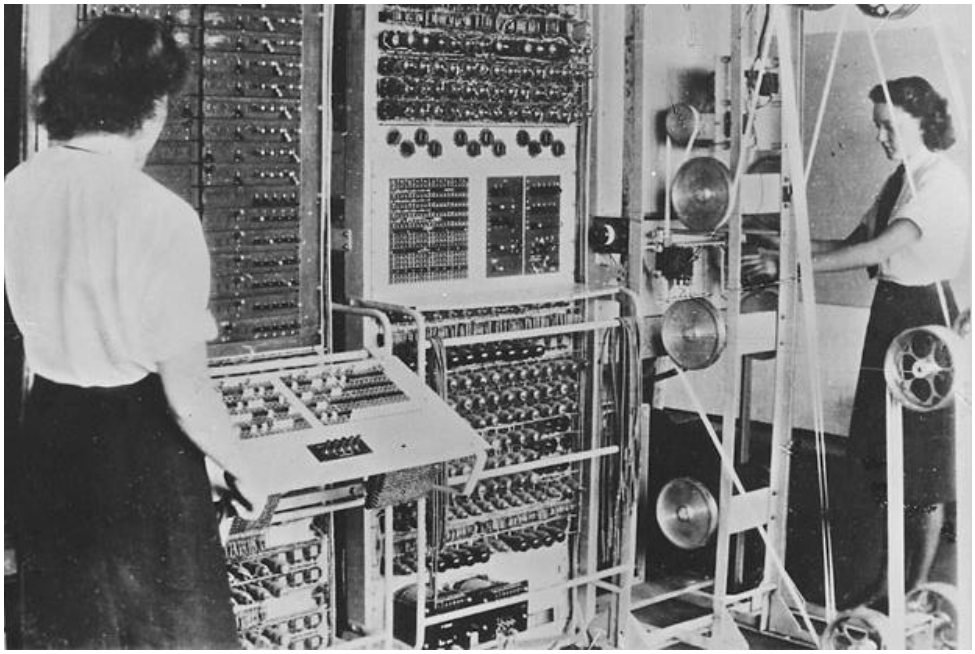

Figure 19 Wrens operating Colossus II machine at Bletchley Park, 1943.[100]

In other realms the Research Branch immediately proved its expertise and carved out an unchallenged, unique role in the wartime state. This was the case with the development of bugging equipment and recording devices which, following the first installation in the POW camp held in the Tower of London, led to supporting human intelligence (HUMINT) activities in many theatres of war. Through word of mouth the Research Branch ended up supporting a range of activities for several branches of the Directorate of Military Intelligence, a department of the War Office. These included domestic counter-intelligence (MI5), secret intelligence service (M16) and signals intelligence (MI8). Unlike Dollis Hill's role in Bletchley Park projects, which came to the fore in 1942 and peaked in 1944, this work was in high demand throughout the war and, in terms of secrecy, considered of equal importance.[101]

The Research Branch's first foray into HUMINT work was coordinating the development and installation of listening-in equipment and communication infrastructure for the Combined Services Detail Interrogation Centre (CSDIC). This military operation was established to interrogate enemy detainees, defectors and POWs. Initially a joint project between MI1(a) and MI5, this came under the control of

[100] TNA: FO 850/234 Annotated photographs of the Colossus electronic digital computer, 1943.

[101] BTA: TCB 371/43 Minutes of the 148th Meeting, 11 October 1944.

MI9 in November 1939, representing the wider interests of MI6, the Navy and the Air Ministry.[102] Instead of gathering crucial information through interrogation, the CSDIC used bugging devices in rooms and outdoor spaces to eavesdrop on prisoners' conversations in cells and POW camps. The audio was recorded onto discs which were maintained by intelligence staff working out of nearby M Rooms.

After demonstrating this intelligence gathering activity was fruitful at the Tower of London, the stately home in Trent Park, Cockfosters, was requisitioned to increase the capacity for prisoners and security service staff. Initially, the CSDIC purchased commercial recording devices and discs from the Radio Corporation of America (R.C.A.) which were then installed by Research Station staff. However, due to the development of bespoke equipment at Dollis Hill, the final installation of Cockfosters Camp, as it became known, also included Post Office devices concealed in telephones, ceiling roses and behind perforated grates around the rooms.[103] These was installed by Assistant Staff Engineer (and Radley's deputy) E. J. Barnes with support from Assistant Engineers J. F. 'Jimmy' Doust and J. O. Ackroyd with assistance from W. H. Clarke, the Chief Engineer of R.C.A.[104]

Based on the quality of the Post Office equipment and the government's desire to reduce imports, the Research Branch took responsibility for designing, constructing and installing all listening-in equipment in CSDIC camps in Britain and abroad.[105] Doust became the Post Office liaison with the Security Services. This involved a wide variety of work, from installing concealed microphones in houses owned by MI5, in hotels and large POW camps. Some of these were permanent fittings and installed during construction, others were only used for a day, and some equipment was specially designed to be portable using short-range radio transmissions.

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[102] Helen Fry, *The Walls Have Ears: The Greatest Intelligence Operation of World War II* (New Haven; London: Yale University Press, 2019), p. 21.

[103] BTA: 4764/16 Diary Entry 15 December 1939.

[104] TNA: WO 208/3457 CSDIC: listening and recording equipment, R.C.A. to Major Percival, War Office, 24 October 1939.

[105] Harris, 'Post Office Engineers in World War II', p. 21; BTA: 4764/16 Diary Entry 30 July 1940.

Following a decision by the Minister of Intelligence to install a camp in the Middle East in late 1940, Doust established a small team of engineers to support this work including Gil Hayward, who eventually installed the microphone recording equipment in a special interrogation centre south of Cairo, on the edge of the desert near Maadi.[106] Eavesdropping proved a successful strategy; around 10,000 POWs were bugged resulting in more than 17,000 intelligence reports, compared to 5,000 reports from direct interrogation.[107] By the end of the war the CSDIC had recorded on 65,000 discs, each containing around six minutes of speech.[108] Secret recordings provided key strategic information about air attacks including the Battle of Britain and the Blitz, as well as details of weapons such as the V1 rocket. When the conflict ended MI9 went to great lengths to hide its methods, even refusing to share the information gained from POWs for the prosecution of war crimes.[109]

The demand for recording equipment and discs for the War Office established a new area of research at Dollis Hill where staff became national experts. These devices were integral to the work of the intelligence branches but were also required, in their numbers, to record interceptions of enemy signals, for foreign propaganda broadcasts by the BBC and MOI, and speech training for the Armed Forces to help improve their diction on the telephone in noisy environments, such as tanks and aeroplanes.[110] Britain had relied on importing recording equipment from Germany and America. During war these routes were either blocked or actively discouraged. A review of commercially available recording devices led one Post Office worker to conclude that it was 'a field which appears to have been completely neglected by manufacturers in this country'.[111] One firm, The M.S.S. Recording Company which made high-grade, studio-type recording equipment for broadcasting was identified as having some of the

[106] Gil Hayward, 'Dollis Hill in the Desert, 1940-44', copy in BTA unpublished paper (1995), p. 6.

[107] Stephen Tyas, 'Allied Intelligence Agencies and the Holocaust: Information Acquired from German Prisoners of War', *Holocaust and Genocide Studies*, 22.1 (2008), 1-24 (p. 2).

[108] Falko Bell, '"One of our most valuable sources of intelligence": British Intelligence and the Prisoner of War System in 1944', *Intelligence and National Security*, 31.4 (2016), 556-578 (p. 572); Hayward, p. 8.

[109] Bell, p. 557.

[110] BTA: TCB 422/12259 A.E. Woods, N.W. Neal, D.L. Richards, 'The development of portable sound-recording equipment for the Admiralty', 12 April 1946.

[111] BTA: TCB 422/11838 F. E. Williams, N. W. Neal, 'Test of Memovox recording equipment', 1942

required experience.[112] The Research Branch developed new machines and improved manufacturing techniques in conjunction with M.S.S. and later took control of the firm's factory. By 1943 several hundred recorders were in circulation, increasing to tens of thousands by the end of the war.[113] This was an unusual step for Dollis Hill, which in peacetime, was discouraged from directly manufacturing goods itself – instead relying on Bulk Supply Agreements with private firms.

By the end of the war a small number of staff in the Research Branch had become unofficial agents of the War Office. They had provided equipment, staff and training operatives to work in all the CSDIC international sites in Algiers, Cairo, Italy, Middle East and Far East. On one occasion Post Office staff actually interrogated a prisoner.[114] Radley was also informed of the results of their work, for example that information gathered from a captured submarine officer had led to the sinking of three German U-boats.[115] An unexpected result of installing covert equipment was that Doust and his team became experts in locating it and were asked to check whether government buildings in Whitehall and Embassies had been bugged. Research Branch staff travelled from Tangier to Ankara to check for concealed microphones. This included searching for Russian microphones as well as German, as demonstrated by the request for a Post Office engineer to search the rooms which would be used by Winston Churchill during the Yalta Conference, the meeting to discuss the post-war reorganisation of Germany and Europe.[116]

Radley was more successful at selling Post Office skills to government departments which did not have their own, dedicated R&D establishment, such as sections of the Directorate of Ministry Intelligence. Dollis Hill faced stronger competition at Bletchley Park, which was in itself a research organisation whose senior staff had close connections to TRE, through shared professional experiences, class and education. The

[112] Edward Lewis Pawley, *BBC Engineering 1922-1963* (London: BBC Publications, 1972) p. 184.

[113] BTA: TCB 422/11981 F. E. Williams, 'The Development of a Portable Disk Recording Equipment', 1940-1943, p. 12; BTA: 4764/16 Diary Entry 26 May 1945.

[114] Hayward, p. 5.

[115] BTA: 4764/16 Diary Entry 18 March 1941.

[116] Ibid., 19 January 1945.

dismissal of the equipment designed by Flowers which used new, electronic techniques supports Smith's findings that Bletchley Park was cautious about untested technologies.[117] However, in the case of Colossus, the potential value of prestige from the Bletchley Park project was worth going ahead with Flowers' design at the expense of other Dollis Hill projects. So while Radley achieved in positioning the Research Station in some realms this was not a complete immersion, missing out on the benefits that came with being a full actor in the warfare state, including control over decision making, access to resources and maintaining staff.

2.6 Staffing Dollis Hill

Following the declaration of the war, as planned, a quarter of the Research Branch were mobilised and dispersed. This equated to around 100 people, many of whom were in the minor grades as skilled and unestablished skilled workers. This had an immediate impact on Dollis Hill and the management of staff. Some areas were more affected than others: for example, the crystal laboratory of the Radio Branch reduced its age limit at entry to eighteen to replace the quartz workers who had been called up. In order to manage losses in the Research Branch, Radley transferred staff between groups to meet the requirements of urgent work, including staff from the Training School. However, the first warning that this approach was reaching its limits was reported in December 1939 following the decision to restart training courses, for the Post Office and Fighting Services and Intelligence Branches. During the first year of war, twenty-four senior staff were released to other war work, thirteen of which were released specifically to support the Battle of Britain operations between June and August 1940. This latter loss of staff coincided with a period of intense activity within Dollis Hill, especially for the groups responsible for providing circuits between Britain and the continent. A considerable number of the staff in the workshop worked 12-hour weekdays and 10-hour weekends on a seven-day week.

The recruitment of new staff to replace those that had been dispersed from the Research Station was restricted by the Treasury's control of the Post Office. Despite

[117] Smith, *The Hidden History of Bletchley Park*, p. 164.

desperately needing to replace the Inspectors who had been lost, through loan or transfer, the Treasury refused to sanction the cost of employing additional unestablished (temporary) Inspectors. Radley's only option was to recruit an Unestablished Skilled Worker, promote them to a Skilled Worker Class I (SW1), make them an established worker and then use the normal promotion procedure to advance the employee to Inspector.[118] This laborious process, taking several years, was made more challenging as men were reluctant to accept the pay of Unestablished Skilled Workers, especially when other R&D establishments offered better salaries. In 1941 Radley reported that 'the rates of pay compared so unfavourably with outside rates that it was found impossible to recruit men at rates of pay lower than these appropriate to SW1 and many of the candidates compared unfavourably with existing SW1 as regards ability'.[119]

Recruitment to Dollis Hill was further impacted by the Post Office not being considered essential war work. Priority industries, such as aircraft production and munitions factories, and R&D establishments run by the Service and Supply Ministries benefitted from privileged access to scientific and engineering staff.[120] They were allocated, or could recruit, scientific and technically qualified men and women from across industry and academia through the Central Register. This list was managed by the Ministry of Labour and National Service and contained the names of scientists across a range of specialisms from physiology to zoology.[121] Initially this register was voluntary and by May 1940, 97,044 names had been registered, sorted into seventy-five main classifications and 735 sub-classifications.[122] Two months later the Ministry of Labour and National Service made it compulsory for engineers, chemists and physicists to register.[123] This reflected a shift in the government's attitude to science, advocated by

[118] BTA: TCB 371/43 Minutes of the 140th Meeting, 11 December 1939.

[119] Ibid., 142nd Meeting, 24 Feb 1941.

[120] Margaret Gowing, 'The Organisation of Manpower in Britain during the Second World War', *Journal of Contemporary History*, 7.1/2 (1972), 147-167 (p. 151).

[121] Peter Hennessy, *Whitehall* (London: Pimlico, 2001), p. 94.

[122] *Eighth Report from the Select Committee on National Expenditure (Central Register), 1939*-1940, HC 140 (London: HMSO, 25 June 1940), p. 4.

[123] William McGucken, 'The Royal Society and the Genesis of the Scientific Advisory Committee to Britain's War Cabinet, 1939-1940', *Notes Rec. R. Soc. Lond.* 33 (1978), 87-115 (p.104).

senior academic scientists and by the new Prime Minister Winston Churchill, who encouraged the improvement of coordination between research activities of R&D establishments and better utilisation of scientific knowledge for the war effort.[124]

With little change to the methods of recruitment at Dollis Hill the Research Station had less opportunity than other R&D establishments to develop new fertile relationships across the wartime state. Sites that benefitted from the mobilisation of scientific manpower established new connections between academia, industry and the military. These often brought together researchers from a wide range of specialisms, from across science and, in the case of Bletchley Park, also the arts. These networks became important loci in the shaping of the relations between scientists, military and the British state which influenced the development of post-war science.[125] This included TRE, which benefited from access to university scientists through the Central Register and transfers from other government departments, such as the BBC Engineering Division. Senior staff at Bletchley Park, cryptanalysts, translators and analysts were recruited through informal academic networks within elite institutions. While coming from a more diverse range of backgrounds than their managers, the thousands of male and female support staff who kept Bletchley Park running were still distinctly middle class.[126] Reflecting the backgrounds of their senior staff both establishments created a scholastic common room culture of problem solving.[127] This was not replicated at Dollis Hill which retained much of its pre-war culture.

Like many other government departments, the Post Office was able to relieve some of its staffing issues by increasing the number of female staff. The employment of women workers became an integral part of the state's management of the 'manpower' problem during the war. Initially the Ministry of Works encouraged women to volunteer to register for wartime employment, but as the number of men in the Armed Forces and the need for munitions increased volunteering changed to

[124] Ibid., p.99.

[125] Agar, *Science and Spectacle*.

[126] Christopher Smith, *The Hidden History of Bletchley Park*, p. 57.

[127] Ibid., p. 40; Bernard Lovell, 'Turning point of the war', *New Scientist*, 96.1330 (4 November 1982), 315-316 (p. 315).

conscription. From December 1941 all women aged between twenty and thirty were called up for service in the military or industry.[128] This led to an increase of 1.5 million women joining the munitions and basic industries.[129] Rarely did female wartime staff benefit from the same working rights as their male counterparts. During the war, industrial unions and the Ministry of Works justified the difference in pay between the sexes. Indeed, the government saw the utilisation of women as a means of reducing labour costs and introduced new job titles to manage this. One technique was breaking down a skilled job into several smaller tasks to be completed by unskilled labour, which was cheaper.[130]

Following the large losses of male staff, the Post Office actively encouraged women to work in positions previously restricted to men, including engineering roles. This was supported by the Post Office Engineering Union (POEU) who accepted the introduction of female staff, known as Female Assistants, on the condition that it was a temporary, wartime measure which would discontinue at the end of hostilities.[131] The POEU argued that female labour should be paid the same as male labour.[132] The Post Office, needing to save money, reflected the Treasury's resistance to equal pay and eventually the Union accepted an offer of 80% of the male rate, in reflection of their restricted duties.[133] These duties included cord repairs, recovering telephone subscriber apparatus and meter reading. An agreement was reached in early 1941 and the Female Assistant became an official role in the Engineering Department. Other unions were more effective at getting equal pay such as the Transport and General Workers Union who successfully fought for female bus and tram conductors to be paid the same as men.[134] Reflecting the competencies of Female Assistants, increased duties

[128] Sonya O. Rose, 'Women's Rights, Women's Obligations: Contradictions of Citizenship in World War II Britain', *European Review of History*, 7.2 (2000), 277-289 (p. 279).

[129] Gowing, 'The Organisation of Manpower', p. 152.

[130] Ian Gazeley, 'Women's pay in British industry during the Second World War', *Economic History Review*, 61.3 (2008), 651-671 (p. 655).

[131] PMA: POST 33/5820 Engineering: Termination of Employment of Temporary Female Assistants Employed as a Wartime Measure 1947, letter to Postmaster General, 14 November 1947.

[132] PMA: POST 30/5692/Pt1 L. John Edwards to P.J. Ridd, 18 December 1940.

[133] Ibid., letter to J. Ramsey, 11 December 1940.

[134] Harold Smith, 'The Problem of "Equal Pay for Equal Work" in Great Britain during World War II', *The Journal of Modern History*, 53.4 (1981), 652-672 (p.657).

and further pressure on releasing men to the forces, in July 1941 the Post Office split the role into two grades. Grade II became the entry grade when women joined the Engineering Department and included the duties outlined above.[135] The new role, Grade I, came with increased responsibilities including maintaining subscribers' apparatus, undertaking minor duties in repeater stations and assisting in teleprinter workshops and dial repairs.[136] Although regarded as equivalent to an Unestablished Skilled Worker, the Grade I salary was lower.

The severe staff shortage and need to attract a female workforce meant the Post Office circumnavigated policies which prevented women's employment in the past. This included taking a more liberal stance to the civil service Marriage Bar, which stipulated women left their jobs after getting married, and restricted hiring divorcees. By August 1941, 1,350 women were in Female Assistant posts undertaking telephony, post and engineering responsibilities.[137] As Mark Crowley has shown the Post Office was one of the more supportive government departments in its treatment of its female staff.[138] This included encouraging professional development through extensive training.[139] This was not reflected in other engineering sectors that were less enthusiastic about the employment of women in male roles. Several industries would only promote women if they proved they could undertake certain tasks without supervision but did not train them in those activities.[140] This practice was observed in the Air Ministry and encouraged by trade unions including the National Union of General and Municipal Workers.[141]

Dollis Hill was one of the first areas of the Engineering Department to consider 'dilution by women', a policy in which female labour filled gaps in the workforce or

[135] BTA: POST 33/5820 Memorandum of Agreement – Female Engineering Assistants, 22 December 1941.

[136] Ibid.

[137] BTA: POST 30/5692/Pt 3 letter to the Assistant DG, 1 Aug 1941.

[138] Mark Crowley, 'Women Post Office Workers in Britain: the Long Struggle Gender Equality and the Positive Impact of World War II', *Essays in Economic and Business History*, 30 (2012), 77-92.

[139] Ibid., p. 84.

[140] Smith, "Equal Pay for Equal Work", p.657.

[141] Gazeley, 'Women's pay in British industry', p. 661; Ian Gazeley, 'The levelling of pay in Britain during the Second World War', *European Review of Economic History*, 10.2 (2006), 175-204 (p. 182).

replaced men who could then be promoted to a higher posts.[142] In December 1939, Radley shared his eagerness to hire female Laboratory Assistants with the rest of the Engineering Department Coordination Committee.[143] However, it took several months before the first women joined the workforce, a delay caused by the time taken to agree the terms of employment with the union. By April 1942 twenty-five Female Assistants were employed in the Research Branch and fifty-two were based at the Radio Branch on the shared site.[144] Reflecting the technical ability of this workforce, two-thirds of these were working at Grade I level. The Post Office took the welfare of women seriously and a scheme that was devised at Dollis Hill was adopted across all Engineering Department branches. This involved a Female Clerical Officer acting as a Welfare Officer, a Female Assistant acting as a Liaison Officer to the Welfare Officer and a representative of the POEU on each course at the Training School elected a Welfare Officer.[145]

Radley hoped to improve the staffing numbers by offering female staff permanent employment. While the agreement with the union prevented this action, Radley promoted women to established scientific positions to release male staff to undertake more complex experimental work.[146] By February 1943, the two Assistant Physicist and four Assistant Chemist positions in the Research Branch were filled by women. While women had been hired as chemists in industrial laboratories during the interwar period, this was the first time they took on these roles in the Post Office.[147] Two of these women held academic qualifications; Miss M. Slack had a MSc and Mrs S. Ashton a BSc, during a time when female graduates were a small minority.[148] Academically

[142] BTA: TCB 371/43 Minutes of the 140th Meeting, 11 December 1939.

[143] Ibid.

[144] Ibid., 144th Meeting, 28 April 1942.

[145] Ibid.

[146] Ibid., 142nd Meeting, 24 February 1941.

[147] Sally Horrocks, 'A promising pioneer profession? Women in Industrial Chemistry in inter-war Britain', *BJHS*, 33.2 (2000), 351-367 (pp. 352-356).

[148] In 1900 women represented 16% of the student population in Great Britain, rising to 24% in 1920 and 27% in 1930. By 1937-38 the UGC figures show a total of 11,299 full-time women students enrolled in British universities. There were 37,890 men, so women nearly represented a quarter of the total. Teaching remained the major occupational outlet for women graduates, Carol Dyhouse, *No Distinction of Sex? Women in British Universities, 1870-1939* (UCL Press, 1995).

qualified female staff were found across the wartime state, but their experiences and opportunities varied depending on their specialism and the cultures and attitudes of the organisations they joined. The Admiralty hired tens of female geographers with specialist knowledge who were recruited into a wide range of duties. The majority became cartographers and chart plotters, but occasionally some were involved in surveying.[149] In this case candidates came straight from university following graduation.[150] Apart from a few exceptions women's roles at Bletchley Park were commonly defined along gender lines.[151]

The Post Office played an important role in the development of female workers, as the largest employer of women during the war. A similar experience was felt by staff working on the Railways. In both organisations many women worked in roles which would have been inaccessible in peacetime. By the end of the war the total number of Female Assistants employed by the Post Office had reached 3,500, contributing to a total of 180,000 women working in other roles as telephonists, post women and sorters.[152] In line with the agreements with the union, many of these were released from their wartime work at the end of the conflict. With slow demobilisation this was often not immediate. While many of the staff at Dollis Hill left little trace of their activity, the contribution of fourteen Assistant Chemists, Assistant Physicists and Female Assistants was acknowledged as named authors on research reports.[153] Seven of these continued to be named on reports after the conflict, with the latest, F. Carder publishing her final report in 1950.

Concerns about staffing the Research Station continued throughout the war but was made easier following the classification of the Post Office as essential war work near

[149] Avrill Maddrell, 'The 'Map Girls'. British Women geographers' war work, shifting gender boundaries and reflections on history of geography', *Royal Geographical Society*, (2007), 127-148 (p. 137).

[150] Ibid., p. 138.

[151] Janet Abbate, *Recoding Gender: Women's Changing Participation in Computing* (Cambridge, MA: MIT Press, 2012), p. 21.

[152] BTA: POST 33/5820 Letter to Postmaster General, 14 November 1947; Crowley, 'Women Workers in the General Post Office', p. 391.

[153] BTA: TCB 422 Review of Research Reports, 1939-1945.

the end of 1941.[154] This meant that the Engineering Department was no longer at risk of losing staff, including women, to other wartime industries. This did not make hiring easier as they were still in competition with other, better paid establishments, but it did allow the Post Office to reallocate staff from other branches of the Engineering Department to the Research Station to meet the urgent requests from the Services. This was not a new phenomenon as the Post Office was used to transferring staff across branches and the country, and it was made easy as most of the staff had received the same training so were familiar with Post Office practices.

By the end of the war there were 800 staff in the Research Branch, nearly double the pre-war number. Most of this large increase was due to the Colossus project. Following the success of the first Colossus, Bletchley Park ordered twelve more to be delivered roughly monthly. This placed an immense strain on the Research Station and a further thirty staff from across the Engineering Department were allocated to the project with expertise in exchange maintenance and construction. Six of these were eventually transferred to Bletchley Park to maintain the equipment. Further staff were assigned to the project from the Circuit Laboratory and Telephone Branch, from other Research Groups and on loan from the Regions.[155] By April 1944, sixty-eight staff were engaged in Flowers' laboratory on the construction of the Colossus and Tunny machines with support from the whole of Dollis Hill's workshops.[156] This included all other projects being banned from using the Workshops for a month. By the end of the war, half the Research Station were working on the projects managed by Doust and Flowers, in support of Military Intelligence.[157]

[154] BTA: TCB 371/43 Minutes of the 143rd Meeting, 26 November 1941.

[155] BTA: 4764/16 Diary Entry 31 March 1944.

[156] Ibid., 20 April 1944.

[157] PMA: POST 69/28 'Engineering Research', p. 3.

2.7 Secrecy in practice

In order to support military projects, Dollis Hill adopted a military culture. This became necessary as the Research Branch took on an increasingly large number of requests from the Directorate of Ministry Intelligence and from 1942, the Foreign Office who managed Bletchley Park. Compartmentalisation ensured that secrets were protected from leaving Dollis Hill as well as establishing an internal secrecy between staff where few people had an overview of a complete project. This was notoriously and effectively applied at Bletchley Park where, as Christopher Grey has observed, this type of secrecy led to multiple in- and out-groups.[158] This experience was not unique to Britain: for example, information was so well divided at the American Naval Research Laboratory that researchers could share the same workspace, even though some were engaged on classified projects and others not.[159]

Compartmentalisation was easily introduced through the pre-war structure of the Research Station. Work was already very subdivided with one or two senior staff allocated to a task in each of the six research branches. A pool of junior staff was available to support these activities from the services section. This is illustrated in the organisational chart (Appendix 6) which represents the Post Office Research Branch in February 1943, when with 148 established staff the potential number of projects was large. For example, Tommy Flowers' team 'Signalling Systems' had five supporting staff, excluding skilled workers. Ralph Jones, who joined Dollis Hill in 1940 as a Youth-in-Training worker, remembered the strict divisions between research groups describing a separate area as 'Harley Street', because of all the doctors who worked there.[160]

Although easy to introduce the restrictions of information affected the research culture at Dollis Hill as Post Office staff had to adapt to a new way of working. This was

[158] Christopher Grey, 'An Organizational Culture of Secrecy: The Case of Bletchley Park', *Management & Organisational History*, 9.1 (2014), 107-122 (p. 115).

[159] David van Keuren, 'Cold War Science in Black and White: US Intelligence Gathering and Its Scientific Cover at the Naval Research Laboratory, 1948-62', *Social Studies of Science*, 31.2 (April, 2001), 207-229 (p. 209); Hughes, *The Manhattan Project*.

[160] BM&A: OH/3/2 Ralph Jones, Oral History, 2001-2002.

most strongly felt by junior staff who, despite being used to working on smaller elements of a large project, were denied information about the bigger picture. As Jones recalled, there was also bewilderment at what their work was contributing to; 'that was the thing about Dollis Hill… you could be doing a job and you wouldn't see where it fitted into the overall pattern'.[161] Secrecy was imposed further as some staff were required to sign the Official Secrets Act and were personally vetted by intelligence agencies.[162] This was felt by the staff at the Research Station as Jones explained 'everyone was trying to keep things a secret as far as possible… even from our colleagues'.[163] In September 1942, Radley imposed further restrictions on Dollis Hill staff. He banned staff in Inspector grades and lower from making requests regarding cases involving cooperation between the Radio and Research Branches at the Research Station. Instead any questions were channelled through staff at an Executive Engineer level or above.[164]

Only Radley and Angwin knew the full picture of what was happening at Bletchley Park. The management of information at Dollis Hill was so successful that the staff who were in on the secret, did not know about each other's involvement. For example, even though Flowers had been involved in cracking the 4-wheel enigma, he was not aware that his supervisor, Frank Morrell, was also working for the CG&CS where he built the Heath Robinson.[165] This was only reconciled when Flowers was brought in to the project to break the Lorentz code. The restrictions imposed by GC&CS on who could be allowed in on the Bletchley Park secret put extra pressure on staff who were involved. The construction of equipment to break the 4-wheel enigma was delayed as only Flowers could develop the circuit designs. Still, Radley had to appeal to Bletchley Park to disclose the project to Sidney Broadhurst, an engineer in the Research Branch,

[161] Ibid.

[162] F. H. Hinsley and C. A. G. Simkins, *British Intelligence in the Second World War: Volume 4, Security and Counter-Intelligence* (Cambridge: Cambridge University Press, 1990), p. 178.

[163] Ibid.

[164] BTA: TCB 371/43 Minutes of the 145th Meeting, 9 September 1942.

[165] Gannon, *Colossus*, p. 232.

to support this work.[166] Even with both engineers, circuit designs were only completed a few hours before other staff wired up the equipment.

Radley and the Head of Radio Research, Albert Mumford, blamed compartmentalisation for the loss of efficiency and morale of their staff. This was an issue as several young Assistant Engineers and Inspectors were frustrated at not knowing how they were supporting the war effort and requested to be transferred to the Armed Forces.[167] Compartmentalisation had a similar effect in other wartime R&D establishments with staff attempting to leave their posts.[168] To mitigate the risk of personnel leaving Dollis Hill, Radley and Angwin agreed to make the staff more aware of their important role. When Radley addressed staff on 18 March 1942, he described in detail only the work of the Carrier Group, who had supplied circuits for the evacuation of France, and the activities of the Local Transmission Group who had provided communication to and intercommunication within, armoured fighting vehicles. The filtering of information meant that a specific narrative about the Research Station at war was communicated to those who worked there. This narrative formed a 'private image' of Dollis Hill which despite being confined to the Research Station's own staff, was as much of a selective presentation as that created for the public in the interwar period. This interaction was recorded in the non-secret Engineer-in-Chief war diary with a note that 'such work is fairly well-known and from it the veil of secrecy has been partially lifted'.[169] The staff had to be content with this explanation since they were told that other work was of 'utmost operational importance, vital to the needs of the three fighting Services'.[170]

[166] BTA: 4764/16 Diary Entry 1 May 1942.

[167] BTA: TCB 371/43 Minutes of the 145th Meeting, 9 September 1942.

[168] Horrocks and Lean, 'Doing it for Britain', in *Scientific Governance in Britain 1914-1979*, ed. by Leggett and Sleigh (Manchester: Manchester University Press, 2016), p. 164.

[169] PMA: POST 56/138, Engineer-in-Chief's Office War Diary, Item No. 425, March 1942.

[170] Ibid.

2.8. Conclusion

In this chapter I have shown that the Post Office aligned itself with the military not just out of a sense of duty as a government department but also as an act of damage limitation during the war years. Experience of the First World War gave it an appreciation of what would be key in the war to come: protection of the infrastructure and the retention of staffing and resources. The Post Office was also mindful to not lose the benefits it had seen from the publicity campaigns of the 1930s. Refocusing advertising around the military and the war effort enabled the Post Office to navigate the promotional restrictions on government and continue an albeit reduced presence in the public consciousness.

