Out of the Shadows:

How secret nuclear bunkers constructed between 1950 and 1970 surreptitiously influenced Scotland's Post-War architecture.

THESIS

Sean Lawrence Kinnear

The Glasgow School of Art, Mackintosh School of Architecture

Supervisors:

Professor Florian Urban

Dr. Thea Stevens

Arts & Humanities Research Council
SCOTTISH GRADUATE SCHOOL FOR ARTS & HUMANITIES
PAUL MELLON CENTRE for Studies in British Art
THE GLASGOW SCHOOL OF ART

Declaration

I, Sean Lawrence Kinnear declare that the enclosed submission for the degree of Doctor of Philosophy (PhD) and consisting of PhD by Thesis meets the regulations stated in the handbook for the mode of submission selected and approved by the Research Degrees Sub-Committee.

I declare that this submission is my own work and has not been submitted for any other academic award.

[redacted]

Sean Lawrence Kinnear

The Macintosh School of Architecture

The Glasgow School of Art

2022

Abstract

Out of the Shadows: How secret nuclear bunkers constructed between 1950 and 1970 surreptitiously influenced Scotland's Post-War architecture.

This PhD thesis reveals for the first time how Scotland's post-war architecture was surreptitiously influenced by the secret push and pull of classified nuclear bunkers as demands seesawed to accommodate shifting Cold War threats. By detailing how these influences were dually experienced across secret nuclear bunkers as well as civil architecture, my investigation evidences a new narrative of inextricably linked relationships between two seemingly separate, yet, undeniably connected realms. While some of these far-reaching influences appear mutually beneficial for nuclear bunkers and civil architecture, others yielded more contentious fractures when both realms collided and vied over the same post-war resources, architects, engineers, contractors, and supply chains. Crucially, the resultant impact led to difficult decisions that either saw nuclear bunkers or civil projects pushed down the priority list to become delayed, significantly altered, or cancelled entirely.

My original contribution to knowledge lies in revisiting these nuclear bunkers and formally acknowledging them as a unique type of architecture (borne in response to unprecedented threats) to provoke an alternative narrative into how Scotland's post-war architecture was influenced beyond that which is currently accepted within existing scholarship.

This new narrative extracts vital data through an historical methodology by bridging siloed and previously overlooked multidisciplinary histories, alongside using detailed archival analysis of declassified government files held in The National Archives (TNA) and the National Records of Scotland (NRS). Trade literature (principally past issues of the *Architects' Journal* and *Architectural Review)* and Sir Robert McAlpine company records held in Glasgow University Archives have proved additionally vital in constructing a more complete narrative. A series of fieldwork visits have supported this in-depth archival review by surveying and recording selected case study bunkers from the ROTOR programme and Emergency Government Controls – spanning a timeline of 1950 to 1970.

This thesis addresses two significant gaps in existing scholarship. First, it brings nuclear bunkers into a more authoritative framing of post-war architectural history, initially overlooked by commentators at the time of construction due to classified project status and thus largely omitted from scholarship as a latent effect. Second, it re-addresses the current knowledge imbalance of Cold War nuclear bunkers due to misconceptions generated across multidisciplinary studies; namely that these bunkers are commensurate with the same levels of violence and complex histories implicit with Second World War European examples.

Preface

Like many others that have been drawn to Cold War nuclear bunkers, my interests leading into this PhD thesis lie in a deeply rooted passion for architectural, social, and military histories. While some researchers describe their similar fascination with the nuclear bunker as emerging from their youth spent as a 'Cold War Kid', by being born in 1989, when the Berlin Wall fell, I hold no such claims in retaining memories of the palpable threat of nuclear war. Likewise, none of my relatives were employed at the various top-secret military sites located across Scotland. Instead, these interests stem entirely from an inner childhood fascination that has gradually evolved into this formal PhD thesis.

Growing up in the East Neuk of Fife – an area intrinsically linked to its well-documented military past – there was a plentiful supply of wartime remains amongst my immediate surroundings. For example, the crumbling ruins of the fifteenth century Newark Castle lay within a mere kilometre from my back door, its stone tower clearly visible from the upstairs windows. There is also an ample stock of anti-invasion defences leftover from Scotland's involvement with twentieth century conflict. These concrete reminders of the Second World War scatter the landscape revealing the locations of coastal gun batteries, tank obstacles, pillboxes, and observation posts that once vigilantly monitored the Firth of Forth. These artefacts, continue to sink steadily into the countryside or creep closer into the sea, are leftover reminders of a time when Scotland faced a genuine threat of invasion by a foreign aggressor. However, as we know these invasion plans were abandoned when the Royal Air Force successfully defended Britain's airspace from the German Luftwaffe in 1940. Although I do not recall the Cold War anxieties over nuclear conflict, I do hold vivid memories of the Coalition War on Terror and Iraq campaigns of the early 2000s. For during both campaigns, I was regularly woken at night with the heavy air traffic flying in and out of RAF Leuchars or startled by the sudden roar of jet engines that often revealed low-flying aircraft on training exercises and overseas sorties.

Having enjoyed numerous trips as a regular visitor to the nearby tourist attraction known as *Scotland's Secret Bunker,* a short drive along the main road from Anstruther to St. Andrews, my interest peaked from a work experience placement during one spring vacation[1]. As mum's cousin-in-law served a brief spell as general manager, I was allowed the unique opportunity of spending a week preparing the bunker ahead of its seasonal reopening. Whilst my tasks were limited to simple maintenance jobs, such as fitting countless new lightbulbs and tidying displays, these activities still involved countless trips into the underground access tunnel as I navigated the bunker's numerous rooms split across two subterranean levels. Importantly, this experience was undertaken when the bunker was closed to the general public, and I was therefore given exclusive permission to access to all areas beyond the chain barriers and 'staff only' notices. It was during this spatial experience of isolation that left a lasting impression and intrigue. There were no other visitors in the underground bunker at this time, but the outdated display mannequins (dressed in full Cold War-period uniform) served as constant and eerie reminders of the long-departed human occupation. Having once been staffed by hundreds of civil servants and military personnel, awaiting potential nuclear war the bunker's dormitories and operations room are now empty, aside from the furniture and equipment left in situ. As part of its reuse as a museum, new cinemas have been installed that play Peter Watkins Academy Award-winning *'The War Game'* on a continuous loop. Despite winning the Best Documentary Feature in 1967, the BBC famously banned its scheduled television broadcast at the time, partly due to Watkin's dramatization of a Soviet nuclear attack on Britain as being too realistic.

[1] Scotland' Secret Bunker now operates as a specialist Cold War museum and has been open to the public since 1994

Its graphic depiction of a hypothetical nuclear attack on Kent used new handheld camera techniques and was backed by Watkin's thorough research into civil defence knowledge[2]. As a result of this painstaking attention to detail viewers have on occasion believed the fictional nuclear attack to be a real-life event.

At the end of each day, after the power was switched off and the blast-proof doors were closed, we would make our way back to surface level by walking up the long access tunnel in near-complete darkness. When the museum was broken into and besieged for 3 days back in 2004, I assumed the unofficial role of class consultant (my high school fell within 5 miles of the unfolding incident) in describing the unnerving spatial and environmental conditions the intruder was facing, emphasising how unsettling the bunker can be even without the police cutting the power supply in an attempt to coax the intruder back above ground.

Later, during the final year of architectural school in 2013, my fascination with the bunker influenced me to return once again for my master's degree project. Using photographic surveys and limited study of floor plans, I conducted a rudimentary investigation into the bunker's architectural fabric, which served as a catalyst for a broader exploration into architecture and design during the Cold War epoch. This work culminated in a written dissertation and interactive exhibition titled 'KAZAM!'. Given some of the more critical knowledge gaps were left unaddressed during the brief studio-based project, I decided to revisit the bunker and further research into this more unusual architectural typology. In pursuing freelance architectural journalism four years later (alongside working a full-time role as a practicing architect), these investigations led to a growing collection of Cold War nuclear bunker essays published in Scottish and UK architectural magazines – including a feature within the profession's own *RIBA Journal*[3]. These writings also led me to providing historical consultancy for television series and factual documentaries, and the additional byproduct of building a specialist network of heritage-based professionals at Historic England and Historic Environment Scotland (including leading experts like Wayne Cocroft) which in turn extended to include a cohort of dedicated bunker explorers as part of the Subterranea Britannica study group – more affectionately known to its members as '*Subbrit.'*[4]

Having approached this study from a background of architectural practice rather than a more traditional architectural history pathway, required additional efforts in developing the necessary skillset that were ultimately incorporated into my journalism explorations. This included learning new methods in archival study alongside fieldwork surveying and documentation. Likewise, volunteering at the Barnton Quarry Restoration Project in Edinburgh, provided experience of ethnographic studies by observing the painstaking restoration efforts of the community-led group. Given that Barnton, and to a lesser-degree Anstruther, appeared to exist in such proximity to Scotland's architectural realm (the site is 5 miles away from the RIAS headquarters on Rutland Square) yet almost ignored by the discipline generated an allure to begin robust study and press for a broader understanding of these obscure, even enigmatic, buildings, as a formal typology. The following thesis presents the results of this investigation.

[2] James Chapman, "The BBC and the Censorship of the War Game (1965)," Journal of Contemporary History 41, (2006) 75-94

[3] The RIBA Journal is a professional quarterly magazine issued monthly to all members of the Royal Institute of British Architects (RIBA)

[4] *Subterranea Britannica* is the UK-based society that conducts enthusiast-based explorations and research into Cold War nuclear bunkers (and other underground structures).

Acknowledgments

Owing to the mammoth task of this thesis, I feel it almost impossible to truly thank everyone who has contributed, even at times in the most modest of ways. I must start by expressing sincere gratitude to my supervisors, Prof. Florian Urban and Dr. Thea Stevens, for their patience, advice, and constant guidance throughout this thesis. Their continued support and availability during extended periods of pandemic-related lockdown provided me with much comfort and reassurance in times of uncertainty. Without their constructive criticism, encouragement, insightful suggestions, and detailed feedback in developing my central arguments and theories, this thesis would have been impossible.

Additionally, I extend thanks to Prof Steve Love, Dr. Robyne Calvert, Prof Johnny Rodger, and Dr. Raid Hanna for their invaluable comments on my annual progress reviews. I must also thank the contributions of Dr. Giovanna Guidicini, Dr. Helen McCormack, and Dr. Marianne McAra for facilitating my mock Viva. Finally, a great deal of gratitude is owed to the Viva exam board of Dr. Barnabas Calder, Prof Bruce Peter, and Prof Lynn-Sayers McHattie for the crucial feedback that ultimately shaped this thesis in its final form. Thanks to the Macintosh School of Architecture for offering me the Graduate Teaching Assistant elective in my second year, which enabled me to test my post-war concrete readings to year two History of Architecture and Urban Studies (HAUS) students.

The funding I received to complete this thesis was vital, for which I am eternally grateful. Firstly, thanks are due to the Arts and Humanities Research Council (AHRC) Doctoral Training Partnership Studentship for their scholarship funding and support throughout my studies. Likewise, the Research Support Grant from the Paul Mellon Centre allowed fieldwork at crucial sites in England in my final year.

Gratitude must also be acknowledged to Dr. Luke Bennett, a fellow 'bunkerologist', for his help and patience during my peer-reviewed paper published in the Journal of War and Culture Studies.
I am deeply indebted to the various others who offered their time in answering my unending research questions; including Wayne Cocroft of Historic England, Devon DeCelles, Allan Kilpatrick, and Kevin Munro of Historic Environment Scotland; Barnton Quarry Restoration Project for allowing my volunteering experience; *Subbrit* members for their assistance in finding under-reviewed archives and enabling the explorations of Cambridge bunker and Orford Ness; Dr. Karen Buchanan for providing extensive details on the Gairloch restoration and permitting a site visit during construction.

I would also like to thank the archivists at the National Archives (Kew), the National Records of Scotland, the Royal Institute of British Architects Collections, and the Historic England Archive. Lastly, I must mention the ever-friendly and helpful staff from bunker museums visited during fieldwork.

Finally, I would like to thank my friends and family (especially my mum) for their eternal support and motivation through yet another extended period of academic focus, which has had me tethered to my studio desk in Glasgow for months on end, rendering me absent from important gatherings and events.

CHAPTER 2. UNEARTHING THE DEEP-ROOTED ARCHITECTURAL FOUNDATIONS

CHAPTER 3. BRINGING NUCLEAR BUNKERS INTO THE MEGASTRUCTURE ARGUMENT

Abbreviations and Special Terms

AA: Anti-Aircraft

AAOR: Anti-Aircraft Operations Room

A-bomb: Atomic bomb

AMWD: Air Ministry Works Directorate

BBC: British Broadcasting Corporation

BRS: Building Research Station

BT: British Telecom

CCA: Cement and Concrete Association.

CRPC: Control and Reporting Progressing Committee (Air Ministry ROTOR programme)

DHS: Department of Health for Scotland (department within Scottish Office)

EGC: Emergency Government Controls

GEC: General Electric Company (bunker component manufacturer)

GPO: General Post Office (the old state-run postal service and telecommunications provider for Britain until 1969)

H-bomb: Hydrogen bomb

HE: Historic England

HES: Historic Environment Scotland (previously Historic Scotland)

HMSO: Her/his majesty's stationary office (Crown publisher)

HQ: Headquarters

LCC: London County Council

MEM: Midland Electrical Manufacturing (bunker component manufacturer)

MHA: Mott, Hay, and Anderson (civil engineering consultant)

MOW: Ministry of Works

MPBW: Ministry of Public Building and Works

NRS: National Records of Scotland

QPR: Quarterly Progress Reports (Air Ministry ROTOR programme)

RAF: Royal Air Force

RSG: Regional Seat of Government (Emergency Government Controls for England)

RIBA: Royal Institute of British Architects

ROC: Royal Observer Corps

ROTOR Programme: Britain's first air defence network orchestrated by the Air Ministry

SAB: Scientific Advisors Branch

The Scottish Office: The (now defunct) Scottish Office was a previous British government department which was replaced by the devolved Scottish Government in 1999.

SHD: Scottish Home Department (department within Scottish Office)

SHHD: Scottish Home and Health Department (department within Scottish Office)

SCC: Scottish Central Control (Emergency Government Controls for Scotland)

SOC: Sector Operations Centre (as R4-type ROTOR)

Subbrit: Subterranea Britannica (The enthusiast-based study group who include nuclear bunkers)

TNA: The National Archives

WW2: Second World War

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INTRODUCTION

Had the geopolitical tensions between east and west superpowers transitioned to physical conflict, Scotland lay squarely within the crosshairs of a Soviet nuclear strike. For if the Soviets had pursued an aerial bombing campaign as a means of delivering this strike, then Scotland's geographical positioning placed the country at far greater risk of unprecedented nuclear devastation than the rest of Britain. Given the shortest route and path of least resistance high-altitude Tupolev Tu-95 'Bear' bombers would fly southwards down through the Norwegian Sea to flank key NATO defences in Europe and had these bomber squadrons managed to evade air interception from Royal Air Force fighter jets or flak fire from the country's strategically positioned anti-aircraft batteries then the Shetland Islands was the first point of contact [5]. The first strike would likely isolate Scotland from the rest of Britain, allowing Soviet sea and land forces to follow with an amphibious landing and establish a base of operations for continued conflict. Here, Scotland would serve as a strategic platform to which the Soviet forces could branch southwards to Edinburgh and then London before ultimately pressing westward across the Atlantic Ocean towards America.

Current estimates suggest that over 1500 nuclear bunkers were constructed across Britain in response to this Soviet threat between 1950 and 1970[6]. From this stock more than 200 were built in Scotland, either above, within or below ground. Architecturally, given the shared design and construction orchestrated by the British government, nuclear bunkers built in Scotland are closely tied to English examples when considered part of a broader scheme. Thus, when studying Scottish nuclear bunkers, the two groupings cannot be entirely detached from one another. Throughout this thesis, however, I will focus on Scottish examples where possible and draw on similar English sites when necessary. Crucially, not only were these top-secret nuclear bunkers sanctioned by the British government during a post-war period of acute economic fragility, compounded by crippling material and labour shortages, but they were initially allocated priority over most other civilian architectural needs. In turn, this either reduced, delayed, or entirely cancelled essential public works programmes for housing, schools, hospitals, offices, and universities.

Unlike other civil realm architecture of the same period, the absence of vital information has perpetually impaired our fuller understanding of nuclear bunkers. In the absence of a thorough architectural history investigation, they have and continue to be deeply misunderstood in broader scholarly and non-scholarly research. More importantly, nuclear bunkers have been implicated as sites of aggression and violence and are thus misaligned as wasteful, redundant, and obsolete. My thesis counters these misconceptions by highlighting how these nuclear bunkers were not constructed by a foreign invader using abhorrent slave labour, nor did they adopt aggressive policies of requisitioning peacetime industries. Thankfully, while there were no nuclear attacks during the Cold War, these bunkers were far from wasteful, redundant, or obsolete, as they were continually occupied and maintained throughout their active operations. Despite uncoupling these complex context-specific histories and removing direct connotations of conflict, I acknowledge the potential issues of mnemonic memory, whereby local inhabitants may associate these bunkers with anxieties over nuclear attack during the sustained period of geopolitical tensions. While these associations can and should be retained to a certain degree, my thesis seeks to redress the current imbalance.

[5] Within the Cold War context North Atlantic Treaty Organisation (NATO) represented the western forces in support of the American stand-off with eastern Soviet counterparts.
[6] Subterranea Britannica. "Locations." Subterranea Britannica. [Accessed May 2, 2022]. https://www.subbrit.org.uk/locations/

While a range of disciplines commonly associate Cold War nuclear bunkers as purely functionalist responses to military aggression, they are, in fact, more architecturally aligned with human occupancy than previously considered. For instance, the advanced building systems that were installed within these autonomous environments to provide more comfortable conditions align much more with civil architectural spaces than the pre-1945 military bunkers. Likewise, the symbiotic relationships with concrete construction transformed the external aesthetics of nuclear bunker facades and shared knowledge transfers with other well-known Brutalist works of the civil realm. As my thesis argues, Cold War nuclear bunkers were very much of an architecture that did not reside within a separate vacuum but rather existed concurrently within the shadows of the civil realm – always present but never officially meeting. Although these bunkers largely remained hidden from public view, cold war events played out enacting a series of pendulum swings that directly and indirectly impacted broader post-war architecture, which, until now, have not yet been assessed.

Cold War nuclear bunkers within Scotland are now seeing more inventive opportunities for adaptive reuse. While historically this was more often constrained to specialist cold war themed museums or tourist attractions the sites examined in this thesis highlight that these buildings are far from obsolete or inflexible. Additionally, while previous heritage-based investigations are currently limited on the grounds of Scotland's statutory heritage policies, there are positive indications that more sites are likely to be studied and recognised for protection in future.

Before unpacking the research established in academic and non-scholarly realms it is important to first understand the origins of Scotland's nuclear bunker construction and active operations for this context was most unlike other architectural building types of the period on one major condition: top secrecy. The following section therefore outlines how Cold War nuclear bunkers were both birthed and retained within the shadows and any attempt at their exposure carried the very real threat of being branded a Soviet spy and charged with treason.

The Shadows: Deterrence through Treason

Nuclear bunkers, like other closely guarded state assets, were completely shrouded in a Cold War secrecy which has and will continue to stymie our fuller understanding of their architectural histories. The primary-source material (including all project correspondence, meeting records, and drawings) relating to their design, construction, and operation remained classified and were thus beyond public dissemination until the mid-1980s. Likewise, few photographs and even fewer film footage was permitted to capture these bunkers during construction or active service[7]. More importantly, physical access to these spaces was entirely off-limits to non-vetted members of public until these sites were eventually decommissioned and passed onto non-governmental ownership. In fact, outwith a core group of entrusted government departments, civilian consultants and contractors, Britain's massive network of highly classified nuclear bunkers largely remained within the shadows until 1963.

This all changed, however, when a radical faction of CND (Campaign for Nuclear Disarmament) activists – under the splinter group 'Spies for Peace' – broke into the Warren Row Regional Seat of Government bunker outside Reading, England, in February 1963. Once inside the RSG bunker, the group spent hours taking photographs and meticulously reviewing classified reports, maps, and phone directories they had found stored on site, eventually leaving with a suitcase full of information[8]. From this hoard of data, the group then self-published a six-page typewritten pamphlet titled '*Danger! Official Secret RSG-6*'!; issuing over 4000 copies to the press, hand-picked officials, and attendees at the 1963 Aldermaston peace rally. Despite this episode resulting in a staged demonstration outside the Warren Row bunker as well as revealing locations of other British bunkers, the culprits were never officially identified or arrested[9]. This security breach not only embarrassed state officials charged with the safeguarding of such sites but forced the government to officially acknowledge the existence and function of this countrywide network of top-secret emergency bunkers in a time of unprecedented foreign threat.

Importantly, as much as the 1963 Spies for Peace efforts had exposed these structures for the first time, thus generating a new public awareness of these buildings, subsequent investigations failed to reveal the full extent of nuclear bunkers hiding within the shadows. As expected, the state defended these top-secret bunkers as necessary evils; required to ensure the survival of government in the aftermath of a nuclear attack. Individual attempting any similar exposes, could jeopardise the security and efficacy of defensive assets, and ultimately place them at risk of being treated as spies. For under the Official Secrets Act (1911), anyone retaining, divulging, or publishing a 'sketch, plan, model, article, note, or official documents' relating to prohibited places like nuclear bunkers, without formal governmental approval, would potentially be accused of putting national safety at risk[10]. In essence, the Official Secrets Act served as a deterrence policy for anyone studying classified nuclear bunkers could be considered treason and if convicted, individuals risked serious jail sentences and criminal records.

[7] The exception of this being the photographs taken of the lesser-classified Royal Observer Corps (ROC) post bunkers.

[8] Richard Taylor, *Against the Bomb: The British Peace Movement 1958-1965* (Oxford: clarendon Press, 1988), p. 259

[9]Ibid., pp. 257-266, The Spies for Peace pamphlet became the first-ever printed account on Britain's Cold War nuclear bunkers and original copies are held by both TNA and NRS archives.

[10] See appendix 3 in David Hooper, *Official Secrets: The Use and Abuse of the Act* (London: Coronet, 1988), pp. 388-389

This deterrence policy is tracible to the early-1950s when Christopher Hutton, a civilian employee at the Air Ministry, was charged after taking home sketches and documents as personal research[11]. Although the case was swiftly dismissed upon Hutton returning the files, and he was never officially charged of being a Soviet spy, he still faced serious repercussions that would make others think twice about removing similar documentation[12]. Hutton's treatment may appear lenient, but his experience served a precursor to the case of Duncan Campbell 20 years later which has been expertly detailed by solicitor David Hooper in *Official Secrets*.

In 1976, while researching an article for the *New Statesman* titled 'the eavesdroppers,' Campbell, a professional journalist, was arrested and charged for allegedly breaching Sections One and Two of the Official Secrets Act; subsequently standing trial in 1979. This was serious, for if found guilty under Section one (reserved specifically for spies and saboteurs), Campbell faced a possible jail sentence of up to 14 years[13]. At the centre of this case, the prosecution accused Campbell of using sketches, maps, and data to amass a hoard of classified information on sites like the Ballistic Missile Early Warning System (BMEWS) at Fylingdales, Yorkshire, and other radar stations across Britain that was deemed of key use to a foreign state in acquiring definitive targets in the event of conflict with Soviet forces[14]. In response, however, Campbell's defence maintained that all of his evidence was legitimately obtained from openly published sources – rather than achieved through covert subterfuge to access classified government documents. Although the prosecution acknowledged this legitimate methodology, they stated that it was Campbell's robust piecing together of this fragmented 'jigsaw' which provided the Soviet Union with a 'jackpot' of evidence'[15]. Fortunately, after 42 days of trial (overall proceedings lasted 20 months) he was finally acquitted of the most serious charges and found not guilty of being a Soviet spy[16]. But even after the trial Campbell was still subjected to further detainment and invasive house raids by Special Branch (Britain's intelligence and counter-espionage unit) ten years later [17].

Crucially, in the words of Hooper, Campbell's treatment posed a 'dreadful warning to other like-minded journalists[18]. In fact, as Campbell's trial was widely reported at the time in the national press, it is entirely possible that his case, to some degree, deterred all disciplines from studying Cold War nuclear bunkers. For even gathering the most basic data from primary-source documents or exploring bunker sites researchers inadvertently risked being charged as Soviet spies, alongside custodial jail sentences, fines, and criminal records. These inherent dangers must therefore be acknowledged, for they most certainly deterred any architectural inquiry from the 1950s through to the 1990s, and importantly, such risks were never experienced in studying other civil building typologies of the same period.

This risk of treason served a very real warning which can in part explain why architectural historians would have consciously avoided studying nuclear bunkers. However, other disciplines appear seemingly undeterred such as fellow journalist Peter Laurie, who also made significant inroads to understanding Britain's nuclear bunkers after the 1963 Spies for Peace expose. While his widely referenced *'Beneath the City Streets'* only used open sources, Laurie still outlined his genuine

[11] Hooper, pp.356-357
[12] Ibid, pp.133-156
[13] Ibid.
[14] Ibid.
[15] Ibid.
[16] Ibid.
[17] House of Commons, *New Statesman and Mr Duncan Campbell*, 26 January 1987, vol. 109
[18] Hooper, p. 155

concerns over potentially breaching State secrets as written within the book's first few pages[19]. Moreover, seemingly undeterred by his previous trial, Duncan Campbell proceeded with his highly influential *War Plan UK*, which has since gone onto be one of the core publications used in nuclear bunker investigations[20]. The CND writings of Malcolm Spaven published an exciting directory in 1983 organised under Scotland's 32-council regions and featured concise biographies on nuclear bunkers[21]. Aside from these investigations into a heavily classified arena of Cold War secrecy, noteworthy accounts by specialist military histories like that of Derek Wood in 1976 also skirted the periphery of potential treason[22]. His renowned *Attack Warning Red* is often cited by nuclear bunker enthusiast groups and heritage professions alike. Wood's account used declassified information retrieved from primary-source documents alongside a collection of plans and sections of Royal Observer Corps (ROC) bunkers, but he importantly omitted any photographic evidence which would have undoubtedly risked national security if acquired by Soviet intelligence at the time of its publication. This robust account offered a platform for later expansions, such as bunker enthusiast Mark Dalton's expanded study of ROC posts[23]. Likewise, in *Air Defence of Great Britain* aviation historian, John Bushby, was the first recorded mention of 'rotor'. However, Bushby limited his ethnographic observations to a summarisation, as his invaluable detailing of the air monitoring operations would be of keen interest to Soviets uncovering how Britain's air surveillance system functioned during the Cold War[24].

What cannot be overlooked from these early accounts is that the authors carefully referenced declassified primary-source material and in turn generated new publications which then furthered discourse during the Cold War period. Despite this growing body of research however, contemporaneous architecture discourse still avoided any serious uptake. Mallory and Ottar's brief mention of Fylingdales ballistic missile defences in the latter pages of *Architecture of Aggression* is indicative of this limited discussion of Britain's Cold War fabric within architectural discourse[25]. Nonetheless, had there been sufficient interest propagated by architectural historians after the 1963 Spies for Peace expose, access to primary-source evidence was heavily impeded by state-imposed secrecy under the 'Thirty-Year Rule'; whereby key records pertaining to nuclear bunkers were closed for a minimum of 30 years after their initial creation[26]. As a result, files on the 1950s ROTOR programme were not declassified until the mid-1980s while others on the 1960s Emergency Government Control system followed some 20 years after. Similarly, although Peter Laurie's site investigation of an unnamed government bunker was eventually approved in 1970, most bunkers were entirely off-limits until the end of the Cold War[27]. Accessing these sites without serious risk of treason charges only became possible in the early-1990s when bunkers were officially decommissioned and sold on the open property market.

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[19] Peter Laurie, *Beneath the City Streets: A Private Enquiry into the Nuclear Preoccupations of Government* (London: Allan Lane the Penguin Press, 1970)
[20] Duncan Campbell, *War Plan UK: The Truth about Civil Defence in Britain* (London: Burnett Books Ltd, 1982)
[21] Malcolm Spaven, *Fortress Scotland* (London: Pluto Press, 1983)
[22] Derek Wood, *Attack Warning Red: The Royal Observer Corps and the Defence of Britain 1925 to 1975* (London: Macdonald and Jane's, 1976)
[23] Dalton, *The Royal Observer Corps Underground Monitoring Posts* (Bath: Folly Books, 2011)
[24] John Bushby, *Air Defence of Great Britain* (London: Ian Allan, 1973)
[25] Keith Mallory and Arvid Ottar, *Architecture of aggression; A history of military architecture in North West Europe 1900-1945* (London: Architectural Press, 1973)
[26] John Schofield, *Combat Archaeology: Material Culture and Modern Conflict* (London: Duckworth, 2005)
[27] Laurie, p*p. ii - iii*

Heritage Disparities with Scotland's Nuclear Bunkers

While the previous section has detailed the complexities of researching nuclear bunkers during the actual Cold War period, I now turn to outlining the exponential growth experienced with studies after the cessation of geopolitical tensions thawed between east and west powers. For after the threat of treason had dissipated by the end of tangible Cold War anxieties, nuclear bunker research could eventually proceed in a more formalised and structured manner.

Albeit mostly beyond a Scottish context, heritage-based disciplines (especially archaeology) have been bringing nuclear bunkers out of the shadows and into more formal studies since the mid-1990s. These analyses have mostly used a combination of fieldwork surveys and detailed archival review of national depositories in tackling this research[28]. It is essential to recognise that current studies, of both academic and non-scholarly approaches, are largely indebted to the earlier efforts of historian Nick McCamley and archaeologist Wayne Cocroft (alongside fellow Historic England (HE) colleagues and associates). McCamley, for example, was one of the earliest to study archival records in the initial period of declassification in-line with the above-mentioned Thirty-Year Rule. His first edition of *Cold War Secret Nuclear Bunkers* provided a comprehensive overview of Britain's Cold War nuclear bunkers which included detailed factual commentary on the ROTOR programme and Emergency Government Control bunkers[29]. Although Nick Catford's coloured photographs were not published in glossy high definition until 2010, a selection of black and white stills were important aids in visualising McCamley's archival narrative[30]. Above all, these longstanding efforts have made significant inroads to better our understanding of these Cold War heritage assets, and as a result, several sites have been afforded preservation status. Despite these commendable developments, new research is still required to expand Scotland's nuclear bunker narrative and establish more parity with the completed (and ongoing) studies within an English heritage context.

This disparity, inadvertently created over the last 20 years, must not detract from the 200-plus nuclear bunkers constructed in Scotland which are equally worthy of study. The current research gap within a Scottish heritage-based context is, however, more complicated, not by the aforementioned risk of treason, but by policies at a national level. For the specific heritage frameworks governing Scotland's built environment are very different when compared to those in England. According to Historic Environment Scotland (HES) staff, the central issue regarding Scotland's shortcomings is not due to a lack of interest, too few examples, or an unwillingness to expand studies[31]. Rather, the limitations are largely rooted in how the Scottish Government currently administers the country's heritage strategies[32]. For instance, Scotland's heritage frameworks are primarily driven by the broader interests of the public; whereby listed building proposals can be submitted through the 'Designation Application Forms' which, in turn, kickstarts the fieldwork and archival research required to determine if the suggested building merits listed building status. Outside of these public applications, a severe lack of resources limits the capacity of HES to pursue more focused studies on Scotland's Cold War nuclear bunkers[33]. Research priorities are instead balanced more evenly across

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[28] In this study, depositories include The National Archives (TNA), at Kew in London and Historic England, Cambridge.
[29] Nick McCamley, *Cold War Secret Nuclear Bunkers* (Barnsley: Leo Cooper, 2002)
[30] Nick Catford, *Cold War bunkers* (Monkton Farleigh: Folly Books, 2010)
[31] HES staff included designations officers Devon DeCelles and Kevin Munro, as well as archaeologist Allan Kilpatrick.
[32] Devon DeCelles and Kevin Munro (designations officers at HES), interviewed by author, February 18 2022.
[33] Historic Environment Scotland was previously known as Historic Scotland until its reorganisation in 2015 and is the statutory body responsible for recording, protecting, and conserving Scotland's built environment.

a broader range of architectural styles and historical movements which typically not only favour a pre-1950s timeline but buildings from the civil realm.