The war transformed Dollis Hill from an overwhelmingly civilian research station to a clandestine military establishment. Whilst the Post Office was expected to play its part in the conflict, this transition was the result of opportunistic and reactionary actions taken by Angwin and Radley to safeguard resources and gain patronage. During this period, the Research Station both exploited the opportunities that arose from the military alignment and looked to mitigate the risks of this approach. The military projects represented an opportunity to widen the Research Branch's knowledge base in adjacent technologies (covert listening and switching equipment) and gain experience in delivering longer term research (as seen in the use of valves in Colossus). Equally, it found itself with opportunities to access the resources and staffing provisions afforded to defence linked organisations which ultimately led to greater prestige across government and the military. Despite Bletchley's unwillingness to take risks, the Post Office's belief in the ingenuity of its staff paid off.

I have also shown the changes to the Research Station as it came into closer alignment with the military. The increased secrecy and compartmentalisation had an impact on morale, learning and development, and cross pollination of knowledge that came with an open site. Running Dollis Hill under these conditions required greater senior level management of processes and coordination, as well as handling the many changes needed to the site itself. The construction of PADDOCK, which was ultimately not utilised for several years, left a large, vacant, yet secret space in the heart of the site. In

spite of problems with the retention of manpower and control over the site, the Research Branch still availed itself to a growing number of opportunities in this period.

The recruitment of women at Dollis Hill conformed to wider trends observed during the war where women were hired to meet labour shortages. Mark Crowley has observed there was an attitudinal change in Post Office managers towards the value of women's skills during the war. This chapter extends Crowley's analysis, which focused on postwomen, telephonists and telephone engineers, by showing this also occurred in Dollis Hill where the professional development of female staff was encouraged in other technical and scientific roles. The employment of Female Assistants and Assistant Physicists and Chemists changed the culture of the Research Station. While most of female staff left their posts at the end of the conflict, the Research Branch hired more women in the immediate post-war period, with twenty new appointees contributing to research reports in the four years after the war.

Despite preparing for war and adapting throughout, the Post Office remained on the backfoot during the conflict. The war was a disruptive experience for all branches of the department. It curtailed the Post Office's ambitions that had been established during the 1930s and dramatically slowed its mechanisation programme. Designed for military requirements, the thousands of miles of new cable and enhanced communications routes did little to meet civilian demand. Post Office equipment and buildings were damaged, staff were dispersed across the country and many were mobilised. Despite this situation, as always, the Post Office was keen to gain prestige from its wartime contributions.

Recognising its publicity potential, the Post Office commemorated its wartime work by commissioning an official history of the department. The idea for a publication gained momentum in 1944 after the success of several other brochures dealing with various aspects of the war effort. Commissioned by the publicity division of the Air Ministry, *The Battle of Britain*, documented the RAF's defensive campaign against the

Luftwaffe.[171] The illustrated pamphlet, which included diagrams and photographs, demonstrated a public appetite for such accounts and sold 4.8 million copies in the first six months after publication.[172] Even with secrecy limiting what could be shared publicly, the Post Office Board agreed the Post Office's story was, in the words of the Postmaster General 'too good to be lost'.[173]

The 1946 publication *The Post Office Went to War*, written by Ian Hay was filled with prestige symbolism. The cover is a striking image of vehicles and telephone lines speeding towards Europe (Figure 20 below). Overlaid is a copy of a letter from President Dwight D. Eisenhower to the Postmaster General, thanking the Post Office for the 'construction of a vast network of communications radiating from key centres of vital importance in the United Kingdom'.[174] The Research Station is the focus of Chapter 6, 'Engineers', where it is described in the familiar language of the pre-war years as 'that Home of Mystery' with some 1,100 'attendant genii'.[175] Some of the projects mentioned include the construction of improved headsets for wireless operators working in tanks, the introduction of a submarine repeater for telephone signals (the first of its type in the world laid in the Irish Sea in 1943) and research into quartz crystals and explaining their value to radio communication. These examples of research were like those shared with Dollis Hill staff, but they were communicated with vastly different intentions, to show the public that the Post Office was on the front line of war.

[171] H. Irving, 'Towards 'A New Kind of Book': Publishing and the Ministry of Information, 1939-46', *Publishing History: the social, economic and literary history of book, newspaper, and magazine publishing*, 75.1 (2016), 53-76 (p. 59).

[172] Ibid., p. 60.

[173] PMA: POST 69/23 Post Office Board 1944, Minutes of Meeting, 3 March 1944, p. 5.

[174] Ian Hay, *The Post Office Went to War* (London: HMSO, 1946), cover image.

[175] Ibid., p. 35.

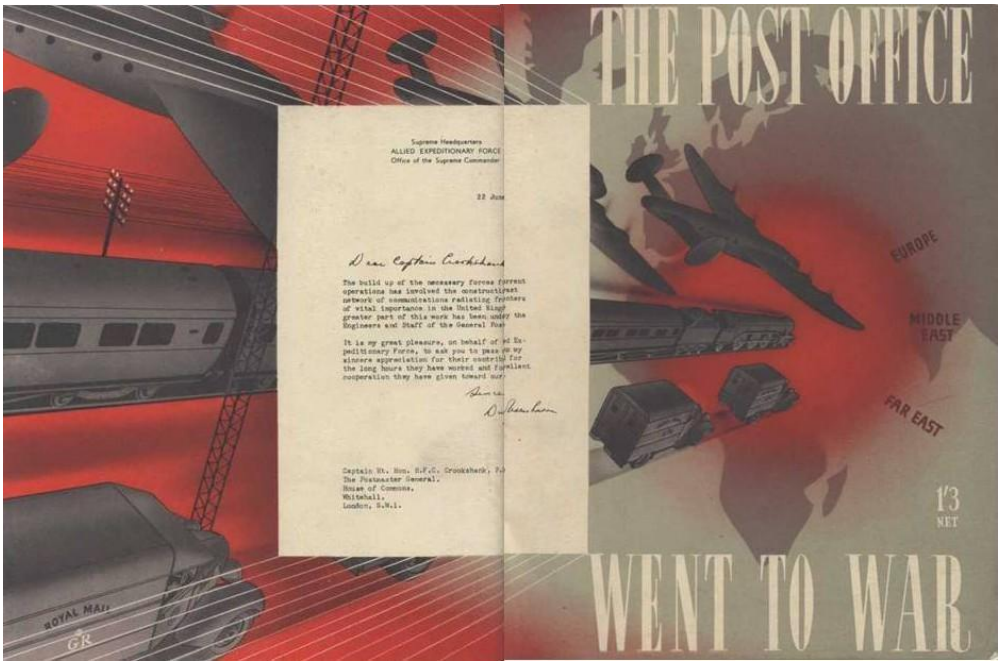

Figure 20 Cover image *The Post Office went to War by* Ian Hay, 1946.[176]

While some work was shared publicly, secrecy impacted what the Post Office could say about the organisation's role in the war, even after the war was over. The Official Secrets Act prevented the release of information about Colossus or listening-in equipment. Some researchers, like Tommy Flowers, received awards in the King's Honours Lists, but they did not publish or parade their experiences like other academic scientists looking to secure patronage in the post-war period.

Despite adopting a military guise for the duration of the war, Radley, saw this as a distraction from the key work of the Research Station to improve the telecommunication services of the Post Office. On 31 May 1945, shortly after the end of the war in Europe, Radley wrote to the staff in the Research Branch thanking them for their contribution to the war effort. While acknowledging that these included projects that would remain a secret as 'the defence of the country in the event of a future war entirely prohibits publicity', Radley was eager to remind staff of their primary duty which was to support reconstruction and post-war development of the Post Office system.[177] In the next chapter I will show how successfully meeting the

[176] Ian Hay, *The Post Office went to War* (London: HMSO, 1946), cover image.

[177] BTA: 4764/16 'Appreciation of Wartime work of the Research Branch Staff', W. G. Radley, 31 May 1945.

needs of the wartime state created further problems for Dollis Hill post-war. While Radley was keen to move away from defence work, the Post Office became caught in a changing landscape in which it benefitted from neither the government's commitment to welfare reforms or defending the nation from the Cold War, despite being expected by the public, politicians and the military to support both.

Chapter 3: Reconstruction and Constraint: Research in the Post Office, 1946–1950

3.1 Introduction

This chapter shows how as the Second World War came to an end and the Cold War began the Post Office and the Research Station faced competing pressures to re-establish and advance public communication networks while continuing to meet military demands of the government. While most Post Office activities were hampered by cuts to capital investment, the prestige of research remained high and the Research Station was a means by which the department could meet some of its aims. However, despite there being widespread enthusiasm for science and technology as a tool for post-war reconstruction, government policies designed to encourage expansion and growth in R&D disadvantaged the aspirations of managers in the Research Branch.

Less than three months after the war in Europe ended, the Labour Party was voted into office on the 26 July 1945, elected on the promise of significant social reforms.[1] Over the next six years Clement Attlee's government implemented a welfare programme including a National Health Service in 1948, introducing free medical care to the whole population; and a social insurance scheme providing unemployment and sickness benefits amongst changes to education and housing. Although these welfare reforms have been heralded as the legacy of Attlee's government by scholars, David Edgerton has shown that the state spent more on defence during this period than is often accounted for.[2] This was a response to the Cold War which emerged shortly after the end of the Second World War as international relations became increasingly hostile between the Anglo-American alliance and the USSR.

Concerns over American isolationism, reflected in the passing of the Atomic Energy Act of 1946 which prevented USA's allies accessing nuclear information, led to Britain

[1] 'Labour Party Election Manifesto, 1945' http://www.labour-party.org.uk/manifestos/1945/1945-labour-manifesto.shtml [accessed 10 February 2020].

[2] Edgerton, *Warfare state*.

starting its own nuclear weapons programme in 1947. Attlee's motivation to construct an atomic bomb was less about establishing a nuclear deterrent, than influencing American foreign policy by demonstrating that Britain could stand alongside the USA in shaping global post-war defence.[3] Defence spending continued to increase as the British government introduced a large-scale rearmament programme following the successful test of an atomic bomb by the Soviet Union in 1949 and the start of the Korean War the following year. All this was delivered despite the economic turbulence of the period, including two financial crises in 1947 and 1949.[4] In order to improve the balance of payments and support post-war reconstruction the government introduced an industrial programme. This involved nationalising industries, encouraging the export trade, investing in state and private R&D and increasing the number of academically trained scientists.

During this period, questions of the constitutional status of the Post Office which had plagued the department in the interwar years ceased as government brought industry closer to Whitehall.[5] This centralisation did not mean that the Post Office benefitted from the same capital investment as other nationalised industries, such railways, electricity or roads despite calls from the Postmaster Generals and other politicians.[6] The Postmaster General position was held by three ministers during Attlee's premiership; William Hare (1945–1947), Wilfred Paling (1947–1950) and Ness Edwards (1950–1951).[7] While in role, each politician campaigned for the Post Office to have

[3] N. J. Wheeler, 'British nuclear weapons and Anglo-American relations 1945-54', *International* Affairs, 62.1 (1985-1986), 71-88, p. 72.

[4] Peter Hennessy, *Never Again: Britain 1945-1951* (London: Jonathan Cape Ltd., 1992), p. 99; Allister Hinds, 'Sterling and Imperial Policy, 1945-1951', *The Journal of Imperial and Commonwealth History*, 15.2 (1987) 148-169. Barry Eichengreen*, The European Economy since 1945* (Princeton; Oxford: Princeton University Press, 2007), p. 77

[5] Campbell-Smith, *Masters of the Post*, pp. 372-373.

[6] Martin Chick, *Industrial Policy in Britain 1945-1951: Economic Planning, Nationalisation and the Labour Government* (Cambridge: Cambridge University Press, 2002), p. 45.

[7] Ben Curtis, 'Edwards, Onesimus [Ness] (1897-1968)', *Oxford Dictionary of National Biography*, (Oxford: Oxford University Press, 2004) <https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-66092?rskey=geH6i7&result=1> [accessed 13 March 2020]; 'Telephone Service (Capital Expenditure)', 1947, Hansard, Vol. 445, cc.412-414, c. 412.

greater freedom from the Treasury and for increased capital investment for communication infrastructure.

On the 5 April 1946, the Post Office Board approved the Engineer-in-Chief Sir Stanley Angwin's memorandum on the future of research in the Post Office.[8] This ambitious proposal was based on three key aspirations to be achieved by 1950. The first was to build up the research organisation to the full capacity of the existing Dollis Hill site second, to redirect research work away from day-to-day concerns towards more fundamental and long-term investigations; and third, to expand the workforce by doubling the number of senior staff and increasing the number of those who had been scientifically trained. Although there was immense support for Angwin's proposal inside the Post Office, in this chapter I show that Dollis Hill's post-war ambitions were challenged by government policies; the export drive, investment in R&D and allocation of scientific manpower. Similarly, the wider Post Office also felt the effects of the government's prioritisation of science over engineering, impacting its ability to repair and improve public services and support the accelerating defence programme. These conflicting priorities were unique to the Post Office as a government department which was expected to act as a public service and as a business.

Section 3.2 shows that the Post Office struggled to restore its communications services after the war. Most challenging was the large telephone subscriber waiting list which had grown during the conflict. I demonstrate how the Post Office's post-war plans were hampered by the government's export drive and the prioritisation of other industries. The economy depended on increasing the value of goods for export, however, the industrial landscape was in disarray. Some industries, such as aviation, had more capacity than was needed post-war, whereas others, including electricity supply and the railways, had deteriorated badly after six years of capital neglect. The government nationalised those most in need; railways, roads, docks and harbour, steel and coal mines. Already being a state-owned service, the Post Office seems to have been overlooked, and did not receive any additional support through this policy. Material stocks continued to be of great strategic value and with limited imports the

[8] PMA: POST 69/30 Post Office Board (POB) 1946, Minutes of the POB meeting, 5 April 1946.

government prioritised industries which supported national reconstruction, the export market and the defence programme, even if they were in a comparatively secure state. This did not extend to the Post Office, despite supporting the third most expensive military project, ROTOR, a radar system for air defence. Not being considered a priority by the Ministry of Supply who managed materials stocks, research at Dollis Hill was directed into looking for alternative materials.

In section 3.3 I challenge the argument posed by business historian Douglas Pitt that Treasury restrictions of capital constrained the Post Office's expansionist aims during this period, by demonstrating the Exchequer's support for Angwin's ambition to increase the amount of long-term and fundamental research.[9] This commitment reflected attitudes across government and industry that investing in R&D would support post-war reconstruction and Britain's position in export markets.[10] With Treasury support, the Post Office managers were able to request changes to the Research Station site and increase capacity by reallocating development work to the other Engineering Department Branches who also received improved facilities. While working to support the needs of the Post Office, staff at the Research Station were expected to contribute to wider government concerns, such as defence work and other civilian projects. Although a drain on resources, these activities were considered as an opportunity for the Post Office to align itself with both welfare and warfare priorities of the post-war government. Overall Dollis Hill went some way to meet its own ambitions, prioritising areas of research which reduced costs, improved services and gained prestige.

Section 3.4 shows that while the Research Branch had the potential to develop its research programme, it was limited by the workforce it was able to hire. Even with Treasury support, the Post Office could not compete with other expanding state and private R&D establishments, promising better opportunities or connected to nationally prestigious projects perceived as more glamourous by new graduates. This was made

[9] Pitt, *The Telecommunications Function in the British Post Office*, p. 46.

[10] Robert Bud, 'Penicillin and the New Elizabethans', *BJHS*, 31.3 (1998), 305-333; Norman Vig, *Science and Technology in British Politics* (Oxford: Pergamon Press, 1968), Hilary Rose and Steven Rose, *Science in Society*.

more challenging as there was more demand for university trained scientists than supply, even though the government had increased capacity following the recommendations of the Barlow Report on scientific manpower. Dollis Hill became distanced from the wider Engineering Department as managers attempted to attract and retain the required staff. This included changing hiring strategies, methods of promotion and restructuring the scientific roles in the Research Branch to align with the scientific Civil Service in the hope of increasing the potential recruitment pool. While the Post Office was able to benefit from some government processes, such as hiring experts from Germany through the Darwin Scheme, there was still the expectation that Dollis Hill would release senior staff on secondment to work on defence projects if required. It is this difficult balance between meeting civil and military requirements which made the Post Office's post-war experience unique.

While foregrounding research did prove to be a worthwhile strategy for retaining some measure of autonomy, this did not translate fully throughout the Post Office who remained at the mercy of the government's requests. Chastised in parliament by MPs flooded with complaints from angry constituents waiting years for the telephone services, struggling to find suitable materials and staff to meet the requirements of military work from other Departments, the Post Office was constrained by the priorities of others.

3.2 The Post Office and national priorities

The war had directed resources away from the Post Office's civilian work, infrastructure had been destroyed and staff had been dispersed. Hoping to reinstate its pre-war aims to mechanise the telephone service and introduce new cost saving schemes, the Post Office's post-war aims focused on re-establishing and expanding public services, replacing damaged and worn equipment and improving the state of their buildings. The most pressing concern was the high number of subscribers on the waiting list. William Hare, Postmaster General, proclaimed in November 1946 that 'the telephone situation was the Achilles heel of the Post Office from the point of view of

the public'.[11] Despite the Post Office's campaign to discourage telephone usage, the number of orders increased during the war. By 1945 there were 209,000 applicants on the waiting list, dramatically higher than the 5,400 in 1939.[12] This number was a result of the prioritisation of telephones for the war effort and shortages of exchange equipment and underground cables.[13] In order to meet this task, the Post Office needed to; expand its engineering workforce, have access to material stocks and purchase equipment from the telecommunications industry: all of these needs were frustrated by government policies.

Publicity remained an important part of the Post Office operations, although under different conditions from its heyday during the 1930s. In order to communicate changes to public policy, the Attlee government established the Central Office of Information (COI) which replaced the Ministry of Information.[14] The COI was designed to centralise publicity outputs across government departments. The Post Office was still allowed to keep its Public Relations Department (PRD), and could independently conceive publicity schemes, but production and distribution was managed through the COI.[15] Despite retaining creative freedom, every project had to be approved by the COI and then the Treasury.[16] Under this arrangement the budget for publicity materials was heavily reduced by more than 83.5% in real terms in comparison with its pre-war spend.[17]

With limited resources, as the PRD was heavily depleted during the war, campaigns focused on the immediate needs of the Post Office, including a special recruiting drive

[11] PMA: POST 69/30, POB meeting, 8 November 1946, p. 16.

[12] PMA: POST 69/25, POB 1945, BP 15(45), 'Provision of Telephone Service', W. R. B., 7 June 1945, p. 1.

[13] Ibid.

[14] Mariel Grant, 'Towards a Central Office of Information: Continuity and Change in British Government Information Policy, 1939-51', *Journal of Contemporary History*, 34.1 (1999) 49-67 (p. 50).

[15] PMA: POST 69/30 B.P. 28(46) 'The Work of the Public Relations Department', T.D.S., 22 November 1946, pp. 1-2.

[16] PMA: POST 69/31 Index Agenda POB 1947, B.P.10(47), 'The Post Office and the Central Office of Information', T.D.S., 28 February 1947, p. 6

[17] In 1950, £27,650 was allocated for direct publicity, compared with £85,000 before the war, PMA: POST 69/47 POB 1950, 'Public Relations Department Expansion of Publicity', C. J. M., 23 March 1950, p. 1.

for telephonists and telegraphists in London.[18] Publicity was also designed to encourage the public to behave in ways which would help the understaffed and pressurised service, including 'post early' campaigns around Christmas. Over this period, the PRD slowly increased publicity activities across all mediums, continuing to commission contemporary artists, both those with whom the Post Office had developed a relationship with before the war and emerging designers. Images of technology remained a strategic feature of publicity, through prestige posters, which was expanded to include a 'pride of craft' series demonstrating the range of work provided by the Post Office.[19] Devices built by the Research Station appeared in several exhibitions including British Industry Fairs, a travelling Graham Bell Centenary Exhibition, the Davy-Faraday Exhibition held in Paris in 1948 (the Post Office's first international show) and in an exhibition at the Science Museum in 1950 celebrating the centenary of the submarine cable.[20]

The ambition and demand to expand public services was countered by the expectation from government that the Post Office would continue to safeguard communications in time of a future war.[21] The Second World War had further demonstrated the strategic value of telecommunications and they would remain a priority for the military into the future. As the Post Office had successfully supported the Service and Intelligence Ministries during the conflict, it was considered the best state machinery to provide this service during the Cold War. The Post Office was expected to support defence work and absorb its associated costs. This had been possible during the war, when the civilian service had been suspended, but these competing demands created an increasing tension between the Post Office's desire to revitalise the public service and its public duty to support the requests of the military and intelligence services.

The Post Office aims were also limited by its financial arrangement with the Treasury. The government refused to reintroduce the Post Office Fund, which had been

[18] PMA: POST 69/31 'The Post Office and the Central Office of Information', p. 6.

[19] Ibid., p. 7.

[20] BTA: TCB 135/7 Engineer-in-Chief's Annual Report, 1947-48, A. J. Gill, p. 63, 80.

[21] TNA: PREM 11/72 Report on Operation ROTOR, Appendix A Section II – Air Ministry Works Programme, p. 19.

suspended during the war, arguing that the economic position meant it was impossible to return to a surplus fund.[22] As discussed in Chapter 1, the Fund was established 1933, to allow the Post Office to retain half of the surplus profits to use at its discretion, with spending focused on research. Without this financial arrangement all profits went straight back to the Treasury and the Post Office had to negotiate its capital spending plans annually.[23] This made it near impossible for the Post Office to introduce a long-term strategy for the telephone service without knowing what funds were going to be released by the Exchequer.[24] This model was criticised within the Labour Party by MPs and allies in the union movement, who called for a greater commitment to long-term spending and restoration of surplus, although unsuccessfully.[25] The Treasury also rejected the Post Office's calls for expansion and denied the request to increase the number of its engineers in order to meet the demand on its service.[26] In 1948, the Postmaster General Wilfred Paling took the unusual step of highlighting his dissatisfaction in parliament, warning his own government that the Post Office had insufficient funds to clear the telephone waiting list.[27]

The Post Office was in a weak position at the end of the war and critically understaffed. Demobilisation was slow and by the end of 1945, 15% of the staff were yet to be reinstated.[28] At the end of hostilities there was an enormous turnover of labour. In agreement with the union female workers were dismissed and demobilised men returned to the Post Office. The telecommunications industry, on which the Post Office relied for manufactured goods, faced similar troubles. During the conflict private firms undertook design, development and production of items that were removed from their peacetime activities. At the end of the war the turnover of staff had left a

[22] Pitt, pp. 102-104.

[23] Campbell-Smith, p. 366.

[24] Pitt, p. 104.

[25] Commons Debate in 1947, in which Harry Wallace, Labour MP and Assistant Secretary of the Union of Postal Workers, argued 'the Chancellor of the Exchequer often tells us that profits should be ploughed back into industry. I wish that some of the £22 million profits of the Post Office could be ploughed back into the Post Office', 'Post Office' 1947, Hansard, vol. 439, cc1327-447 (c.1372, 1418 and 1424)

[26] Pitt, p. 105.

[27] 'Post Office and Telegraph', 1948, Hansard, vol. 466, cc1358-93.

[28] Campbell-Smith, p. 363.

gap in the training and skills needed to re-establish a peacetime industry. Alongside staff changes, factory equipment had also suffered during the war with machine and manufacturing tools worn out and in need of replacing.[29]

In 1948, while the Post Office was still waiting for the reallocation of its engineering staff, the department had to reduce its building and civil labour from 6,000 to 4,000 in accordance with the government's White Paper on Capital Investment.[30] This directly impacted the Post Office's building programme to expand and modernise Post Offices and sorting offices and convert the telephone system from manual to automatic working. The largest impact in the reduction of labour was on duct work (cabling) for new domestic subscribers, which lost two-thirds of its capacity. The remaining third, between 600 and 800 men, were directed by the Exchequer to prioritise telephone installations for businesses with export trade, farmers and health services, over domestic users, implemented with the acceptance that the waiting list would grow as a result.[31] Of the remaining staff, 2000 continued to work on the building programme described above, however, under the White Paper the number of labourers was not allowed to increase as had been expected. The annual expenditure for this work was also reduced to £1.25 million, equivalent to around half the same investment for 1938-39.[32] The remaining staff, around 1,200–1,400, were directed to support the excavation of new ducts for long-distance cables to provide trunk traffic.[33] This decision was financial. Despite local calls being more popular than trunk calls, the latter were more lucrative for the Post Office and of great value to the defence services.[34]

Post Office reconstruction was further challenged by the Government's problems transitioning from a wartime to peacetime economy. In winning the war the country had sold a third of its oversea assets, spent 33% of its gold reserves and incurred a

[29] J. A. Mason, 'The Telecommunications Industry and the Export Drive (I)', *Post Office Telecoms Journal*, 1 (May 1949), 78-82 (p. 80).

[30] *Capital Investment in 1948*, Cmnd. 7268 (London: HMSO, 1947), p. 18.

[31] Ibid., p. 19.

[32] Ibid., p. 18.

[33] Ibid.

[34] BTA: TCB 10/21 Post Office Commercial Accounts, 1947-48, p. 29.

huge debt.[35] The financial situation was hindered further by the United States abruptly ending the lend-lease agreement after the war and the financial crisis which followed the harsh winter of 1946-47. By the end of the war British exports had dropped to 30% of their pre-war level and in 1947, spearheaded by the Chancellor of the Exchequer, Sir Stafford Cripps, the Labour government introduced a hard export drive to curb inflation and maintain the viability of the sterling area.[36] Under this direction industry focused its attention on making goods for export, not equipment for domestic use. The Post Office was particularly affected as around half the telephone equipment manufactured in Britain between 1945 and 1950 was exported.[37] In 1946 telephone and telegraph apparatus accounted for £460,000 of the government's £88.74 million monthly target for exports. By October 1948 the value of telecommunications equipment for export had tripled to £1.25m to support the national monthly export target which had increased, though by a smaller percentage, to £150.5m.[38] The Post Office worked with the telecommunications industry to support this policy and, in 1948, reduced its annual equipment orders from £8.5m to £5m to release an additional £3.5m for export. This equated to the organisation receiving less than 70% of its pre-war orders.[39]

As a result of austerity and exports, the ambition to improve communication services was limited by reduced access to materials. In 1947 the new Engineer-in-Chief, Archibald Gill, reported that 'programs, systems, materials and practices cannot be stabilized as is essential to steady progress; there has to be a constant search for alternatives and, often, alternatives to alternatives'.[40] Whilst the ambition of the wider Post Office to install new equipment were hampered, the Research Station continued to develop expertise in material compositions in search for replacements. Materials were in high demand as they were key to the nation's reconstruction plans, both for

[35] Peter Hennessey, *Never Again: Britain 1945-1951*, p. 99.

[36] Jim Tomlinson, 'The Attlee Government and the Balance of Payments, 1945-1951', *Twentieth Century British History*, 2.1 (1991), 47-66 (p. 48).

[37] Frank Bealey, *The Post Office Engineering Union*, p. 263; 'Postal and Telephone Services', Hansard, Vol. 477, cc. 808-18, c. 813.

[38] Mason, 'Export Drive', p. 80.

[39] 'Post Office and Telegraph', 1948, Hansard, vol 466, cc1358-93.

[40] BTA: TCB 135/6, Engineer-in-Chief's Annual Report 1946-47, A. J. Gill, p. 1.

export goods and national projects. Steps were taken to control stocks with the publication of the Prime Minister's List of Priorities in May 1947.[41] This did not benefit the Post Office, as telecommunications, along with water and sewage, health and local services, were omitted and their investments remained static. This policy favoured the recently nationalised industries and those which supported energy production and the movement of goods. Power, mining, gas, plant for coal and oil conversion, railway freight traffic and atomic energy projects all benefitted from a rise in investment and resources. There was little resource left after the needs of the six main industries were met and, at this time, it could take up to a year for the Post Office to obtain materials after an order was placed.[42]

Limited stocks meant prices skyrocketed, meaning the Post Office were spending more on materials than they had before the war. In April 1947 it was reported that lead, the main component of telephone cables, had increased by 460% from £16 before the war to £90 a ton.[43] Copper, another key material for telecommunication equipment, had increased to £137 per ton up from £48 over the same period.[44] Unsurprisingly, the Post Office criticised firms for exporting equipment with high quantities of desirable materials.[45] Restricted access to materials meant the Post Office committed to purchasing stocks, without fully testing their suitability. Research into PVC and polythene as an alternative to lead cable sheathing had started during the war. Although there was confidence that these could be introduced as a replacement, guaranteeing access to plastics was another issue. The Post Office was highly reliant on the Ministry of Supply's allocation of the materials that were in demand from all industries. In 1946 it was reported that if polythene was the favoured material, they might not be able to access a significant amount until 1948.[46] ICI were the primary producers of polythene in the country and, even without conclusive research reports,

[41] Mason, 'Export Drive', p. 80.

[42] Pitt, p. 105.

[43] 'Post Office', 2 July 1947, Hansard, vol 439, cc1327-447 (c.1352).

[44] Ibid.

[45] PMA: POST 69/30 Board Meeting, 8 November 1946.

[46] BTA: TCB 371/43 Minutes of the 149th meeting, Review of Research Cases, 11 November 1946.

to secure the required stocks the Post Office agreed to commit to a required minimum order of 2000 tons per annum for five to ten years.[47]

In some cases, there was no alternative to materials necessary for the telecommunications industry. There were serious concerns about the impact of shortage of nickel silver which was used in relays and key springs.[48] The aeronautics industry was consuming high proportions of these materials in jet propulsion. In 1947 it was reported that one of the only two factories in the country which produced nickel-silver was turning over its whole production to 'Nimonic' for jet engines. As other industries developed the Post Office knew that 'strenuous efforts' would have to be made to safeguard the supply of materials for the telecommunications industry.[49]

The materials crisis directed the research priorities at Dollis Hill and by February 1947 the Research Branch became responsible for providing the other Engineering Branches with technical information about the suitability of substitutes.[50] The chemistry section at Dollis Hill continued to investigate alternative materials. This was a continuation of its pre-war work which diversified further during the war. New materials had to be integrated into old systems. For example, in 1946 the Research Branch started investigating a method to joint polythene to lead for cable manufacture to share with the wider telecommunications industry.[51] The Research Branch and the Radio Branch at Dollis Hill started experimental and theoretical work on the production of synthetic piezo-electric crystals as an alternative to quartz in 1945. This was stimulated by concerns that it would be harder to import quartz from Brazil, their main supplier, as the country was planning on making changes to their export agreements as part of their reconstruction plans including placing an embargo on all equipment bar finished crystal units.[52] As Brazil had an almost global monopoly on raw quartz it was reported by a Radio Branch engineer that this arrangement would 'inevitably lead to the

[47] Ibid., 152nd Meeting, 20 October 1947.

[48] Ibid., 150th Meeting, 17 February 1947.

[49] PMA: POST 69/33 POB, 1947, minutes of the POB meeting, 7 February 1947, p. 10.

[50] BTA: TCB 371/43 Minutes of the 150th meeting, 17 February 1947.

[51] BTA: TCB 135/6 Engineer-in-Chief's Annual Report 1946-47, A. J. Gill, p. 49

[52] BTA: TCB 277/1267 J. L. Creighton, 'A summary of the uses and sources of piezoelectric quartz with some considerations of applying to the use of alternative materials', December 1944, (pp. 1-32), p. 3

extinction of the UK quartz industry'.[53] Quartz was needed to support the growing need for more inter-city telephone circuits, giving a new impetus to development of coaxial cables, which depended on crystal filters which had previously been made from quartz.[54] The other motivation was the needs of the military and intelligence services as quartz oscillators and resonators were important components of transmitting and receiving equipment.