There is no scope within annual budgets to sanction targeted fieldwork or specific archival studies on Scotland's Cold War assets, in the meantime, HES is largely reliant on independent research from academia and enthusiasts to assist with designation entries [34]. One of the casualties of this limited research scope is tracible to an in-house thematic review produced by designations officer, Devon DeCelles. In 2007, DeCelles identified a range of existing Cold War installations that included nuclear bunkers of the ROTOR programme and Emergency Government Control networks[35]. However, this desktop-based scoping study was regrettably left unpublished, and there are no plans to revisit or expand the report. Yet the importance of why such studies are needed is best explained through the now-demolished Kirknewton bunker, which at one point, was the most valued political asset of the Scottish Office during the Cold War. Had there been a greater awareness of its unique architectural and historical value (both critical indicators for nominated designations within Scotland's heritage framework) prior to demolition then it is possible that the Kirknewton bunker could have been saved, preserved, or adaptively reused[36].

This situation is markedly different when considering similar Cold War bunkers extant within English-based heritage studies. Here, HE functions as the English counterpart to HES and has established a platform for continued expansion since the late-1990s, including an impressive number of helpful resources publicly available online for free download[37]. These outputs include a series of photographs taken across Cold War sites and archaeology survey reports such as that produced for the Cambridge bunker located on Brooklands Avenue**.** Unlike Kirknewton, HE successfully identified the unique architectural and historical value of the Cambridge bunker, which not only secured its listed building status, but ultimately influenced and altered an attempt to demolish the bunker in 2005[38]. Although these investigations tend to focus on sites located in England, the early research spearheaded by HE has helped create a directory of information through collectively organised community outreach schemes like the 'Cold War Project' and 'Defence of Britain Project'[39]. This archaeology-based fieldwork has steadily grown and recently progressed to initiate European exchanges (including the likes of online Webinar series) with a shared aim of integrating knowledge to better understand our remnant, and removed, Cold War-built environments[40].

Despite the existing limitations within Scotland's national heritage policy, the ongoing efforts by dedicated archaeologists and designations officers at HES are now experiencing more sustained

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[34] HES, "Former RAF Turnhouse Sector Operations Command centre and R4 ROTOR Sector Operations Centre, Barnton Quarry, Edinburgh." HES. http://portal.historicenvironment.scot/designation/LB52578 [Accessed June 7, 2022)

[35] Devon DeCelles (Designations Officer at Historic Environment Scotland), email to author, October 13, 2017.

[36] Historic Environment Scotland, Designation Policy and Selection Guidance, Historic Environment Scotland, https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=8d8bbaeb-ce5a-46c1-a558-aa2500ff7d3b [Accessed May 2, 2021]

[37] Wayne Cocroft, "The Cold War." Historic England. https://historicengland.org.uk/research/current/discover-and-understand/military/cold-war/ [Accessed January 2, 2022]

[38] Wayne Cocroft (Archaeologist at Historic England), email to author, 25 June 2018

[39] John Schofield, ed., *Monuments of War: The evaluation, recording and management of twentieth-century military sites* (London: English Heritage, 1998)

[40] Sean L. Kinnear, "Detailing Scotland's Nuclear Bunkers: From the Macro to the Micro" (webinar, *European Cold War Heritage*, Online, June 9, 2022)

progress with preserving Cold War nuclear bunkers. The more tangible results of these endeavours lie with the CAT A listed building protection recently awarded to Barnton Quarry[41].

Literature Context: A Paucity of Architectural Histories

It is important to note at the outset is that although the scope of this thesis is primarily concerned with a Scottish context, owing to inextricably linked histories with English case studies, the literature review has thus expanded accordingly to convey a combined narrative for nuclear bunkers across Britain.

Even with this scope significantly expanded however, discipline-specific architectural histories have and continue to elide inclusion within the scholarship of Cold War nuclear bunkers. In fact, from an extensive literature review, that covered a protracted timeframe, architectural histories are effectively missing from this growing body of research. Although urbanist Stephen Graham recently described how Cold War nuclear bunkers are now more widely available for exploration, architectural historians do not feature within the 'spectrum of groups' he accredits to these ongoing investigations[42]. Similarly, in her latest research paper, historian Silvia Berger Ziauddin, overlooks architectural history from an 'ever-growing' cohort of disciplines interested in studying nuclear bunkers[43]. This acute paucity is most notable when considering the absence of robust architectural histories from the aforementioned heritage-based work. Does this knowledge gap suggest a disciplinary divide?

This disciplinary imbalance was compounded in 2005, when archaeologist John Schofield went so far as suggesting that archaeology is and will remain the only available discipline capable of interpreting restricted sites held under the Official Secrets Act; which, as confirmed in the previous section encompasses Cold War nuclear bunkers[44]. While his multidisciplinary compendium *Fearsome Heritage*, co-edited with leading archaeologist, Wayne Cocroft, included exciting new contributions from artists, politicians, and sociologists, it fell short of incorporating the robust architectural histories urgently required for expanding nuclear bunker discourse[45]. Thus, by the time Luke Bennett contributed vital scholarship on ROC posts in 2011, he coined the phrase 'bunkerology' as a sub-theme of the urban exploration canon and described 'bunkerologists' as its practitioners[46]. What is particularly telling from Bennett's decision to form these portmanteaus is the obvious borrowing of from archaeological disciplines deeply invested with the study of nuclear bunkers. Under the umbrella of Bennett's 'bunkerology' scholarship has expanded further to include social and cultural geographer Bradley L Garrett's 'bizarre history' of Burlington bunker in Cosham, Wiltshire, England (Britain's Central Government War Headquarters for use in the event of a nuclear war)[47]. Through his urban exploration research methodology, Garrett, and his fellow explorers, spent a night

[41] based on assessment of historical and architectural importance HES classifies listed building entries under three categories (CAT) A, B, or C. CAT A being the most important and C the least.
[42] Stephen Graham, "Secret City: Burlington, Wiltshire" in Paul Dobraszczyk, Carlos Lopez Galviz, and Bradley L. Garrett ed., *Global Undergrounds: Exploring Cities Within* (London: Reaktion Books, 2016), p. 141
[43] Silvia Berger Ziauddin, "(De)territorializing the home. The nuclear bomb shelter as malleable site of passage" *Environment and Planning D: Society and Space*, vol 35, 4 (2017) 502-521
[44] John Schofield, *Combat Archaeology*, pp.36-37
[45] John Schofield and Wayne Cocroft, ed., *A Fearsome Heritage: Diverse Legacies of the Cold War* (Walnut Creek, California: Left Coast Press, 2007)
[46] Luke Bennett, "Bunkerology – case study in the theory and practice of urban exploration", *Environment and Planning D: Society and Space*, vol. 29, (2011), pp. 421-434
[47] Bradley L. Garrett, "Secret City: Burlington, Wiltshire" in Paul Dobraszczyk, Carlos Lopez Galviz, and Bradley L. Garrett ed., *Global Undergrounds: Exploring Cities Within* (London: Reaktion Books, 2016), p. 208

traversing the nuclear bunker's underground tunnels in electric carts they found on-site; photographing the escapade as they left[48]. Incidentally, like Duncan Campbell mentioned earlier, Garrett also stood trial for breaking and entering the Burlington bunker site under MOD ownership and being charged with the criminal damage done to the bunker's door upon entry[49]. It is this continued omnipresence of archaeology-centred disciplines which undoubtedly led to archaeologist Bob Clarke's most recent contribution to urbanist scholarship. The archaeologist's detailed account on Bristol's Cold War civil defence plans, published in *Cold War Cities,* convincingly posits nuclear bunkers within an academic context, however, the editorial decision to not include an architectural historian (more inherently associated with urbanism) is both symptom and cause of this continued paucity[50].

In truth, unlike the vast archaeology and heritage-based studies, there has been little uptake in the architectural history analysis of Cold War nuclear bunkers. David Monteyne's in-depth account of American Cold War civil defences and fallout shelters still represents one of the most definitive contributions that successfully integrates architectural histories of nuclear bunkers and the wider civil context[51]. Even though it was published ten years ago, there is still no commensurate example that tackles a Scottish (or British) context. Although my own peer-reviewed paper *Reopening the Bunker,* investigated the afterlives of four different Scottish bunkers (at Barnton Quarry, Gairloch, Cultubraggan, and Kirknewton) the piece was consciously written from a heritage-focused angle. As a result, this particular perspective inadvertently restricts a fuller integration within architectural history discourse[52]**.** Aside from passing references through other concrete and Brutalism histories, the most promising account to include nuclear bunkers within architectural history lies in Miles Glendinning's research[53]. Using a set of black and white archival photographs, Glendinning assembled a limited, yet tantalising glimpse at these enigmatic buildings that was published in *The Architecture of Scottish Government*. In this account, he even went so far as to say these bunkers were Scotland's 'most innovative government complexes'[54]. Glendinning cited the 1950s ROTOR programme as well as identifying two other bunker categories: emergency administration for the Scottish Office and monitoring nuclear attack[55]. However, given the underdeveloped architectural history at the time, Glendinning's study stopped short in revealing the full importance of Scotland's nuclear bunkers assigned as key political centres in a potential future of nuclear war.

Around the same time as Glendinning's forays, social theorist Paul Hirst (who maintained close ties with the architecture discipline until his untimely death in 2003) began to convincingly press nuclear bunkers towards more formalised academic discourse. His earlier lecture series delivered at the Architectural Association (AA) in 1997 had established a robust platform to bridge architecture and

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[48] Ibid.

[49] Ibid.

[50] Bob Clarke, "The city of Bristol: Ground Zero in the making", in *Cold War Cities: Politics, Culture and Atomic Urbanism, 1945-1965*, ed. Richard Brook, Martin Dodge, and Jonathan Boyd Hogg (London: Routledge, 2021), 55-76

[51] David Monteyne, *Fallout Shelter: Designing for Civil Defense* (Minneapolis: University of Minnesota Press, 2011)

[52] Sean L. Kinnear, Reopening the Bunker: An Architectural Investigation of the Post-war Fate of Four Scottish Nuclear Bunkers*", Journal of War and Culture Studies*, (2019), 75-96

[53] For example: Barnabas Calder, *Raw concrete: the beauty of brutalism* (London: William Heinemann. 2015), Adrian Forty, *Concrete and Culture: A Material History* (London: Reaktion books, 2013), Elain Harwood, *Space, Hope, and Brutalism* (New Haven. Yale University Press, 2014)

[54] Glendinning, M., *The Architecture of Scottish Government: From Kingship to Parliamentary Democracy* (Dundee: Dundee University Press, 2004)

[55] Ibid.,

archaeology silos by expertly framing the origins of European fortress design[56]. More importantly, Hirt's later revisit to these discussions as published in *Space and Power,* took a vital step in synthesising Cold War nuclear bunkers within formal architectural history scholarship. Here, he outlined east and west responses to the geopolitical threats, and he noted the nuclear bunker types specific to Britain (and Scotland) through the ROC, civil defence, and RSG framework. In line with Glendinning's writings this brief overview provided a key point to progress our understanding of nuclear bunkers from an architectural history lens. Although both Glendinning and Hirst had set vital primers for expanding these overdue architectural investigations there has been little uptake required to address historian Brian P. Jamison's academic call for greater interest, research, and analysis of Scotland's Cold War history[57].

Despite these limited contributions, some commentators have suggested that the architectural histories of nuclear bunkers have already been completed. For instance, although Nick McCamley's early work was vital in bolstering heritage-based research and understandings, in 2003 he claimed that there was 'little left to learn' on Britain's nuclear bunkers[58]. Similarly, in 2011 John Beck wrote that architectural histories had produced a 'staggering level of detail' on Cold War nuclear bunkers that further filled the knowledge gap identified by architectural historians Mallory and Ottar back in 1970[59]. Importantly, when cross-examining Beck's references, they were largely produced by archaeology-based studies and cover an extensive array of sites not especially relevant to this analysis. For example, the vast online databases and other secondary sources Beck cites, are predominantly concentrated on WW2-period structures; some of which, are not actually bunkers at all. Furthermore, Beck's latest revisit as published within *Landscape as War* maintains the view that Cold War nuclear bunkers have been fully interrogated[60]. However, despite an intervening period of ten years between these separate accounts, and given Beck resorts to re-citing much the same sources from his 2011 paper, we must recognise the acute shortage of relevant architectural histories inadvertently perpetuates the misconception that these research gaps have since been addressed.

Given the gaps in understanding nuclear bunkers from a robust architectural history lens have been left unaddressed for so long I argue this literature context has subsequently induced a latent effect. As a result, this has since contributed a series of key misunderstandings which in turn implicates Cold War nuclear bunkers with more problematic examples of entirely different and irrelevant contexts. For instance, John Beck's scholarship has and continues to attribute a strong inclination of violence towards these buildings. In describing the peaceful heritage preservation of nuclear bunkers as public museums, Beck highlights that the post-Cold War re-purposing helps to 'gut the site of the awful connotations that make it historically relevant in the first place'[61]. Beck continues by claiming how the 'implicit violence' of bunkers continues in perpetuity and thus 'remains unresolved'[62]. When investigated from a more robust architectural history lens, however, this thesis counters that Beck's "awful connotations" and "implicit violence" are not commensurate across all bunkers. Each site – whether it be in Scotland or England – must therefore be treated on an individual case-by-case basis.

[56] Lectures were conducted in two-consecutive parts: Paul Hirst, "The Defence of Places: Fortification as Architecture [part 1], AA Files, vol. Summer, no. 33 (1997), Paul Hirst, "The Defence of Places: Fortification as Architecture [part 2], AA Files, vol. Autumn, no. 34, (1997)
[57] Brian P. Jamison, ed. *Scotland, and the Cold War* (Dunfermline: Cualann Press, 2003), p.29
[58] McCamley, p. 280
[59] John Beck, "Concrete Ambivalence: Inside the Bunker Complex" *Cultural Politics*, 7 (2011)79-102 (p.94)
[60] John Beck, *Landscape as Weapon: Cultures of Exhaustion and Refusal* (London: Reaktion, 2021)
[61] Beck, p. 133
[62] Beck, p. 134

Importantly, although Britain's Cold War nuclear bunkers are largely exempt from the implications of violence and problematic histories inherent with pre-1945 military bunkers, Beck's argument has gone unresolved and has permeated further into scholarship such as that of architectural theorist Albena Yaneva. In *Five Ways to Make Architecture Political,* Yaneva argues that the bunker 'is a highly ambivalent building type; attractive and repulsive by the same token'[63]. Again, we see another instance from the unaddressed knowledge gaps remaining, whereby the ambivalences and repulsions are applied as broad-brush assumptions. In turn, such views fail to recognise contexts and distinguish that not all bunkers are connected to the same violence.

Akin to this misplaced assumption of violence a language of obsolescence has been widely used across studies which again restrict a fuller understanding of the historical functions and future re-use potential of nuclear bunkers. Since 1970, multidisciplinary writings have shared in a common trend that implies nuclear bunkers are defunct, redundant, and useless; or as Campbell put it, 'consigned to the scrapheap'[64]. In *Concrete and Culture*, Adrian Forty strongly associated concrete with conflict and quoted Virilio's observation that bunkers were an 'entirely obsolete function'[65]. However, given Forty is an authority in architectural history, his decision to draw on such language inadvertently compounds misleading assumptions and likewise further implicates nuclear bunkers with notions of waste.