In 1945, the Research Branch agreed to sponsor and coordinate all work into the provision of synthetic quartz to meet the requirements of the Post Office, the Ministry of Supply and Admiralty.[55] The Post Office's role in directing this work is suggestive of their reputation for expertise and high standards, among wider government. The practice of growing artificial quartz had started in the late nineteenth century, but its usefulness was limited by the sizes of crystals formed.[56] This was a new area of research for Dollis Hill staff who experimented with different methods to grow artificial crystals. In 1948 some seventy-five different tartrates had been prepared and were undergoing tests.[57] Work took place in the sub-basement of PADDOCK, providing a controlled atmosphere desirable for this research.[58] The Post Office was in control of a wider industrial-academic-military network: not only was this work supported by the GEC Research Laboratory under a development contract, but the GEC was also collaborating with Brooklyn Crystallographic Laboratory in Cambridge who were independently researching alternatives to natural quartz.[59] Research work intensified and in 1948 Radley reported that the Research Branch was working to a 'long-term view of ensuring adequate stocks in the event of a future war'.[60]

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[53] Ibid.

[54] John Bray, *Innovation and the Communications Revolution: from the Victorian pioneers to broadband Internet* (London: Institution of Engineering and Technology, 2002), p. 121.

[55] BTA: TCB 371/43 Minutes of the 152nd meeting, 20 October 1947.

[56] Christopher Shawn McGahey, 'Harnessing Nature's Timekeeper: A History of the Piezoelectric Quartz Crystal Technological Community (1880-1959)' (unpublished PhD thesis, Georgia Institute of Technology, 2009), p. 268.

[57] BTA: TCB 135/8 Engineer-in-Chief's Annual Report, 1948-1949, A. J. Gill, (pp. 1-92), p. 64.

[58] PMA: POST 110/6037, Post Office Research Station, Dollis Hill, Open Day, 1948, p. 14.

[59] BTA: TCB 371/43 Minutes of the 152nd Meeting, 20 October 1947; McGahey, p. 272.

[60] BTA: TCB 371/43 Minutes of the 154th Meeting, 31 May 1948.

The Post Office was expected to support large-scale infrastructure projects for defence, at the expense of public communication networks. As the Cold War intensified the Ministry of Defence recommended reinstating the Second World War defence chain of coastal radar stations as a provision to detect hostile aircraft and control the movement of British fighter aircraft.[61] The wartime scheme known as Chain Home, was introduced by the Tizard Committee based on research by the Air Ministry radar development team and designed with Post Office assistance. Practically this new system required the restoration, modification and extension of twenty-eight war-time Chain Home stations and the construction of new sites for more advanced Centimetric Early Warning Stations and Ground Controlled Interception Stations which, when completed would cover an area from Portland Bill to Moray Firth.[62] As Post Office engineers had been responsible for installing and maintaining these strategic points during the war, they were required to support this work. This scheme was called ROTOR and in December 1949 it was estimated to cost £24 million and take five to six years to install.[63] It became the third most expensive defence project after atomic energy and guided missiles.[64] The Post Office was directed by the Treasury to absorb the costs of ROTOR into its normal investment programme, who argued that the large expenditure on equipment would 'represent additional assets to the Post Office civilian communications system'.[65] Although the Post Office followed Treasury direction, the Board was not convinced by this line of argument and concerned about the impact of the project on its public services.

Despite all these challenges the Post Office did improve the state of some of its services. By the end of 1947, the Engineering Department had restored all the overseas telegraph and telephone services for line and wireless which were in place

[61] TNA: T 229/878 Post Office Civil Defence Measures, Memorandum by the Minister of Defence, H. Parker, 10 December 1951.

[62] Ibid., Report on Operation ROTOR Control and Reporting System (Report by the Inter-Departmental Working Party).

[63] Ibid., Post Office Defence Measures UK Telecommunications in War D.O.(49)83, J. Spicer, Treasury, December 1949.

[64] Stephen Twigge and Len Scott, *Planning Armageddon: Britain, the United States and the Command of Western Nuclear Forces, 1945-1964* (Routledge, 2013), p. 270; TNA: PREM 11/72 Report on Operation ROTOR, Control and Report System (Report by the Inter-Department Working Part, p. 8

[65] Ibid.

before the war.[66] The Speaking Clock and the emergency '999' number were expanded to other cities. The London-Birmingham coaxial cable was installed providing the first inter-city links for television in the country.[67] By September 1950, the total number of telephone installations had increased to 5,294,000, with one in three introduced since the end of the war.[68] However, as telephone popularity continued to grow there were still over 500,000 outstanding applications in 1950.[69] With little hope of reducing the waiting list, the Post Office Board and managers in the Engineering Department directed their attention to ways research could support post-war reconstruction. While it was not thought research would help immediate need, research into long-term problems promised further cost saving which could be used to improve relations with government.

3.3 The ambitions of research

The post-war aims for the Research Station were set by Angwin's memorandum on the future of research. Angwin proposed three changes, to increase the number of staff working at Dollis Hill, especially those with scientific training, to use the full capacity of the Research Station and to increase the proportion of long-term and fundamental research in the Research Branch. Whilst emphasising that it was not possible to know exactly where long-term or fundamental research might lead, Angwin identified several areas of possible investigation including submerged repeaters for long distance telephone communication, the production of electronic systems of switching, the use of very high frequency radio installations for the telephone services, and other areas to improve existing methods and apparatus.[70] Angwin was keen to return to work to support Post Office needs, arguing that 'altogether the work during the war may be said to have been invaluable from the point of view of the prosecution of the war but

[66] 'Post Office and Telegraph', 1948, Hansard, vol 466 cc1358-93.

[67] BTA: TCB 135/10, Engineer-in-Chief's Annual Report, 1950-51, p. 1.

[68] Bealey, p. 263; 'Postal and Telephone Services', 1950, Hansard, vol. 477, cc808-18 (c. 813).

[69] BTA: TCB 10/23, Post Office Commercial Accounts 1949-50, p. 8; TCB 10/24, Post Office Commercial Accounts 1950-51, p. 9; states that there were 551,631 applications outstanding 31 March 1949 and 532,000 outstanding applications 31 March 1950.

[70] PMA: POST 69/30 'Research', A. S. Angwin, 27 March 1946, p. 6.

to have spread in very different directions from those required for ordinary Post Office purposes and we now have very much leeway to make up'.[71] Angwin did not suggest that services would change immediately and expected it would take between ten and twenty years before research might be fully absorbed into communication systems.[72]

Angwin used similar methods to Bertram Cohen, the pre-war Executive Engineer in charge of the Research Station, to convince the Post Office Board to approve the expansion of Dollis Hill. Both cited the expansive and well-funded work of the Bell Laboratories in America and the ambition to expand the service which could lead to an increased income. Angwin was concerned that, due to a lack of staff, the Research Branch spent more time working on day-to-day engineering problems than fundamental investigations. He argued that this misplaced attention was keeping the United Kingdom behind large American telecommunications firms who were expanding their already sizable research and development organisations at the time.[73] Examples included Bell Laboratories, the Automatic Telephone Company of Chicago and the General Electric Company. The Post Office Board accepted the proposal in April 1946 as it was keen to encourage changes which would lower the cost of equipment, expand communication services and boost the country's international reputation.

Unlike the experience of the wider Post Office, which was restricted in its spending, the Treasury helped facilitate Angwin's ambitions by agreeing to support changes to increase the capacity of Dollis Hill and for more long-term and fundamental research. Factors that would have influenced Treasury support were the Research Station's prestige, evidence of its contribution to wider government's aims during the war and the promise that research would continue to support cost savings and increase profits. There was cross-party support for the Research Station, heralded as the source of the Post Office's efficiency with calls to increase its funding. Labour MP William Williams, whose career started as a Post Office clerk, argued that 'I agree that money spent on

[71] Ibid., p. 3.

[72] Ibid., p. 1.

[73] Ibid.

research at Dollis Hill or any other station or extension will be well spent. We can never make the Post Office too efficient'.[74] The Conservatives used Dollis Hill's high standing to criticise government spending priorities as demonstrated by Conservative MP Sir Ralph Glyn's comment that 'it seems to me that the work done at Dollis Hill is so good and efficient, and the savings that have been made are so considerable, that it is high time Parliament appreciated the value of that work'.[75] The support for Dollis Hill was indicative of widespread enthusiasm for R&D across government and industry as a tool for post-war reconstruction.[76] As a result the state increased financial support to industrial research by more than half between 1945 and 1951, enabling the expansion of R&D establishments and industry across the country.[77]

Several changes were made to Dollis Hill requiring the release of capital funds by the Treasury. Training School facilities were relocated to a new Central Training School in Stone, Staffordshire which opened in September 1946. This new establishment was first proposed by Angwin in May 1944, to provide the training that had been delivered at Dollis Hill and also expand facilities to support up to 1,000 students and provide residential courses.[78] The Treasury gave authority for the Post Office to take over the site in Stone, originally built for the United State Forces during the war, approving changes and financial support to make it suitable for Post Office needs.[79] The transition of training responsibilities was not immediate and initially the school was only equipped to offer twenty-five courses for up to 580 students. The same year the schools, including Dollis Hill, trained 4,220 members of the Engineering Department, and 281 members of the armed forces over 281 courses.[80] However, by 1949, Stone was training around 5,000 students a year, while the number at Dollis Hill had

[74] 'Post Office', 1947, Hansard, vol 439 cc1327-447 (c.1372, 1418 and 1424).

[75] Ibid.

[76] Sally Horrocks, 'Enthusiasm Constrained? British Industrial R&D and the Transition from War to Peace, 1942-51', *Business History*, 41.3 (1999) 42-63 (pp. 43-44).

[77] Herran, 'Spreading Nucleonics', p. 575.

[78] BTA: POST 122/235 Central Engineering Training School, part 1, 1944-1950.

[79] BTA: TCB 135/6 Engineer-in-Chief's Annual Report, 1946-1947, A. J. Gill, p. 50; BTA: POST 122/235 Central Engineering Training School, part 1, 1944-1950.

[80] BTA: TCB 135/6 Engineer-in-Chief Annual Report, 1946-47, A. J. Gill, p. 50.

decreased to 576.[81] This freed up much needed space, yet was not enough for the expanding requirements of research.

In order to increase capacity at Dollis Hill, development work was transferred from the Research Station to other Branches in the Engineering Department. From 1946, these sections were encouraged to create or expand their own facilities for experimental work, likely requiring Treasury support. The Local Lines and Wire Broadcasting Branch, formed in 1947, took over accommodation in the Palace of Engineering at Wembley to develop and study audio and television wire broadcasting systems.[82] A laboratory was established in the Transmission and Main Lines Branch in 1948. Originally housed in the basement of Castle House, Aldersgate Street in central London, it was moved further down the street in April 1949 to a 1,900 square feet laboratory and workshop on the mezzanine floor of Alder House, home of the Engineer-in-Chief's Office, increasing the staff from three to twenty-six.[83] This branch designed and developed transmission equipment, constructed prototype models and tested samples developed by contractors.[84] The Director of Research retained oversight over all projects through the Research and Development Sub-Committee. Some routine work which needed specialist equipment was retained but this reallocation allowed the Research Branch to align its priorities towards long-term and fundamental research.

The Post Office also gained approval from the Treasury for the Ministry of Works to make alterations to the Dollis Hill site following the removal of the Training School and development laboratories, both the construction of new buildings and the adaptation of others. Despite Treasury support, the Post Office was a victim of building controls which had been established to manage the short supply of materials and labour, prioritising the construction of state and private R&D facilities for defence needs over civilian requirements.[85] Radley was publicly critical of this situation, writing in the *Post*

[81] BTA: TCB 135/8 Engineer-in-Chief's Annual Report, 1948-1949, A. J. Gill, p. 82.

[82] W. West, 'Facilities for Experimental work in the Engineering Department', *POEEJ*, 47.1 (April 1954), p. 11.

[83] Ibid.

[84] Ibid.

[85] Carol Heim, 'Government Research Establishments, State Capacity and Distribution of Industry Policy in Britain', *Regional Studies*, 22.5 (1988), 375-386, p. 376; Horrocks, 'Enthusiasm Constrained?' p. 50.

Office Electrical Engineers' Journal in 1948, complaining that 'shortage of accommodation and the difficulty of getting alterations made to existing buildings so as to make them suitable for the increased staff and the work to be done have been greater embarrassments and of a kind common to other Branches and Departments'.[86] The Training School building was eventually converted into the Lines Transmission Laboratories in 1951. New buildings for the Service Group including workshops and canteen facilities were completed in June 1953, just under five years after the proposal was made to the Ministry of Works to carry out the work.[87] This took a long time in comparison with the new Atomic Weapons Research Establishment, Aldermaston and Royal Aircraft Establishment, Bedford which were established within two years of being proposed.[88] Despite Dollis Hill's key role in the military-industrial-scientific complex, not being classified as a military site meant it's needs were second to those of defence establishments.

The Post Office Board's support for Angwin's proposal was reflected in the funding made available for R&D activities at Dollis Hill. These figures were recorded separately for the first time in 1949, reporting that the Post Office spent £991,018 on R&D, including salaries and stores, of which a third was directed to 'research'.[89] Despite being only a fraction of the Post Office's total funds, equating to 0.026% of spend by the Engineering Department that year and 0.019% of the total capital expenditure of the whole organisation, the value was sizable when compared with other research establishments.[90] Whilst this figure paled in comparison with the R&D expenditure of the Ministry of Supply (£74 million) and the single atomic project at Harwell (£5.2 million) it was more closely aligned with other research departments, at roughly a quarter of DSIR's total funding (£4.2 million), around half the Medical Research Council's (£1.7 million) and exceeding the Agricultural Research Council's (£0.8

[86] William Radley, 'Reorganisation of Post Office Research', *POEEJ*, 41:3 (October 1948), p. 147.

[87] BTA: TCB 135/7 Engineer-in-Chief's Annual Report, 1947-48, A. J. Gill, p. 55.

[88] Heim, pp. 375-386.

[89] BTA: TCB 135/8 Engineer-in-Chief's Annual Report, 1948-49, A. J. Gill, Appendix VI.

[90] Clinton, *Post Office Workers*, appendix 33: capital expenditure in the Post Office, 1947-80.

million).[91] Unlike the Post Office, the DSIR's funding was split across 13 Research Stations including the Building Research Laboratory, Road Research Laboratory and its most well-funded site, the NPL, which received £689,528 that year.[92]

Despite being well-funded there were drains on Research Station resources as the Post Office was asked, or expected, to work on projects for other government departments. The Post Office did not always receive payment for these activities. For example, the costs of research undertaken at Dollis Hill for top secret intelligence projects were borne by Post Office funds, reportedly 'under the special financial procedure which exists for losing sight of such amounts at a high level'.[93] This was despite the existence of the Secret Vote, a budget allocated to cover this type of covert activity.[94] Although this funding arrangement did not directly affect the Research Station's budget, the cost in terms of staff time was not compensated. This was not, however, always at the Post Office's expense. A balance was struck between undertaking work not connected directly to Post Office concerns, which absorbed much needed staff for the post-war research programme (often senior engineers due the sensitivity of the request or level of expertise required) and the opportunities and prestige gained by the Research Station by delivering certain projects. This friction is illustrated by the Research Station's involvement in developing computers for the NPL and Ministry of Supply, and Medresco, the first hearing aid released by the NHS.

Having demonstrated their engineering expertise on the Colossus codebreaking machine, Angwin was approached by the director of the NPL, Sir Charles Darwin, in February 1946 to support the construction of one of Britain's first electronic stored-

[91] David Edgerton, 'Whatever happened to the British warfare state? The Ministry of Supply, 1945-1951', in *Labour Governments and Private Industry: The Experience of 1945*-1951 ed. by H. Mercer, et. al. (Edinburgh: Edinburgh University Press: 1992), (pp. 91-116), p. 103.

[92] *Department of Scientific and Industrial Research, Report for the Year, 1948-49*, Cmd. 8045 (HMSO: 1950), p. 208

[93] TNA: KV 4/200, Funds devoted to the Security Service by the Foreign Office, Report by Col. Cumming, 19 April 1950, p. 2.

[94] Richard Aldrich, 'Counting the Cost of Intelligence: The Treasury, National Service and GCHQ', *The English Historical Review*, 128:532 (2013), 597-627 (p. 600).

program computers, the Automatic Computing Engine (ACE).[95] ACE was the brainchild of the mathematician and Bletchley Park codebreaker Alan Turing, a combination of his pre-war theoretical work and his practical wartime experience constructing the Bombe machine. Despite Radley's hesitation about Dollis Hill supporting computing work he agreed to give the project the highest priority, enthused by 'the fascinating nature of the task and the prestige value'.[96] Internally, Radley justified the Research Branch involvement in the project as an opportunity to develop techniques which could be applied to electronic switching, which promised a more efficient and cheaper telephone service for the Post Office. Initially, Tommy Flowers and two of his Colossus engineers, Allen Coombs and William Chandler, were allocated to the ACE project, which started with the construction of a prototype computer, the Pilot ACE. But despite Radley's early enthusiasm a combination of staffing issues and more immediate Post Office needs meant Flowers, who had been specifically requested by Darwin, was removed from the project to work to develop telephone switching techniques solely for Post Office needs. Even with the expertise of Coombs and Chandler, the leader of the ACE project, John Womersley, raised concerns that it was not ideal to separate this work out. The engineering responsibility for the ACE project was eventually transferred to NPL in Autumn 1947 once it had established its own electronics team.[97] Radley reported that this decision provided some relief to the Research Branch to focus on Post Office projects.

Around the same time as Dollis Hill was removed from the NPL project, the Ministry of Supply approached the Post Office to build a digital computer to calculate aircraft trajectories for radar data. According to Coombs, he persuaded Radley to accept the Ministry of Supply request, as he was keen to 'try this new art' of digital computer development.[98] However, Radley's decision may also have been shaped by wanting the

[95] The Turing Archive for the History of Computing (TTAHC): 'Sir Charles Darwin to Sir Stanley Angwin, 22 February 1946' http://www.alanturing.net/turing_archive/archive/p/p02/p02.php [accessed 20 February 2020].

[96] TTAHC: 'Radley to J. R. Womersley, 25 February 1946' http://www.alanturing.net/turing_archive/archive/p/p02/P02-003.html [accessed 20 February 2020].

[97] SMG: MS/0129 Pioneers of Computing, A.W.M. Coombs.

[98] Ibid.

support of the Ministry of Supply, the largest single funder of state and private R&D during this period. For example, the Atomic Energy Research Establishment, founded in January 1946, received the same amount of funding from the Ministry of Supply as the total budget of the DSIR that year.[99] The Ministry of Supply was an important patron as high investment in defence research trickled down to private firms who won contracts to manufacture equipment and were allocated R&D projects.[100] GEC, Ferranti and Imperial Chemical Industries (ICI) all benefitted from defence work. Ferranti used funds from the Ministry of Supply to work on guided missiles for development work on computers.[101] Hundreds of firms supported the atomic energy project, but ICI was the largest beneficiary receiving £4.25m between 1946 and 1952.[102]

Coombs and Chandler took responsibility for the Ministry of Supply Automatic Integrator and Computer (MOSAIC for short) which was based on Version VII of Turing's logical design for the ACE. Parts of the machine were also informed by the EDSAC computer at Cambridge. Coombs reported that MOSAIC was poorly resourced: 'it was just Chandler and I who designed every scrap of that machine and a couple of data recorders as well which involved complicated processes with cathode ray tubes'.[103] This was less support than was allocated to both EDSAC and ACE, which were built by teams of researchers. Like the ACE project, it is possible that this was all Radley could, or wanted to spare, while keeping the Ministry of Supply satisfied.

There was friction between senior members of the Engineering Department about whether the Post Office should support MOSAIC at all. In a meeting of the Coordination Committee in 1951, the Engineer-in-Chief, Archibald Gill, stated that 'he deplored the fact the Post Office should still be burdened with commitments outstanding since the last war'.[104] In response the new Controller of the Research

[99] Herran, p. 575.

[100] Edgerton, *Warfare State*.

[101] Horrocks, 'Enthusiasm Constrained?', p. 50.

[102] Margaret Gowing and Lorna Arnold, *Independence and Deterrence: Britain and atomic energy, 1945-1952, Volume 2: Policy execution* (London: Macmillan, 1974). 176.

[103] SMG: MS/0129 A.W.M. Coombs

[104] BTA: TCB 371/43 Minutes of the 168th Meeting, 19 March 1951.

Station, Lionel Harris claimed that 'effort on this development had not been a complete loss to the Post Office, as much had been learned which was of use in the development of electronic switching'.[105] The machine was eventually delivered to Malvern sometime between late 1952 and early 1953 and contained 6,480 electronic valves and about 2,000 semiconductors. This project may have strengthened the relationship between the Post Office, Dollis Hill and the Ministry of Supply but it did not give the Research Station privileged access to all materials. Short supplies of steel meant the ninety-five mercury delay lines required for MOSAIC were designed around the only source readily available, steel tubes used by welders.[106]

While the Research Branch's involvement in ACE was not obviously telecommunications, it had close connections to, and applied ongoing research into electronic valves. Dollis Hill's involvement in Medresco, the first hearing aid provided free by the new National Health Service, was more of a departure from the Post Office's brief. However, this project was an opportunity for the Post Office to align itself with the government's popular welfare ambitions. The Medresco was the output of the Medical Research Council Electro-Acoustic Committee (hence the name) established in 1944 and chaired by Radley. The Research Branch undertook experimental work which informed the committee's report into the use of electro-acoustical equipment to alleviate deafness in 1946 and constructed the prototype hearing aid which became the Medresco Mk 1. This was a new application of Post Office expertise which built on staff experience designing telephone receivers and special apparatus for deaf subscribers. This was not an industry they had previously been involved with.

Initially the Ministry of Supply was tasked with manufacturing of Mk 1 but struggled to source the necessary parts including American valves, microphones and crystal insert receivers. As a result, the Research Branch was asked to build a new model with British parts. In 1948, the Post Office took control of the design and manufacture of the Medresco aids at the request of the Exchequer on the understanding that the Ministry

[105] Ibid.

[106] SMG: MS/0129 A.W.M. Coombs

of Health covered all the costs.[107] As soon as one model was manufactured the Research Branch started work on newer versions and later models utilised research into magnetic receivers, synthetic crystals and newer lower consumption valves (Figure 21 below). While sitting outside the Post Office's remit and directing resource away from other departmental needs, this project was celebrated by the Post Office Board. The Director General, Sir Raymond Birchall described the hearing aid as 'an interesting example of the Post Office performing agency work on the telecommunications side'.[108]

Figure 21 Medresco hearing aid, 1953.[109]

[107] PMA: POST 69/41 POB 1949.

[108] PMA: POST 69/43 POB 5(49) Post Office Work in Connection with the Medresco Hearing Aid, p. 4

[109] SCM: 1981-1684, Medresco portable hearing aid, c. 1953.

Alongside undertaking work with immediate applications which could align the Post Office with wider government defence and civil aims, resources at Dollis Hill were steadily directed to longer-term projects and investigations of a more fundamental nature.[110] In 1948, Gill reported that four long-term projects had been prioritised around the available staff, areas which were not being investigated elsewhere and which seemed the most profitable.[111] These were submerged telephone repeaters, the modernisation of the subscriber's telephone, an electronic telephone exchange and the mechanisation of letter sorting.[112] All of these had received some attention in the 1930s and although they had been officially suspended during the war the experience gained, directly or indirectly, helped shape the projects in the post-war period. Each project promised cost savings, increased capacity, improved efficiency and potential to support the export market.

Research into submerged repeaters during the war had already proved it was an area worth investigating to increase communications between lands separated by water. In June 1943, the Research Branch inserted a submerged repeater into a cable between Anglesey and the Isle of Man. The repeater amplified the number of telephone circuits in the wire from twenty-four to forty-eight, thus proving that capacity could be increased by introducing one component into an established system. By the end of the war the Post Office confidently installed another repeater in the first cable connecting Britain and Germany, the longest telephone cable in the world. The Research Station worked closely with industry to construct the repeaters and bring them into the cable making process. In 1947, the Post Office installed a submerged repeater in the first commercial submarine coaxial cable laid across the North Sea allowing eighty-four simultaneous conversations between Britain and the Netherlands (Figure 22 below).[113] A similar cable was laid the following year between Britain and Belgium providing 216 telephone circuits.

[110] BTA: TCB 135/8 Engineer-in-Chief's Annual Report, 1948-49, A. J. Gill

[111] PMA: POST 69/35 Vol 1 index agenda papers 1948, 'Engineering Developments – Telecommunications and Postal' p. 10, A. J. Gill, 28 April 1948.

[112] BTA: TCB 371/43 Minutes of the 157th Meeting, 29 November 1948.

[113] 'Post Office and Telegraph (Money Bill)', 30 Jan 1948, Hansard, vol 466 cc1358-93.

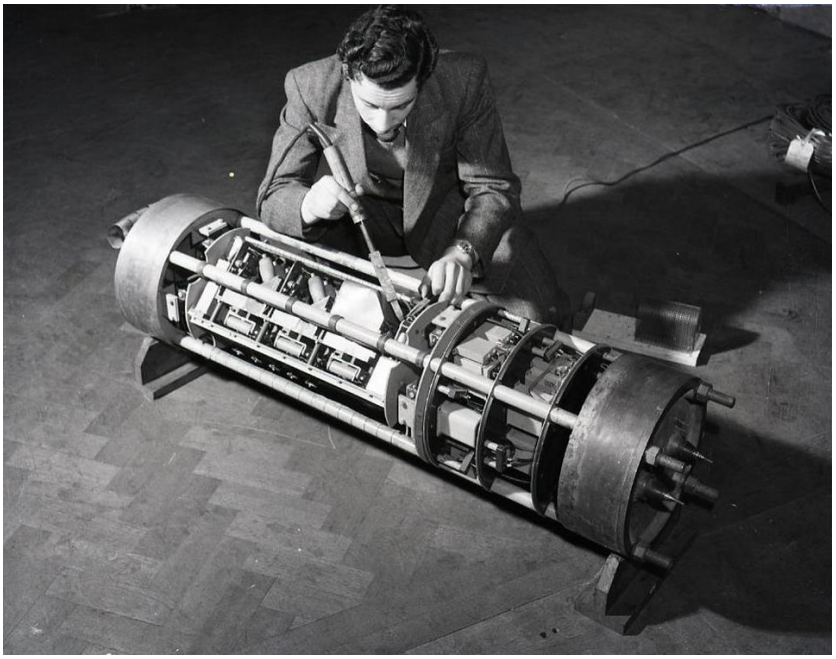

Figure 22 Post Office scientist with submarine repeater, Dollis Hill, 1947.[114]

These prestigious cable projects enabled the Post Office to demonstrate its support of government aims to expand international trade by improving communications links with other countries and raise the profile of British manufacturing for the export market. The British government was able to save money on these international projects, contributing in kind through the use of the GPO cable ships *Monarch* and *Alert*. The Research Station's long-term goal was to install the first submarine telephone cable across the Atlantic to increase telephonic communication between Britain and America. It was calculated that this activity would only be financially feasible if the repeater could survive the temperature and pressure of the ocean for at least twenty years.[115] A limiting factor was the life of the thermionic valves used in the submerged repeaters and in 1946 a new group was set up at Dollis Hill equipped with a new laboratory.[116] This required basic research and the development of new rapid testing techniques as until this point valve manufacturers had not focused on the construction of long-life valves.

[114] BTA: TCB 473/P 3527, Scientist with submarine repeater (undersea amplifier station), 21 April 1947.

[115] PMA: POST 69/35 'Engineering Developments – Telecommunications and Postal' p. 5.

[116] BTA: TCB 135/8 Engineer-in-Chief's Annual Report, 1948-49, A. J. Gill, p. 59.

The subscriber's telephone remained high on the research agenda. Between 1946 and 1950 Dollis Hill focused on improving the specifications for the telephone microphone and receiver as a guide for new designs. The focus of this research was improving the carbon microphone which was responsible for most of the distortion in telephone speech. This investigation had a direct impact on costs, as the improved microphone was made with less of the hard to obtain materials and fewer cables.[117] The Post Office continued to control the specifications of telephone equipment, which were defined by research at Dollis Hill. This information was communicated to manufacturers through the British Telephone Technical Development Committee, that then submitted samples of new devices to the Post Office for testing.[118] There was an incentive for telephone firms to engage with this development because if their device was accepted, it guaranteed sales to the Post Office and provided a competitive device for export. Experimental work to determine the required performance of a new subscriber set was completed at Dollis Hill in 1951 and eventually released in 1959. The reason for this delay is discussed in the following chapter.

There were three motivations for Dollis Hill staff to work on the design of an all-electronic exchange. Tommy Flowers had experimented with using valves as switches before the war. His experience leading the team which designed and built Colossus proved to Radley and Angwin, that the theory was practically possible. The Post Office was keen to replace the electro-mechanical switches in its automatic telephone exchanges as they caused numerous maintenance issues. It was expected that an electronic exchange would be easier to maintain, have lower fault liability and would eliminate the need for skilled mechanical adjustments.[119] Finally, the Post Office was aware that other telephone laboratories across the world were also exploring the opportunity to replace switches with electronic tubes. By April 1948, a new team had been established at Dollis Hill to solely work on this project under the leadership of Flowers.[120] Based on his wartime experience, Flower's discounted electromechanical

[117] PMA: POST 69/33 POB meeting, 7 Feb 1947, p. 1.

[118] BTA: TCB 135/8 Engineer-in-Chief's Annual Report, 1948-49, p. 63.

[119] PMA: POST 69/35 minutes of POB meeting, 2 July 1948, p. 9.

[120] PMA: POST 69/35 'Engineering Developments – Telecommunications and Postal', A. Gill, 28 April 1948.

designs of the type being developed in the United States, Germany and Sweden, for a fully electronic exchange. As we will see in the next chapter, this decision would eventually lead to the project's failure.

A long-term Post Office goal was to replace heavy postal work with machines. Research in this area had started before the war at Dollis Hill and culminated in the 'Transorma', a sorting machine designed to turn or 'face' letters in the same plane. This experimental device was installed in the Brighton sorting office with some success, but it was highly disruptive to the workforce, noisy and uncomfortable to run.[121] The Post Office Board was keen to introduce more labour-saving devices after the war, but the organisation could not be seen to be actively removing positions which, by government sanction, reduced the available jobs for war veterans.[122] This may account for why postal mechanisation received the least resource out of the four prioritised projects.[123] Another explanation, as described by Angwin, was that 'it has now been realised that many of the problems of Postal Mechanization required the application of scientific principles not hitherto applied'.[124] Therefore, such a high-risk project could only be considered as part of a portfolio of other investigations where the probability of success was much higher. This proved to be a sensible approach as despite the early promise of a prototype sorting machine which could face 600 letters per minute, refining the mechanics proved more challenging than expected and trials were eventually abandoned in 1955. There was also little success on another Dollis Hill investigation, started in 1948, to use fluorescent code markings on envelopes for automatic sorting by photo-electric devices.[125] While postal problems continued to be allocated resource, this was much smaller than the other three projects which went on to receive further development or showed more immediate promise.

This section has shown how the Research Branch was successful in its ambition to move into fundamental and long-term work as the Treasury approved requests to

[121] Campbell-Smith, p. 395.

[122] PMA: POST 69/30 minutes of POB meeting, 5 April 1946, p. 11.

[123] PMA: POST 69/30 'Research', Angwin.

[124] Ibid., p. 3.

[125] BTA: TCB 135/8 Engineer-in-Chief Annual Report, 1947-48, p. 58.

increase the capacity of the site. However, changes were not made instantly as the Post Office building requirements were second to military needs. Radley agreed to undertake projects which were not of direct relevance to challenges in the Post Office but were an opportunity to gain prestige from aligning with both welfare and warfare ambitions. While managing external pressures the Research Branch prioritised four projects which promised to decrease costs and improve services. By the end of 1950, the Research Branch had undertaken around 115 individual investigations in connection with these projects, equating to roughly a fifth of the total recorded investigations. This matches Radley's description that a fifth of work could be described as 'basic research'.[126] This change in culture was recognised by the staff in the Research Branch. Arnold Lynch, who joined Dollis Hill in 1936, recalled that the biggest change in his working experience was 'in the direction of long-term research, almost like university research, instead of tackling small jobs as they were wanted'.[127] The widespread belief that R&D would improve the nation's financial position supported Angwin's research priorities. However, as the next section shows, this also created challenges for Dollis Hill in recruiting the desired workforce.

3.4 The 'manpower' problem

In reflection of its value to the Post Office by 1946, the Research Branch was the largest Branch of the Engineering Department with around 800 staff, populated with the highest number of senior grades and was the only section to include the scientific positions of Chemist and Physicist.[128] Nonetheless, Angwin pushed for further increases to fulfil his plans for an expansion of long-term and fundamental research. In particular he wanted to attract a specific type of workforce 'men who had a good grasp of fundamental research, but also they would be required to have knowledge and experiment of work in the field'.[129] The desired rate of expansion is illustrated in Table

[126] *Fourth Report from the Select Committee on Estimates: The Post Office* (HC 1950, 130), p. 33.

[127] BM&A: OH/3/6 Dr Arnold Lynch, Oral History, (2001-2002).

[128] TNA: T 162/696/5 Establishment. Post Office: Engineering department Research Station; BTA: uncatalogued, The Handbook for the new Member, 1947, pp. 2-3; Hay, 6, p. 35

[129] PMA: POST 69/30 minutes of POB meeting, 5 April 1946, p. 8.

2 (below), with an increase of more fundamental research reflected in a greater rate of change for scientific officers compared with engineers.[130]

	April 1946	End 1946	1950 (Proposed)
Executive and Assistant Engineers	40	75	100
Scientific and Senior Scientific Officers	14	26	46

Table 2 Proposed expansion of the Research Branch, 1946.[131]

In his memorandum, Angwin proposed two methods to acquire the desired workforce: the first was to change how staff were promoted within the Engineering Department and the second was to hire scientists being released from wartime service. These sources likely account for Angwin's optimistic proposals for an increase in staff by the end of 1946. Before the war, a member of the Engineering Department was only promoted when a vacancy was made available at a higher level. This meant it was normal for an officer to move to a different part of the country on promotion. Angwin argued that this system impacted the efficiency of the Research Branch as it removed trained personnel away from research work.[132] To speed up recruitment Angwin suggested that promotion should be awarded based on ability, not because there was a vacancy. He also wished to remove the expectation that all senior roles in the Research Branch should have to take on management responsibilities, as was expected on promotion. The Post Office Board approved this change but only for staff at Dollis Hill, not in any of the other Engineering branches.

Angwin hoped to secure the services of scientists being released from war work, either men who went straight into the forces after graduation or from the wartime military establishments which were due to be cut. He was particularly interested in hiring staff from the TRE which overlapped with Post Office research, including work on signalling

[130] PMA: POST 69/30 'Research', Angwin, 27 March 1946, p. 4.

[131] Ibid.

[132] Ibid.

and transmission.[133] However, there was competition over this workforce and as was the case during the war the Service Ministries were prioritised over civilian needs, including those of the Post Office. Although some scientists returned to their pre-war research in universities many continued to work on defence projects post-war. Out of the 230 scientific officers working under John Cockcroft at Harwell, three quarters had worked on the atom bomb or radar during the war. William Penney recruited his staff directly from the Armament Research Department, which by the end of the war was the largest single R&D establishment supporting the development of the atomic bomb.[134] The DSIR also benefitted from this dispersal as in agreement with the Ministry of Supply and Ministry of Aircraft Production, sixty-five Senior Officers and Executive Officers from TRE were absorbed.[135] Despite being considered a civil research establishment, the needs of the defence programme were so great, that the Research Branch risked losing staff through secondments to the Service Ministries.

Post Office plans to increase the number of scientifically trained staff were also impacted by a large expansion of R&D establishments at this time, creating high demand for this workforce. Equally, because of slow expansion of the number of students of pure and applied science in the interwar period, and the effects of the war, supply was low.[136] As all post-war reconstruction plans were reliant on science and technology the government looked to increase supply. This led to the appointment of two committees to consider the future of scientific and technical training to provide the personnel required.

The report entitled *Higher Technological Education*, also known as the Percy Report, submitted its findings in July 1945. This was followed by the Barlow Report on *Scientific Man-Power* in 1946. Both reports emphasised the importance of technical and scientific jobs, argued for the need to expand the workforce and recommended reforms in education and training. The Barlow Report recommended the doubling of university qualified scientists (those studying mathematics, physics, chemistry and

[133] Ibid.

[134] Gowing and Arnold, p. 22-23.

[135] TNA: DSIR 11/330 Organisation: transfer of TRE work and staff, Dr Buckley to Mr Brown, 1 July 1946.

[136] Vig, p. 9.

biological sciences) from 2,500 to 5,000 a year based on estimates that by 1955, 90,000 scientists would be needed to meet the demands of British industry.[137] This was accepted by the government and the DSIR provided 400 studentships for work in pure and applied science, universities increased their expenditure fivefold and new facilities were constructed.[138] The Barlow Report suggested that scientific manpower should be allocated in the following order of priority; i) Teaching and Fundamental Research, ii) Civil Science, both Governmental and Industrial and iii) Defence Science.[139] This would have favoured the Research Branch however, the government prioritised the allocation of scientists and engineers to state R&D establishments connected with defence.

The Post Office's post-war plans relied on experienced engineers as much as pure scientists. This was the focus of the Percy Report, which called for changes to the organisation of higher technical education so that it could better support industry's needs, establish technical colleges with courses comparable to university degrees and include 'management studies' to improve a student's understanding of industrial organisation.[140] However, with few practical solutions to deliver these recommendations very little action was taken by government.[141] Without significant reforms to technical education the country faced a dearth of engineers, a situation which was not addressed until 1956 when the situation had become critical.[142] The Post Office was significantly affected by the prioritisation of the Barlow Report over the Percy Report. Between 1945 and 1951 the Research Station struggled to fill posts for Mechanical Engineers and Chemists.[143]

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[137] J. A. Barlow, *Scientific Man-Power: report of a Committee appointed by The Lord President of the Council* (London: HMSO, 1946), p. 6.

[138] Vig, p.16; Robert O. Berdahl, *British Universities and the State*s (Cambridge: Cambridge University Press, 1959), p. 94.

[139] J. A. Barlow, *Scientific Man-Power* p. 18-19.

[140] *Higher Technological Education*, (HMSO, 1945), p. 22-23.

[141] Martin Davis, 'Technology, institutions and status: technological education, debate and policy 1944-1956', in *Technical Education and the State since 1850: Historical and Contemporary Perspectives*, ed. by Penny Summerfield and Eric Evans (Manchester: Manchester University Press, 1990) p. 123.

[142] Vig, p. 20.

[143] BTA: TCB 135/8 Engineer-in-Cheif Annual Report, 1947-48, p. 55; TCB 135/9 Engineer-in-Cheif Annual Report, 1949-50, p. 81.

Changes in the Civil Service coupled with expanding R&D establishment not only made it harder for the Post Office to attract staff, but also had an impact on retention of its workforce. The reorganisation of the Scientific Civil Service was an attempt by government to mitigate the manpower crisis. This was informed by a Committee on Scientific Staff in Government Departments also chaired by Sir James Barlow.[144] Its report was published in April 1943 and influenced the Government's White Paper on *The Scientific Civil Service*. Until the end of the war scientific and technical roles were separately organised, recruited and paid for by each government department.[145] This policy created a division between the scientific and administrative positions with the latter having access to better salaries and career prospects.[146] In 1945, over 500 departmental grades were reclassified into three scientific classes; Scientific Officer, Experimental Officer and Assistant Experimental Officer.[147] This change also aligned government scientists with those in industry. The new government grades led to dissatisfaction among the Post Office research staff as these roles offered better pay and opportunities.[148] In his 1946 memorandum Angwin reported that he had received 'many' applications requesting to transfer to other government departments that benefitted from the Civil Service scheme and their loss 'would be a serious setback to work'.[149] In particular Imperial Chemical Industries and the government's expanding atomic energy programme were considered the biggest threat to retaining staff in the Research Branch.[150]

The regrading of scientific staff in the Civil Service prompted debate among the Post Office Board about whether it was sensible to change the engineering grades to match. The argument to retain the engineering structure was to enable the interchange of staff between laboratories across the department. However, fearful of a large loss of

[144] E. N. Gladden, *Civil Service of the United Kingdom: 1885-1970* (London: Psychology Press, 1967), p.36.

[145] Dorothy Johnstone, 'Developments in the British Civil Service, 1945-51', *Public Administration*, 30.1 (1952), 49-59 (p. 51).

[146] 'Man-Power Problem', 1946, Hansard, Vol. 140, cc. 545-73 (c. 549).

[147] Vig, p. 16.

[148] PMA: POST 69/30 'Research', Angwin, p. 7.

[149] Ibid.

[150] PMA: POST 69/30 3(46) Minutes of POB meeting, 9 April 1946, p. 8.

staff, Angwin suggested that the staff who carried out 'purely scientific' work should be hired on a Scientific Civil Service grade which would allow the Post Office to draw staff from the same recruitment pools as other government research establishments.[151] The Scientific Grades were eventually revised to match the Civil Service in 1948, coinciding with the complete restructure of the Research Branch. This reorganisation simplified the number of research groups from nine to five, two of which were categorised as 'Engineering' and three 'Scientific' (see Table 3 below). They were directed by a Staff Engineer and Senior Principal Scientific Officer respectively, both of whom answered to the Controller of Research.

Section	Research Groups
Engineering	Telephone and telegraph apparatus and mechanisation of postal services (Division R/A)
	Long-line transmission, including communication by submarines cables (Division R/C)
Scientific	Electronic devices and associated circuitry (Division R/B)
	Materials (Division R/D)
	Mathematical and basic physical research; patents (Division R/E)

Table 3 Organisation of Research Branch, 1948.[152]

The restructure was designed to best meet Angwin's aims of long-term and fundamental research and was communicated to the Engineering Department as such. Radley wrote about this restructure in the *Post Office Electrical Engineers' Journal*, presenting these change as an opportunity to make the Branch 'as flexible as possible so that it may be able to cope efficiently with new and, as yet, unforeseen problems with which it will have to deal, or with changes in emphasis on the different requirements of work to be done'.[153] Likely in response to the increased number of requests from external bodies, an additional division was established, called R/S under the control of a senior Staff Engineer. This reportedly took control of work in 'field of

[151] Ibid.

[152] William Radley, 'Reorganisation of the Post Office Research', *POEEJ*, 41.3 (October 1948), p. 147

[153] Ibid.

national interest allied to communications but not necessarily of direct application to Post Office requirements'.[154]

The Treasury supported this organisational change, agreeing to fund a complement of 151 posts across the Research Branch and Tests and Inspection Branch. In reality this did not actually increase the supply of staff as many of these posts were filled by assimilating the former Chemist and Physicist grades, regrading suitably qualified engineering officers and a small number of new recruits from the Civil Service competition.[155] Most of the workforce in the Research Branch remained in engineering grades and their salaries were decided internally between the Post Office trade unions and Post Office management. Scientists, on grades common across the scientific Civil Service, amounted to around a third of the staff at the level of Inspector/Assistant Scientific Officer and above.[156] A small number of these posts were filled by women. While the number of Female Assistants in the Engineering Department fell steadily after the war, in agreement with the union, the number of women employed in the Research Branch in scientific roles increased. Between 1946 and 1950, the number of women named on research reports rose from fourteen to thirty, seven of whom had joined during the war. This workforce was concentrated in working on chemistry and physics problems, but they did not fill the senior scientific roles.

The new grades placed the Research Branch on an equal footing with other government departments for the scientific Civil Service recruitment pool. The Post Office also saw opportunity in the expanding numbers of science students at universities.[157] This growth had been stimulated by the enrolment of deployed servicemen and the government's support of the Barlow recommendations.[158] The Post Office adapted its hiring strategy by sending senior engineering staff to source candidates directly from universities. Managers hoped this might be a solution the

[154] Ibid.

[155] BTA: TCB 135/8 Engineer-in-Chief's Annual Report 1947-48, A. J. Gill, p. 66.

[156] Ibid., p. 55.

[157] Agar, *Science and Spectacle*, p. 12.

[158] Vig, p. 18.

dearth of candidates applying to engineering grades. It was considered a good way of recruiting staff of the quality desired however, the Post Office struggled to attract students to consider a career in the organisation, even after aligning with Civil Service salaries.[159] This was made harder as even with increased support from the government the number of scientific graduates did not meet the expanding needs of state and industry.[160]

While struggling to attract new graduate staff Dollis Hill was able to increase its scientifically qualified staff through the Darwin Panel. This government scheme transferred German scientific and technical experts to Britain to work in industrial research for government departments and private industry. The committee was established in December 1945 under the chairmanship of Sir Charles Darwin, the Director of the NPL. It brought together representatives from across government including the DSIR, Board of Trade, Control Commission for Germany, Home Office, Admiralty, Ministry of Supply, Ministry of Aircraft Production, Ministry of Agriculture and Fisheries and the Ministry of Fuel and Power.[161] In 1946, sixty worked under contract in Britain, rising to 290 (121 on defence projects) by November 1948.[162] The Post Office joined the Darwin Committee in July 1946 representing their interests as well as those of the wider telecommunications industry. In total the Post Office was allocated ten scientists. Four joined the Research Branch at Dollis Hill and the others went straight into industry. Their appointment was welcomed by the Research Branch as the Germans were 'regarded as a specialist in his own particularly sphere and to be capable of making a valuable contribution to research in this country'.[163]

The appointments themselves show the Post Office's priorities at the time. Especially the ambition to move into fundamental research including; valves, piezo-electrics and

[159] BTA: TCB 371/43 Minutes of the 169th Meeting, 21 May 1951; BTA: TCB 135/6 Engineer-in-Chief's Annual Report, 1949-50, A. J. Gill, p. 81.

[160] Vig, p. 20.

[161] TNA: LAB 8/1449 Recruitment of scientist and technicians from Germany: minutes of meetings 1-39, Minutes, 21 November 1945.

[162] Jon Agar and Brian Balmer, 'British Scientists and the Cold War: The Defence Research Policy Committee and Information Networks, 1947-1963', *Historical Studies in the Physical and Biological Sciences*, 28.2 (1998), 209-252 (p. 225).

[163] BTA: TCB 135/7 Engineer-in-Chief's Annual Report, 1947-48, Gill, p. 66.

plastic materials. Ex-Telefunken researcher Dr Siegfried Wagener was employed by the Research Branch in early 1947 at the highest grade, Scientist I. He was hired as an authority on oxide cathodes and design of small valves. He proved so valuable that the Post Office extended his contract for another two years after his initial period. Dr Josef Linke was presented to the Darwin Panel in March 1948 to work alongside Dr Wagener at the Research Branch. Unlike other nominees, Dr Linke was transferred from the Deputy Chiefs of Staff scheme, which employed German experts on British defence research.[164] Dr Linke's salary was discussed at length due to the fact he had been offered employment by the private firm Telephone Manufacturing Co. at £843, more than the Post Office could afford. It was decided instead to offer Linke £750 at a higher grade than proposed, Scientist I, with subsidies to his accommodation and food. The focus of Linke's work was Electrical Network Design with special reference to Filter Design.[165]

Some of those appointed by the Darwin Panel had played an important role in Nazi Germany's defence programme. Dr Rudolf Bechmann is one example. Bechmann was hired by the Post Office in January 1948 at the highest level, Scientist Grade I. At the time he was regarded as one on the leading authorities in the world of quartz crystal vibrators and piezo-electric materials. When his contract came up for renewal the Research Branch described him as 'the only one whom they [the Post Office] have with specialised and long experience in this field'.[166] During the war Bechmann was Chief Engineer of Telefunken's Quartz Crystal Department and the Chairman of the Committee in charge of the control of the whole quartz industry in Germany. This research was relevant to the Post Office who had taken control of co-ordinating research into the production of the synthetic crystals in 1946. The material itself was required for radar and telecommunications, specifically carrier telephones. Bechmann's work was so integral to the Research Branch that his contract was extended to a two-year period.[167]

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[164] Paul Maddrell, *Spying on Science: Western Intelligence in Divided Germany, 1945-1951* (Oxford: Oxford University Press, 2006), p. 32.

[165] TNA: LAB 8/1449 Recruitment of scientist and technicians from Germany: minutes of meetings 1-39, Minutes of 29th Meeting, 27 May 1948.

[166] TNA: LAB 8/1449 'Post Office memorandum to extend the employment of Dr Rudolf Bechmann', 6 July 1948.

[167] TNA: LAB 8/1449 Minutes of the 30th Meeting, 6 July 1948.

Another scientist, Dr Horn filled an important gap in the Research Branch's chemistry division, specialising in new materials. Horn had been Chief Engineer at the Norddeutsch Seekabelwerke, Nordenham, where he was responsible for the development of Oriented Polystyrene Film (Styroflex). He also designed machines for sheathing cable with Styroflex, one of which had been evacuated to the UK for use by a contractor working on behalf of the Post Office. At the time, research into the production of satisfactory polystyrene film 'had made little progress', despite the Inter-Service Working Panel concerned with the development of the material. Dr Horn was required to assist in the reinstallation of the machine and help design similar machines with a larger capacity. He was stationed at Dollis Hill at the highest grade, Scientist I.[168]

The Research Station gained necessary skills from German telecommunication experts but were unable to protect their own staff from being called up to support Service Ministries. The Post Office was put under further pressure to support national defence Following the successful test of a Soviet atom bomb in 1949 which fuelled the Cold War arms race to produce more powerful nuclear weapons and revelations of atomic espionage with the arrest of Klaus Fuchs and defection of Bruno Pontecorvo the following year leading to the dismissal of foreign personal from defence establishments.[169] Treated as a reservoir of state expertise, this became acute in 1950 when the Engineer-in-Chief, Gill, reported that his department had released staff 'whose expert knowledge and experience can be of direct assistance in the national defence effort… despite the Department's own pressing needs for such staff to meet the increasing volume of scientific and engineering work'.[170]

As we have already seen Dollis Hill continued to support wartime projects in the post-war period. Although the Research Station adopted a culture of secrecy during the war Radley and Harris were reluctant to manage secret work in siloes. In some cases, this was unavoidable as was the case with work in connection with the Government Communications Headquarters (until 1946 the GC&CS) at Eastcote. This work was so

[168] TNA: LAB 8/1449 Meeting of the 28th Meeting, April 1948

[169] Simone Turchetti, *The Pontecorvo Affair: A Cold War Defection and Nuclear Physics* (Chicago: Chicago University Press, 2012), p. 2.

[170] BTA: TCB 135/10 Engineer-in-Chief's Annual Report, 1950-51, A. J. Gill, p. 1.

far removed from 'orthodox Post Office business' that a special group was established and completely segregated from the rest of the site which reportedly aroused 'considerable curiosity' across the staff.[171]

The only way to protect staff from being seconded was to bring the secret work inside Dollis Hill formally. This strategy was adopted by Radley and Harris in April 1950 when the Research Station was under so much pressure to support civilian and military work they could not approve the secondment of one of their senior staff for three months.[172] The request came through Sir Henry Tizard, then Chief Scientific Adviser to the Ministry of Defence and chairman of the Defence Research Policy Committee and Advisory Council for Scientific Policy, and it is not unreasonable to suspect it was in connection with guided weapons.[173] Radley and Harris successfully campaigned to change the way defence projects were managed and gained support from the Security Service and Treasury to establish a new research group. The group was staffed by one Staff Engineer, one Assistant Staff Engineer, one Executive Engineer, one Engineer, three Assistant Engineers and ten Technicians. The sizable outfit cost £6,700 in wages and £4,000 for research and production equipment.[174] This was paid for by the Post Office under the special agreement to absorb military costs into the budget.

By 1950, the Post Office had convinced the Treasury to fund posts for 106 engineers and sixty-five scientists in the Research Branch.[175] Although exceeding Angwin's initial estimations, the Research Branch struggled to fill these positions. While the government had followed the recommendations of the Barlow Report, the number of science students was insufficient for the demand. There were also issues attracting academically qualified engineers as the government did little in implementing the recommendations of the Percy Report. The desire to hire specific staff distanced the Research Branch from the wider Engineering Department as it went through a change

[171] TNA: KV 4/200 Funds devoted to the Security Service by the Foreign Office: Secret Votes funding of the Security Service, Report by Col. Cumming, 19 April 1950, p. 1.

[172] Ibid., p. 4.

[173] John Baylis, *British Defence Policy: Striking the Right Balance* (Basingstoke: Macmillan, 1989), p. 51; Agar and Balmer, p. 212.

[174] TNA: KV 4/200, Report by Cumming, 19 April 1950, p. 1.

[175] *Fourth Report from the Select Committee on Estimates: The Post Office, 1950*, p. 107.

which brought it more closely in line with the wider scientific Civil Service. Although this gave the Post Office access to a wider pool of candidates, the Research Branch did not attract enough applicants with the desired experience. It was not enough to have Treasury support for establishing new posts when the Post Office could not compete with other expanding industrial and state R&D establishments. Despite assistance from the Treasury, changes to recruitment techniques and the system of promotion, there were still outstanding vacancies in the Research Branch for engineers and scientists in 1950.[176] At the same time as failing to attract new staff, managers struggled to retain the workforce they had in the Research Branch. Many requested a transfer to the R&D establishments of the Ministry of Supply and Admiralty and others moved to overseas administrations. Without the desired workforce, the Research Branch was limited by how much it could increase the amount of long-term and fundamental research.

3.5 Conclusion

In this chapter we have seen how due to its unique identity as a public service and a business the Post Office was hindered by wider government policies. The export drive and prioritisation of other industries over the Post Office meant it struggled to access raw materials and equipment required to restore damaged and neglected systems and install new services. As such it was ill-equipped to introduce a public service and support the accelerating defence programme. This remained the case when the department was working on ROTOR, the third most expensive military project in the period. The Post Office could achieve some of its long-term goals through the research at Dollis Hill. Both the Engineers-in-Chief, Angwin and Gill, and the Heads of Research, Radley followed by Harris, had bold ambitions for Dollis Hill in the post-war period. They had the support of the Post Office Board who hoped a move to more long-term and fundamental research would, eventually, save the department money by using cheaper materials and increase efficiency though better infrastructure.

[176] BTA: TCB 135/9 Engineer-in Chief's Annual Report, 1949-50, A. J. Gill, p. 82.

Whilst not benefitting from most post-war policies for R&D and national reconstruction, by 1950 the Research Branch had gone some way towards Angwin's ambitions, implementing long-term and fundamental research, adapting areas of the site, and increasing the number of senior positions, although these roles were not easily filled. In contrast, the Post Office aims to reconstruct and develop the telephone service were consistently hampered by government actions to improve the balance of payments and respond to financial crises. Thus, there emerged a disjoint between the promise of research and what the Post Office could provide. During this period this disconnect was not immediately problematic, but once research had developed to a stage to be absorbed into the national infrastructure its implementation was harder to achieve. This is discussed in the following chapter. By examining the large-scale operations of the Post Office alongside the experience of Dollis Hill, I challenge Douglas Pitt's argument that the development of telecommunications during this period was solely constrained by the financial restrictions imposed by the Treasury and central government. I have shown that Dollis Hill did receive protected funding from the Treasury, but its research was constrained by wider factors including the expansion of other R&D establishments.

This chapter supports David Edgerton's argument that Britain's immediate post-war priorities were tilted more heavily towards liberal militarist defence spending, rather than social democratic welfare spending. Not only did this divert funds away from civilian requirements, such as the national telephone network, but also the Post Office budget was used to finance military projects, for both large infrastructure and covert intelligence work undertaken by Dollis Hill staff. The identity of the Research Station became confused during this period, treated as a civilian-focused R&D establishment, but, having proved itself as experts during the Second World War, was expected to continue to support military needs without the favourable conditions of defence institutions. While Dollis Hill's unique character meant the Post Office could gain patronage and prestige by simultaneously aligning to the government's warfare and welfare needs, this did redirect resources away from departmental needs.

Chapter 4: High-technology visions in an underinvested service, 1951–1958

> When Her Majesty makes the first call from Bristol she will, in effect, ring up the future.[1]
>
> 'Ringing up the Future', *Post Office Telecommunications Journal*, 2.1 (1958), p. 1.

4.1 Introduction

Between 1951 and 1958, the Post Office continued to harness high-technology visions emanating from Dollis Hill to align its research activities with government aims, thus safeguarding funding and protecting staff. Whilst the promotion of technologies was a well-established Post Office strategy, during this period the department attempted to associate itself with the new rhetoric around British scientific research. A major route to prestige was to be one of the institutions seen to shape Britain's post-war identity by delivering scientific and technological 'firsts'.[2] Robert Bud has described this as a time of 'defiant modernism', a period which saw the first civilian jet airliner Comet, the first civil nuclear power station Calder Hall and a number of world speed records.[3] Queen Elizabeth II, the new, young monarch on the throne, became symbolic of the country's modernising ambitions, and, through association legitimised new technology.[4]

While the Post Office's aspirations intersected with the 'defiant modernism' trend of other national prestige projects, its contribution was not in the form of imposing architecture like the towers at Calder Hall power station or the unusual structure of the Mark 1 Telescope at Jodrell Bank, nor was it through record breaking vehicles; instead it was through infrastructure. As very little of this infrastructure was publicly

[1] 'Ringing up the Future', *Post Office Telecommunications Journal*, 2.1 (1958), p. 1.

[2] Robert Bud, 'Penicillin and the new Elizabethans', *BJHS*, 31.3 (1998), 305-333 (p. 313)

[3] Ibid., p. 312.

[4] Ian Welsh, *Mobilising Modernity: The Nuclear Movement* (London: Routledge, 2000), p. 42; Agar, *Science and Spectacle*.

visible this posed a unique challenge in its promotion, particularly concerning the economic imperative to sell British technology abroad. This was a necessary element of international trade, but new technologies also became symbols of progress and national prestige. Bodies like the National Research Development Council (NRDC) were established to support this aim, with NRDC becoming an influential sponsor in the development of Britain's computer industry.[5] By contributing to this agenda, the Post Office sought to demonstrate the value of its research activities at Dollis Hill to a sceptical public experiencing long waiting lists for telephone connections. With reasonable freedom over the research agenda at Dollis Hill, the Post Office continued to take on a breadth of activities which aligned with and supported the government's civil and military aims.

Section 4.2 shows that the Cold War continued to impinge on the Post Office's plans to improve and expand the public network. During this period, the Post Office's identity as a civil department was further complicated as demands for national defence absorbed sizable portions of the annual budget. The Engineering Department provided alternative routes for major communication networks through the ongoing ROTOR programme and a new scheme to install a radio-relay system across the country to be used in event of a nuclear attack. Dollis Hill also retained its identity as a civilian establishment supporting military activities. Research Branch staff designed bespoke equipment for Military Intelligence and took part in covert activities, including phone tapping Soviet cables. Whilst these projects deflected attention away from purely civilian problems, it was also a means by which senior staff could be seen to support military patrons and reduced the risk that staff would be seconded away from Dollis Hill.

In section 4.3 I show that the government's enthusiasm for new technologies, especially those with export potential, helped the Post Office to develop its research activities. For most of this period the Treasury considered the Post Office's more urgent requirements – reducing the telephone waiting list and increasing its

[5] John Hendry, *Innovating for Failure: Government Policy and the Early British Computer Industry* (Cambridge, MA; London, MIT Press, 1990)

mechanisation programme – a low priority. As such, the Treasury would use the Post Office budget to help meet macroeconomic needs by cutting capital expenditure for the public service. In contrast the Treasury was consistently supportive of new developments being researched at Dollis Hill, reflecting the Conservative government's technological enthusiasm. The expanding research programme became an important means by which the Post Office could continue to influence the telecommunications industry as government policies to increase goods for export meant the department had become one among many customers. While the Post Office did not suffer the same misguided investment as British Rail, whose modernisation severely lacked holistic planning, by 1958 the domestic telephone service was a patchwork of equipment with some portions over thirty years old and hundreds of thousands still waiting for their installation.[6]

Section 4.4 explores how Post Office managers used the research activities at Dollis Hill to convince the government to support the installation of a submarine telephone cable across the Atlantic. With an Empire in decline the Post Office highlighted the value of this cable as a diplomatic tool for the British government to strengthen relationships with the USA and Commonwealth. The transatlantic telephone cable, TAT-1 as it later became known, opened in 1956 as a collaborative venture between the Post Office, American Telephone and Telegraph Company (AT&T), the Canadian Overseas Telecommunications Corporation (COTO) and the Telegraph Company of Canada. While the Research Branch had planned a system incorporating the most advanced technology, I show that the final design of the service was shaped more by international relations than ambitions to utilise the most contemporary equipment. Post Office prestige was sacrificed to guarantee Britain was not left behind in this significant development in long-distance telecommunications, which tripled the number of consecutive telephone calls across the Atlantic and improved their quality. While this diminished the Research Branch's involvement, the Post Office could demonstrate its role in expanding British industry and supporting the export market.

[6] David Henshaw, *The Great Railway Conspiracy: the fall and rise of Britain's railways since the 1950s* (London: Leading Edge Press & Publishing, Ltd. 1991); Christian Wolmar, *The Great British Railway Disaster* (Shepperton: Ian Allan Limited, 1996).

During this period, the Post Office continued to use the promise of new technology to present itself as a forward-looking organisation but it had to adapt how it communicated this message. Section 4.5 explores how the Post Office promoted its activities when many of its technological triumphs were in invisible infrastructure. Another challenge for the Post Office's Public Relations Department (PRD) was navigating government-imposed constraints on publicity, its mediums and messaging. While being restricted in its use of film, posters and press notices, the Post Office instead took part in exhibitions which served wider government aims. More than ever, the launch of new services became an important opportunity to gain prestige, press coverage and shape public opinion. In the face of fears around increased mechanisation and automation, the Post Office humanised new automated technologies to build public trust. Whilst familiar publicity methods were denied to the Post Office in this period Dollis Hill's work remained central to the public portrayal of a modern efficient organisation.

Section 4.6 considers the impact of these activities on the culture of the Research Station, highlighting how Dollis Hill's flexible identity as both a civil and military establishment was also experienced by the staff. By undertaking a wide variety of activities for the Post Office and to support a variety of government aims, senior staff had pushed Dollis Hill to its practical limits. The decision to look for an alternative site for the Research Station in 1958 recognised the need for improved facilities, but also the opportunity to design an R&D establishment which better reflected Post Office ambitions.