Moreover, this language also lends nuclear bunkers to the ruination discourse cited in *Buildings Must Die* by Cairns and Jacobs where they quote 'ruin building loss of function' [66]. Visually, some nuclear bunkers may appear to align with ruin scholarship. For when viewed purely in aesthetic terms, certain sites possess apparent similarities with urban exploration spots, especially through their shared concrete materiality. When comparing Barnton Quarry bunker (specifically from its phase of abandonment) with St. Peter's Seminary, for instance, the decaying and crumbling Brutalist concrete of the now-disused theology college appears near identical to that of the nuclear bunker[67]. With a better understanding of its architectural history however, the comparison proves more complex. On the one hand, the concrete used in Barnton Quarry, as with most other nuclear bunkers, was technically more robust for defensive rationales and thus does not decay, spall, or weather in the same manner, or timeframe. Therefore, should be acknowledged for its superior technical properties which will in turn provide greater building lifecycles than parallel-running civil works. On the other hand, nuclear bunkers are inherently removed from other building types physically damaged by conflict as featured within *Buildings Must Die*. There are thankfully no Cold War nuclear bunkers anywhere in the world that evidence the battle scars of a nuclear exchange between two (or more) opposing forces. Whereas the concrete buildings damaged by the atomic attack on Hiroshima are the focus of ruination theory developed by Japanese architect Arata Isozaki. Although his 1968 photomontage, entitled "Re-ruined Hiroshima", superimposes abstract structures upon the devastated post-attack landscape, it is important to remember this scene was of a contextually specific period of 1945[68]. Therefore, when framing nuclear bunkers within problematic

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[63] Albena Yaneva, *Five Ways to Make Architecture Political: An Introduction to the Politics of Deign Practice* (London: Bloomsbury, 2017), p. 25

[64] Duncan Campbell, *War Plan UK: The Truth about Civil Defence in Britain* (London: Burnett Books Ltd, 1982), p. 263

[65] Forty, *Concrete and Culture,* p. 178

[66] Stephen Cairns and Jane M Jacobs, *Buildings Must Die: A Perverse View of Architecture* (Cambridge, Massachusetts: The MIT Press, 2014), p. 169

[67] See photographs in Diane M Watters, *St Peter's, Cardross: Birth, Death and Renewal (*Edinburgh: Historic Environment Scotland, 2016)

[68] Cairns and Jacobs, pp.175-177

academic discourse on violence, obsolescence, and ruination careful consideration for appropriate and accurate context must be retained. If not, the misunderstandings introduced above can and will inadvertently impact formal placement within architectural history and also carries the possibility of having deflected previous study from architectural history.

In summary, a lack of robust architectural histories on nuclear bunkers has led to a situation whereby other disciplines have filled certain knowledge gaps and developed scholarship through exemplary research. However, this process has inadvertently caused key misunderstandings which have since been left unaddressed. Some of these misunderstandings implicate all nuclear bunkers with irrelevant problematic histories and may even have discouraged research from architectural history throughout discussions.

Principally, I argue one of the main reasons for both research paucities and subsequent misunderstandings is due, in part, to what Paul Hirst described as histories 'written in splendid isolation'[69]. By this, Hirst argued that architectural histories and military histories tend to remain siloed from each other within their respective disciplinary realms, but they can be mutually beneficial when combined into broader disciplines[70]. Although Hirst ascribed this limitation as being evident with broader military histories in a wider sense, the concept of isolation has proved equally applicable to Cold War nuclear bunker histories.

As demonstrated in this thesis, an effective means of successfully bridging and navigating these separate research silos, can be achieved by integrating a much more diverse body of literature, typically well-beyond the peripheries of architectural history. My investigations have therefore identified and extracted key evidence from a vast spectrum of primary and secondary sources by making full use of archaeology and military histories. Moreover, incorporating a broader disciplinary range to include pertinent economics, politics, geography, cultural theory, art and design, has proved vital in developing central themes and narratives within this thesis. For example, the post-Cold War archival work of historians Peter Hennessy and Mathew Grant which outlines the Emergency Government Controls and other key aspects of civil defence has been vital in understanding Britain's political timeline surrounding nuclear bunkers[71].

Lastly, in the words of Andrew Leach, it would be 'foolish' to 'overlook the material gathered and processed by the vast number of enthusiasts, hobbyists, and dilettantes who share the academic's interest in architectural history'[72]. For beyond the academic realm, the combined fieldwork and archival research of study groups (especially *Subterranea Britannica)* has proved instrumental in documenting Britain's nuclear bunkers since the mid-1970s. Aside from establishing early methods of investigation, recording, and categorisation, members of this group have photographed certain examples of Cold War nuclear bunkers that have since been demolished, altered beyond recognition, or their physical exploration is no longer possible due to safety concerns or restricted by new site owners. This unique archive collection has and will continue to become an invaluable resource in future should the remnant nuclear bunkers across Britain suffer additional decay or deliberate demolition.

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[69] Paul Hirst, *Space and Power: Politics, War and Architecture* (Cambridge: Polity, 2005), p.182

[70] Ibid., p.184

[71] Matthew Grant, *After the Bomb: Civil Defence and Nuclear War in Britain, 1945-68* (Basingstoke, Hampshire: Palgrave Macmillan, 2010), Peter Hennessy, *The Secret State* (London: Penguin Books, 2003)

[72] Andrew Leach, *What is Architectural History?* (Cambridge: Polity Press, 2010), p. 3

Research Hypothesis

As Nancy Steiber says in *Rethinking Architectural Historiography*, 'the most interesting questions about architecture and its history are being posed by historians exploring problems and not styles'[73]. In positing the unprecedented bunker building as protection against the problem of nuclear conflict this thesis therefore permits a viable means of expanding Scotland's post-war architectural history from an entirely new perspective. In furthering the central hypothesis of this thesis, I draw on the exciting architectural developments and the hotly debated theories discussed during the period. I focus on three key channels that caused (simultaneously) beneficial or detrimental influences over both nuclear bunkers and civil architecture.

1. Consider how nuclear bunkers dovetailed with civil architecture to benefit broader post-war rebuilding.
2. Assess the shoehorning of nuclear bunkers into broader post-war rebuilding that resulted in far-reaching detriments to other civilian needs.
3. Re-frame how the as-built nuclear bunkers could have enriched architectural discourse on Megastructure theory and Brutalism, if they had not been secretly concealed from timely dissemination.

Case Studies

Given the importance of accurate typological recognition, it is essential to highlight the careful rationale behind the nuclear bunkers selected for this thesis. At root, from Britain's two main bunker-building programmes constructed from 1950 to 1970, I have chosen examples from the ROTOR programme and Emergency Government Control network as case studies to investigate my research hypothesis for the following three reasons. First, research limitations were imposed on available sites by the small quantity of surviving primary source data, alongside difficulties in securing access to explore and survey bunkers now under non-governmental ownership. Second, the bunkers constructed within this defined timeframe accounts for critical Cold War flashpoints; from the Berlin Blockade in 1949 to the Cuban Missile Crisis of 1962, as well as coinciding with the peak development of architectural discourse on Megastructure and Brutalism. Third, given these two primary bunker-building schemes were closely associated, this sampling permits an accurate and fair comparison of the similarities and differences between Scottish and English sites. In situations where access to sites in Scotland was not possible or in some instances, where sites like Kirknewton have since been demolished, I was able to draw on suitably available English surrogates that are representative of the broader British bunker stockpile.

Within this defined scope the chosen case studies are presented chronologically; beginning with bunker examples from the ROTOR programme and progressing to the Emergency Government Controls. Based on its strategic importance, Barnton Quarry was selected as a central case study as it continued to be repurposed throughout the Cold War in response to the changing threats across the 1950-1970 timeline. Additionally, where gaps in archival study or fieldwork surveying limitations presented further research problems, I was able to draw on Inverbervie and Anstruther bunkers, owing to the transnational standardisation evidenced across the ROTOR programme. Similarly, as nuclear bunkers dramatically evolved in the 1960s, their architectural dispositions shifted considerably, case studies were also included for the Scottish Central Control system and the English Regional Seat of Governments. From this sampling, I have chosen to focus on the now demolished

[73] Nancy Stieber, "Space, time, and architectural history" in Rethinking Architectural Historiography ed. Dana Arnold, Elvan Altan Ergut, and Belgin Turan Ozkaya (London: Routledge, 2006), p. 173

Kirknewton bunker and apply the very similar (surviving) Cambridge bunker to address the inevitable research gaps.

Research Methodology

In order to explore my central hypothesis, an historical methodology was applied to collect primary qualitative data. This approach consisted of two main methods of evidence gathering:

1. Archival study.
2. Fieldwork explorations of visited bunkers.

Upon concluding meticulous due diligence across Scottish and other UK archives, the National Records of Scotland (NRS) in Edinburgh and The National Archives (TNA) in London were identified as the two primary depositories[74]. It is also worth noting that the company holdings for Scottish contractor Sir Robert McAlpine, held at the University of Glasgow Archives, provided vital supporting evidence when analysing the nuclear bunker project teams.

My thorough analysis of these archives included the review of primary-source material generated by now-defunct central government departments; such as the Air Ministry, the Ministry of Supply, and the Ministry of Works (alongside its latter reorganisation into the Ministry of Public Building and Works). The most relevant files within the NRS holdings included documents generated by the Department of Health, Scottish Home Department, and the latter amalgamated Scottish Home and Health Department – all part of the old Scottish Office set-up (prior to the establishment of the new Scottish Government in 1999). All told, this data combines into a somewhat convoluted collection of papers which is incredibly difficult to navigate[75]. One of the main issues experienced in analysing these archive documents is that they were primarily written using an outmoded departmental jargon, mostly created by male civil servants of the post-war period[76]. After a lengthy period deciphering critical files of Britain's central government and the devolved Scottish Office departments, I made particular use of 50 plus bounded folders; each containing hundreds of fragile paper documents, tightly fastened together with treasury tags. Within these bounded folders I uncovered useful meeting minutes, official correspondence, progress reports, a small collection of drawings, and a large quantity of loose and informal notes. To assist this process, I employed a careful curatorial system of photographing the original documents and filing them in accordance with the thematics explored in the following chapters.

To mitigate the restricted access to central depositories in London (further exacerbated by the COVID-19 pandemic), I shifted focus to desk-based study of digital online archives and made use of post-war trade literature primarily held by the *AJ* and *AR* alongside key career data for nuclear bunker architects stored within remote RIBA archive collections[77]. Additional measures included using marketplaces like eBay to procure an extensive private collection of the primary-source

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[74] In this study due diligence included searching online Hansard entries for historical debates held in the House of Commons, investigating national and local authority depositories, private collections, and submitting Freedom of Information Requests (FOI).

[75] For instance, the Air Ministry works department, charged with the early 1950s ROTOR bunker programme, was latterly absorbed into what is now the MOD.

[76] The candid narratives from military personnel and civil servants revealed from these archive files is also worth mentioning. Alongside a dominant male-orientated language where very few women are cited is often, incredibly jarring and coincides with the broader literature of the post-war period – far-removed from the current progression of recognising gender equality.

[77] The RIBA Collections are mainly held in London between the RIBA Headquarters and the V&A Museum

literature produced by Central Government departments and published through the HMSO[78]. Extensive reviews of *Subterranea Britannica's* online photographic databases also permitted a visual framing of certain nuclear bunkers whilst still in their previous Cold War configurations[79].

Fieldwork was also an essential element of this thesis study, where important nuclear bunkers of special importance were selected and visited from the core case studies mentioned earlier. Here, I used photographic survey methods to record the interiors and exteriors of buildings; documenting concrete materiality and standardised component parts that were installed across both bunker and civil architectural schemes. From these surveys, I amassed a sizeable image gallery which proved extremely helpful in developing the key bunker case studies from the ROTOR programme and Emergency Government Control system mentioned above.

I was then able to use these more robust bunker profiles as vital cross-examination tools for studying other bunkers and equally important sites acknowledged within Brutalist discourse. For instance, in chapter 2, I deploy bunkers from the ROTOR programme to explore thematics of post-war industry innovations, construction project management, the architect's evolving role, and state-led reconstruction programmes. These case studies are retained in chapter 3 to review nuclear bunkers within the formal Megastructure theory and revisit salient points identified within the architectural discourse of the time. In chapter 4, I use Kirknewton (supplemented with Cambridge) to examine the development of Brutalist concrete during the 1960s and frame the subsequent industry innovations which later transferred into civilian architecture. Lastly, to conclude this thesis, I combine all case studies to assess the adaptive reuse merits of Scotland's existing nuclear bunker stock and determine further research needed on sites of interest.

Additionally, it is worth noting that an ethnographic research methodology was considered in the earlier stages of my PhD, in which research would be structured around volunteering at the Barnton Quarry restoration project in Edinburgh. However, problems were subsequently identified during due diligence which ultimately carried serious issues that could impact the study. For example, limited site access would have to coincide with the organised volunteering days which were only conducted on Saturday afternoons from 9am to 5pm. Under an informal management structure, I was acutely aware of potential problems should the restoration project suddenly change, stop altogether, or be seriously impeded by a multitude of unexpected events. Even in a reduced scope, to account for these potential issues, this approach would have fallen short of the long-term requirements typically held by ethnographic methodologies. Likewise, given the adaptive reuse merits identified in the Gairloch Heritage Museum project, another research approach briefly considered analysing the sustainability credentials of a Cold War nuclear bunker as it transformed into a multiuse building for the broader Highland community. However, despite the project adhering to formal architectural framework problems were identified in this alternative practice-based approach. For instance, the planned project dates of the scheme were entirely misaligned with my designated PhD research timeline, and the potential issues with this remote Highland location, ultimately discounted this alternative research methodology on practicality grounds[80].

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[78] This included procurement of primary-source government files published through (HMSO) that were publicly available for purchase during the Cold War period, declassified Air Ministry and Ministry of Public Building and Works documents, construction industry reports, alongside industry literature (such as Cement and Concrete Association pamphlets.) These sources were all purchased from publicly available marketplaces such as eBay and online bookstores.

[79] Subterranea Britannica, *Subterranea Britannica Collection*, https://www.subbrit.org.uk/collection/ [Accessed May 2 2018]

[80] The typical 12-month post-completion period of works (assigned for discovering any latent defects in the bunker's renovation) did not align with this study window and would therefore lead to potential contradictions of assumptions and hypothesis.

Research Problems

As mentioned above, the availability of primary-source documents detailing Britain's nuclear bunkers is entirely different when compared to most other architectural typologies. Their archival records have largely been destroyed, lost, or incidentally remain classified, restricting any in-depth study archive holdings to a limited quantity of relevant files. Unlike other examples of post-war civil architecture such is the case with social housing, schools, hospitals, or civic buildings, the same level of material (crucial to architectural historians) simply does not exist, or its access is still off-limits to any form of public dissemination[81]. Architectural historian Elain Harwood intimates there are enough original drawings of the Barbican Estate to 'fill a small van', yet, despite my thorough archival investigation there is only one original hand-drawn elevation and site plan found to have survived for the Kirknewton bunker[82]. Allegedly, there are more than 700 original bunker drawings produced for the ROTOR programme by the lead engineer Mott, Hay, and Anderson (MHA) who now operate as Mott MacDonald, but they remain secured within the company's private archives and public access is off-limits for the foreseeable future over security measures still in place[83].

In fact, the main research problems in studying these Cold War nuclear bunkers align more with military and archaeology disciplines rather than architectural history. For example, similar to the issues reported by archaeologist Bernard Lowry locating the relevant archival collections proved extremely difficult and time consuming due to how central government depositories are organised[84]. Nonetheless, this predicament is only applicable to the few relevant documents which have actually survived. As in accordance with the historical protocols in place across Britain's state archives files held in storage were subject to ongoing internal reviews. Meaning that documents could be retained and released through a secured public access system. If, however, for any reason, these files were not to be released to the general public, or kept for further review, they were subsequently destroyed[85]. Although a limited quantity of these documents are safely held at the National Archives (TNA), others remain in the National Records of Scotland (NRS), with Local Authorities, or have since been widely scattered through years of post-Cold War reformatting between the central UK government and devolved Scottish administration[86]. To mitigate these issues, I had to quickly decipher a way of understanding how the documents had been curated based on the internal codes and organisational frameworks of now-defunct departments. An in-depth understanding was devised through a rigorous archival strategy based on the historical origins of the bunkers themselves enabled me to use specific keyword searches precise to their historical typologies. Laborious and time-consuming reviews of these fragmented records typically contained notable gaps within the archival commentary. For example, while certain documents explicitly referenced original drawings, reports, maps, and appendices, physical copies were often missing from bound files.

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81 Barnabas Calder's research for *Raw Concrete*, benefits from more extensive material held by Denys Lasdun Royal Academy archive collection (including architectural drawings, documentation, and specifications for the National Theatre in London)

82 Elain Harwood, English Heritage, Barbican Centre Instagram live video Q & A interview as part of London History Day. Sunday 31 May 2020

83 Ibid.

84 Bernard Lowry, *20th Century Defences in Britain: No 12, Practical handbooks in archaeology* (London: Council for British Archaeology, 1995)

85 Air Historical Branch (Royal Air Force), email to author, September 12, 2019

86 While the National Archives (TNA) provide specialist guides and data sets to assist in some areas of Cold War study, there are currently none of use for nuclear bunkers.

Chapter Summary

Chapter 1. Fallout: Re-defining Scottish Nuclear Bunkers
Sets out the importance of acknowledging Scottish Cold War nuclear bunkers as a unique type of bunker architecture given their rapid evolution omits these buildings from a singular predefined solution. By framing the historical European precedents provides a rationale as to why WW2-period bunkers are intrinsically more problematic with historically issues over slave labour, foreign occupation, and the trauma of physical conflict – not applicable to Scotland. This cross-examination establishes a barometer to help measure bunker architecture as it matured to cope with new Cold War threats and required a more sophisticated solution. Concludes by highlighting how Britain's nuclear bunkers differed from similar NATO-allied American and West German examples, then narrows to frame contrasting aspects of Scotland's bunkers compared to specific English counterparts.

Chapter 2. Unearthing the Deep-Rooted Architectural Foundations
Performs a deep dive into the historical origins of the Air Ministry's ROTOR programme to examine in detail the various architectural attributes underpinning the scheme. Reveals the deep-rooted hidden relationships tracible between Cold War nuclear bunkers and civil architecture. Outlines the high-value afforded to these early projects, deemed more critical than all other post-war civilian requirements through state-backed patronage, Treasury finances, and resource priority. Highlights the unprecedented Cold War threats that required new input from civilian architects to facilitate viable solutions for nuclear defence. Concludes by framing a retrospective appraisal of the Air Ministry to counter argue misconceptions of poor architecture and cite key contributions through shared industry-leading project management, public works consortia, new town and planning stipulations, and efficient prototyping practices transferred out of nuclear bunkers.

Chapter 3. Bringing Nuclear Bunkers into the Megastructure Argument
Approaches Cold War nuclear bunkers from the retrospective lens of Megastructure theory as a legitimate way of understanding the colossal scale of the ROTOR programme and how the interconnected parts contributed to its successful functioning. This framing is split into two parts: macro-Megastructure (considers the individual bunkers as a Megastructure framework when combined), micro-Megastructure (views the individual bunker examples as Megastructure units). Outlines the vast network of Mains services that provided the permanent framework of megastructure theory and individual bunkers as replaceable units that plugged into the framework. Highlights the sophisticated climate controls to protect occupants from the extreme environment of a nuclear attack and its aftermath. In turn, this focus on comfort levels represents another paradigm shift in bunker architecture – away from the utilitarian conditions of pre-1945 military bunkers.

Chapter 4. Brutal Cold War Shifts
Illustrates how the paradigm shifts in Cold War threats induced a pendulum swing from the previous position of privilege through removing state patronage and pressing economic policies for the adaptive reuse of existing bunker stock. Through a process of 'decoding' Kirknewton's concrete form and aesthetics reveals an evolutionary change in bunker architecture, signalling the departure from historic single-cast monolithic concrete in favour of more complex assemblies, serving fallout protection and civic ornamentation. Argues that Kirknewton was intended as the Nuclear St. Andrews House for the Scottish Office to operate as a devolved government. Then frames the advanced camouflage techniques through blending bunkers into Brutalist contexts. Concludes with an epilogue detailing the very different post-Cold War afterlives of Kirknewton's demolition and Cambridge's listing, protection, and adaptive reuse.

Conclusion
Concludes this thesis by arguing that Cold War nuclear bunkers are very much architecture. When viewed holistically, the inextricable relationships between top-secret bunkers and the civilian realm suggests their proximity leaned towards a symbiotic relationship. Calls for continued future study, understanding, heritage protection, and further reuse of existing sites using three central recommendations: 'Robust Recording,' 'Heritage Policy Review,' and 'Adaptive Reuse Credentials.'

CHAPTER 1. FALLOUT: RE-DEFINING SCOTLAND'S NUCLEAR BUNKERS

1.1: Introduction

Although Paul Hirst appraised the earlier work of Paul Virilio in identifying the architectural beauty of Atlantic Wall bunkers, he took issue with how Virilio suggested that all bunkers, in architectural terms, are the same and quipped, 'a bunker is a bunker is a bunker?'[87]. For Hirst, in situ concrete construction was an inherently malleable building material that offered a multitude in alternative 'imagination and design' rather than being restricted to one pre-conditioned outcome[88]. From this perspective, Hirst argued that just as the case with other types of civil architecture countries could produce different bunker designs to suit national preferences and specific site conditions[89]. Although Hirst centres his critique on materiality, this chapter expands this inquiry to highlight the broader typological differences identifiable with Scotland's Cold War nuclear bunkers that were omitted from earlier discussions owed to State secrecy.

In this chapter I will highlight the fundamental need of removing Scottish nuclear bunkers from non-relevant narratives, including the problematic histories more applicable with Second World War examples in France. The chapter begins with a cross-examination of these historical bunker systems, focusing on the Atlantic Wall and the Maginot Line, to establish a more accurate understanding of inherent differences between Scotland's Cold War nuclear bunkers and these European Precursors. In tracing a lineage with Second World War Royal Air Force bunkers I then assess how Scotland's bunker architecture evolved when faced with new Cold War-period threats and how this has generated an entirely new bunker typology in response to nuclear weapons. As a result of this missing analysis, I firstly demonstrate how Scotland's Cold War nuclear bunkers can carry significant differences when compared with other allied-NATO as well as nuanced deviations that exist with the closer neighbouring English examples.

[87] Hirst, *Space and Power,* p. 213
[88] Ibid.,
[89] Ibid.,

1.2: *Bunker Archaeology* of the Atlantic Wall

As per the more recent study by geographers Garrett and Klinke, researchers framing Cold War nuclear bunkers often use Paul Virilio's *Bunker Archaeology* as a barometer for measuring bunker architecture[90]. However, what is often overlooked from this publication is that the Atlantic Wall bunkers, studied by social theorist Paul Virilio, are inherently different to Cold War nuclear bunkers as they belong to a particular historical context of Nazi occupation during WW2. Before unpacking these complex differences, it is helpful to first introduce a basic overview of these Atlantic Wall bunkers to better understand the historical example so often used in cross-comparisons.

After defeating France in June 1940, Adolf Hitler's military juggernaut – which had invaded and defeated Europe's Low Countries at an unprecedented rate – came to a sudden halt as it approached the English Channel. During this brief pause in ground offences the German Luftwaffe attempted to secure air superiority ahead of an amphibious assault but ultimately fell to defeat at the Battle of Britain (July to October 1940) and thus the planned invasion of mainland Britain was suspended indefinitely. Contrary to the innovative 'blitzkrieg' tactics of quick, progressive movement (which had proved a military success), Hitler instead reverted to an historical mode of static fortification to protect his western flank that directly faced Britain[91]. Based on outdated patterns of fixed linear defences Hitler entrusted a series of concrete bunkers to protect this new frontline as he shifted his military strategy eastwards with the invasion of the Soviet Union.

The Atlantic Wall, as it became known, was constructed from 1940 to 1944 through a series of 'War Directives' numbered 1 to 51; each containing instructions to build specific sections of the defensive line, similar to the assigned phases in a staged building programme. By its completion, at nearly 5,000km in length, the Atlantic Wall extended from the Spanish border up the northern tip of Norway and traversed the coastline of seven countries (fig 1.2). What is particularly interesting is that the Nazis not only publicly showcased the Atlantic Wall but also exaggerated its geographical coverage as a means of concealing its weakness and defensive gaps. Architect and scholar Rose Tzalomana has uncovered the mass propaganda behind this ruse within her thorough research outlining the posters, films, and other print media that were deployed as part of this phycological bluff[92].

Typologically, the Atlantic Wall's architectural framework consisted of nearly 12,000 bunkers with more than 700 standard designs (some of which were designed by Hitler himself) to function as observation towers, submarine pens, and coastal gun batteries[93]. Crucially, as well as these bunkers were to be shell-proof and fire-resistant, they also required a careful design that camouflaged into their surrounding landscapes to avoid visual detection from allied reconnaissance[94]. While Britain's WW2 camouflage strategies resorted to the literal use of scrim netting, foliage cover, paintwork schemes and the occasional 'droll' examples in which pillboxes were disguised as seaside carousels and railway wagons, the Atlantic Wall adopted much more creative architectural solutions[95].

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[90] Bradley Garrett and Ian Klinke, "Opening the bunker: Function, materiality, temporality", *Politics and Space C*, 37(6), (2019), pp. 1063-1081

[91] Blitzkrieg; meaning 'lightening war' is the military strategy couched in fast, progressive advancement and cross-collaboration of military ground and air forces.

[92] Rose Tzalmona, "The Atlantikwall: from forgotten military space towards places of collective remembrance" in *Ordnance: war + architecture & space*, ed. Gary A. Boyd and Denis Lineham, (London: Routledge, 2013), p. 140

[93] Colin Partridge, *Hitler's Atlantic Wall* (Guernsey: Castel, 1976), p.16

[94] Tzalmona, p. 143

[95] Hirst, *Space and Power,* p. 209

Examples of these approaches can be seen in Colin Partridge's black and white photographs which illustrate how exposed concrete finishes 'were frequently broken up with a textured finish' at sites without available earth cover[96].

Although Atlantic Wall bunkers were by no means the first instance of bunkers, and Paul Virilio was not the first to publish academic theorisations, *Bunker Archaeolog*y (not translated into English until 1994) has become the most commonly cited resource that considers bunkers within post-war architectural history. In 1962, architect Sholto Brooks, for example, studied the observation tower-type Atlantic Wall bunkers located on the Channel Islands for an article published in the *AR;* emphasising the good quality of *in situ* concrete construction complete with 'deeply impressed' timber board marks[97]. Others followed with similar discussion through the 1960s and 1970s, the architectural merit of the Atlantic Wall is more often than not credited to Paul Virilio[98].

Atlantic Wall bunkers were however, also tinged with problematic histories. Architectural historian Jean Louis-Cohen vividly recalls the shock he felt towards Virilio's seminars and early articles published in *Architecture Principe*[99]. For Louis-Cohen had previously considered bunkers and military buildings of Nazi Germany 'utterly excluded from the field of architecture', yet Virilio was elevating them as objects worthy of 'technical and aesthetic analysis'[100]. Although Paul Hirst also recognises the value of Virilio's work in discovering the 'architectural merit' of aesthetic qualities found in Atlantic Wall bunkers he does not ignore the chequered pasts as found within their historical provenance[101]. Similarly, Luke Bennett has also highlighted the significance of Virilio's investigations as positing military bunkers within broader architectural discourse[102]. In Bennett's research paper he described how Virilio's 'pioneering' work managed to navigate complex post-war understandings to appreciate an architectural aesthetic unique to these military bunkers[103]. Having established a starting point for considering bunkers within architectural history we must be mindful of the specific Atlantic Wall contexts, especially those which are enmeshed with problematic histories.

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[96] Partridge, p 45

[97] Sholto Brooks, History: War Time Watch-Towers, *AR*, 131, (1962) 288

[98] See, Keith Mallory and Arvid Ottar, *Architecture of aggression; A history of military architecture in North West Europe 1900-1945* (London: The Architectural Press, 1973)

[99] Jean-Louis Cohen, *Architecture in Uniform: Designing and Building for the Second World War* (Paris: Hazan, 2011), p. 9

[100] Ibid.

[101] Hirst, *Space and Power,* pp. 210-211

[102] Luke Bennett, "Concrete multivalence: practising representation in bunkerology", *Environment and Planning D: Society and Space,* 31, (2013) 502-521

[103] Ibid., p. 512

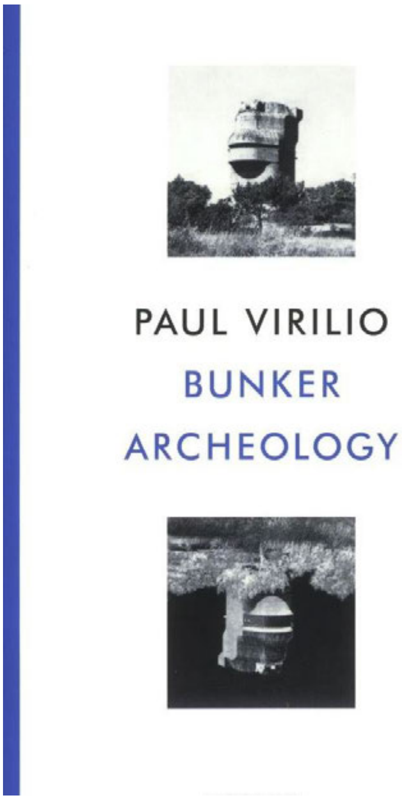

Figure 1.1: Paul Virilio's Bunker Archaeology (Virilio, Bunker Archaeology, 1994)

1.2.1: Problematic Bunker Histories

Within the specific context of the Atlantic Wall there are certain problematic aspects indelible to the WW2 bunkers which simply do not apply when considering Scotland's Cold War nuclear bunkers. At the more extreme end of the barometer, the Atlantic Wall construction inflicted huge costs (in terms of materials, forced labour, and displaced civilian populations) and resulted in the deliberate demolition of both architectural and natural landscapes. On a material level, it consumed approximately thirteen million cubic meters of concrete and nearly one million tons of steel during its construction, all forcibly requisitioned by the combined Nazi and French Vichy regimes[104]. In short, this supply chain diverted vast quantities of invaluable materials away from other civilian needs within Nazi-occupied territories. Moreover, in order to maintain this supply chain, the quasi-military Organisation Todt (OT) tasked with overseeing this works programme, employed civilian contractors 'under duress', who experienced mistreatment and poor working conditions[105]. At times in the construction process, these contractors were required to continuously pour liquid concrete mixes 'night and day' to achieve completion of vital sites such as the massive submarine pens required for nefarious U-boat operations against Allied forces in the Atlantic Sea[106]. As the war progressed, this was further exacerbated when the OT resorted to abhorrent use of forced labour. Here, more than one million persecuted peoples (including prisoners of war and enslaved peoples, interned within horrific concentration and labour camps) were forced to work in order to facilitate

[104] Partridge, p. 148.
[105] Forty, *Concrete and Culture*, p. 117
[106] Ibid.

the completion of Atlantic Wall bunkers amid growing concerns of an Allied liberation [107]. Additionally, its construction and operation strictly prohibited French civilians the basic right to access beaches and other urbanised locations previously used for leisure in peacetime[108]. Beyond restricting movement, vast sections of natural topography were excavated, and, in some cases, whole towns were removed in clearing worksites ahead of bunker construction. In the Netherlands, 135,000 Dutch civilians were forcibly displaced from Den Haag after one-third of the city's buildings were demolished to make way for sections of the Atlantic Wall[109]. Despite these accumulative costs, Albert Speer, the Nazi architect who was latterly in charge of OT, callously branded the Atlantic Wall a 'sheer waste'[110].

A lasting result of these wartime events can be found in what Rose Tzalmona describes as 'collective amnesia' which continued long after the war by civilian populations in peacetime France[111]. As Atlantic Wall bunkers carried traces of physical battle and were inextricably tied to deaths experienced during the D-Day landings post-war responses naturally turned to their erasure. However, some of these monolithic bunkers proved so robust that they were impossible to demolish without damaging the neighbouring civilian buildings. Thus, while some bunkers were initially buried as a means of hiding their existence, others – especially the colossal submarine pens – still remain untouched today, serving as tangible reminders of the cruel and abhorrent Nazi occupation.

Previous commentators have implied the concrete used in nuclear bunkers is identical to that found in the Atlantic Wall, but we must be careful with such quick comparisons given the broader implications of the post-war collective memory. Paul Hirst was one of the first to highlight the limitations of Virilio's account by challenging the short-sightedness on concrete materiality that was noted at the start of this chapter. Principally, this thesis argues how the nuclear bunker's evolution shed the homogenous 'monolithic character' historically cited in the Atlantic Wall in favour of more refined concrete assemblies which matched civil contemporary examples[112].