4.2 Cold War commitments

As the Cold War deepened the government expected the Post Office to devote considerable effort to protecting and expanding telecommunication routes of strategic importance for the armed forces. The Treasury refused to provide the Post Office with extra capital for this work under the assumption that this new infrastructure could eventually be used for public services. This was despite the Post Office arguing that the

degree of civilian usefulness of defence schemes varied from project to project.[7] The redirection of funds, labour and materials was of great concern to the Post Office Board. In June 1952, following the return to power of Churchill and the Conservatives, David Gammans, the Assistant Postmaster General warned Parliament that there was 'a very real danger that we shall soon be running into quite a serious situation in connection with the telephone services'.[8] The Post Office was not the only nationalised industry to be affected by cuts to capital expenditure, with spending on railways and mining also reduced to support the military programme.

For the first time, in 1951, the Post Office's financial contribution to national defence was made public, being included in the department's annual funds voted on by Parliament. As the Post Office was a civil department conducting military work, this meant that questions from the Opposition whilst apparently concerned with protecting civil funding, took aim at the governments' escalating response to the Cold War. William Williams, Labour MP and former Post Office worker, asked why 'they [the Post Office] are having to bear the burden of public criticism in regard to finance, much of which has not been spent upon legitimate normal Post Office work'.[9] Labour MP Ness Edwards, previous Postmaster General and spokesman for the opposition on Post Office affairs, inquired as to why this work, much of which was for the Air Defence 'should not be put in the Air Ministry Vote, so that we do not distort the commercial accounts of the Post Office and deceive the country into believing that it is paying less than it actually is for rearmament?'.[10] Nonetheless, between 1951 and 1952 the Post Office reportedly spent a third of its capital on defence (£20.7 million) dropping to a quarter in 1953. This figure fell significantly after the end of the Korean War, in line with the national curtailing of rearmament, to 10% in 1955 and 3% in 1958.[11] This was

[7] TNA: T 229/878 Civil Defence Post Office Measures, R.J.P Harvey (GPO) to J.G.P. Spicer (Treasury), 15 October 1952.

[8] 'Post Office and Telegraph (Money) Bill', 1952, Hansard, vol 502, cc 646-736 (c. 659).

[9] Ibid.

[10] Ibid.; Ben Curtis, 'Edwards, Onesimus [Ness] (1897-1968)'.

[11] TNA: CAB 21/4922, Defence Plans of the civil departments: General Post Office, Harvey GPO to C. G. Buttenshaw, Cabinet Office, 31 January 1951.

in line with wider government spending, and in 1952 international instability meant a quarter of the country's total expenditure was directed to defence.

The Post Office was already heavily involved in ensuring communications for defence purposes and continued to play a key role in advancing defence technologies. The air defence system, ROTOR, remained a top priority and continued to draw resource from the Post Office's public schemes. The first stage of this project, the reactivation of Second World War radar stations and the construction of new underground warning and intercept stations, was delivered to Fighter Command in 1956. Due to advances in radar technology, some of the ROTOR stations had already become obsolete and were retired, placed on standby or required updating with new equipment. Between 1951 and 1954 the Post Office spent £30 million on several other projects which fell under its responsibility to 'safeguard telecommunications at time of war'.[12] This included building a deep shelter at Chancery Lane and installing terminal transmission equipment for circuits serving Whitehall.[13] In 1952, this project meant four-fifths of the trunk network programme was determined by defence requirements as regards locations and timings.[14]

The Post Office's defence plans changed following the USA's detonation of a hydrogen bomb in 1952 and the decision for Britain to construct its own weapon. Under the assumption that thermonuclear bombardment would likely target areas which contained the major telecommunication routes for the country, in 1954 the Post Office committed to construct twenty-five alternative switching centres to provide a skeleton trunk cable network in the event of the main industrial centres being destroyed and to install a radio-relay chain running the length of the country.[15] This absorbed half the Post Office's planned development of the trunk and junction network. The lines of this contingency network served no practical purpose for the civilian network with the

[12] Ibid., Defence Committee – Protection of Telecommunication Services, Memorandum by PMG, 1955.

[13] Ibid.

[14] PMA: POST 69/52, Post Office Board (POB) 1951, P.O.B (51)68 Appendix B, Defence Programme.

[15] TNA: CAB 21/4922 Home Defence Committee Meeting, 10 December 1954.

prioritisation of military needs further denying the investment required to meet the demands of increasingly impatient subscribers.

The large-scale programme of rearmament during the Korean War dramatically impacted the landscape of British R&D. This policy disproportionately favoured military research which benefited from high investment and recruitment of staff, limiting available funds and staff for civil research. By 1955 half the nation's scientists were employed on military research. Industries that demonstrated their usefulness to the government's military programme gained state patronage through defence contracts.[16] While some fields, including electronic and chemical research, benefitted from this arrangement, others suffered as state support of civil industrial research dropped.[17] This imbalance led to many British firms and industries becoming uncompetitive on the international market, a state of affairs which was not addressed until the publication of the 1957 *White Paper on Defence* which aimed to improve the standing of British industry.[18]

The programme of civilian research at Dollis Hill was impacted by the demands of the Intelligence and Service Ministries. The Research Station remained an important node in the 'secret state', designing equipment to transport, intercept and decrypt intelligence information. This deflected resources away from problems relating to the public service. In 1951, 80% of the staff working in the Research Station in a professional grade (Inspector and higher), were 'either engaged on urgent defence work which Defence Departments had asked the Post Office to undertake or on work which they would wish to be continued because it had a defence interest'.[19] This figure was higher than that of the wider Engineering Department, where it was estimated that half the total number of staff were undertaking work for the defence departments. This was also greater than the DSIR where 69% of research output fell

[16] Sally Horrocks, 'The Nature and Extent of British Industrial Research and Development, 1945-1970', *Refresh*, 29 (1999b), 5-8 (p. 5).

[17] Norman Vig, *Science and Technology in British Politics* (Oxford: Pergamon Press, 1968), p. 20

[18] Richard Moore, 'Bad Strategy and Bomber Dreams: A New View of the Blue Streak Cancellation, *Contemporary British History*, 27.2 (2013), 145-166; David French, 'Duncan Sandys and the Projection of British Power after Suez', *Diplomacy & Statecraft*, 24.1 (2013), 41-58.

[19] BTA: TCB 371/43 Minutes of the 172nd Meeting, 4 February 1952

into these categories.[20] Staff were working on similar activities to those undertaken during the Second World War, such as increasing circuits between sites of strategic importance and, as the following examples suggests, continuing to design novel equipment and support British intelligence agencies.

During this period, the identity of the Research Station as a civilian establishment was further challenged as the site became physically divided between secret and non-secret work. The needs of the military and intelligence departments led to the formation of discrete project teams working within Dollis Hill. For example, the Joint Speech Research Unit (JSRU), was established in 1953 to focus on the development of scrambler phones and vocoder scrambling systems. Whilst the JSRU was based in the Government Communications Headquarters (GCHQ), in Eastcote, North-West London, it was led by Dollis Hill research engineer John Swaffield, staffed by Post Office personnel and used resources at Dollis Hill.[21] As part of this wider programme, the Post Office managed the Services Cypher Development Unit, also with facilities in Eastcote and Dollis Hill.[22] At other times projects were undertaken by individual researchers, not whole research groups. For example, F. J. Scalan spent nine months in 1951 designing a miniature radio transmitter for a 'special purpose'. While never explicit, given that the parameters stipulated it had to be small enough to be carried in the user's pockets, it is highly likely it was intended to eavesdrop on conversations. The final device, of which six were made, was a crystal-controlled transmitter capable of sending Morse-code signals over a range of two miles.[23]

[20] Jon Agar and Brian Balmer, 'British Scientists and the Cold War: The Defence Research Policy Committee and Information Networks, 1947-1963', *Historical Studies in the Physical and Biological Sciences*, 28:2 (1998) 209-252 (p. 235).

[21] Richard Aldrich, 'Whitehall Wiring; The communication-electronics security group and the struggle for secure speech', *Public Policy and Administration*, 28:2 (2013b) 178-195 (p. 183); 'Reminiscence of working at Eastcote by J. S.', Ruislip Online <http://www.ruisliponline.com/eastcotemod/index.htm> [accessed 8 May 2020]

[22] Ibid.

[23] BTA: TCB 277/2190 F. J. Scanlan, 'A miniature radio transmitter Mark 2', July-October 1951.

Acting as a clandestine workshop did not guarantee improved facilities for Research Station staff. Assistant Staff Engineer John Taylor ran a laboratory as part of the Special Investigations Unit inside the Research Station undertaking work for MI5 and MI6.[24] Reportedly Taylor's team researched infrared detection and listening devices in a basement where rooms were 'dark and overcrowded, and thoroughly unsuitable for the work that was being attempted inside'.[25] Taylor's team supported joint MI6/CIA activities involving tunnelling and tapping into Soviet communications projects, first in Vienna in 1949 and later Operation Gold in the Russian section of Berlin in 1955.[26] It is likely that this work was a continuation of Dollis Hill's role in interception during the Second World War. Not only did Dollis Hill engineers design and construct the phone taps, they were also sent to the sites to install them into the cables, intercepting central communications of the Soviet Military Command. The cost of this and other phone tapping work for MI5 was paid for by the Post Office.[27]

Despite this important role in gathering intelligence for the government's military strategy, the Post Office did not benefit from military patronage in the same way as other parts of the warfare state. Instead the Treasury used the Post Office to meet the government's immediate aims, restricting the Post Office's ability to improve the public service. The impact of this is explored in the next section. While there was some openness in how Post Office funding was supporting defence projects, this was not the case at Dollis Hill. In reflection of the sensitive nature of the projects undertaken at the Research Station this work was paid for through less transparent means.

[24] Peter Wright, *Spycatcher* (New York: Viking Penguin Inc., 1987), p. 18; 'Staff Changes: Promotions, F. J. D. Taylor', *POEEJ*, 44.1 (April 1951), p. 46.

[25] Wright, p. 46.

[26] David Stafford, *Spies Beneath Berlin* (London: John Murray, 2003).

[27] Richard Aldrich, 'Counting the Cost of Intelligence: The Treasury, National Service and GCHQ', *The English Historical Review*, 128:532 (2013a), 596-627 (p. 604).

4.3 Securing funding through research

It is only possible to understand the activities of the Research Station by considering its wider context; the influence of the Treasury, the priorities of the telecommunications industry and the expectations of the Post Office as a government department. While there was little appetite from the Treasury to fund much needed improvements to domestic infrastructure, involving banal tried and tested technologies, it was much more supportive of new developments, which offered Britain prestige and possible exports. The Post Office used the promise of new technologies for several aims; to present itself as forward looking, in defence of criticism (most commonly about the slow installation of telephones for the public), and to protect development work from cuts in capital.

The Post Office was ill-equipped to meet the rising public demand for telephone installations. As I have described this was due to ongoing and new Cold War commitments and cuts in capital expenditure following successive economic crises. By the early 1950s the Post Office was still working on restoring civilian networks which had been destroyed or damaged during the Second Word War. Restrictions on labour and capital directly affected the consumer as the Post Office was unable to clear the waiting list which stood at 582,000 applications in March 1951.[28] The Post Office received little sympathy from their paymasters. The Treasury continued to consider the telephone a non-essential luxury and a low priority compared with other demands on capital.[29] This was despite arguments that telephones would help make businesses and industry more efficient.[30]

A factor bound to influence the Treasury's reluctance to increase capital for public lines was that the telephone service had become uneconomical. Little had changed in rental and tariff charges since the 1930s when they were reduced to encourage people to get their own telephone. This model subsidised the subscriber's installation and rental fee, with costs recouped through call charges. Paradoxically, despite there being

[28] BTA: TCB 10/24 Post Office Commercial Accounts, 1950-51, p. 9

[29] PMA: POST 69/56 POB 1954, Minutes of Meeting, 3 June 1954.

[30] Ibid; 'Telephone Service' 1954, Hansard, Vol. 527, cc. 1572-1633.

a high demand for the telephone, the service itself was under-used, with the number of annual calls decreasing over the 1950s.[31] As such, the Post Office was installing residential connections at a loss, which then generated little revenue.[32] The spiral of low revenue, low investment from the Treasury, but high expenditure on military research prevented the Post Office from capitalising on demand for telephone connections.

Parliament's approval of the *Post Office Development and Finance* White Paper in November 1955 marked a turning point in the Post Office's campaign to improve its domestic telephone service.[33] With a backlog of 380,000 telephone applications, over 40,000 of which had been waiting for over three years, the public were becoming impatient and the government acknowledged it was time for a change in policy.[34] The report reintroduced the Bridgeman system of finance whereby the Post Office could keep any surplus above a fixed annual amount which had to be paid to Treasury, set at £5 million for the next five years. This change was welcomed across the Post Office as Postmaster-Generals, Earl de le Warr and Charles Hill, the officials of the Post Office and the trade unions campaigned for a return to the pre-war financial arrangement.[35]

The White Paper indicated a government commitment to support a large-scale investment programme, with the Treasury pledging £175 million to eliminate the telephone order list and to further the mechanisation of the telephone service. This included the development of Subscriber Trunk Dialling (STD), a means by which people could make direct calls over the trunk network between automatic exchanges without the need for an operator to make the connection or calculate the charge. The commitment for new developments sat within a wider capital programme of £300 million to be spent between 1956 and 1959, of which 95% was directed to support the telephone service. In return the Post Office agreed to raise additional revenue by increasing telephone charges, a fundamentally flawed logic, given the business model.

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[31] Chris Harlow, *Innovation and productivity under nationalisation*, p. 118.

[32] Jill Hills, I*nformation Technology and Industrial Policy* (London: Croom Helm, 1984), p. 112.

[33] *Post Office Development and Finance*, 1955, Hansard, Vol. 546, cc.48-159.

[34] Report on Post Office Development and Finance, Cmd. 9576 (HMSO, 1955).

[35] Douglas Pitt, *The Telecommunications Function in the British Post Office*, p. 110.

Post Office hopes that increased financial control would lead to widespread improvements were hampered by the Conservative government's stop-go economic policy which cut public expenditure and starved telecommunications of capital.[36] This became critical in 1957 when the Exchequer froze capital spending in the public sector for two years. The Post Office continued to pay its fixed dividend, but the Treasury could and did veto Post Office plans.[37]

Shortage of capital restricted the Post Office's ability to mechanise the national telephone network. This project had started in the interwar period by replacing manual exchange with automatic versions which used electromechanical switches, with the Post Office adopting the Strowger system in 1923. This was successful before the war when the Post Office received discounts on equipment by placing large orders with manufacturers through the Bulk Supply Agreement (BSA). However, post-war constraints on spending meant the Post Office no longer had this advantage. Without being able to make best use of BSAs, equipment prices were kept higher than under a competitive purchasing model.[38] The impact on the domestic network meant that by 1954, 1,500 of the 6,000 exchanges in the country still contained manual equipment.[39] At the same time only 30% of the trunk system was run by automatic methods.[40] In order to meet customer demand the Post Office had to use older equipment and despite steadily upgrading automatic exchanges, between 1951 and 1958 the number of connections to manual exchanges increased.[41]

The government's economic policy in this period was to improve the balance of payments through encouraging exports, rather than sales to the domestic market. As a result, the government created the conditions for the telecommunication manufacturers to grow in power in relation to the Post Office. This was largely due to

[36] Kenneth Lipartito, 'Failure to Communicate', p. 156; Barry Eichengreen, *The European Economy since 1945: Coordinated Capitalism and Beyond* (Princeton; Oxford: Princeton University Press, 2007), p. 123.

[37] Campbell-Smith, p. 409.

[38] James Foreman-Peck, 'Competition and Performance in the UK telecommunications industry', *Telecommunications Policy*, 9.3 (1985) 218-228 (p. 225).

[39] 'Telephone Service', 1954, Hansard, Vol 527, cc1571-633.

[40] Ibid.

[41] BTA TCB 10/25-31 - Post Office Commercial Accounts, 1951-1958.

the encouragement of export markets and exclusion of new entrants to industry. For example, in 1956, 40% of telecommunications equipment constructed in Britain was exported.[42] The effects of this decision were that industry's business models became more export focused and the opening of new markets meant that the Post Office became a less important customer. New firms were discouraged by government through ongoing cartel agreements and the desire to reduce demands on already scarce capital. An adequate domestic market for current goods provided less incentive to industry to undertake development of novel products.[43] In some cases, this made it more challenging for the research staff to turn their ideas and prototypes into mass produced equipment, including items with export potential. In contrast, the Post Office's biggest rivals Bell Labs did not have the same trouble being a subsidiary of the manufacturer AT&T.

The Post Office directed research into designing a new telephone, motivated by the desire to reduce manufacturing costs and improve the user experience. By 1955 the Research Branch had designed a telephone instrument with improved transmission, which meant speech could be communicated over longer wires, reducing the need for intermediate stages facilitated by exchanges or operators and thus saving money on materials.[44] This was achieved by updating nearly all the components in the device including the receiver, induction coil, dial and bell.[45] Once the internal specifications were set by the Research Branch, the Post Office invited firms in their telephone bulk supply agreement to submit designs. These had to satisfy the needs of the Post Office, an industry which prioritised the telephone for the export market, and the Council of Industrial Design (CoID), acting an agent for the state. The CoID had final say on the new telephone design (submitted by Ericsson) and the range of colours; New Ivory, Lacquer Red, Colonial Blue, Topaz Yellow, Two-tone Grey, Two-tone Green and Black.[46]

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[42] Hills, *Information Technology and Industrial Policy*, p. 125.

[43] Eli Noam, *Telecommunications in Europe* (Oxford: Oxford University Press, 1992), p. 124.

[44] PMA: POST 69/60 POB 1956, POB(56)8 'Engineering Developments', Lionel Harris 4 January 1956.

[45] F. C. Carter, 'The New Telephone', *POTJ*, 11.2, (Spring 1959), 57-61 (p. 59); BTA: TCB 422/13479 D. L. Richards et al 'The Subscriber's Set Tester, Mark 2', 1951-1954.

[46] BTA: POST 122/582, Telephone: introduction of new 700 type. Part 1, F. C. Carter, Post Office to Council of Industrial Design to Post Office, 13 December 1957.

The name Colonial Blue was eventually replaced with Concord Blue following a request from Ericsson who, considering their international market, asked that 'the adjective should be innocuous from the political angle'.[47] The final product was christened the 700 series, with the first production model, the No. 706, becoming available in 1959 (Figure 23 below).

Figure 23 700-series telephone in seven colours, 1959.[48]

Despite extolling the virtues of the new telephone as a cost saving device and promising an improved service for the subscriber, to begin with the Post Office ordered the minimum possible number of devices from manufacturers. This was because it still had 1.25 million instruments in store of earlier models, the result of overstocking from BSAs and the slow rate of installations due to resource pressures on the department.[49] The press attention around the 700-series telephone projected the Post Office as a modern organisation, however, in reality the department was just as keen to install older versions so as not to waste equipment which had already been

[47] BTA: POST 122/583, Telephone: introduction of new 700 type. Part 2, J. Reading, Ericsson to F. C. Carter, Post Office, 23 December 1958.

[48] H. J. C. Spencer, 'The New 700-type table telephone', *POEEJ*, 52.1 (April 1959), 1-12, p. 2.

[49] BTA: POST 122/582 New Telephone Instruments, Meeting Minutes, 18 April 1958.

paid for. One strategy was to reduce the charge for the older coloured models from £3 to £2 and charge £5 for the new 706 telephone.[50]

Complaints that the Post Office was failing to provide an efficient public service were never directed at the Research Station, which only received praise from both Labour and Government politicians. The Research Branch had little interference from outside organisations about which civil technologies they chose to work on. These decisions were made by the Post Office Board comprising the executive from each function of the organisation, from telegrams to the savings bank. During the 1950s the Board was dominated by men who had spent some, if not most of their careers working at Dollis Hill and continued to support and shape its research agenda.[51] This influence was clearly seen in discussions about postal R&D, where despite the request from the Postmaster General to increase the effort in this area, authority for the research programme sat with the Engineer-in-Chief, resulting in only three out of thirty-seven projects being directed to postal research in 1956.[52] Despite economic trouble the Treasury protected some long-term investments, including research.[53] As a result the Post Office increased its investment in R&D and between 1950 and 1955 funding grew by 58% (see Figure 24 below).[54] This was a faster rate of change than the DSIR, where spending on R&D increased by 20% over the same period.[55]

[50] Ibid., Memo for Parliamentary Question, May 1958.

[51] Gordon Radley was Engineer-in-Chief between 1951 and 1954 when he was promoted to Deputy Director General. The following year Radley was appointed Director General, the first engineer in the role. He was supported by A. H. Mumford as Assistant Engineer-in-Chief (1951-54), then Deputy Engineer-in-Chief (1954-1960) who had worked through the ranks at the Radio Research Branch at Dollis Hill. L. Harris became Engineer-in-Chief in 1954 after being the Controller of Research at Dollis Hill since 1949.

[52] PMA: POST 69/60 'Engineering Developments', Lionel Harris 4 January 1956.

[53] Lipartito, p. 157.

[54] BTA: TCB 135/10 Engineer-in-Chief's Annual Report, 1950-51; BTA: TCB 135/15 Engineer-in-Chief's Annual Report, 1955-56.

[55] David Edgerton, 'Liberal Militarism and the British State', *New Left Review*, 185 (1991), 138-169.

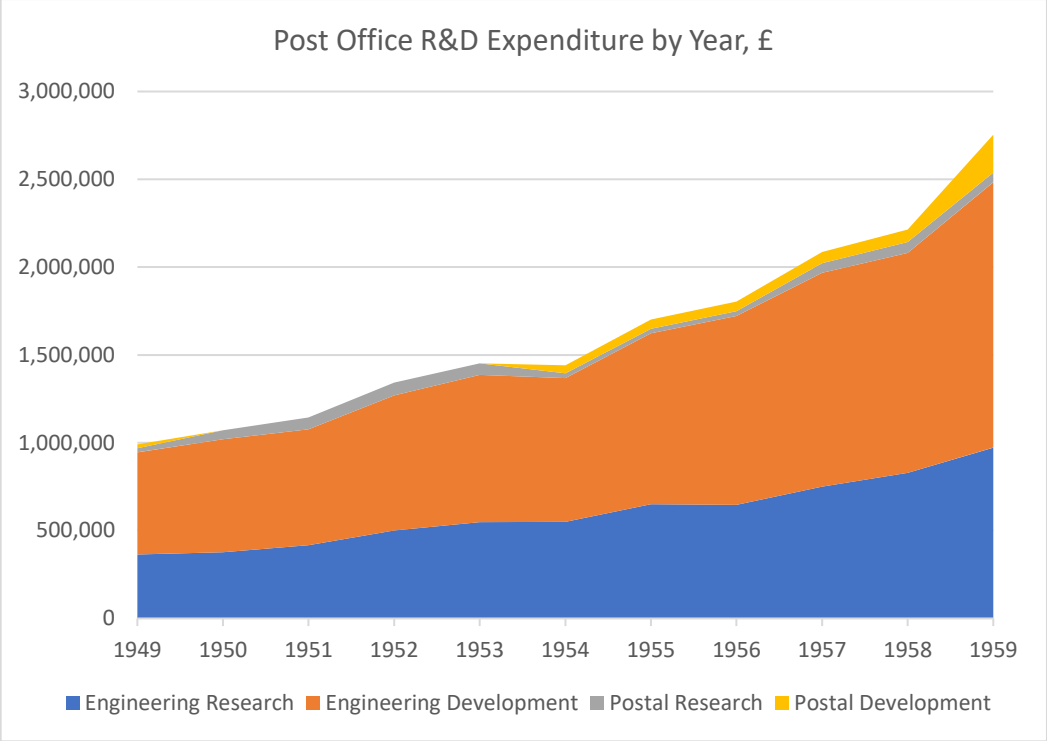

Figure 24 Post Office R&D Expenditure, 1949-1959.[56]

The Post Office's monopoly over the implementation of the nation's communications service meant the Research Branch was unchallenged in its choice of investigations. This autonomy was one factor in the failure of the Post Office's first electronic exchange project. As we saw in Chapter 3, Tommy Flowers decided to pursue the design for an exchange which was fully electronic, rather than investigate electromechanical systems being explored in other countries. These alternatives, including crossbar and reed-relay, relied on switches operated using electromagnetics, rather than electronic valves. Flowers discounted these systems, citing high maintenance costs and numbers of moving parts.[57] Instead, the Research Branch pursued a design which incorporated two electronic techniques: pulse-amplitude modulation (PAM), which encoded telephone signals as pulses, and time-division multiplexing (TDM) which meant multiple signals could be transmitted over one circuit. Together, they promised to increase capacity and speed of connections.

[56] BTA: TCB 135 Engineer-in-Chief's Annual Reports, 1949-1959

[57] T. H. Flowers, 'Introduction to Electronic Automatic Telephone Exchanges: Speech Path Switches and Lines Signalling', *POEEJ*, 43.2 (July 1950), 61-68 (p. 62).

It is likely that personal pride and the desire for prestige also had a role to play in Flowers' choice of design. Flowers argued that, due to the secrecy around codebreaking, he was less able to apply his knowledge of electronics to Post Office telecommunications research than his peers from Bletchley Park such as Alan Turing and Max Newman who directed their wartime experience into the new, nationally celebrated field of computers. Later in his life, Flowers suggested that, if Colossus had been made public, he would have been able to convince manufacturers to take notice of electronic exchanges, describing this moment as being 'one-eyed in the kingdom of the blind'.[58] However, the aims of government and industry had a greater influence on the development of electronic exchanges than Flowers' inability to share information.

The government's encouragement of telecommunication goods for export made it difficult for the Post Office to convince industry to support the development of an electronic exchange. With little opportunity for the Post Office to update the telephone system there continued to be a local market for manufacturers to produce exchanges and replacement parts for manual and automatic designs. Alongside a lack of national need, there was little motivation from industry to start developing new, electronic exchanges as there was an export market for Strowger equipment. There were also concerns amongst the firms who were looking at the application of electronic components in their own R&D facilities that Dollis Hill staff were being too ambitious with their design, proposing a completely new exchange rather than applying electronics to existing exchange functions.[59] In this landscape firms were reluctant to enter an agreement with the Post Office to develop electronic exchanges, a new field with financial risk. This challenged the Research Branch's way of working, which relied on industry to develop and manufacture new equipment. By 1951 a small prototype exchange known as PAM-TDM had been built at Dollis Hill. Recognising the limitations of their laboratory work, the Engineering Department proposed a basis of joint research with industry to construct equipment designed to fit with the existing telephone system.

[58] Thomas Flowers, 'D-Day at Bletchley Park', in *Colossus* ed. by Copeland, pp. 95-100 (p. 100).

[59] Harlow, p. 113.

An electronic telephone exchange was one such development which fitted with the government's enthusiasm for new technologies and was presented by the Post Office as such.[60] In recognition of the export potential this proposal received support from the Board of Trade, Treasury, Ministry of Supply and NRDC. This was met with trepidation by the contractors, who were concerned over patent exploitation and cooperating with competitors in the export field.[61] It took four years before an agreement was reached, according to Radley, after he threatened to select only one of the firms.[62] This would have been undesirable both for the Post Office, as it reduced the pool of expertise and was likely to delay progress, and for the firms who would be blocked from accessing new research.[63] The Joint Electronic Research Agreement (JERA) was finally signed on the 15 May 1956 between the Post Office and the five switching equipment manufacturers: Siemens Edison Swan, Automatic Telephone and Electric Co., Ericsson Telephones, The General Electric Co. and Standard Telephone and Cables. Together they established the Joint Electronic Research Committee (JERC) to coordinate research, share knowledge and avoid unnecessary duplication of research.[64]

Although JERC was meant to be a forum in which different switching methods could be discussed, the Post Office directed its developments. Manufacturers were told their first objective was to build an all-electronic exchange based on PAM-TDM designed at Dollis Hill, to be installed at Highgate Exchange in 1958.[65] Work had continued in the Research Branch and by 1955 there was a prototype operating fifty telephone extensions in the Research Station and around sixty patents had been filed.[66] The technical task of constructing an experimental exchange with 600 lines for use in the

[60] 'Post Office and Telegraph (Money) Bill', 1953, Hansard, Vol. 520, cc. 1164-1245.

[61] BTA: TCB 2/113, Highgate Wood Electronic Exchange, Letter from Gordon Radley to Postmaster General, 12 April 1957.

[62] Ibid.

[63] Ibid.

[64] S. W. Broadhurst, 'The Highgate Wood Electronic Telephone Exchange', *POEEJ*, 55.4 (January, 1963), 265-273 (p. 265).

[65] BTA: TCB 2/113 Letter from Gordon Radley to Postmaster General, 12 April 1957.

[66] BTA: TCB 422/20942, T. H. Flowers, 'Electronic Exchanges – Contribution under the Joint Electronic Research Committee to the Philosophy of Exchange Design', Appendix 3: Post Office Patent Applications Relating to Electronic Telephone Exchange, pp. 20-21.

field proved more challenging than expected, reflected in the delay in the programme and installation date. Another issue was financial. By September 1957, the design was known to be uneconomical in comparison with the electromechanical Strowger exchange, following updated calculations on the exchange's power requirements and the cost of electricity.[67]

Suggestions that the project should be postponed by some senior Post Office staff were defended by Controller of Research, Lionel Harris, citing national prestige and risk of international competition.[68] The exchange was eventually opened in 1962, heralded by the Post Office and manufacturers as a British triumph. But no sooner had it launched, than technical issues meant the exchange stopped handling live traffic after a couple of months, and was used instead as an experimental site, to test artificial traffic.[69] Problems included high power consumption, costs of components (for which 3000 valves, 150,000 diodes and 26,000 transistors were required) and incompatibility with the existing network.[70] While Radley had justified the construction of an all-electronic exchange as being a means to improve Britain's export position by keeping a stage ahead of competitors, the project proved overambitious.[71] The decision to focus on one method of electronic switching had the opposite effect, with other British firms falling behind international developments. With no contingency plan, the Post Office ended up purchasing crossbar exchanges while they continued their research into other electronic exchanges. Not having been designed with the Post Office in mind crossbar exchanges were not ideally suited for the British system.[72] In focusing on one ambitious project the Post Office had limited its options and forced purchase of generic equipment, missing features the department found desirable.

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[67] BTA: TCB 2/113 Minutes of the Meeting of the Joint Electronic Research Committee, 2 September 1957.

[68] Ibid.

[69] Lionel Harris, 'Electronic telephone exchanges: An introduction review of developments', *POEEJ*, 59.3 (October 1966), 211-219 (p. 214).

[70] S. W. Broadhurst, 'The Highgate Wood Electronic Telephone Exchange', 55.4 (January 1963) 265-274 (p. 273); Anton Huurdeman*, The Worldwide History of Telecommunications*, p. 490; John Bray, *The Communications Miracle*, p. 220.

[71] BTA: TCB 2/113 Gordon Radley to Postmaster General, 12 April 1957.

[72] Harlow, p. 99.

While many domestic projects were curtailed by restrictions on public spending, including much needed renewals and replacements, new developments were better protected from Treasury cuts. Financial and technical factors ensured the survival of the Post Office's Standard Trunk Dialling (STD) project. Research work at Dollis Hill had proved it was technologically possible, the trunk network had developed enough that the service was economical to introduce; and most importantly the project had the Treasury's support, highlighted in the publication of two further White Papers in 1957 and 1958 which demonstrated the Post Office and government's commitment to introduce STD to forty-six towns by the end of 1960.[73]

The key development for STD was the construction of a controlling register-translator, an electronic machine which replicated the actions of a human operator, receiving and storing the dialled number, determining the charging rate and routing the call. The device was given the name GRACE, short for Group Routing and Charging Equipment. As I show later in this chapter, humanising technologies was a Post Office strategy to build public trust in equipment which relied less on human involvement. GRACE was developed at Dollis Hill, initially as part of the electronic exchange programme, but it was soon realised it could support subscriber to subscriber dialling.[74] This was overseen by Sidney Broadhurst, one of the team who designed Colossus, who demonstrated that valves were a suitable replacement for relays used in manual register-translators.[75] This made the STD scheme economically attractive, as relays were subject to heavy mechanical wear and high maintenance costs.