Although reference to *Bunker Archaeology* can benefit the analysis of Scottish (and British) nuclear bunkers, caution must be observed given the aforementioned issues attached to the very different contextually specific Atlantic Wall bunkers. Thus, while it is possible to borrow certain analytical tools from Virilio's study, such as the photographic documentation and measured surveys obtained though fieldwork in combination with archival investigations, due diligence should be carefully maintained.

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[107] Tzalmona, p. 147
[108] Ibid., p. 140
[109] Ibid.
[110] Albert Speer, *Inside the Third Reich*, trans. Richard and Clara Winston (London: Weidenfeld and Nicolson, 1970)
[111] Tzalmona, p. 140
[112] Virilio, *Bunker Archaeology,* 'monolithic' is repeatedly used throughout.

Figure 1.2: Atlantic Wall coastal outline (Mallory and Ottar, Architecture of aggression, 1973)

Figure 1.3: Atlantic Wall concrete camouflage 1 (Mallory and Ottar, Architecture of aggression, 1973)

Figure 1.4: Atlantic Wall concrete camouflage 2 (Mallory and Ottar, Architecture of aggression, 1973)

1.3: Peacetime Pre-cursor: The Maginot Line

While the Atlantic Wall has been used as a wartime case study for analysing nuclear bunkers another example that has been considered within architectural discourse is the French Maginot Line. Importantly, as with the Atlantic Wall the Maginot Line also belongs to a very different context of peacetime, yet previous scholarship has claimed that the Maginot Line both mirrored and influenced aspects of the Atlantic Wall[113]. Similar to my framing of the Atlantic Wall it is worthwhile outlining a basic overview of the Maginot Line to help better understand this equally context-specific precursor.

Based on traditional fixed fortifications that date back centuries of European warfare, the Maginot Line was designed as an impenetrable barrier to protect France from any future hostilities with Germany after the experiences of WW1. Constructed between 1929 and 1936 the Maginot Line stretched along the Alsace-Lorrain region, cut through regional France, and terminated in the Alps. Using one and a half million cubic meters of concrete, French military engineers designed a line of continuous casemates and fortresses that were integrated and camouflaged into the French terrain at depths up to 100ft below ground. What is particularly interesting is that like the Atlantic Wall, the Maginot Line was also publicly showcased throughout the press at the time of its creation. Architecturally, it was even touted as an entirely innovative defence system as published in French print media featured within Mallory and Ottar's *Architecture of Aggression*[114].

Crucially, despite the significant shortfalls in its design and building performance, the Maginot Line has also seen formal placement within architectural discourse. For example, in 1973, Mallory and Ottar argued, 'had it been erected for anything but this highly military purpose with all the attached secrecy; the Maginot Line would have been acclaimed as the greatest subterranean architectural and environmental experiment or achievement of our century[115]. Although these innovations were once hailed as 'luxurious in comparison with any fortification previously built,' it must be acknowledged that the Maginot Line carried significant shortcomings in regard to troop living conditions, space planning, and ventilation strategies[116]. For instance, alongside the awful smells, dampness, and poor lighting, the underground accommodation was uncomfortable and cramped. Despite being designed with sophisticated air filtration systems to protect troops against gas attacks, the forced ventilation strategy experienced severe operational flaws. For instance, poor consideration in design and a lack of thorough testing resulted in sporadic and violent gusts of air that either blew intensely or heated the internal spaces to unbearable temperatures, creating 'heavy' atmospheres in which stationed troops found it difficult to sleep[117]. Separately, these issues might seem insignificant; however, when considered together, indicates that these bunkers were not designed with the inhabitant's well-being, comfort, nor a pleasurable aesthetic. These basic conditions prove vital in my later examination of Scotland's much more advanced climates as design briefs shifted in Scotland's Cold War nuclear bunkers.

Beyond these design flaws, additional associations with problematic histories (like those experienced at the Atlantic Wall) have further impeded the Maginot Line's post-war public acceptance and architectural reuse. For instance, it is widely documented the Maginot Line represents an

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113 Lisa Haber-Thomson, "Fortresse Invisible: The Casemates of the Maginot Line in Alsace-Lorrain" in *Ordnance: War + Architecture & Space,* ed. Gary A. Boyd and Denis Linehan (London: Routledge, 2013), p. 193
114 Mallory and Ottar, *Architecture of aggression,* p. 93
115 Ibid.,p. 105
116 Ian V Hogg, *Fortress: A History of Military Defence* (London: Purnell Book Services, 1975), p. 130
117 Vivian Rowe, *The Great Wall of France: The Triumph of the Maginot Line* (London: Putnam, 1959) pp. 72-74, 91

'embarrassing episode' in French history in which the country is keen to forget[118]. Based on historical military tactics French planners expected German forces to directly engage the Maginot Line from the east. However, this strategy had grossly overlooked blitzkrieg tactics which, in the end, simply bypassed the fixed defences by carefully navigating the weakest section located in the Ardennes Forest on the northern flank that bordered Belgium. Although a perception of architectural failure was heavily misleading as noted in Paul Hirst's expert analysis, it did not stop a pointed critique on the Maginot Line from featuring in Egon Eis's *Forts of Folly*[119]. Ultimately, it is the indelible historical associations of WW2 conflict and Nazi occupation, which have directly impacted post-war reuse amid conscious attempts to forget, conceal, or destroy the remnant bunkers. Haber-Thomson describes a collective amnesia for these bunkers to be forgotten in a 'graveyard of architecture' and given their ridged underpinnings as a fixed-fortification, inflexibility has limited some bunkers to only see post-WW2 reuse as prosaic museums[120].

Figure 1.5: French troops receive 'sun lamp' treatment (Mallory and Ottar, Architecture of aggression, 1973)

[118] Haber-Thomson, p. 194
[119] Egon Eis, *The Forts of Folly: The History of an Illusion* translated by A. J. Pomerans (London: Oswald Wolff Publishers, 1959)
[120] Haber-Thomson, p. 194

1.4: WW2 Ancestry: RAF Fighter Command

If we are limited in our ability to draw on the above European precursors then what other examples can we use for a more accurate comparison? Historically, the closest pre-Cold War nuclear bunkers traceable within a British context are structures of the WW2 Chain Home radar network; specifically, the two primary Headquarters for both Bomber and Fighter Command. Although the Bomber Command bunker at High Wycombe, Buckinghamshire is inaccessible, given its current MOD use, I managed to visit the Fighter Command bunker located at Uxbridge, about 15 miles west of central London, to form the basic overview as set out below[121].

Initially operating as the No. 11 Group Operations Room for Fighter Command during the 1940s, the underground bunker is now run by Hillington Council, who conduct limited, yet insightful, tours open to the general public. Interestingly, not only did the Treasury gift the bunker to Hillington Council at zero cost, but it also awarded a £1m grant to assist in its restoration[122].The 40ft by 115ft (12.65m by 35.58m) concrete bunker lies 60ft underground and is accessed through an unassuming concrete plinth at ground level, which leads to a steep staircase of 76-steps that kinks near the bottom in the shape of a dog's leg for protection against bomb blasts. Designed by the Air Ministry Works Directorate (AMWD) ahead of construction in 1939 by Sir Robert McAlpine the bunker originally functioned as a crucial part of Britain's early WW2 air defences; particularly known for its contributions during the Battle of Britain[123]. A combined staff of 80 (male and female) RAF personnel conducted vital air defence work from within the double-height plotting room – tiered in section to allow uninterrupted views of the angled map table and wall-mounted tote board (fig. 1.6)[124]. Special sections of curved glass were installed at the upper viewing cabins so as to prevent glare and reflections from interfering with sightlines (fig.1.7). Upon completion, the bunker was connected to the mains grid for electricity and GPO telecommunications lines alongside being fitted with an air

Figure 1.6: WW2 RAF Operations room (Imperial War Museum)

[121] Royal Air Force, RAF High Wycombe: History, Ministry of Defence, https://www.raf.mod.uk/our-organisation/stations/raf-high-wycombe/[Accessed 22 April 2020)
[122] Hillingdon Council, *RAF Battle of Britain Enclave*, p. 1
[123] Hillingdon Council, *RAF Battle of Britain Enclave*, Cabinet Report (London: Hillingdon Council, 2015) 1-7, p.2 https://modgov.hillingdon.gov.uk/documents/s28853/07%20-%20FINAL%20Cabinet%20Report%20RAF%20Bunker%20Enclave%201.pdf [Accessed 22 May 2020)
[124] Information obtained from Battle of Britain Bunker Museum tour guide 2022

filtration system[125]. In 2005 Historic England afforded the Fighter Command bunker with Grade I listed building status in recognition of its historical importance during WW2.

Figure 1.7: WW2 RAF Operations room (Imperial War Museum)

[125] Ibid.

1.5: 'For Every Conceivable Purpose': An Unprecedented Architectural Problem

By outlining the precursors above, we gain a brief yet insightful understanding of how bunkers, as a form of architecture, were historically conceived, designed, and constructed, which, in turn, impacts their external aesthetics and internal spaces. In the context of my thesis hypothesis, I argue that the nuclear bunker was conceived as an entirely new type of bunker architecture; generated as a solution to the unprecedented problem of Cold War threats. However, my argument centres on the view that this did not result in one specific outcome and the remainder of this chapter addresses how the nuclear bunker's purpose varied extensively throughout its Cold War evolution and thus cannot be ascribed to a one-size-fits-all definition.

At this point it is important to note the words of architectural critic and historian Nikolaus Pevsner. As outlined in *A history of building types*, Pevsner quotes architect Henry van Brunt, who, in 1886, claimed that 'the architect, in the course of his (*sic*) career, is called upon to erect buildings for every conceivable purpose, most of them adapted to requirements which have never before arisen in history'[126]. When reframing this quote within Britain's post-war civilian context there are certain typologies that addressed new architectural problems; such as the expansion of Britain's infrastructure which required a series of new buildings that were conceived for specialist purposes. For instance, in assuaging Britain's energy demands new colliery buildings were conceived as vital infrastructure to support the expanding National Grid programme; including the deep-mining sites at Rothes (1957) and Monktonhall (1965) in Scotland, perhaps best-known from published photographs showcasing the massive concrete winding towers that projected skywards. As part of their progressive post-war design, Egon Riss, the chief architect of the National Coal Board in Scotland, integrated new surface-level welfare facilities that were required to address key health and hygiene problems identified across the mining industry[127]. Here, for the first time, wash facilities were incorporated at coal mines to enable miners the chance of cleaning themselves after a long shift working in filthy underground conditions. At the same time, Riss also conceived an 'artistic expression' for the architecture of colliery sites, to depart from functionalist restrictions and consciously celebrate these buildings as 'landmarks' which broadcasted mining's modern prestige[128]. Riss described these projects as inducing a 'sharp rupture in the patterns of monumental urban expression', yet when Scotland's coal mining industry collapsed towards the late-1980s most of these structures were deemed obsolete, considered unworthy of heritage protection, and were subsequently demolished[129].

In returning to the nuclear bunker, similar to the evolving colliery buildings, a new type of architecture was also required to suit specific purposes. However, within the sub-context of Cold War tensions, this solution centred on an unprecedented architectural problem as the world faced an existential crisis. Alongside the nuclear bunker requiring better staffing conditions compared with the pre-1945 bunkers, suitable buildings had to be conceived for use before, during, and after a nuclear strike; each bunker type driven by unique conditions of time and geographical contexts. While the historic military forts largely remained unchanged for 300 years, the nuclear bunker's rapid evolution utterly eclipsed this timeline across a much shorter period of only 20 years. Thus,

[126] Nikolaus Pevsner, *A History of Building Types* (London: Thames and Hudson, 1979), p. 9
[127] Miles Glendinning, Ranald MacInnes and Aonghus MacKechnie, *A History of Scottish Architecture: From the Renaissance to the Present Da*y (Edinburgh: Edinburgh University Press, 1996), p. 444
[128] Ibid.
[129] Ibid.

British bunkers conceived between 1950 and 1970 depended more and more on the architectural profession to cope with the developing problems and resulting requirements.

The nuclear bunker's rapid evolution falls squarely with Paul Hirst's theory on fortifications, where he reiterated the widely accepted military history that fortifications designed for pre-1945 problems ended when Allied forces breached the Atlantic Wall on D-Day. Crucially, Hirst suggested that 'fortifications in the sense of mass concrete structures and underground chambers did not disappear after 1945, but either changed their military function or their nature'[130]. As I argue in this thesis, the nuclear bunker evolution occurred on much larger scale which eventually resulted in a total reconfiguration of the bunker's core architecture; departing from a strict military utilitarianism and migrating toward a new civilian disposition.

1.5.1: The New Nuclear Threats

This paradigm shift neatly ties in with Hirst's insights into the wider sea changes that occurred during the nuclear epoch. In echoing Paul Virilio's earlier stance, Hirst stated that nuclear weapons had altered the 'fundamental principles of war', whereby politicians, rather than military generals, quickly realised that nuclear war threatened the 'end of civilisation'[131]. Especially after the Cuban Missile Crisis of 1962 (widely accepted as the closest event to actual nuclear confrontation), governments became 'profoundly cautious' in their respective geopolitical strategies, for they were acutely aware that miscalculation and unintentional escalations could inadvertently lead to all-out conflict[132]. For Virilio, this modified version of warfare meant it was no longer about the execution of war but rather its 'infinite preparation'[133].

Alongside influencing Cold War geopolitics, the evolution of nuclear weapons and the resulting counter defences, also carried direct impacts on bunker architecture. While the Limited Nuclear Test Ban Treaty, ratified in 1963 by America, Britain, and the Soviet Union, ended nearly 20 years of atmospheric nuclear testing it was ultimately too late[134]. For if we consider just the first half of this developmental period, the world had already witnessed the first atomic bomb (A-bomb) detonation of 1945, evolve into the Hydrogen bomb (H-bomb) by 1953. In terms of weaponry power this saw earlier A-bomb yields of 20KT significantly increased to more devastating payloads of 15MT[135]. In 1945, western militaries estimated that the Soviets could not develop a working A-bomb until at least 1952, however, these expectations were entirely exceeded in 1949 when the Soviet Union unexpectedly achieved its first successful nuclear detonation[136]. As a result of this fast-paced context, Britain rapidly conceived a new type of underground blast-proof bunker, which at first focussed on protecting the ROTOR air defence network (that will be discussed in the next chapter). In another swift succession, the Soviets subsequently produced their first thermonuclear H-bomb in 1953 inducing a further shift in bunker architecture. In response to this second event, Britain's

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[130] Hirst, *Space and Power,* p. 216

[131] Paul Hirst, *War and Power in the 21st Century* (Cambridge: Polity, 2001), pp. 36-37. See Paul Virilio and Sylvere Lotringer, *Pure War* trans. Mark Polizzotti, (New York: Semiotext(e), 1997), p. 24

[132] Ibid.

[133] Ibid., p. 92

[134] The Limited Nuclear Test Ban Treaty prohibited all test detonations of nuclear weapons, excluding underground experiments

[135] Note: A 'Kiloton' (KT) unit was equivalent to 1,000 tons of T.N.T. high explosive, whereas the 'Megaton' (MT) unit was 1,000 times more powerful which in turn was equivalent to 1,000,000 tons of T.N.T.

[136] Richard, N., Rosecrance, *Defence of the Realm: British Strategy in the Nuclear Epoch* (New York: Columbia University Press, 1968), p. 92

bunkers transitioned from protecting air defences to providing governmental buildings for the post-nuclear recovery and securing a continued means of state administration.

It is important at this point to note that whilst more recent scholarship has re-framed the ethics surrounding these nuclear tests, concerns were also raised at the outset of their deployment. For example, in 1948 Blackett's writings were among the earliest to highlight the moral dilemmas raised by the scientists involved with creating the A-bomb and debated the validity of the nuclear strikes on Japan as a justified military strategy[137]. Later, in the 1960s, CND members protested against the unethical existence and testing of nuclear weapons, primarily underpinned by deep moral objections as well as the devastating environmental and human impacts[138]. The recent scholarship of geographer Becky Alexis-Martin, however, has assessed the longer-term health implications experienced by the 'atomic veterans', including the soldiers, scientists (and their families) who had unknowingly been exposed to high doses of radiation during their involvement with Cold War nuclear tests[139].

Amid this unprecedented context of nuclear threats, there was no readymade architectural handbook available for designing buildings, however, we must acknowledge how planners made efficient use of the primary source data collected from these atmospheric tests. Beyond the harmful and extensive post-1945 experiments, the abhorrent wartime bombings of Hiroshima and Nagasaki were also used to gather vital data on the effects of nuclear weapons. Prior to 1952, as Britain had not achieved nuclear status, the government had to rely on secondary sources to better understand the likely problems expected from a nuclear attack. An earlier attempt to bridge this gap is tracible to the 1946 British Mission to Japan, where delegates from the Home Office, Admiralty, War Office, and Air Ministry Departments were dispatched to study the post-nuclear impacts on both Japanese cities[140]. Their fist-hand observations were subsequently published through the HMSO as *The Effects of the Atomic Bombs at Hiroshima and Nagasaki*[141]*.* As historian Mathew Grant notes, this primary account became the 'master document' which enabled Britain to understand the nature of atomic warfare and, in turn, form credible defences until the H-bomb developments gazumped protection suited for lesser atomic devices[142]. Crucially, this report was not only made available for public dissemination but proved an invaluable design guide in developing all of Britain's nuclear bunkers over the next decade.

Amongst the widespread devastation evidenced in this report, one of the more alarming finds was identified in the unimaginable damage caused to the human body by radiation. When studying the casualty reports, it was noted that invisible gamma rays released by both nuclear bombs proved 'very penetrating' and had passed through the victim's skin without visible injury, unlike typical wounds that were experienced with burns or lacerations resulting from heat and blasts[143]. Instead, patients that had been exposed to these gamma rays presented no obvious evidence but later suffered from a horrific illness (now recognised as radiation sickness), which, in many cases, led to

[137] P. M. S. Blackett, *Military and Political Consequences of Atomic Energy* (London: Turnstile Press, 1948)
[138] Christopher Driver*, The Disarmers: A Study in Protest* (London: Hodder and Stoughton, 1964), see for a more comprehensive primary-source account.
[139] Becky Alexis-Martin, *Disarming Doomsday: The Human Impact of Nuclear Weapons Since Hiroshima* (London: Pluto Press, 2019), p. 42
[140] The delegates arrived in November 1945 and spent the following month in both Japanese cities assessing the effects of the atomic bombs to conclude the potential results from similar attacks on Britain.
[141] Home Office and Air Ministry, T*he Effects of the Atomic Bombs at Hiroshima and Nagasaki: Report of the British Mission to Japan* (London: HMSO, 1946)
[142] Grant, p. 20
[143] Home Office and Air Ministry, T*he Effects of the Atomic Bombs at Hiroshima and Nagasaki,* p. 15

an excruciating death within weeks[144]. While the British Government was familiar in dealing with casualties from conventional WW2 weapons this invisible radiation posed unprecedented concerns. Over time, and after subsequent atmospheric tests, more information on the threat of radiation was fed into this less-conventional body of design knowledge, further developing the architectural evolution of bunkers**.**

Architecturally, what also exacerbated these concerns was that gamma rays penetrated 'considerable thicknesses of building and other material', and therefore posed 'new problems of protection'[145]. For example, the '*Manual of Civil Defence: Vol,1 Pamphlet No. 1 Nuclear weapons'* published in 1959 does not shy away from the grim realities of nuclear weapons and the incumbent complex design problems[146]. This primary source featured scientific tables for projecting the human casualties, horrific injuries, and extensive building damage. Uncensored photographs taken from American detonations at the Nevada test site depicted the frightening power of a nuclear explosion upon a typical domestic house[147]. Although it may seem unrealistic in hindsight, this official scientific data was robustly disseminated and contributed to preparing genuine attempts of optimum protection. Bunker design teams were supplied technical data by the Home Office Scientific Advisors Branch (SAB) on protection factors (PF) and overpressures to determine the required thicknesses of concrete and resistance for steel blast-proof doors and ventilation louvers. Furthermore, against the backdrop of new nuclear threats the problem with radiation and fallout subsequently impacted architectural design briefs. Specifically, this required new bunkers to endure lengthy lockdown periods – where personnel sheltered inside bunkers, without venturing outside until fallout had reduced to safer levels. This lockdown period lasted between 7 days (for smaller bunkers) and upwards of 21 days (for larger bunkers) and required additional emergency backup supply for the likes of power and drinking water)[148]. While many have argued these bunkers were futile attempts at defending against nuclear weapons, this new type of bunker was, in fact, based on the most updated primary-source scientific data available at the time. Therefore, was similar in many ways to the other building typologies of the civil realm.

1.5.2: Critical Miss: Analysis

Despite their robust scientific-backed design solutions these new examples of bunker architecture were missed from critical analysis at the time of conception. This overlooking was exacerbated further as the very existence of nuclear bunkers faced criticism on multiple fronts ever since being exposed by the Spies for Peace incident of 1963. One of the more prominent arguments levelled from a pro-CND perspective declared Britain's nuclear bunkers as 'boltholes for the privileged few' and called them safe havens for the likes of government officials to shelter from nuclear attack, while the general population was left to suffer[149]. In response however, the Conservative administration stated that 'any government would be failing in its duty if it did not make plans for a system of emergency control' in the unfortunate event of nuclear war[150]. Investigative journalist

[144] Alexis-Martin, *Disarming Doomsday* Subsequent research has linked additional instances of lifechanging and long-term health issues such as cancers from these abhorrent attacks.
[145] Home Office and Air Ministry, T*he Effects of the Atomic Bombs at Hiroshima and Nagasaki,* p. 16
[146] Home Office and Scottish Office, Manual of Civil Defence 1 (1): Nuclear Weapons (London: HMSO, 1959), for example see Table 2 'Immediate sickness effects of whole body ionising radiation on human beings', p. 11
[147] Ibid., Plates 12-15
[148] NRS HH51/260, Meeting notes, Central Government Controls in Scotland, 14 November 1961
[149] McCamley, p. 279
[150] Ibid.

Peter Laurie acknowledged the need for Britain's government to prepare for nuclear war and protect the nation as it would be 'criminally negligent' to do nothing[151].

Amongst the broader criticism aimed towards the nuclear bunker from CND activists and even members of the clergy, the architectural discipline appears to have elided comment. After the 1963, unearthing, these nuclear bunkers (which in some instances were over ten years old) remained entirely excluded from any form of architectural review. Importantly, unlike the American context, no British examples were ever reviewed within the professional industry press or national news outlets despite their architectural and technical merits outlined in this thesis[152]. Although these bunkers evidence some of the most advanced building services of the post-war period the limited focus on military architecture tends to frame the familiar WW2-period examples (outlined above) rather than the Cold War nuclear bunkers. This gap is understandable given their classified nature as mentioned earlier, but whilst this explains why detailed analysis was missing at the time, it does not account for the missing investigations after the Cold War; either within mainstream architectural practice or academic scholarship. As a result of this continued overlooking, there is a lack in understanding the different types of nuclear bunkers, how they functioned, and who inhabited them. This subsequently leaves Cold War nuclear bunkers exposed to longterm inaccuracies, including the recently reiterated assumption by Alexis-Martin that Britain's nuclear bunkers were built to 'protect the state instead of society' during nuclear warfare, essentially leaving the general civilian population to 'fend for themselves'[153].

Although architectural analysis has missed a critical opportunity to categorise and define their typological systems, other disciplines have successfully embraced this challenge for the nuclear bunker. Despite John Beck claiming the bunker 'defies categorization', UK heritage-based efforts have in fact been ordering these buildings into rational typological frameworks since 2003 (see literature review)[154]. Largely driven by HE, an archaeological-specific ordering has developed inroads to help us better understand the different types of nuclear bunkers conceived within different British contexts. As this archaeological ordering has expanded however, the various 'categories' and 'monument classes' adopted within this discipline-specific system does not quite marry with an architectural ordering[155]. For instance, the current heritage system has grouped radar, Royal Observer Corps, and anti-aircraft bunkers within the 'Air Defence' category, but these monument classes also encapture 'surface to air missiles' and 'fighter interceptor airfields,' which are entirely beyond my defined scope of an architectural framework[156]. Although this system has proved effective in heritage assessments for listed building considerations and has recently expanded to cross-examine Britain's Cold War nuclear bunkers against European and Soviet counterparts, it is not recognised architectural history. [157]

While these heritage-centred taxonomies are not wholly transferrable to architectural typologies, wider scholarship found in similar NATO bunkers provide promising comparisons. Both Tom

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[151] Laurie, p. vii

[152] Monteyne, pp. 213-214. American civil defence bunkers featured in press reports and televised ribbon cutting ceremonies to millions of viewers.

[153] Alexis-Martin, p. 75

[154] Beck, "Concrete Ambivalence: Inside the Bunker Complex", p.83. Note: Given the cross-border design standards for Britain's nuclear bunkers, English Heritage has included certain key Scottish examples into these typological frameworks.

[155] See table 4 in Schofield, *Combat Archaeology*, p. 125

[156] Ibid.

[157] Schofield, John, Cocroft, Wayne & Dobronovskaya, Marina, "Cold War: a Transnational Approach to a Global Heritage" *Post-Medieval Archaeology,* 55, (2021) 39-58

Vanderbilt and Stephen Graham contribute worthy accounts of the nuclear bunkers that served as US ballistic missile siloes, however the most robust analysis to date is by architectural historian David Monteyne through his critical analysis of American bunkers [158]. Here, Monteyne carefully recognised how different bunkers within a specific American context served different purposes and housed different personnel which in turn expressed different outcomes[159]. The Greenbrier underground bunker in Western Virginia, for example, secretly constructed beneath a hotel complex during the late-1950s, provided shelter space for US Congress politicians in the event of a nuclear attack. Alternatively, the Cheyenne Mountain Complex in Colorado, was a different type of bunker assigned the task of hosting military personnel of the North American Aerospace Defence Command (NORAD), similar in sorts to Britain's air defence measures. Thus, the need to organise nuclear bunkers not only enables a better understanding of what bunkers did, who occupied them, and how they looked, but also allows us to recognise the various context-specific responses that were elicited by shared Cold War threats.

Lastly, there is a further need to acknowledge when British Cold War nuclear bunkers should remain distanced with other NATO examples, such as the West German nuclear bunkers detailed in the scholarship of geographer Ian Klinke[160]. Had nuclear war occurred, the Marenthial bunker complex, built near Bonn (between 1965 and 1971), was designated as the emergency seat for the Federal Government of West Germany. This large underground bunker provided a far greater occupancy capacity for some 3000 government and military personnel than British counterparts, but the facility holds similar properties if we consider aspects of stated-backed funding and integrated building systems[161]. On the other hand, Marenthial's contextually specific origins also holds 'dark connections' dating back to WW2 Nazi bunkers. Importantly, Klinke outlines how the actual site for the Marenthial bunker harboured problematic histories that are directly linked with the use of abhorrent slave labour and Nazi concentration camps[162]. Crucially, this difficult past continued into the Cold War period given the Marenthial bunker was built by the same construction consortia directly responsible for building these concentration camps, alongside sections of the Atlantic Wall, and Adolf Hitler's infamous Fuhrerbunker in Berlin[163]. Crucially, these issues are entirely irrelevant in the context of Britain's bunker architecture of the Cold War and should be highlighted in future research.

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[158] See: Tom Vanderbilt, *Survival city: adventures among the ruins of atomic America* (Chicago: University of Chicago Press, 2010) and Stephen Graham., "Dark Tourism and Data Dumps: Reusing Missile Silos in the American West" in Paul Dobraszczyk, Carlos Lopez Galviz, and Bradley L. Garrett ed., *Global Undergrounds: Exploring Cities Within* (London: Reaktion Books, 2016)

[159] Monteyne, pp. 211-228

[160] Ian Klinke, *Cryptic Concrete: A Subterranean Journey into Cold War Germany*, (Hoboken, NJ: Wiley Blackwell, 2018)

[161] Ibid., pp. 75-83

[162] Ibid.

[163] Ibid.

1.5.3: Scotland's (Unbuilt) Fallout Shelters

Until now I have consciously kept Scottish and English nuclear bunkers under the shared umbrella of British bunkers, however, it is necessary to distinguish them apart for two main points of divergence in regard fallout shelters in Scotland and problematic sites in England.

Firstly, despite fallout shelter types of nuclear bunkers being omitted from this study it is worth highlighting Scotland's unknown history. When considering the global context of different Cold War nuclear bunker architecture, the importance of defining an accurate typological framework cannot be overstated. Crucially, unlike American or Swiss contexts, there was no stockpile of nuclear bunkers designed as mass public fallout shelters within Scotland.

Historians accept that the British Government did not pursue public fallout shelter programmes during the Cold War largely based on economic experiences with WW2 air raid shelters. For example, in 1938 Finsbury Council in London collaborated with the architectural firm Tecton and the structural engineer Ove Arup to develop communal underground air raid shelters, however the elaborate spiralling ramp, was deemed unfeasible and confined to drawn forms only[164]. The eight deep-level prototype shelters designed by Mott, Hay, and Anderson were constructed across sites in London, but these shelters soon transitioned for use by the Central Government and military chiefs rather than the intended civilian dwellers[165]. in fact, outwith the few public examples, most of the air raid shelters that were built were essentially a luxury reserved for private clients who could afford the personal expense. A prime example of this is tracible to the basement ARP (Air Raid Precautions) shelter at Great Westminster House commissioned by the Associated London Properties Ltd and built by contractor Sir Robert McAlpine.[166].

Simply put, in a repeat of the 1940s wartime context, the State still could not afford to provide communal fallout shelters for the civilian population. This financial burden of such a vast undertaking was revealed as early as 1949 when ARP studies concluded that providing nuclear shelter for Britain's entire civilian population was economically unviable[167]. What is currently unknown within this discussion, however, are the serious considerations tabled for establishing communal fallout shelters across Scotland during the 1960s. Initially, the Home Office established the Working Party on Communal Fall-Out Shelter (administered in Scotland by the Scottish Office) which assessed communal fallout shelter options largely based on transatlantic examples of their American allies. After the Cuban Missile Crisis of 1962, in tandem with the much larger endeavour sanctioned by American President John F. Kennedy, the British government backed a more concise 'pilot survey' to identify existing basement space suitable as communal fallout shelters[168]. In Scotland, this pilot survey sampled the four Local Authorities of Berwick, Rutherglen, Dundee, and Monifieth [169]. Alarming conclusions revealed that 40 percent of these Local Authorities contained no available basements at all for use as communal fallout shelters in the event of a nuclear attack. Further yet, from the Local Authorities that did have basement space, the pilot survey highlighted that only 20 percent of the basements surveyed met a defined standard set for sufficient provisions[170]. While this pilot survey appears confined to paper planning, we must acknowledge that

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[164] Mallory and Ottar, *Architecture of aggression,* p. 219
[165] Ibid., p. 237
[166] UGD 254/1/4/28 Block I, Westminster, Proposed Layout of Basement ARP Shelter, 28 June 1940
[167] Grant,p. 60
[168] NRS HH51/298, Restricted Appendix, 'The Pilot Shelter Survey' undated
[169] Ibid.
[170] Ibid.

these efforts are indicative of the palpable anxiety felt within the Central Government over an unprecedented threat of nuclear war, and the discretion of those surveyors.

1.5.4: Re-evaluating Aggression and Violence

Beyond these different provisions for fallout shelters as evidenced in allied NATO countries, certain disparities are also identifiable between Scottish and English nuclear bunkers constructed within a British context. Vitally, while it is yet to be highlighted, there are specific bunker types found within England that carry more implicit connotations of aggression and violence that are not applicable to Scotland's more defensively minded examples. For instance, as far as records indicate, no nuclear bunkers were ever constructed in Scotland for either storing nuclear weapons or conducting tests on trigger mechanisms, protective casings, or other weaponry components. Therefore, Scotland has no equivalent 'pagodas' like the well-documented pair that were constructed at the Atomic Weapons Research Establishment (AWRE) in Orford Ness on the Suffolk coast. Historically, the shingle spit, which stretches almost 10 miles, has been used as a classified testing ground as far back as 1915 but saw its active operations resume through to the 1970s given the ongoing Cold War threats and anxieties. Now recognised as a Scheduled Monument by Historic England, the specialist pagoda-type bunkers were part of a much larger masterplan of top-secret laboratories haphazardly dotted throughout the landscape.