Unlike the electronic exchange project which included twelve different teams working on similar problems, STD benefitted from clear division of labour between each firm. Automatic Telephone and Electric Company designed magnetic drum equipment for storage, General Electric produced both an electro-mechanical and fully electronic register-translator and Ericsson Telephones developed equipment which enabled

[73] Full Automation of the Telephone System, Cmnd. 303 (HMSO, 1957); Telephone Policy The Next Steps, Cmnd. 436, (HMSO, 1958), p. 13.

[74] Lionel Harris, 'Electronic telephone exchanges: An introduction review of developments', *POEEJ*, 59.3 (October 1966), 211-219 (p. 212).

[75] BTA: TCB 422/13050, S. W. Broadhurst, 'The application of electronic switching techniques to the circuits of register-translators', 1947-1948.

automatic exchanges to receive and process signals sent from the register-translator.[76] While STD relied on several other changes to the telephone system including the introduction of a national number scheme for trunk calls and the design of new coin-boxes for public kiosks, part of its success, where the electronic exchange project had failed, was that the equipment was easily introduced into the network. STD was made available in Bristol in December 1958, and by May the following year local residents could make direct calls to around half the telephones in Britain.[77]

During this period, the aims of the government and industry greatly influenced the development of new technologies and systems under investigation in the Research Branch. The financial protection of work at the Research Station and new prestige projects, such as STD, went some way in meeting the Post Office's long-term goal for full automation of the telephone network. In particular, the 1955 and 1957 White Papers signify a change in Treasury thinking regarding funding the network. One factor which is important to consider in understanding why there was a particular turning point in Treasury thinking over funding of the telephone system infrastructure at this time lies in the examples of STD and TAT-1. These projects may be thought of as subsystems of the overall telephone network which exemplify the workings of the larger network. Up until this point the Research Station's outputs could be classified as either new services or upgrades to existing infrastructure. New services could be judged on their own merit through metrics of subscriber uptake. However, upgrades to existing infrastructure were harder to measure if we consider the problems being fixed as 'salients'.[78] Therefore, any one of these outputs from the Research Branch could not convey the benefits of an updated telephone network. However, with TAT-1 and STD being good examples of the overall infrastructure housed within separate and distinct subsystems, they offered the Treasury an opportunity to see how investment in the telephone infrastructure could lead to improvements in the long term profitability of the telephone network.

[76] Harlow, p. 121.

[77] Subscriber Trunk Dialling, Bristol', 1959, Hansard, Vol 605, cc1223-4, c. 1223.

[78] Thomas Hughes, *Networks of Power*, p. 79

The introduction of new, discrete services did not help the Post Office manage the immediate pressures of a saturated service as no significant in-flows of capital were immediately forthcoming. The slow roll-out of automatic exchanges meant that by 1958 only four-fifths of the network had been automated.[79] Around 1.5 million subscribers remained connected to manual exchanges which were over thirty years old and susceptible to failure. The number of outstanding telephone applications fell between 1956 and 1958 by around half to 171,000.[80] This trend was not due to an increase in new installations, which dropped during this period, but can be accounted for by higher telephone charges dissuading new applications during a period of stop-go uncertainty. Pressure to expand the telephone service continued to plague the Post Office into the 1960s and would become the justification for further reform by government.

4.4 Diplomacy and decision-making in laying the transatlantic telephone cable

The Post Office benefitted from the government's support of projects which strengthened political alliances and encouraged trade. With Britain's Empire in decline, relations with the United States became increasingly important. Communication infrastructure became a key diplomatic tool to provide the reliable and secure lines needed to maintain these ties. Not only were these systems income generating, they were also an extension of a country's diplomatic and military power.[81] As a result, international communication networks were prioritised over other areas of post-war reconstruction. In this climate the Post Office successfully convinced the government to support the installation of the first transatlantic telephone cable (known as TAT-1) in collaboration with AT&T, the Canadian Overseas Telecommunications Corporation (COTO) and the Telegraph Company of Canada. The project was an opportunity for the Post Office to gain international technological prestige, increase its income from

[79] *Telephone Policy the Next Steps*, Cmnd. 436, (HMSO, 1958), p. 6.

[80] BTA: TCB 10/28-31, Post Office Commercial Accounts, 1955-1958.

[81] Daniel Headrick and Pascal Griset, 'Submarine telegraph cables: business and politics, 1838-1939', *Business History Review*, 75.3 (2001) 543-578.

international calls and support British exports, all of which were important in safeguarding the Post Office's operational security and government support. While research at Dollis Hill was instrumental in the approval of the scheme, this section shows that the final design of the system was shaped by international politics, rather than the Post Office's desire for the most advanced technological system.

In the early 1950s research activities at Dollis Hill proved that a transatlantic telephone was technically and financially viable. Advances in the design of long-life repeater valves and electric components by the Research Branch and in collaboration with industry extended the life expectancy of submerged repeaters to a stage where their construction and installation became economically viable.[82] In February 1951, the Research Branch undertook its first trial of deep-water repeaters installed in a coaxial cable laid in the Bay of Biscay. This experiment successfully showed that the repeaters could be installed to depths of 1,700 fathoms and could be recovered if required for maintenance or replacement.[83] Research also demonstrated the potential cost savings of applying new equipment to submarine infrastructure. Post Office engineers, led by Dr Richard Brockbank from the Research Branch, developed a new type of deep-sea telephone cable, known as the 'lightweight submarine cable' as its weight in water was one fifth of comparable cable.[84] The centre core was made of stranded high tensile steel wire and provided the necessary strength without heavy and expensive armouring wires. Its outer sheath was made of polythene to protect the cable at depths greater than 500 fathoms. This design meant it was cheaper to make and less bulky. It cost £905 per nautical mile as compared with £1,790 for the Post Office's previous design, a 0.81-inch double armoured cable.[85] With a distance of at least 1950 nautical miles across the Atlantic this development promised large savings.

[82] BTA: TCB 422/13684 'Submerged Repeater Development in Great Britain', November 1952, p. 12.

[83] BTA: TCB 422/13461 V. G. Welsby and G. Haley 'Laying Trials of Deep-Water Repeaters in the Bay of Biscay', February 1951, p. 18.

[84] R. A. Brockbank, 'Overseas Telephone Cables Since the War', *The New Scientist*, 4.105 (November 1958), 1320-1323 (p. 1322).

[85] BTA: TCB 2/270 'Lightweight cable and repeaters: development and laying trials, Transatlantic Telephone Cable – Trials of Deep Sea Cable', W. G. Radley, 4 June 1952.

Limitations of the radio-telephone service between the United States and Britain, particularly regarding privacy, meant the need for alternative communication routes became a pressing issue at a time of Cold War tension. The radio-telephone service, which had been introduced in 1927 by AT&T and the Post Office, provided twelve circuits between the two countries which allowed twelve simultaneous calls at any time. As the service increased in popularity the Post Office predicted that by 1960 all the available frequency bands used for the radio-telephone service would reach capacity. The quality of the radio service varied as it was susceptible to fade-outs when weather conditions were bad. It was estimated that around a fifth of booked calls fell foul to this issue and were not connected. As radio circuits were liable to interruption, they were inherently non-secret and did not lend themselves for defence purposes. Cables promised a more secure service than radio, reducing the risk of interception or jamming and did not rely on large visible infrastructure, such as transmitters and receivers, being installed in different countries where they could be sabotaged. With no improvements to radio techniques expected, cables became the most attractive option to expand and improve the service.

The transatlantic project was received favourably across government departments as it was seen to serve a variety of interests, political, defence and economic. While not designed as an explicit or covert military project, advances in communication infrastructure were of great interest to national defence. Although described by the Post Office as a civilian technology, senior staff initially sought support for the project from the military rather than other government departments. This priority was reflected by the Chiefs of Staff being the first government body to see the Post Office plans.[86] The Ministry of Defence saw the cable as being 'a most valuable asset in war, and no doubt of some military advantage from time to time in the present troubled peace'.[87] The Commonwealth Office saw the cable as a means to create closer ties between Britain and Canada, with the hope facilities would be extended to Australia. The Ministry of Supply, who managed the stocks, valued having the cable made in

[86] TNA: DEFE 5/30/205, Strategic submarine cable network, 10 April 1951, p. 1

[87] BTA: TCB 176/12/1 R. R. Powell to Sir Ben L Barnett, 22 August 1952.

Britain, noting that 'the prestige gained by the engineering industry would be considerable'.[88]

Although the Post Office demonstrated that a British designed system would be possible, there were several reasons why a collaborative project with AT&T was considered mutually beneficial for both parties. Not only would the costs of the project be shared but, by ensuring that the cable was manufactured in Britain and Post Office cable ships were used for the installation, dollar expenditure could be kept to a minimum (important in helping service the American debt). Access to these facilities and years of experience made Britain an attractive partner for AT&T. There was a close connection between the associated R&D establishments, as a professional relationship already existed between Bell Labs and Dollis Hill and there had been an exchange of information through research reports and official visits since the 1920s. The cable was framed as an opportunity for Britain and the United States to strengthen business and social ties, an argument evoked by Cleo Craig, President of AT&T in his approach to Earl de la Warr about the possibility of a joint project in June 1952.[89]

With pressure from AT&T to install the system as quickly as possible, proven reliability became the deciding factor in debates between engineers about which scheme was most suitable technologically. Informal negotiations between Dollis Hill and Bell Laboratories, AT&T's research department, began in 1952. While both teams agreed on the route, from Oban to Newfoundland and across Canada, each had its own idea about how best to design the main transatlantic cable. The proposed American system relied on two cables, one transmitting speech in one direction and the other in the reverse direction with the signal boosted by flexible repeaters. It was based on twenty years of development, and its main design had been fixed in 1940. The Bell system had been rigorously tested, with all its elements subject to a long field trial. A system installed between Havana and Key West in 1951 was working efficiently.[90] Bell Labs claimed that they could have equipment ready to be installed by 1956. In contrast the

[88] Ibid., Sir Leslie Hutchinson to Sir Ben L Barnett, 23 September 1952.

[89] BTA: TCB 176/10/1 Mr Craig, President AT&T, to Earl de la Warr, 20 June 1952.

[90] Huurdeman, p. 335.

Post Office system, incorporating modern valves and components, used a single lightweight submarine cable for transmission both ways, utilising their new rigid repeater. This halved the quantity of cable thus saving costs and promised greater security. The issue was the lack of experimental evidence that the system would work in deep waters. The Post Office estimated that they would be ready to install their system between 1958 and 1960. In the opinion of AT&T, this was too late.

While the Post Office could have argued to delay the project, the final design of the transatlantic cable was also shaped by American, British and Canadian relations and Cold War geopolitics. This was recognised at the time, with one Post Office engineer suggesting that 'political rather than technical consideration might well be the deciding factor on which system was agreed'.[91] There were serious concerns in Cabinet that if the Post Office did not agree, AT&T would seek collaboration with another country. This scenario was highly undesirable as once radio circuits were saturated, Britain would have to rely on foreign owned cables for international communications which would lead to heavy dollar expenditure. So concerned were the Treasury about dollar out-payments that in January 1953, before formal negotiations had begun, the Chancellor of the Exchequer "Rab" Butler told the Earl de la Warr not to encourage Canada's involvement.[92] While it was recognised that as a third partner Canada would decrease capital costs, there were concerns their dollar receipts would also drop. However, it was recognised in Cabinet that it would be unpolitical to exclude Canada if they wished to join, which they did.[93] One motivation from Canadian officials was to ensure AT&T did not use the scheme to infiltrate their domestic communications.[94]

Having a share in the infrastructure was more important than having the most modern system and the Post Office decided to pursue negotiations on the basis that the American design would cover the main Atlantic crossing (Figure 25 below).[95] As

[91] BTA: TCB 371/43 Minutes of the 175th Meeting, 7 November 1952.

[92] TNA: CAB 195/11/13 C.C.5(53) Minutes of the Cabinet Meeting, 27 January 1953, p. 53.

[93] TNA: CAB 128/26/5 Transatlantic Telephone Cable, January 1953.

[94] Ibid.; BTA: TCB 176/10/3 First Draft Agreement handed to Post Office by AT&T Co.

[95] TNA: CAB 129/58/27 C(53)27 Project for a Transatlantic Telephone Cable, Memorandums by the Postmaster General, 23 January 1953.

Radley's letter to AT&T reveals, the apparent sacrifice of Post Office technology became a bartering tool to achieve other national aims:

> rushing us [the Post Office] into a project for completion in 1957 although we could manage with radio until about 1960. In doing so you ask us to abandon our superior system in favour of your inferior one involving considerable extra expenses: you are asking a great deal, but, for the sake of old associations we are prepared to play, but on terms: these terms are that we take it for granted that our system will be used between Newfoundland and Halifax, Nova Scotia, and that the second cable will also be laid between the USA and UK.[96]

The final agreement signed between the Post Office, AT&T, the Canadian Overseas Telecommunications Corporation (COTO) and the Telegraph Company of Canada in November 1953 met the first of Radley's demands but not the second. The Post Office also guaranteed that most of the cable manufacture would take place in Britain. The project cost £12.5 million with an equal split between the USA and the Commonwealth with AT&T owning 50%, the Post Office having 41% and COTO having 9%. These percentages also reflected the division of income from calls placed through the cable. Three years later, on the 25 September 1956, TAT-1 was inaugurated. Overnight the number of available telephone channels across the Atlantic increased from twelve provided by radio-telephony to thirty-five, six between London and Montreal and twenty-nine between London and New York.[97]

[96] BTA TCB 176/10/1 Memorandum, 1 January 1953.

[97] Bray, *The Communications Miracle*, p. 148.

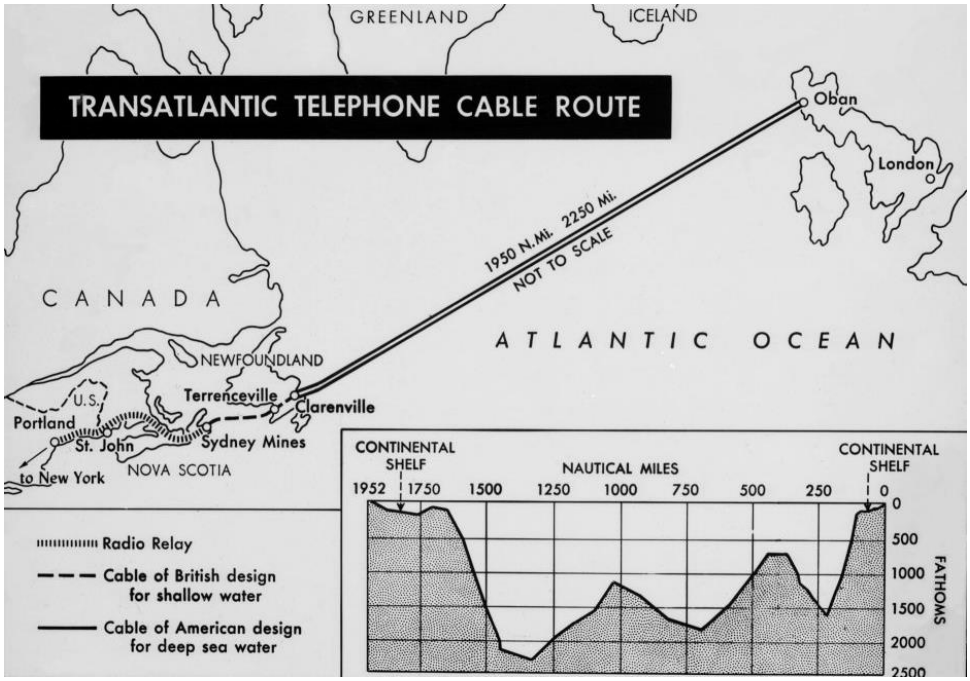

Figure 25 Transatlantic Telephone Cable (TAT-1) route map, 1956.[98]

Dollis Hill was adapted to meet the needs of the transatlantic project. Steps had been made in the immediate post-war period to increase resources for research into long-life valves. In 1953, a new Submarine Cable Systems division was established in the Research Branch under the guidance of Reginald Halsey.[99] In recognition of its importance to the Post Office Halsey was promoted to a new role, Assistant Engineer-in-Chief, to oversee the whole project. A couple of months later this group moved into a new building on the north side of the Station and, from 1954, benefitted from the new workshop with space to study the design of thermionic valves and associated life-testing equipment.[100]

The Research Station also trained Post Office engineers for the project and released staff to supervise work across Newfoundland. The cable jointers received special training at Dollis Hill to use equipment designed to facilitate the jointing of the cable at sea on *Monarch* (the Post Office cable laying ship) and across land. These included

[98] Bill Burns, 'TAT-1 Fault Repair', Atlantic Cable <https://atlantic-cable.com/Cables/1956TAT-1/repair.htm> [accessed 24 October 2019].

[99] 'Staff Change: Promotion, R. J. Halsey', *POEEJ*, 47.1 (April 1954), p. 50.

[100] O. W. G., 'New Workshop Building at the Research Station', *POEEJ*, 47.1, (July 1954), 113-114 (p. 114); BTA: TCB 135/13 Engineer-in-Chief's Annual Report, 1953-54, p. 92.

portable x-ray cameras, electric brazing machines and polythene injection moulding machines which were designed and constructed by the Research Branch.[101] Despite arguing that proved reliability must lead design decisions, Bell Labs still made modification to the system which were shaped by discussions with Dollis Hill staff. This including replacing Bakelite moulding with ceramics and exchanging the Paragutta dielectric used in the coaxial cable with polythene, manufactured by ICI.[102]

The transatlantic telephone cable provided a welcomed boost to British cable manufacturers and justified the expansion of facilities in the firms involved. Submarine Cables Ltd., jointly owned by Siemens Brothers and Co. and The Telegraph Construction and Maintenance Co. (TC&M), was contracted by the Post Office to construct 92% of the cable. Work took place in a new, purpose-built cable factory called Ocean Works, at Erith, Kent. In reflection of potential gains of the project the company spent £1,000,000 on the site, machinery and erection of new buildings.[103] In order to control quality and due to the precise nature of the work, TC&M established another new factory in Greenwich to draw and roll the central conductor. AT&T oversaw the construction of 102 flexible repeaters, which were flown to Britain to be built into the cable.[104] The final 8% of the cable was made by the American company Simplex Wire & Cable. Standard Telephone and Cables (ST&C) constructed the twenty-one rigid repeaters, including five spares for the Newfoundland-Nova Scotia link, to Post Office specifications.

Apart from the repeater valves and some resistors made and assembled at Dollis Hill, all the components were manufactured in a new type of laboratory at ST&C designed to meet the conditions of cleanliness required. This task impacted the working culture at ST&C as, unlike other workshops, operators had to change into clean protective

[101] BTA: TCB 176/33/2A General Publicity, 'Transatlantic Telephone Cable, Newfoundland Section Leaves Today, why x-ray photographs will be used' Press and Broadcast notice, 5 April 1955.

[102] Mervin J Kelly, Sir Gordon Radley, G. W. Gilman and R. J. Halsey, 'A Transatlantic telephone cable', *Transactions of the American Institute of Electrical Engineers, Part I: Communication and Electronics*, 74.1 (March 1955) 124-139.

[103] F. Mattingley, 'Manufacture of Submarine Cable at Ocean Works, Erith', *POEEJ*, 49.4 (January 1957) 308-315 (p. 315).

[104] Ibid.

clothing and maintain the highest levels of hygiene.[105] This environment, reminiscent of a milking parlour with rows of technicians wearing white overalls in a clinical setting, was given the nickname 'The Dairy'. Following the success of TAT-1, ST&C was awarded a contract to build repeaters for a transatlantic cable managed by the French Government and AT&T.[106]

TAT-1 established a new field of long-distance communication using submarine cables. The infrastructure proved to be a good financial investment with the traffic between USA and Britain doubling shortly after its launch and remaining at a high level.[107] While the system was mostly American in design, the project demonstrated that the Post Office's two-way repeater could deliver the desired service and encouraged further innovation. The Research Branch continued its research into deep sea repeaters and long-life valves and successfully designed equipment that was included in the subsequent Commonwealth telephone cable projects. The Canada Trans-Atlantic Telephone Cable (CANTAT) opened in December 1961 and the Commonwealth Pacific Cable System (COMPAC) connected Canada with New Zealand and Australia in December 1963. These were constructed yet again by ST&C, who also manufactured the cable.

4.5 Visions of research

Displaying the research activities at Dollis Hill became increasingly important as one of the few methods by which the Post Office could influence opinion during this period, a time when the presentation of science was as important as the science itself in creating a narrative around British prestige. With many of the Post Office's landmark projects taking the form of invisible infrastructure, unlike the visual icons of other prestigious science projects, public displays and the launch of new services which

[105] R. A. Brockbank, D. C. Walker and V. G. Welsby 'Repeater Design for the Newfoundland-Nova Scotia Link', *POEEJ*, 49.4 (January 1957), 389-399 (p. 396).

[106] [Anon.], *The Story of STC 1883-1958*, (London: Connaught House, 1958).

[107] BTA: TCB 10/30, Post Office Commercial Accounts and Report, 1956-57, p. 18; Hugh R. Slotton, 'Satellite Communications, Globalization, and the Cold War', *Technology and Culture*, 43.2 (April 2002) 315-35 (p. 318).

attracted press attention became important platforms for the Post Office to promote its work and shape consumer attitudes.[108] Where possible the Post Office sought to secure the Queen's involvement in these publicity activities, to associate its new technologies with the modern monarch.[109]

Whilst science was a means by which the government could project its power, policies restricted departmental advertising, thus limiting the Post Office's opportunities for such engagement. The Central Office of Information remained the gatekeeper for government publicity, under whose rules the Post Office was barred from advertising its achievements or publicising the work of its staff in print, films, or posters. The mediums that had made the Post Office famous in the interwar period were not regarded as a good use of public money.[110] The use of advertising was allowed for a small number of special purposes which encouraged the public to behave in ways which helped the Post Office do their job. Confined to posters, this medium was described by the PRD as 'reminder advertising' and included the Post 'Early for Christmas' and 'Write Clearly' campaigns. While there was little need to promote the telephone, the PRD saw advertising as an important means in managing public opinion.

4.5.1 Exhibition

In spite of many restrictions, the Post Office was able to promote its work through exhibitions which promoted British goods for export and encouraged scientific careers. The latter reflected ongoing national concerns about the scientific workforce.[111] The Engineering Department contributed objects and provided support at many large and small exhibitions. There was a Post Office stand at several of the Earls Court and Olympia fairs, including the British Industries Fair, Motor Shows, National Radio Shows, Ideal Home Exhibition and Schoolboys Exhibition. Some of these displays were at the request of government departments to explain certain Post Office services, such as a

[108] Agar, *Science and Spectacle*; Bud, 'Penicillin and the new Elizabethans'.

[109] Ibid., p. 329.

[110] PMA: POST 69/60 'Report on Public Relations', T. O'Brian, 15 February 1956, p. 12.

[111] Brian Balmer, Matthew Godwin and Jane Gregory, 'The Royal Society and the "brain drain": natural scientists meet social science', *Notes Rec. R. Soc. Lond*, 63 (2009), 339-353.

display about the '999' emergency number, which was shown in twenty-eight provincial towns in 1951, and one about television detector vans which were used as a deterrent against the use of unlicensed televisions.[112] These publicity acts were reported on in the press and photographed for newspapers, and special interest publications shared Post Office devices with a wider audience.

The Post Office was given the opportunity to demonstrate its contribution to British life at the Festival of Britain which took place between May and September 1951. Designed to be 'a tonic for the nation' the Festival aimed to celebrate Britain's victory in the war and a future without austerity.[113] Progress and modernity was presented through spectacle and entertainment, framing science as the answer to a better tomorrow.[114] Reflecting the Post Office's proactive and creative approach to public relations, the suggestion that the department should be represented at the Festival came from the Engineer-in-Chief. The request was welcomed by the Festival authorities, happy for the Post Office to suggest topics which showed its pioneering work or distinctive contribution to a specific field. While the final decision sat with the Festival organisers, the Public Relations Department was keen to 'do everything to get as many Post Office exhibits into the Exhibition as was economically possible'.[115] Eleven exhibitions were offered, which focused on the Post Office's more recent achievements and contemporary services, including an automatic telephone exchange, scale model of the *Monarch* cable ship and a coastal Radio Station showing distress and commercial working. A submerged repeater was considered a key exhibit, representing a recent application of research to advance submarine communications.[116] The Post Office was careful not to claim technological developments as reflected in the debate around displaying coaxial cable. Although this

[112] BTA: TCB 135/11 Engineer-in-Cheif's Annual Report, 1951-52, p. 86; TCB 135/12 Engineer-in-Cheif's Annual Report, 1952-53, p. 91.

[113] F. M. Leventhal (1995), '"A Tonic for the Nation": The Festival of Britain, 1951', *Albion: A Quarterly Journal Concerned with British Studies*, 27.3 (1995) 445-453 (p. 453).

[114] Sophie Forgan, 'Festivals of science and the two cultures: science, design and display in the Festival of Britain, 1951', *BJHS*, 31.2 (1998) 217-240 (p. 221); Becky Conekin, *The autobiography of a nation; the 1951 exhibition of Britain, representing Britain in the post-war world*, (Manchester: Manchester University Press, 2003), p. 4.

[115] PMA: POST 122/324 Festival of Britain: Post Office contribution, Memoradum.

[116] Ibid. Festival of Britain, Minutes of Meeting, 20 February 1950, p. 2.

had originally been an American development, it was agreed that the one-inch diameter cable development for television transmission was a British achievement.[117]

While the Post Office had avoided pageantry, only recommending one historical display (Post Office uniforms throughout the ages), the Festival authorities were keen to add exhibits which represented the longer histories of the post, telephone and telegraph. This included key moments in the organisation's history, such as Henry VIII's introduction of a Master of the Post, Rowland Hill's reforms and the first adhesive postage stamp, the 1840 Penny Black. Further displays of postal technology were added later, including stamp cancelling machines and conveyors.[118] Although its presentation was as a public service, the Post Office referenced one of its wartime contributions. In the Festival's Radio Section, the department displayed a 1931 report on radio aids to navigation which was considered the first published work on the discovery of radar in Britain. This was shown alongside a seven-foot insulator and large transmitting valves from Rugby Radio Station, the focus of the section, which illustrated the department's contribution to worldwide communications.[119]

Alongside the displays of Post Office equipment and ingenuity in two exhibition spaces, the Hall of Communications and the Dome of Discovery, the department was omnipresent throughout the festival through its provision of all the communication services. The Post Office provided the Southbank Exhibition with the 'WATerloo 1951' telephone number, and letters posted within the exhibition received a special Festival of Britain cancellation mark. It installed 'crowd counting' equipment to monitor visitor numbers and an 'emergency control network' with twenty cabinets erected throughout the grounds.[120] The Festival's futuristic and modern aesthetic was aligned with the image the Post Office wanted to project. Festival architects created a new design for the sixty-seven telephone call offices and kiosks installed on the site and revamped the main public office with a counter with eleven positions offset at 20

[117] Ibid.

[118] Ibid.

[119] Ibid., The Post Office and the Festival of Britain.

[120] C. G. Dann, 'Communications for the Festival', *POTJ*, 3.3 (May 1951), 96-99 (p. 96).

degrees to give the appearance of a saw-tooth edge.[121] Post Office services and exhibitions were also installed on the Festival ship, *Campania*, which was used to take a travelling exhibition by sea to several coastal towns. All these displays associated the Post Office with the wider projection of national modernity to millions of spectators.

4.5.2 Promoting collaboration

The transatlantic telephone cable was an opportunity for the Post Office to demonstrate its technological and diplomatic ability. While it was recognised that adopting the American system would reduce Britain's share of prestige, the Post Office still engaged with the rhetoric of defiant modernism when promoting the project. With restrictions in place, the Postmaster General's appearances in Parliament became an increasingly important means by which the Public Relations Department could communicate publicity messages. Fortunately for the Post Office, the sheer feat of the task and the money involved in the transatlantic telephone cable attracted press interest. In 1953, several newspapers reported on the signing of the agreement between the international partners and quoted Earl de la Warr's speech in the House of Lords celebrating the momentous occasion.

With most of the project being of American design, the Post Office highlighted its contribution by focusing on specific and new technologies developed by the Research Branch even if they played minor roles. This rhetoric was reflected in an article in *The Times* explaining the final design of the system 'because the American repeater, although not as advanced as the British type, has been more adequately tested in deep water'.[122] While stressing the Post Office's unique contribution, prestige was also gained by emphasising the collaborative nature of the project, in effect borrowing Bell Labs' reputation as world leaders in communications. The *Daily Mail* reported the following section of de le Warr's speech: 'this scheme has been talked of for years and has become possible only as a result of long and patient research, both in the famous Bell Telephone Laboratories of America and also here, at Dollis Hill, in London'.[123] The

[121] Ibid., p. 99.

[122] Parliamentary Correspondent. 'Telephone Cable to America', *The Times*, (2 December 1953), p. 8.

[123] Anon., '£12,500,000 deal signed', *Daily Mail*, (2 December 1953), p. 7.

collaboration was promoted by the engineers themselves, with the Post Office and Bell Labs publishing several joint papers in specialist publications on both sides of the Atlantic. Journalists continued to report on TAT-1 as the project developed, from the announcement in April 1954 that work was starting on the cable, to the launch of *Monarch* in July 1955 to lay the first cable across the Atlantic, to diagrams showing the new cable and its route, and to the inauguration in 25 September 1956.[124]

In reflection of the technological feat, the Post Office had hoped that the Queen would open the service with a telephone call to President Eisenhower and the Governor General of Canada. This would, in part, replicate the launch of the transatlantic telegraph cable on the 16 August 1858 in which telegraphs were exchanged between Queen Victoria and USA President James Buchanan. Despite enthusiasm from the Palace this did not go ahead because the timing was close to the American presidential election. The Prime Minister and Foreign Office were concerned that the call could be considered an endorsement which would be impolitic.[125] There was more to be gained by Britain in this exchange than the USA and this was a great blow to the Post Office who were reluctant to 'abandon a ceremony at Head of State level with all that it represents in focusing the world attention on a major British technical achievement and Anglo-American economic co-operation'.[126] Tellingly there is no mention of the opportunity of having the Queen in conversation with the Prime Minister of Canada during the historic moment, reflecting the decreasing importance of Anglo-Commonwealth relations.[127] The Post Office considered delaying the inauguration of the cable to allow the event to go ahead after the election, but this was met unfavourably by AT&T who wanted the cable in use as quickly as possible.

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[124] Anon., 'Ocean Phone', *Daily Mail*, (10 April 1955), p. 1; Anon., 'Laying of Atlantic Telephone Link', *The Times*, (26 July 1955), p. 4; 'Laying the First Transatlantic Telephone Cable', *The Illustrated London News*, (9 July 1955), p. 62-63.

[125] BTA: TCB 2/433 TAT cable opening ceremony, N. F. Cairncross, 10 Downing Street, to J. A. N. Graham, Foreign Office, 31 August 1956.

[126] Ibid., Cuthbert Alport, Assistant Postmaster General to Prime Minister, Antony Eden, 17 August 1956.

[127] Oliver Daddow, *Britain and Europe since 1945: Historiographical perspective on integration* (Manchester: Manchester University Press, 2004); A. May ed. *Britain, the Commonwealth and Europe: The Commonwealth and Britain's applications to join the European Communities* (Basingstoke: Palgrave, 2001); George Wilkes ed. *Britain's Failure to Enter the European Community, 1961-63: The Enlargement Negotiations and Crises in European, Atlantic and Commonwealth Relations* (London: Routledge, 1997).

The inauguration of TAT-1 emphasised the collaborative nature of the project, involving a three-way conversation between representatives from Britain, the USA and Canada at government level and geographically between London, New York and Ottawa. In Britain, the ceremony took place in Lancaster House, part of the Foreign Office, with the Postmaster General Charles Hill leading proceedings. In his speech, which described the route of the cable, Hill illustrated how the Post Office was improving the user experience, explaining to the public that this cable would mean 'regularity, reliability and clarity' and 'gives three times the chances of getting your call through when you want it'.[128] Both the American Ambassador Winthrop Aldrich, and the Canadian High Commissioner, Norman Robertson, gave speeches. The former chose to 'speak to the value of Anglo-American co-operation as exemplified in the cable' and the latter to 'speak of Commonwealth participation in the cable'.[129] The ceremony was filmed by the BBC for television newsreel and broadcast on BBC Radio, specially advertised in the Radio Times, which had a readership of close to 8.8 million.[130]

Although the project had been a joint affair, each party was keen to promote its individual contribution to further its own international trade. National prestige was important to this endeavour, and the Post Office considered a film the best medium for 'identifying the contribution that British engineering and British initiative have made to the project'.[131] The Post Office was happy to meet the request of AT&T to exchange film material to represent both organisations' roles in the construction and laying of the cable, and to prevent a film which 'shows the whole scheme to be almost wholly American with the exception of the use of *Monarch*'.[132] However, there was an increased impetus to make a film which focused solely on Britain's role in the project

[128] 'Inauguration TAT-1, the first transatlantic telephone cable, 1956' (BBC, 1956), HistoryPod, YouTube <https://www.youtube.com/watch?v=KvpdWsjjMyM> [accessed 3 January 2020].

[129] BTA: TCB 2/433 T O'Brian to Postmaster General, 13 September 1956.

[130] Ibid., Charles Hill Postmaster General to Winthrop Aldrich, 19 September 1956; https://www.pressgazette.co.uk/happy-birthday-radio-times-ten-best-covers-last-90-years.

[131] BTA: TCB 176/33/1 letter to the DDG, November 1954, p. 2.

[132] Ibid., S. McMillan to T. A. O'Brien, 20 September 1954.

following the discovery that AT&T were spending $250,000 on their featurette, leading Radley to remark that 'quite clearly… they are going to 'cash in' on this interest'.[133]

While the Post Office was normally banned from promoting their activities, the COI was supportive of a film which encouraged British trade, as long as external funding could be secured. Still not being able to spend its own money on the project, the Post Office went cap in hand to government departments and industry in search of the £10,000 required. The Foreign Office and Commonwealth Relations Office contributed £6,000 to the scheme, supportive of activities which would benefit manufacturing interests abroad. The remaining £4,000 was secured from ICI, ST&C and the British Iron and Steel Federation. While the Post Office successfully obtained the funds required and a script was written by the COI Film Unit, there is no further evidence a British film was made. However, the COI appear to have filmed some British activities which were shared with AT&T for its film 'The Voice Beneath the Sea'. This 25-minute colour film includes a couple of shots of Post Office engineers laying cable and the rigid submarine repeaters across Newfoundland, and the cable being pulled ashore at Oban. However, unsurprisingly, AT&T firmly framed the project as an American achievement. The organisational differences between AT&T and the Post Office are highlighted in the making of the TAT-1 film. AT&T had its own money and could spend it on what it wanted. In contrast the Post Office did not receive state support, despite trying to do everything the government wanted, in this case reducing expenditure, serving military purposes by installing infrastructure with improved security and contributing to national prestige.

4.5.3 A friendly service

The Post Office humanised and, in some cases, anthropomorphised its equipment to build public trust in its new, unfamiliar technologies. This had started in 1936 with TIM, the speaking clock, but became a recognisable marketing strategy during the 1950s to manage national concerns about the impact of mechanisation and automation on jobs

[133] Ibid., letter to D.D.G. November 1954.

and society.[134] As part of this strategy the Post Office consistently and consciously used common names for all their devices and examples include, ESME (Electronic Speaking MachinE), ELSIE (Electronic Letter Sorting Indicating Equipment) and ALF (Automatic Letter Facer).[135] The tea shop and computer company Lyons, used a similar tactic, naming its computers 'LEO' to make them seen approachable.[136]

The Post Office used the popular image of computers to describe their new services. Since the immediate post-war years, computers had been described in the popular press as 'electronic brains'.[137] This meant there was a lexicon in place by the time the Post Office started producing its own information machines using electronic components.[138] This is seen in Post Office descriptions of GRACE, which despite being a register-translator, was referred to as 'a robot telephone operator' and being 'the brain of the new system'.[139] Computers were projected as national symbols of prestige and may explain why some Post Office projects which were not core to the department's activities were promoted.[140] The previous chapter showed how there was dispute among senior members of the Engineering Department around whether the Research Station should be involved in the MOSAIC project. Despite the anomalous nature of the project, the computer was publicised through machinery and large-scale photographs at the Dollis Hill Open Days in 1951 and 1954 and in the press.

Possibly the most famous anthropomorphised machine, built at Dollis Hill, was the vehicle by which the new Premium Bonds scheme was publicised. This enabled the Post Office to promote itself through a new government service. Premium Bonds were announced by the Chancellor of the Exchequer Harold Macmillan in April 1956 as part of his 'savings budget', aimed at getting more people to save money. Bonds could be

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[134] David Edgerton, *Shock of the Old: Technology and Global History since 1900* (London: Profile Books, 2011) p. 103.

[135] Campbell-Smith, p. 400.

[136] Tom Lean, *Electronic Dreams: How 1980s Britain Learned to Love the Computer* (London: Bloomsbury Sigma, 2016), p. 17.

[137] James Sumner, 'Defiance to compliance: visions of the computer in postwar Britain', *History and Technology*, 30.4 (2014) 309-333 (p. 310).

[138] 'The Post Office Research Station, Dollis Hill', *Post Office Magazine*, 14 (1953), p. 195.

[139] *Full Automation of the Telephone System*, p. 7.

[140] Sumner, p. 310.

bought in twenty-three denominations between £1 and £1000 from any Post Office counter, thus continuing the department's role as the interface between the state and its people. Or, as one research engineer described it 'the Government's maid-of-all-work'.[141] Premium Bonds were new and exciting and the Post Office benefitted from being connected to a service which promised the chance of winning a life changing amount of money.[142] The scheme received a lot of public and press attention and the first draw, which took place in June 1957, was televised and widely reported on. The Post Office also demonstrated its usefulness to the state by constructing the machine which generated the winning numbers. The Electronic Random Number Indicator Equipment, known as ERNIE, was built at Dollis Hill by a sizable team working under Tommy Flowers.[143] With £25,000 allocated to the project by the government, ERNIE was an opportunity to use new processes on a large scale, including printed circuits, rectangular-loop ferrites and transistors.[144]

Not only did the Research Branch construct ERNIE, but they also became part of its promotion. Before completing the full-scale version, the team at Dollis Hill constructed a demonstration model which became part of the publicity drive. 'Mini ERNIE' was the perfect vehicle for the Post Office to promote its work and introduce a friendly and trustworthy machine to the public. The model was designed to explain how ERNIE worked, frequently photographed with the Postmaster General Charles Hill, and shown at public exhibitions (Figure 26Figure 26 below).[145] Unlike the full-sized ERNIE, which was composed of five racks with exposed circuit boards and electronic components, the model had a veneer cabinet, likely chosen as it was more reminiscent of the kind of television or radio set someone might have at home, than a computer which took up a very large space (Figure 27 below). Another difference was the smaller version

[141] T. Kilvington, 'The Post Office Research Station Holds a 'Open Day'', *POTJ*, 10.1 (Autumn 1957), 15-17 (p. 17).

[142] Stephanie Shirley, 'Career story: The importance of being ERNIE', *Significance*, 3.1 (2006), 33-36 (p. 34).

[143] BTA: TCB 422/14093 R. K. Hayward, et. al., 'The Electronic Random Number Indicator Equipment (ERNIE)', January 1958, p. 8.

[144] R. K. Hayward and E. L. Bubb, '"ERNIE" – the Electronic Random Number Indicating Equipment for the Premium Savings Bonds Prize Draws', *POEEJ*, 50.1, (April 1957), 1- 6 (p. 2).

[145] Anon., 'Bond Draw by "ERNIE"', *The Daily Telegraph*, (27 July 1956), p. 11.

produced two random numbers displayed on dials which looked a lot like eyes, rather than the eleven numbers generated by ERNIE and printed by teleprinter. Once the final version was complete, the team at Dollis Hill were tasked with explaining ERNIE's operation to journalists. While it might have been practical to keep ERNIE's cabinets uncovered for adjustments and cooling, it is possible that by making the machine as transparent as possible, the Post Office hoped to meet public concerns about its true randomness. ERNIE was further anthropomorphised, becoming the face of Premium Bonds, appearing on mugs and moneyboxes. In this presentation ERNIE looked little like the equipment as designed, shown instead as a humanised robot, likely reflecting popular images at the time (Figure 28 below).

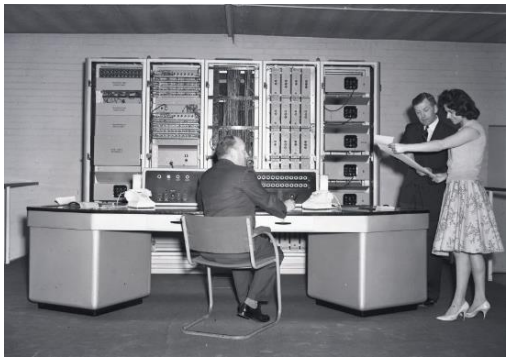

Figure 26 Charles Hill, Postmaster General, with a demonstration model of ERNIE (Electronic Random Number Indicator Equipment) at a press conference on Premium Bonds, 26 July 1956 (top right).

Figure 27 ERNIE at Lytham St. Annes, 1961 (bottom right).

Figure 28 Ceramic ERNIE money box, c. 1957 (left).[146]

[146] SCM: 1995-757, Ceramic ERNIE money box, c. 1957; BTA: [uncatalogued], Charles Hill, the Postmaster-General, with a demonstration model of ERNIE (Electronic Random Number Indicator

The public were introduced to GRACE on 5 December 1958 in Bristol, when the Queen made the first public Subscriber Trunk Dialling call (Figure 29 below). During the ceremony, the system was tested to its limits with the Queen telephoning Edinburgh, the furthest distance a call could be dialled. After a conversation with the Lord Provost of Edinburgh in which she shared her interest in 'any development which brings my people closer together' she threw a switch connecting 18,000 Bristol subscribers to the new system.[147] In contrast to ERNIE, little of GRACE was visible during the event, hidden behind information boards explaining the new service and a screen displaying the number which had been dialled '031CAL3636'. Instead, the Post Office presented their new 700-series telephone as the physical embodiment of the service, thus advertising both STD and their new subscriber instrument in one event.

Figure 29 The Queen Opening the STD System at Bristol Telephone Exchange, 1958.[148]

Equipment) at a press conference on Premium Bonds, 26 July 1956; BTA: TCB 473/P 7627, ERNIE at Lytham St. Annes, 1961.

[147] 'Queen Dials Edinburgh, 1958' (Pathé newsreels, 1958), British Pathé < https://www.britishpathe.com/video/queen-dials-edinburgh/query/queen+dials+edinburgh> [accessed 6 April 2020], 'The Queen dials the first STD call and tours Burnham Radio Station', *POTJ*, 11.2 (Spring 1959), 48-49, (p. 48).

[148] BTA: TCB 473/P 9503

This publicity stunt was carefully orchestrated: the Queen had been invited to choose from the new telephone colours picking Colonial Blue (before it was renamed), which was gifted to her after the event by the Postmaster General, Ernest Marples. The telephone was re-established as an instrument of modernity, collapsing time and space, now without the need of any human support, in the form of an operator. When the 700-series was released to the public in early 1959 the Post Office named it the 'Modern' telephone. Manufactures adopted similar language in their advertisements for the new subscriber instrument. While the public launch of the new service was important to promote the Post Office, it also benefitted private industry, who targeted its advertising campaigns around the event. This is demonstrated in the *Daily Mail*'s article on STD, surrounded by adverts from telephone companies promoting their contribution to the public telephone service (Figure 30 below).[149]

[149] Anon., 'The Post Office of the Future: This year of GRACE', *Daily Mail*, (30 January 1958), p. 13.

Figure 30 Advertisements for private firms surrounding an article on the Post Office and the launch of Subscriber Trunk Dialling, *Daily Mail*, 1958.[150]

[150] Grant Miller, 'The Post Office of the Future: This year of Grace', *Daily Mail* (30 January 1958).

Although challenged by government policy, the Post Office utilised all opportunities to promote itself. Despite COI restrictions the Post Office used many tactics, from exhibitions to ERNIE, to ensure publicity. The publicity around new services and technological advances shaped the Post Office's prestige. The biggest change from the early days of the Research Station was that by the 1950s, the site itself was not part of the narrative of the modern Post Office, as it no longer fitted the image of the work being undertaken within, nor the outputs of those investigations. The promotion of Dollis Hill as a site was no longer required to justify the existence of a Research Station to the taxpayer or legitimise Post Office expertise. This is also reflected in the absence of a publicly visible Controller of Research, as neither Harris, nor G. S. Little who took over the role in 1954 played a significant part in the promotion of the Research Station unlike their predecessors. Instead the activities of Dollis Hill became important in shaping opinions of the Post Office as a whole.

4.6 Research Station culture

Treasury support for the Research Station can be traced in its expanding numbers of staff. Between 1954 and 1958 the staff increased from around one thousand to 1,337 and was expected to grow further, putting pressure on laboratory facilities. While growth was welcomed, the Engineering Department still struggled to hire senior engineers and scientists with the preferred qualifications.[151]

While the Engineering Department claimed that 'the principle purpose of the work at Dollis Hill is to maintain and improve the efficiency of the telecommunications services which the Post Office provides for the public', we have seen that the identity of the Research Station was flexible, adapting to meet the needs of government.[152] This explains the often unexpected activities of the station which built on the knowledge of research staff, but were not directly linked to the Post Office. While Dollis Hill staff worked on defence projects for the Ministry of Supply, this contribution was suppressed when the Minister of Supply, Duncan Sandys, was asked in the Commons

[151] PMA: POST 69/60 POB (56)8 Minutes of Meeting, 6 December 1956.

[152] BTA: Post Office Engineering Research Station, Dollis Hill, Open Day, 28 September 1951.

to justify the existence of two government funded telecommunication R&D establishments, the Research Station and TRE. To differentiate, Sandys described the former as working on the public telecommunication services of the Post Office, while the latter developed equipment for the RAF and Naval Aviation.[153]

A dual identity coexisted within Dollis Hill, as a culture of secrecy ran seamlessly alongside the wider social activities which took place on the site. Cliff Wandsworth joined Dollis Hill in 1953 at the age of sixteen after finishing school at the local Willesden Technical College. Although knowing that a fellow member of the Dollis Hill running club worked in the 'ultra-secret place' Wandsworth 'never asked what he did down there, and he never told us'.[154] There was an awareness within Dollis Hill that secret research was happening but with most staff signing the Official Secrets Act, including Wandsworth, there was an understanding not to ask questions.[155]

The Research Station remained male dominated. In the early 1950s there were only about a dozen women in scientific and engineering roles in a workforce of around a thousand.[156] Stephanie Brooks (later Shirley) was one of the team who developed ERNIE, and, one of the few women working at Dollis Hill at the time. The environment was also hostile to women which meant Brooks supressed her femininity by consciously dressing in a plain suit and pin-tucked blouse 'to be the female equivalent of a man'.[157] The number of female staff named on Research Reports decreased during this time from thirty between 1946 and 1950 to ten between 1951 and 1958. Of the latter, Mrs A. L. Allen was the only one who had joined the Research Branch during the Second World War and three others had been hired in the immediate post-war period.

The Dollis Hill site became a limiting factor on the research activities within the Research Station. Dollis Hill, having been built for 800, became uncomfortably

[153] 'Telecommunications Research', 1952, Hansard, Vol. 499, cc 995-996.

[154] BM&A: OH/3/1 Cliff Wandsworth, Oral History, (2001-2002).

[155] Ibid.

[156] Dame Stephanie Shirley, *Let It Go: The Memoirs of Dame Stephanie Shirley* (London: Andrews, UK Ltd, 2012), p.58; F.E. Williams, 'The Post Office Research Station', *POTJ*, 6.3 (May-July 1954), 86-91.

[157] Shirley, 'The importance of being ERNIE', p. 35.

overcrowded.[158] Steps were taken to relieve this pressure and in 1954 a new chemistry laboratory was completed; this was much needed and had been first requested before the war. It was hoped that there would be some flexibility in the design of the new laboratory, with freestanding units which could improve the working conditions of the staff and could be adapted to the future needs of work. However, this approach was seen to be 'in conflict with certain building traditions' and had to be abandoned.[159] Construction of a new workshop began in the summer of 1950.[160] Unlike the chemistry laboratories which had been built inside the original station, the workshops, drawing office and photo-printing staff were housed in a new three-story building, designed to adapt to future needs with removable partitions. The original plan was to demolish part of the old workshop and turn the remaining section into a garage and mess room for drivers. However, the demand for research space meant the old site was retained and converted into laboratories.

Despite doing everything they could to improve the facilities, including adapting buildings which were not suitable for research work, staff were still constrained by the congested site. This particularly affected teams working on postal mechanisation and submarine cables, who needed large pieces of equipment, and research into waveguides which demanded a suitable environment for field trails but were confined to the space in their laboratories.[161] In 1958 Radley, Harris and Little agreed that any future development on the site would only provide temporary relief and it was time to start looking for an alternative site for the Research Station.[162] Having succeeded in demonstrating their value to the government by adapting the research agenda to support post-war reconstruction and defence programmes, senior Post Office staff had made the working nature of Dollis Hill incompatible with its physical form. Leaving the Dollis Hill site presented the Post Office with an opportunity to design a Research

[158] BTA: BT1-CEN2/6/790 'Sites – Dollis Hill Research Station – Proposed Moved of the Post Office Engineering Station – Location of Engineering Department Research, 1958-1962, J. Gibson to the Treasury, 1958.

[159] E. A. S., 'New Chemistry Labs at the Research Station', *POEEJ*, 47.2 (July 1954), 111-112 (p. 111).

[160] O. W. G., 'New Workshop Building at the Research Station', *POEEJ*, 47.2 (July 1954), 113-114 (p. 114).

[161] BTA: BT1-CEN2/6/790 letter from J. Gibson to the Treasury, 1959.

[162] Ibid., Memorandum New Site for P.O. Research Station, 15 August 1958; Ibid., Radley to Harris, 23 September 1958.

Station on a larger and grander scale, like other private and government funded R&D establishments built post-war.[163]

4.7 Conclusion

In this chapter, I have shown how the Research Station helped to redefine the Post Office's relationship with government. During a period of 'defiant modernism', enthusiasm for electronics and the importance of international relations, the Post Office harnessed these cultural shifts to approve and implement Research Station projects that would increase the long-term profitability of the telephone service. By engaging with the discourse of 'defiant modernism' the Post Office was able to gain support for the development of new equipment that promised British prestige and supported the government's export policy by creating new markets and diversifying industry. Even the internationally collaborative TAT-1 project, which did not take the traditional form of 'defiant modernism', was still presented as a national triumph through the new developments of the Research Station. Although engaging with such rhetoric, Post Office projects were more akin to steady improvement than leaps in technological progress and British 'firsts'. Where this differed was in the electronic exchange project, which, like many other icons associated with 'defiant modernism' failed to deliver on its promise.

Concurrently, a shift in the relationship between industry and the Post Office emerged. The new markets for export encouraged by government created greater complexity in the Post Office's supplier agreements with the telecommunications industry. There were clear benefits for all parties in goods for both domestic and foreign markets, like the new telephone design. Yet the Post Office now faced challenges in products that deviated from what was being done in international markets. In the case of the electronic exchange, its pursuance by the Post Office made sense considering the speed at which it was receiving capital. To opt for technology which was not cutting-edge for updating exchanges could risk that technology being surpassed whilst the

[163] Carol Heim, 'R & D, Defense, and Spatial Divisions of Labor in Twentieth-Century Britain', *The Journal of Economic History*, 47.2 (1987) 365-378.

Post Office were still rolling it out. However, for industry the TDM needed to have significant benefits over technology appearing in the interim in foreign markets to make the switch to electronic exchanges. Faced with resistance from telecommunication manufacturers, the Post Office was able to encourage cooperation through the Research Station that promised access to new knowledge in exchange for support.

We have also seen the Research Branch rise in influence within the Post Office as previous restructures moved sections out of Dollis Hill, spreading its culture as key engineering staff rose through the ranks into senior management positions. The goals and aims of the wider Post Office bore unprecedented commonality with those set out by the path of research at Dollis Hill. This left staff at Dollis Hill free to set the direction of their research without scrutiny over the development of specific technologies, the dangers of which have been illustrated in the choice to pursue the TDM electronic exchange project at the expense of alternatives. The status of the Research Station was further enhanced as its outputs were one of the few ways in which the Post Office could publicly promote itself and physically be seen to align itself with wider government aims, both civil and military.

The Research Station had comparatively greater freedom than the wider Post Office whose aims to expand public communication services were challenged by restricted capital and commitments to national defence. Whilst the latter also impacted Dollis Hill by absorbing military activities into the Research Station, senior Post Office staff had greater influence over maintaining resources and staff. The level of control over the research agenda can be measured by its wide range of outputs. Across the period, Dollis Hill staff and research outputs were utilised as promotional gimmicks, to generate new income streams and influence policy makers. The success of the Post Office's strategy of using Dollis Hill to navigate between military and civilian projects whilst delivering on some of their own technological promises ironically rendered the Dollis Hill site obsolete. Whilst Dollis Hill had been constructed to meet the needs of the 1930s Post Office, a new site offered the opportunity to design a Research Station encompassing and projecting the department's modern aspirations through its environment, facilities and design.

Conclusion

Dollis Hill was unlike any other twentieth century British R&D establishment. Whilst government funded it does not fit into a recognisable model of a state institution. Although undertaking work for the military, it did not receive the benefits of defence sponsored laboratories. Despite shaping the telecommunications equipment manufactured and sold by private firms, its contributions to the business activities of the Post Office were subject to strict state control. This anomalous identity enabled Dollis Hill to move beyond its remit of investigating cost savings, setting standards and developing new technologies to improve communication services owned and operated by the Post Office, to play a significant and largely undiscussed role in the Second World War, post-war reconstruction and Cold War. Whilst the Research Station and its outputs cannot be exclusively characterised as belonging to either the 'welfare state' or the 'warfare state', to employ David Edgerton's categories, this thesis shows it was a clearly embedded in both.[1]

In my introduction I presented the following questions to provide a framework to tell the history of Dollis Hill between 1933 and 1958: 'how did a civil state institution like the General Post Office (GPO) use a technological research facility to further political and bureaucratic goals'? and 'how did the staff at Dollis Hill negotiate boundaries and priorities between civilian and military requirements while working within governmental and industrial networks'? In addressing these questions this study has uncovered wider findings on the nature of how both we as historians, and contemporary actors, measured the value of research and how it is categorised. I will first show how I have addressed the questions in turn before focusing on the broader outcomes. Finally, I will suggest some future avenues for research.

Dollis Hill and its research activities were framed by senior staff in the Engineering Department as the location of Post Office cost savings and service improvements. This interpretation was shared with the public and wider government to justify the state

[1] David Edgerton, *Warfare State*.

sponsorship of research during periods of economic uncertainty. Demonstrating the value of research supported Post Office claims that it was working to reduce the cost of services for its users. This rhetoric was used consistently, irrespective of whether senior Post Office staff were justifying applied research (in the 1930s) or the move to fundamental research (post-war). Post Office staff claimed that underinvestment in research was the sole reason why Britain was falling behind American telecommunication firms. As employees of the state, they would be reticent to acknowledge the reason for this lay with their vastly different funding models, the Post Office as a publicly owned department compared to private American companies. A more effective approach to increase research funding was through the promise of new technologies capable of reaching export markets and cutting manufacturing costs. Such proposals designed to attract (and successfully did attract) Treasury support at a time when cuts to capital were restricting the development of the Post Office domestic service.

This is not a story of individual visionaries: the trajectory of Post Office research was inevitably defined strongly by both bureaucratic and technological networks. However, my findings show that three individuals influenced the course of events in directions that might not otherwise have been taken. In the 1930s, motivated by elevating the Research Station's reputation (as well as establishing his own legacy) Bertram Cohen, Executive Engineer in charge of Dollis Hill, used his platform to emphasis the monetary and societal contribution of a state-funded research establishment. By taking his campaign to professional societies and newspaper columns, Cohen fruitfully expanded the Research Station's networks of influence. Post-war, Engineer-in-Chief Stanley Angwin successfully convinced the Post Office Board and Treasury to support a more scientific research programme in the Research Branch. This led to the removal of training and development work from Dollis Hill, a commitment to more long-term and fundamental research and an expansion of scientific roles. This shift meant Dollis Hill could seek benefits available to other government departments. Gordon Radley was the most influential actor in shaping the research culture at Dollis Hill, not only heading up the Research Station during the 1940s, but as Engineer-in-Chief and later the first engineer to become Director General of the Post Office. To protect Research Station

resources, increase prestige and further patronage, Radley shaped Dollis Hill's research agenda to fit both Post Office and wider government priorities, whether these were macro-economic, civilian or defence led. This ensured a place for Dollis Hill and the Post Office in the key activities of both the warfare and welfare states.

Post Office aims to strengthen ties with telecommunication manufacturers were supported by having a dedicated research establishment. The Research Station validated the Post Office's monopoly over the nation's telecommunication services as it was a site of specialist knowledge which was respected and valued by industry leaders. By establishing the technical standards of the Post Office service, Dollis Hill ensured equipment manufactured by industry met the needs of the department and prevented a patchwork system of incompatible devices which would require expensive, bespoke maintenance. As the Post Office's market dominance was challenged by the expanding export market, Dollis Hill was a way the department could still influence the development of telecommunications equipment by private industry. In the 1950s, the promise of access to research, patents and potential new markets, convinced firms to help develop an electronic exchange when there were several factors which made the project unattractive; an ongoing market for established exchange equipment, hesitancy over Dollis Hill's ambitious design and, with increased R&D capabilities inside the firms, the development of alternative models. The importance of this lever in controlling industry, coupled with the fact cost savings were situated at Dollis Hill, meant that the Research Station's value grew within the department. As successive governments introduced policies hampering Post Office aims, Dollis Hill became the site where progress could be made.

Dollis Hill was both the site where the Post Office research agenda was realised and pursued, and a carefully managed symbolic representation of this activity. The research at Dollis Hill was publicised to show the Post Office engaging in prestigious, modern research for the benefit of the nation, countering critiques that the organisation was inefficient and antiquated. Messages about new developments and services were a key part of the Post Office's 1930s modernising campaign, but policy changes limiting departmental publicity post-war meant that the activities of the Research Station increasingly became the only means by which the Post Office could

share its successes. The Research Station and its outputs provided highly visible artefacts to represent the Post Office's predominately invisible infrastructure. Displaying submarine repeaters in exhibitions and demonstrating an anthropomorphised ERNIE enabled the Post Office to contribute to the 'defiant modernism' of the 1950s alongside other aesthetic icons of British progress. Throughout, the promises of new technologies, shaped by Dollis Hill research, were shared in publicity, commercial accounts and parliamentary debates, enabling the Post Office to trade on future visions at a time when they were struggling to provide an established service. For the Post Office, the fruits of research were not just in improving communications equipment, but also a key factor in securing and maintaining patronage at a time when domestic telephone services were considered a luxury.

The Post Office exploited the flexibility of the Research Station to realise additional benefits by aligning with wider government aims. Senior staff at Dollis Hill sought high status projects via civil and military patronage to gain prestige and knowledge which could be applied to Post Office developments. The motivations behind aligning with military need were most clearly revealed during the Second World War, when, faced with staff losses and reduced access to materials stocks, Radley manoeuvred Dollis Hill into the wartime state, through persuasion and perseverance. When Research Station expertise was dismissed by Bletchley Park, Radley persisted regardless by identifying and courting key stakeholders and, in the case of Colossus, re-prioritising Dollis Hill resources away from other research commitments in the short-term, in the hope of further patronage.

Dollis Hill existed in an environment shaped by 'warfare state' and 'welfare state' influences. This thesis highlights the unique place which Dollis Hill negotiated for itself by utilising its research outcomes for the benefit of these agendas of government in times of war and peace. However, other factors were also present in motivating Post Office decision making, including self-preservation and reputation, alongside any welfare and warfare considerations. The weighting attached to these influences shifted depending on the priorities of the Post Office at any one time. Whilst Edgerton's analysis is useful in framing this period, at Dollis Hill the relationship between civil and

military and public and private was more complex. Even applied at the most granular level, it is hard to trace how funding, outputs, benefits and resources are accounted for when considering specific research projects. Senior Post Office staff strategically steered the Research Station between warfare and welfare patrons by sitting outside recognisable models of R&D. Whilst this flexibility meant that Dollis Hill resources could be directed to whichever 'customer' best suited Post Office aims to reduce costs and improve services, the Research Station did not fully benefit from the access obtained by those in a fixed category.

It was Dollis Hill's uniqueness which enabled it to adapt to serving the needs of the warfare and welfare states and, in doing so, new layers of distinctiveness emerged setting it apart from other R&D models. Radley's post-war plans to return to civil telecommunications research were complicated by the emerging Cold War and the opportunities presented by the growing welfare state. Defence work ensured resources were retained in Dollis Hill, whilst the welfare state represented an opportunity to strengthen the Post Office's status within government. Changes to the site and culture resulted in the adoption of military secrecy, but it is a testament to Dollis Hill's Post Office identity that for most this was not impactful, friendships were maintained and social clubs continued to thrive. Furthermore, senior Dollis Hill staff's consideration of status or national need in selecting their research priorities not only accounts for the varied and perhaps unexpected outputs of a Post Office Research Station, but means it is possible to trace national trends of technological enthusiasm through the activities of the Research Station.

At a broader level this thesis widens our understand of the categorisation, location and presentation of state-funded R&D. While David Edgerton has shown that state funding on defence was far greater than civil, I show that the distinction between 'civil' and 'military' itself did not always operate. This is highlighted by the Post Office, a department with dual identity and purpose, presenting itself as civil whilst financing R&D directed to military applications. I have also tried to highlight the difficulties of accounts that treat state departments as monolithic. Tracing how R&D funding, staff numbers and facilities changed at Dollis Hill, has shown that whilst Post Office aims were limited by constraints on capital funding, it was one government policy amongst

many which hampered progress for the Post Office.[2] The same capital constraints did not apply to the outputs of research as supported by the Treasury's continued investment in the Research Station.

This thesis supports and expands on Sally Horrocks' work showing that government funding, especially defence funding, shaped the development and expansion of industrial R&D.[3] Additionally, the Post Office as a public service which raises commercial revenue provides a useful case study for the broader role of governments in the development and expansion of R&D beyond funding. In the case of the Post Office we have seen how it helped publicise R&D, contributing to raising the public profile of innovation and engineering, disseminating knowledge, providing links between industries internationally and in some cases creating new industries in the cases of manufacturing quartz crystals, and later growing synthetic equivalents, and constructing long-life valves. By situating such activities in the Post Office with its wide reach within the public sphere, it could be more successful than the targeted approach often taken by government departments like the Board of Trade. This highlights the importance of the state as the centre of innovation in post-war Britain.

This case study is also a demonstration of the power of prestige. The output of the research establishment provided the Post Office with prestige to influence private industry, cultivate national and international collaboration and through training ensured standardisation of practice across the department which extended to wider patrons. Unlike trends seen in studies of other scientific spaces, the legitimacy of the Research Station and the validity of the knowledge generated there was not negatively impacted during this period, despite public criticism from Post Office staff that the site was unsuitable for their activities. Scholars have shown that the physical environment and architecture of a laboratory imparts credibility to those who visit or are omitted from such a space.[4] In the case of Dollis Hill, the credibility of such a site extends

[2] Pitt, *The Telecommunications Function in the British Post Office*, p. 46.

[3] Horrocks, 'Enthusiasm Constrained?' pp. 42-63.

[4] Agar and Smith, *Making Space for Science: Territorial Themes in the Shaping of Knowledge*; Kohler, *Landscapes and* Labscapes*:* Naylor, 'Introduction: Historical Geographies of Science – Places, Contexts, Cartographies'.

beyond its bricks and mortar and can be sourced through Post Office projected images. Whilst Thomas Gieryn's work does not lack case studies, this research further shows that while buildings are structurally fixed, they continue to be reinterpreted to serve different institutional aims.[5] Indeed, Dollis Hill was used by the Post Office simultaneously to build professional networks with specific audiences while also projecting another narrative to the wider public.

This thesis contributes to a small, but growing literature on engineering working cultures. By focusing my research on the Engineering Department and Dollis Hill as a whole I have identified the influential role of Post Office engineers and scientists in shaping the department's research agenda. Whilst for Edgerton, the scientific 'research corps' of the nation worked in limited and clearly defined establishments, this work shows the extent to which Post Office staff could influence government telecommunication policy and the design and construction of national and international infrastructure.[6] Considering the influences, aims and ambitions of Post Office engineers, provides a more comprehensive view of the scientific community, one which is more nuanced than Edgerton's 'research corps' accounts for. Instead I have attempted to give a sense of them as a distinct entity, created through shared training and working experiences and a commitment to build a strong identity, through publication, patents and training. Thus, I expand Edgerton's account of the scientific civil service, by revealing state sponsored work of a body of experts, whose effectiveness and influence on Britain's economy, society, culture and national security have otherwise been overlooked.

This thesis contributes to conceptions of modernity in Britain, by taking a longer view; extending the observation by scholars that the Post Office established a new way for government to shape public perception through advertising and establishing ideas of modernity. Between 1933 and 1958 the launch of new services became an increasingly important means by which the Post Office could project its modernity even as economic and political changes supressed government publicity activities. With the

[5] Gieryn, 'What Buildings Do'.

[6] Edgerton, *Warfare State*, pp. 143-144.

source of new innovations rooted in research activities, Dollis Hill continued to provide an ideal platform to shape public opinion of the Post Office. I have shown that the spectacle of visual icons which are synonymous with Robert Bud's concept, of 'defiant modernism' of 1950s and 1960s Britain, can be traced back to Post Office publicity practices during the 1930s where highly visual artefacts were used as icons of the invisible infrastructure it managed.[7] The research conducted at Dollis Hill was recognised within the Post Office for both its scientific value and its value as a tool for creating good publicity.

Avenues for future work

This thesis completes the history of research in the Post Office during the twentieth century, from the establishment of a Research Branch in 1908 to the privatisation of the Post Office in 1984. The following recommendations for future work are made considering my thesis, Alice Haigh's which explored the early years of Dollis Hill and Jacob Ward's which covered the move to Martlesham Heath.[8]

As this thesis has highlighted the value of an anomalous research establishment in tracing science-state relations, studies of parallel institutions would reveal whether there were shared trends in navigating this landscape. The Laboratory of the Government Chemist (LGC) would make an interesting comparison as it was a separate department until 1959 when it was transferred to the DSIR. Whilst the LGC appears as a case study in Peter Morris' history of chemistry laboratories and a book was published by two government chemists, Geoff Egan and P. W. Hammond, in celebration of the laboratory's 150th anniversary, there is the potential for further study which places the institution in a broader social and scientific context.[9] Whilst the development of Britain's telecommunication networks have received scholarly attention many other invisible infrastructure providers have not. Several of these

[7] Bud, 'Penicillin and the new Elizabethans', p. 312.

[8] Alice Haigh, 'To Strive, To Seek, To Find'; Jacob Ward, 'Information and Control'.

[9] Peter Morris, The Matter Factory: A History of the Chemistry Laboratory (London: Reaktion Books, 2015); P. W. Hammond and Geoff Egan, Weighed in the Balance: A History of the Laboratory of the Government Chemist (London: HSMO, 1992).

institutions had their own research stations which significantly shaped an unseen part of daily life and technological culture in the United Kingdom. Such investigations could look at social, political and cultural factors in shaping the local and national growth of public utilities including sewer disposal, gas and electricity supply, through to studies of Regional Electricity Boards, the Central Electricity Generating Board and the National Coal Board. Glen O'Hara's book on the politics of water in post-war Britain is one such study from which others could build on.[10] Some of these institutions, especially those which were or still are under government control, may have more complete staff records than were available for this study, from which a greater understanding of how gender, class and education influenced the working culture of these institutions.

The presentation of the Post Office's organisational messages through publicity has been a theme which runs throughout this thesis. Missing from this analysis is how these messages were received, what success they had in shaping the public's opinion of the Post Office and what impact they had on the diffusion rate of the telephone. Indeed, to contain the scope of this project, the telecommunications user has been omitted from the sociotechnical approach taken. To include the user would reveal what role this material had compared with other social, cultural and political influences in the diffusion and development of technology in Britain. Answers may be found in the Mass Observation Archive and the rich material on the Post Office Publicity Department held by the Postal Museum Archives. Considering the British experience alongside those of other countries would highlight what, if any, of these factors were universal or significantly different. Claude S. Fisher's *America Calling: A Social History of the Telephone to 1940* would provide a baseline for a comparative study into the development of telephone culture in Britain and North America.

This narrative has situated Dollis Hill at the centre of research in the Post Office and I have attempted to uncover what influences affected the direction of research. The Research Station was, however, only one part of the wider Engineering Department which would provide a rich subject for any historian interested in understanding the

[10] Glen O'Hara, *The Politics of Water in Post-War Britain* (Basingstoke: Palgrave Macmillan, 2017)

role of the Post Office in regulating society through Wireless and Television Licences. There is scope to explore how Post Office telecommunication services were used to control and shape Empire and Commonwealth relations, or the impact of its infrastructure on environments and geographies. This thesis has also used Dollis Hill as a lens to explore the relationship between the Post Office and manufacturers, but more could be learned of private industry's attitude towards government-controlled utilities. As discussed in Chapters 1 and 4, whilst the introduction of Bulk Supply Agreements protected 'The Ring' of firms from external competition, there is scope for further work to understand what impact these cartels had on innovation, technological development and Britain's industrial landscape.

Appendices

Appendix 1: Branches of the Engineer-in-Chief's Office, Engineering Department, 1957[1]

Accounting and Statistical Branch
External Plant and Protection Branch
Exchange Equipment and Accommodation Branch of the Department
Editorial and Office Practices Branch
Test and Inspection Branch
Local Lines and Wire Broadcasting Branch
Transmission and Main Lines Branch
Motor Transport Branch
Engineering Organisation and Efficiency Branch
Power Branch
Research Branch
Subscribers' Apparatus and Miscellaneous Services Branch
Stores Line Section
Submarine Branch
Training Branch
Telegraph Branch
Telephone Development and Maintenance Branch
Radio Experimental and Development Branch
Radio Planning and Provision Branch

[1] PMA: POST 76/76, Report No. 126 on the planned review of the Engineering Department Staff Branch.

Appendix 2: Senior roles in the Post Office and Government, 1933-1958

	Executive Engineer/ Controller of Research	Engineer-in-Chief[1]	Director General	Postmaster General	Prime Minister
1933	Bertram S. Cohen	A. G. Lee	Donald Banks (14 August)	Sir Kingsley Wood	J. Ramsey MacDonald [National Coalition] (24 August)
1934					
1935				George Tryon (7 June)	Stanley Baldwin [Con] (7 June)
1936			Thomas Gardiner (9 August)		
1937					Neville Chamberlain [Con] (28 May)
1938					
1939	(William) Gordon Radley (1 January)	(Arthur) Stanley Angwin (July)			
1940				W. S. Morrison (5 April)	Winston Churchill [Con] (10 May)
1941					
1942					
1943				Harry Crookshank (6 February)	
1944					
1945				William Hare, Earl of Listowel (4 August)	Clement Attlee [Lab] (26 July)
1946			Raymond Birchall (1 January)		
1947		Archibald Joseph Gill (January)		Wilfred Paling (23 April)	
1948					
1949	Brig. Lionel H. Harris		R. A. Little (1 October)		
1950				Ness Edwards (2 March)	
1951		(William) Gordon Radley (October)		Herbrand Sackville, Earl De La Warr (6 November)	Winston Churchill [Con] (26 October)
1952					
1953					
1954	G. J. S. Little (October)	Brig. Lionel H. Harris (October)			
1955			(William) Gordon Radley (1 October)	Charles Hill (8 April)	Anthony Eden [Con] (6 April)
1956					
1957				Ernest Marples (17 January)	Harold Macmillan [Con] (10 January)
1958					

[1] Frank Bealey, The Post Office Engineering Union: The History of the Post Office Engineers 1870-1970 (London: Bachman & Turner, 1976), p. 423.

Appendix 3: Biographies of senior Post Office engineering staff

Captain Bertram S. Cohen (1876–1943)

Cohen was the Staff Engineer in charge of the Post Office Research Station between 1930 and 1938. His technical training led him to join the National Telephone Company (NTC) in 1897 where he was allocated responsibility for the organisation's research department.[1] When NTC transferred to the Post Office in 1912, Cohen became Assistant Staff Engineer in the Research Branch. He served in the R.A.F. during the First World War. In 1926 he briefly left Dollis Hill to become Staff Engineer in charge of the Test Section, returning in 1928 as head of the Research Station where he stayed until his retirement.[2] During his tenure as Staff Engineer Cohen was a vocal promoter of the Research Branch and Station.

Sir Albert George Lee (1879–1967)

Lee was Engineer in Chief between 1932 and 1939. Lee joined the Post Office Engineering Department in 1901 as an engineering assistant in London, and achieved a BSc studying part time. He contributed to improvements in the performance of cables and was promoted to Assistant Staff Engineer in 1912. In 1914, Lee was commissioned into the Royal Engineers (Signals Service), ultimately becoming Officer-in-Charge, General Headquarters Signal Area. He was awarded the Military Cross and after the war he remained in the Supplementary Reserve with the grade of Lieutenant Colonel. On his return to the Post Office George Lee was appointed Staff Engineer of the Radio Branch, where he worked on the transatlantic telephone, collaborating with AT&T, which resulted in the opening of the first commercial service in 1926.[3] This was the start of strategically important communications networks across the British Empire. In 1927 he was Chairman of the IEE Wireless Section and was awarded an OBE. Lee left

[1] F. C. M., 'Retirement of Captain B. S. Cohen, O.B.E., M.I.E.E. F.Inst.P.', *POEEJ*, 31.4 (January 1939), 310.

[2] Ibid.

[3] J. H. H. Merriman, 'Lee, Sir (Albert) George', *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004) < https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-34465?rskey=TIFEKc&result=1 [accessed 5 January 2020].

the Post Office in 1939 and during the Second World War he was Director of communications, research and development at the Air Ministry. In 1944 he was appointed senior telecommunications officer in the Ministry of Supply. After the war he was a member of the Scientific Advisory Council of the Ministry of Supply.[4]

(William) Gordon Radley (1898–1970) [5]

Radley started his career in the Post Office in 1920 and became one of the first staff to move to the Research Station at Dollis Hill the following year.[6] There he developed expertise in materials science, later taking charge of the Materials Group. In 1934 he was awarded a PhD by London University for his work in cooperation with the Electrical Research Association on the interference of power cables on telephone lines.[7] He took control of the Research Station in 1939, following Bertram Cohen's retirement, where he became the key influence in the direction of research at Dollis Hill and its culture. Radley was response for the Research Station during the Second World War, directing its research and shaping wider government policy through committees. He was chairman of the Materials Committee of the Radio Research Board, Radar and Signals Advisory Board and the Electro-Acoustics Sub-Committee of the Ministry of Supply, the latter which led to the introduction of the Medresco, the first hearing aid to be released by the new National Health Service in 1947. In 1951, Radley was promoted to Engineer-in-Chief, a post he held for four years.[8] During this time Radley represented Britain and the Post Office in the negotiations leading to the first transatlantic telephone cable, TAT-1. Sir Gordon Radley became the first engineer to hold the role of Director General of the Post Office, appointed in 1955. In November of that year he took over as chairman of the Mechanical Aids Committee where he gave prominence to projects to mechanise sorting the post and ultimately to introduce

[4] Ibid.

[5] J. H. H. M., 'Sir Gordon Radley', *POEEJ*, 61.1 (April 1971), 78.

[6] W. W., 'W. G. Radley, C.B.E. Ph.D.(Eng.), M.I.E.E.', *POEEJ*, 44.3 (October, 1951), 131.

[7] 'W. G. Radley, C.B.E. Ph.D.(Eng.), M.I.E.E', *POEEJ*, 47.1 (January, 1955), p. 45.

[8] Ibid.

post codes.[9] Gordon Radley retired from the Post Office in May 1960. From 1961 until 1970 he was Chairman of various parts of the Marconi Company.[10]

Col. Sir Arthur Stanley Angwin (1883–1959)

Angwin was Assistant Director-General and Engineer-in-Chief between 1939 and 1947. After studying engineering at East London College, Angwin joined Yarrow & Co. shipbuilders on the Clyde.[11] He entered the Post Office Engineering Department in 1906, starting his career installing telephones in Glasgow. During the First World War, Angwin took command of the 52nd divisional signal company serving in Gallipoli, Egypt, Palestine and France.[12] In the interwar period Angwin specialised in radio communications and was involved in designing radio stations for the Imperial Wireless Chain, in Leafield, Rugby and Cairo.[13] He was promoted to Staff Engineer in charge of the Radio Branch in 1928 in recognition of his work. The following decade saw Angwin rise the ranks of the Engineering Department, first as Assistant Engineer-in-Chief in 1933, Deputy Engineer-in-Chief in 1935 and in 1939 Engineer-in-Chief where he played a key role maintaining Post Office communications during the war.[14] Angwin retired from the Post Office to become the first Chairman of Cable and Wireless Co. (C&W) following its nationalisation in 1947. He continued to play an important role in international telecommunications, leaving C&W in 1951 to be chairman of the Commonwealth Telecommunications Board, established to managed and maintain Commonwealth cables, until his retirement in 1956.[15] Alongside these roles, Angwin represented British interests in international telecommunication conferences to

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[9] Peter Sutton, 'Designing the postcode: sorting machines, psychology and Sir Gordon Radley', https://postalheritage.wordpress.com/2011/01/14/designing-the-postcode-sorting-machines-psychology-and-sir-gordon-radley/ [accessed 5 January 2020].

[10] 'Seventieth Marconi Marine AGM', *Mariner: Journal of The Marconi International Marine Company Limited,* 11.136 (March-April 1970), 183-186.

[11] A. J. G., 'Col. A. S. Angwin, D.S.O., M.C., T.D., M.I.E.E.,' *POEEJ*, 32.2 (July 1939), 146.

[12] Ibid.

[13] Ibid.

[14] Gordon Radley, 'Angwin, Sir (Arthur) Stanley (1883-1959)', *Oxford Dictionary of National Biography*, (Oxford: Oxford University Press, 2004), <https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-30421> [accessed 5 January 2020].

[15] Ibid.

regulate radio waves and define standards, was President of the Institution of Electrical Engineers (1943–44), was part of Lord Reith's tour of the Commonwealth in 1945 and chairman of the Radio Research Board (1947–52).[16]

Sir Archibald Joseph Gill (1889–1976)

Gill started his engineering training at the shipbuilders Yarrow & Co. Ltd in 1906 leaving four years later to join the British Thomson-Houston Company to design steam turbines.[17] Gill joined the Post Office in 1913, appointed to the Radio Branch where, like Angwin, he was involved in the construction of the Rugby Radio Station. Building on his early experience, Gill was heavily involved in the design and construction of Post Office cable ships, including *Monarch* which was the largest ship of its kind in the world. In 1932 he became the first engineer in charge of the Radio Branch Laboratories at Dollis Hill.[18] In 1938 he was appointed Assistant Engineer-in-Chief and during the Second World War he was responsible for constructing deep-level tunnels in London to protect the security of communication, directed the installation of radio transmitting and receiving stations for the Chain Home radio link and advised on the Pluto oil pipe project. Gill was promoted to Engineer-in-Chief in 1947 where stayed until his retirement in 1951.[19]

Brigadier Sir Lionel Harris (1897–1971)

Lionel Harris was Engineer in Chief of the GPO from 1954–1960. He served as a linesman in the 5th Australian Signals Company from 1915–18. On being demobbed in the UK he obtained a 1st class engineering degree at the City and Guilds College and then joined the Engineering Department. In 1922, Harris was one of the first engineers to join the Research Branch where he stayed until 1932.[20] In the interwar period his research was mainly in relays for automatic switchboards and in transforming the telegraph into teleprinters and telex machines. He was appointed to management

[16] Ibid.

[17] A. H. M., 'Mr. A. J. Gill, B.Sc.(Eng.), M.I.E.E. F.I.R.E.', *POEEJ*, 39.4 (January 1947), 183.

[18] Ibid

[19] A. H. M., 'Sir Archibald J. Gill, B.Sc.(Eng.), M.I.E.E. F.I.R.E.', *POEEJ*, 44.3 (October 1951), 130.

[20] 'Sir Lionel Harris: A Profile', *New Scientist*, 4.96 (18 Sept 1958), pp. 856- 857.

roles, including superintending engineer of the North Midlands Division in 1938. As a member of the Territorial Army he was called up as soon as war was declared. With his expertise he was promoted to running the signals unit at GHQ in 1941. He ended the war as Chief of Telecommunications to Eisenhower, of SHAEF. Harris was Chief of the Post Office in Scotland from 1945–1949 after which he returned to London as Controller of Research at Dollis Hill. He wrote a memoir of his war experience, *Signal Venture*, that was published in 1951.[21] During his time as Engineer-in-Chief (1954–1960) the Post Office introduced STD and TAT-1. He also was influential in committees that planned the expansion of television services. Harris received a knighthood in 1957 and retired from the Post Office in January 1960.[22]

Thomas 'Tommy' Flowers (1905–1998)

Following his apprenticeship training at Woolwich Dockyard, Flowers joined the Engineering Department in 1926 initially looking after its stores. Flowers continued his education at night school and after doing well in the Post Office's engineering exams he transferred to Dollis Hill in 1930.[23] Before the war he investigated the application of electronics in improving telephone exchanges and represented the Post Office on many international telecommunications committees. From 1942 Flowers worked with Bletchley Park staff on improving the Bombe machines which decoded German messages and later in the war he led the project to build Colossus. He was awarded an MBE in 1943. After the war Flowers remained at Dollis Hill to continue his pre-war research on electronics which he applied to exchange designs and also ERNIE, the Electronic Random Number Indicator Equipment, the machine which selected the first Premium Bond numbers.[24] Between 1950 and 1964 he was Staff Engineer, often deputising for the Controller of Research. Flowers left the Post Office in 1964 to work at STC. He retired in 1970. His role in the construction of Colossus was not publicly

[21] L. H. Harris, *Signal* Venture (Aldershot: Gale and Polden, 1951).

[22] H.W, 'Retirement of Brigadier Sir Lionel H. Harris', *POEEJ,* 53.1 (April 1960) 58.

[23] IWM: 18332, Flowers, Oral History.

[24] Jon Agar, 'Flowers, Thomas Harold (1905-1998)', *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2008) < https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-71253> [accessed 5 January 2020].

recognised until 1976, and on its 70th anniversary BT unveiled a bronze bust of Flowers at its current research site at Martlesham Heath.

Gilbert Joseph Stephen Little (1897–1978)

Little was Controller of Research at Dollis Hill from October 1954, till his retirement in 1958.[25] Little had originally completed a degree in mechanical engineering and served as an airman during the First World War. He joined the Engineering Department by the Open Competitive Examination in 1922 and his first role was in the Line Transmission Section of the Research Branch. By 1932 he was an Executive Engineer in the Lines Branch. Over this decade Little worked on improving carrier telephony, and in 1938 under his presidency, a sub-committee of the CCIF, the International Telephone Consultative Committee, agreed international standards for the frequency allocations for twelve-circuit carrier and coaxial systems. In 1939 he became the first Chief Regional Engineer of the newly-formed North West Region and was awarded the George Medal for meritorious work and conduct in connection 'with the saving of Central Exchange Manchester from fire, following air attack on the night of December 23rd and 24th, 1940'.[26] Post war he held the position of Staff Engineer of the Radio Maintenance Branch and in January 1947 was appointed as the Assistant Engineer-in-Chief with responsibility for trunk lines, local transmission and external construction. There are no details of his achievements as Controller of Research. The Post Office Electrical Engineers' Journal in July 1959 records that Little had retired in 1958.

[25] H.W., 'G. J. S. Little'; W. D. Florence, 'Retired Members' *POEEJ*, 52.1 (April 1959), 75.

[26] H. W. 'G. J. S. Little C.B.E., G.M., B.Sc., M.I.E.E.', *POEEJ*, 47.4 (January 1955), 244.

Appendix 4: Portraits of senior Post Office engineering staff[1]

1. Capt. Bertram Cohen, c. 1930s

2. Sir Albert George Lee, c. 1930s

3. Sir (William) Gordon Radley, 1954

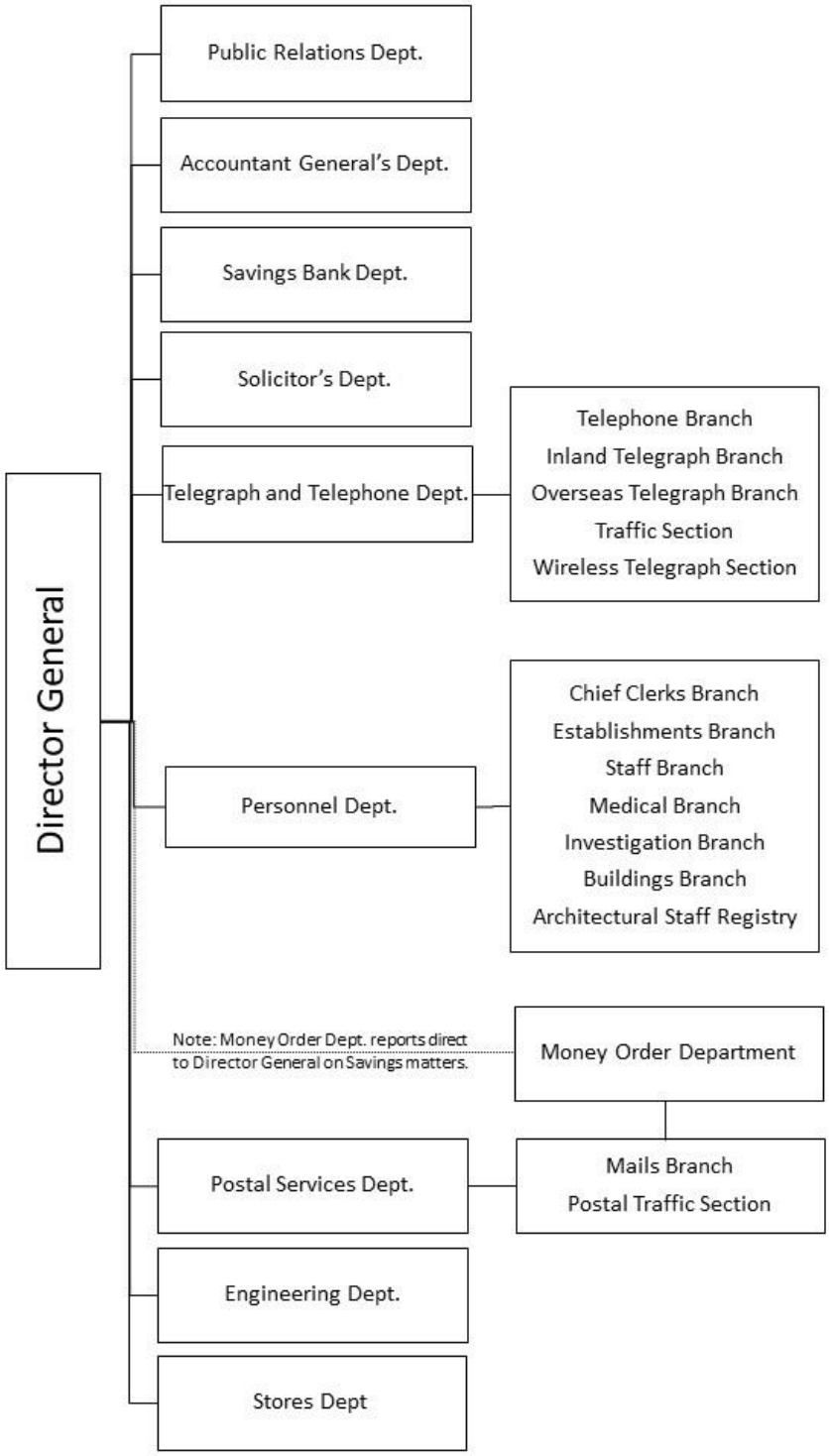
4. Sir (Arthur) Stanley Angwin, 1943

5. Sir Archibald Joseph Gill, 1949

6. Thomas 'Tommy' Flowers, c. 1940

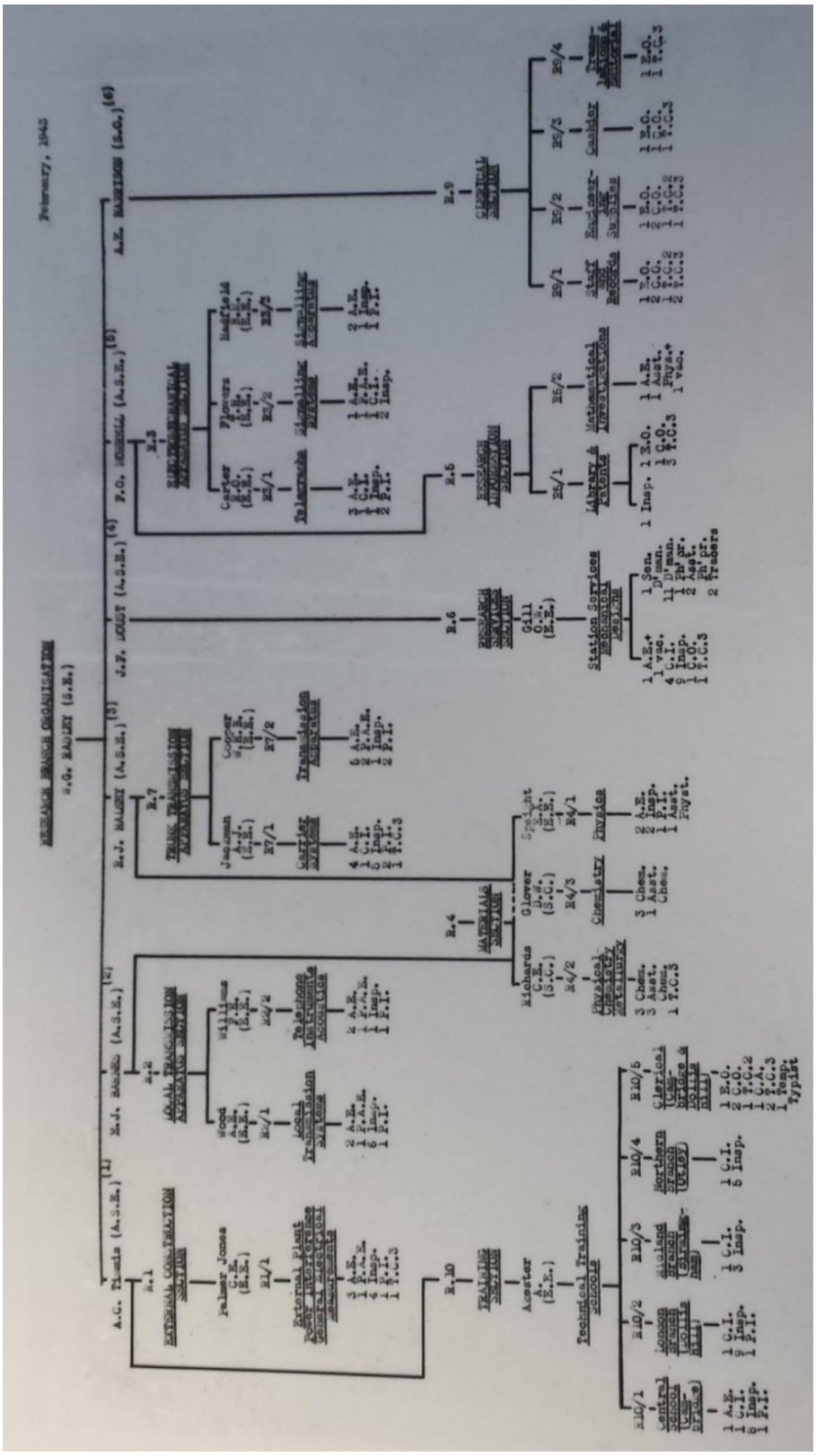
[1] Image references: 1. 'Retirement of Captain B. S. Cohen, OBE, M.I.E.E., FInstP', *POEEJ*, 31.4 (January 1939), p. 310; 2. BTA: TCB 417/E 10282, Sir Albert George Lee, 3. NPG: x159779 (William) Gordon Radley, by Walter Stoneman, 1954; 4. NPG: x163630, Sir (Arthur) Stanely Angwin, by Walter Stoneman 1943; 5. NPG: x97879 Sir Archibald Joseph Gill, by Navana Vandyk, 1949; 6. BTA: TCE 361/ARC 1481, Tommy Flowers, 1950.

Appendix 5: Organisation of Post Office Headquarters, 1934[1]



[1] PMA: Redrawn from POST 33/4314 POB: Headquarters reorganisation, 1934.

Appendix 6: Organisation of Research Branch, Dollis Hill, February 1943[1]



[1] TNA: T 162/696/5 Organisation of Research Branch, Dollis Hill, February 1943.

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http://www.digitalarchives.bt.com/CalmView/Default.aspx

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TCB 135	Engineer-in-Chief's Annual Reports; 1936-1967.
TCB 176/10	TAT 1: Discussions, Correspondence, Reports between Post Office and AT & T Co. (including COTC from June 1953), prior to August 1953, with the exception of one report in file 10/2.
TCB 176/12	TAT 1: Treasury and other Government Departments
TCB 176/33	TAT 1: Publicity
TCB 211/19	Extracts from newspapers, 1932-33.
TCB 211/20	Extracts from newspapers, 1933.
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