Around the same time heritage disciplines began categorising Britain's Cold War structures, Orford Ness attracted a sustained and diverse academic focus upon its declassification and subsequent acquisition by the National Trust in 1993. In geographer Rachel Woodward's *Military Geographies,* she frames feelings of unease from her visit here; stating, 'this is not a celebratory site' but one of 'ambivalence' and 'doubt'[171]. Similarly, these remnant concrete bunkers were important research subjects for artist Louise K Wilson. Her temporary audio and visual installations titled 'A Record of Fear' responded to the site's violent history which bifurcated a breath-taking post-Cold War landscape[172]. Having visited myself, in the right weather conditions the stunningly white expanses of shingles is reminiscent of the Nevada proving grounds, infamous for conducting atmospheric nuclear tests. Moreover, Catherine Heatherington's recent scholarship positions these historical site secrets alongside elements of abandonment, decay, and natural ruination, atmospheric photographs show ample qualification for Cairns and Jacobs's ruination criteria (outlined in chapter 1) (fig 4.18). [173]. As the Orford Ness bunkers have drastically deteriorated since Woodword's first visit in 2004 few bunkers are deemed safe to explore internally: replacing issues in Cold War restricted access with contemporary health and safety concerns.

When categorising Scotland's nuclear bunkers, we must therefore be mindful of recalling these visceral feelings of unease. While we cannot simply ignore the notion of 'ambivalence,' we can however strike a measured balance which permits the implications of aggression and violence to be more accurately reflected, rather than applying broad-brush assumptions across all bunker architecture. Their typological origins were consciously rooted in military-aligned defence functions, but most nuclear bunkers built within Scotland have since continued their rapid evolution and as a result, shifted towards peacetime applications. This thesis therefore argues that their architectural configurations subsequently align more with civilian building types than pre-1945 military fortresses

[171] Rachel Woodward, *Miliary Geographies* (London: Blackwell, 2004), p. 149
[172] Louise, K. Wilson., "Notes on A Record of Fear: On the Threshold of the Audible." *Leonardo Music Journal* 16 (2006) 28-33
[173] Catherine Heatherington, *Reimagining Industrial Landscapes: Changing Histories and Landscapes* (London: Routledge, 2018)

and results in more diverse opportunities for adaptive reuse (discussed in the following thesis), as they are inherently more flexible.

Figure 1.8: Atomic Weapons Research Establishment bunker Orford Ness

1.6: Conclusion

As this chapter has shown, when reframing Scotland's specific Cold War nuclear bunkers alongside Paul Hirst's quip the nuclear bunker is not simply just a nuclear bunker but in echoing Hirst's view, also possessed the ability for producing a variety of different bunker types. Not only were there discernible differences between nuclear bunkers and pre-1945 military examples but when interrogated at greater length – outwith the restricted context of Cold War secrets – there are still variations across nuclear bunkers that do not reside under a one-size-fits-all definition. First, when compared to the well-known European precedents, I have shown that Scotland's Cold War nuclear bunkers should not be implicated with abhorrent slave labour under foreign occupation, nor should they be misaligned with latent issues of conflict given the core fact that nuclear war did not happen. Second, similarly when compared to other Cold War global contexts, I have explained that Scotland's Cold War nuclear bunkers are also notably different when considering the disparities with American fallout shelter programmes, and further divorced from the dark pasts shared with some West German examples and historical association with WW2 Nazi works. Lastly, even under the narrower cross-examination against English cousins, this chapter had revealed that were even nuanced differences with Scottish and English examples, where there are no parallel sites in Scotland that share the most aggressive architectural dispositions as the Cold War nuclear bunkers on Orford Ness bunkers; used to develop Britain's first nuclear weapons programme.

CHAPTER 2. UNEARTHING THE DEEP-ROOTED ARCHITECTURAL FOUNDATIONS

2.1: Introduction

In the previous chapter, I explained how Scotland's nuclear bunkers are representative of a new typological form of bunker architecture, conceived for defending against the unprecedented threats borne out of a specific Cold War context. Although different variations were constructed in Scotland as part of a British-wide network from 1950 to 1970, it was the Air Ministry's ROTOR programme bunkers that best reflect their deep-rooted architectural origins. As the largest, most complex, and most technologically advanced nuclear bunkers built across the Cold War, this chapter begins with an introduction of the various component parts that combined to forming the ROTOR programme.

My leading argument within this chapter is based on previous misconceptions that inadvertently lead to rejecting these nuclear bunkers as worthy buildings of architectural status. In reviewing *Cold War: Building for Nuclear Confrontation 1946 – 1989* for the *Architects Journal*, Edwin Heathcote described the publication (which captured ROTOR bunkers in detail) as an 'exploration of a world of non-architecture'[174]. Heathcote's critique continued to downplay any notion of architectural merit by stating the choice of 'building' as the book's subtitle instead of 'architecture' was 'no accident'[175]. As a parting shot, he simply declared the publication's content included 'some of the dullest building'[176].

By conducting a thorough architectural study of the ROTOR programme network this chapter will explore the deep-rooted architectural origins of these bunkers, where I determine the recognisable attributes typically shared across civil architectural schemes. This will begin by outlining the state-patronage assigned to these nuclear bunkers and examine how they fared against competing civilian schemes in a post-war context of crippling shortages and limited finances. I will then detail the vital contributions made by specially vetted civilian architects faced with unprecedented design problems of the Cold War period and highlight how architectural spaces, building fabric, and concealment strategies changed as a result of the broader typological evolution. This chapter also reveals how industry-leading project management structures and advanced prototyping methods benefited the successful completion of these bunkers whilst also generating key channels of knowledge exchange with the civil realm. Lastly, this chapter revisits the much earlier criticism levelled at the Air Ministry's 'poor' design standards and provides a retrospective counterargument which could not be conducted during the period of Cold War tensions.

[174] Edwin Heathcote, 'Cold comfort form'. *AJ,* 219 (2004), p. 53
[175] Ibid.
[176] Ibid.

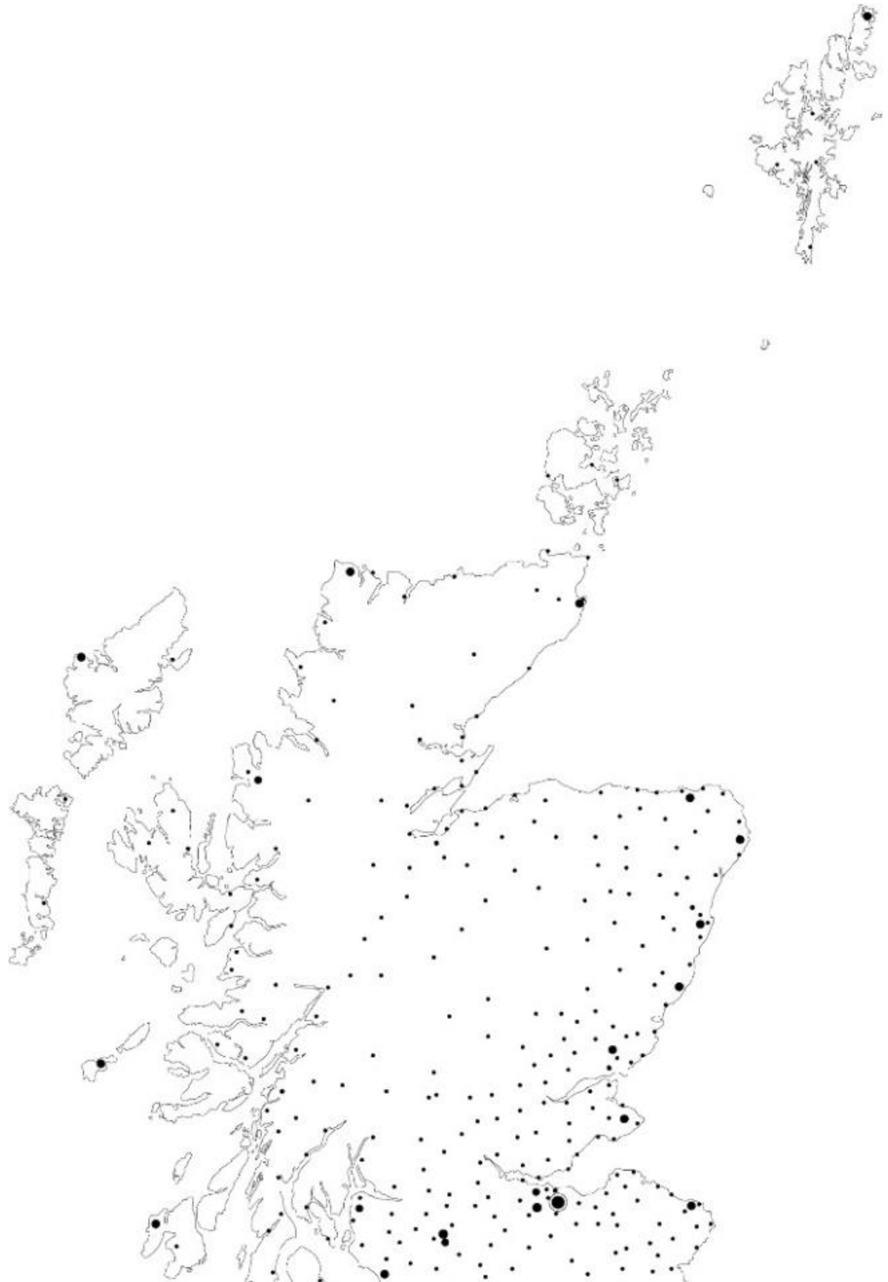

Figure 2.1: Map showing estimated ROTOR programme bunkers constructed in Scotland.

2.2: The ROTOR Programme

At this point it is worthwhile to first outline the fundamental parameters specific to the ROTOR programme. In 1948, physicist P.M.S. Blackett noted the importance of air superiority in nuclear warfare, citing that the countries with control over their airspace and a viable means of defending it placed them at a significant advantage over others[177]. The following year saw the newly elected post-war Labour government commission the ROTOR programme as a top-secret air defence system; providing Britain with comprehensive monitoring and detection during the early period of Cold War tensions. An extensive network of integrated radar stations, operations rooms, and observation posts operated under this umbrella to monitor British airspace for encroaching Soviet bombers. In the event of a nuclear attack from above, flight data (recorded through the ROTOR programme network) would be issued to assist the intercept or down the incoming enemy aircraft armed with devastating nuclear payloads. These separate elements were incorporated into a series of standardised nuclear bunkers constructed using in situ reinforced concrete; either underground, semi-submerged or surface-level) to protect the ROTOR programme's operation. Upon completion, these bunkers stretched from the Shetland Islands (200 miles northeast of the Scottish mainland) to the Portland Bill (140 miles southwest of London), providing a fully integrated air defence system for the whole of Britain.

Crucially, unlike the earlier military fortifications outlined in chapter 1, the new ROTOR programme departed from the conventional 'continuous linear fortifications' – such as the Maginot Line and Atlantic Wall – and adopted a new defence pattern more suited to unprecedented Cold War threats[178]. The concrete gun batteries, pillboxes, turrets, troop garrisons, and field obstacles deployed before 1945 were ultimately abandoned in this new epoch. Instead, the ROTOR programme based its innovative formation on the highly effective Chain Home radar network, which had proved vital to Britain's defence during WW2 – mainly known for its successful operation during the Battle of Britain (1940)[179]. This historical precedent allowed a starting point for the ROTOR programme's design; based on a more flexible scheme of dispersed nodal points, typically positioned around Britain's coastal crust with triangulated sites strategically inland. Air coverage was carefully planned around a system of redundancy; if a location had been particularly devastated and knocked out of service by a nuclear attack, the neighbouring region served as the backup.

The ROTOR programme was devised in top-secret by a small cohort of Whitehall-based defence chiefs, Cabinet staff, and civil servants. Although it was primarily orchestrated by the Air Ministry, it also received input from the Ministry of Defence (MOD), the Ministry of Supply, the Ministry of Works and, to a lesser extent, the War Office[180]. Specialist consultants were additionally sourced from the civil realm to assist with key elements and together this combined project team produced a set of standardised building types, later tendered to civilian building contractors, sub-contractors, and suppliers. For the most part, this standardised model permitted ROTOR bunkers to be issued on a transnational basis and facilitated the cross-border completion. Moreover, this setup allowed the same bunker designs to be used in Scotland and England, meaning the R4-type bunker at Barnton

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[177] Blackett, *pp. 119-122*
[178] Hirst, *Space and Power*, p. 206
[179] Colin Dobinson, *Building Radar: Forging Britain's Early-Warning Chain, 1935-1945* (London: Methuen, 2010), presents a comprehensive account of pre-Cold War Chain Home radar development.
[180] The (now defunct) Air Ministry was a Whitehall-based department of central government located in London who were responsible for Britain's Royal Air Force (RAF) works programmes until 1963. To maintain consistency, I have continued citing the Air Ministry as the central client for the ROTOR programme throughout this study.

Quarry, Edinburgh, was of the same standard as Kelvedon Hatch located at in Essex, London; the R3-type bunker at Anstruther matched Wartling near Eastbourne on the southern English coast, and the R1-type bunker at Inverbervie paralleled Portland, Dorset. However, the additional complexities experienced in Scotland do not always match those encountered south of the border. Firstly, building on remote sites at both the Western and Shetland Islands incurred additional logistic issues for transporting labour and materials. Here, challenges were so extreme that some cases required landing craft previously used at the D-Day landings to assist transit. Also, these locations presented much harsher climates with heavy snow and gale-force winds, causing dangerous delays in building programmes. Furthermore, on a humanity level, the personnel assigned to these remote locations constructed bunkers without any relief from nearby emergency services; in the event of a fire, on-site accident, injury, or illness, operatives were without immediate access to rescue and medical treatment.

As mentioned in the previous chapter, the importance of framing Scotland's nuclear bunkers within architectural history lies in placing them within a more accurate typological framework. To do so, we must understand the Scottish examples within Britain's holistic ROTOR programme framework. In Scotland, these bunkers stretched from the Scottish-English border to form a concentrated cluster on the east coast – facing the threat of the then-Soviet Union. Bunkers then extended the entire coastal crust; including Saxa Vord in Shetland, Aird Uig, Scarinish, Kilchiaran, and Gailes covering the western flank (fig 2.1.). Within this framework, there was a sub-typology that included 15 different ROTOR 'R' type bunkers (prefixed R1 to R30), Anti-Aircraft Operations Room (AAOR), Royal Observation Corps (ROC) Group Headquarters, and the hundreds of clustered ROC posts[181]. Widely accepted as the main elements within this framework were the R4-type ROTOR bunkers known as Sector Operations Centre (SOC). These boasted the most significant building footprint, largest internal space, and were fitted out with the most technologically advanced building systems (see chapter 3). Typically, an SOC was constructed 100 feet below ground and housed a staff of over 300 (male and female) personnel. These bunkers functioned as the lynchpins of the ROTOR programme and performed the crucial task of accumulating all incoming data from all other R-type ROTOR bunkers and ROC networks before coordinating retaliation responses[182]. While a total of six SOC bunkers were built across Britain, the only example constructed in Scotland was at Barnton Quarry, Edinburgh.

Most other R-type ROTOR bunkers functioned as 'operations blocks,' housing radar and communications equipment largely run by RAF and GPO personnel[183]. Except for a few exemptions, these bunkers were predominately constructed 60-100ft underground (the agreed depths for optimum nuclear defence and concealment) and were typically in a rectangular form, built with monolithic reinforced concrete. Cast in situ builders appointed on the ROTOR programme borrowed a technique used in subterranean transport systems known as 'cut and cover,' which, interestingly, still remains 'the most economical construction method' for underground projects[184]. An aerial photograph of the bunker at RAF Trimingham, Norfolk, shows how these buildings were positioned at the bottom of an excavated hole (cut) and capped with soil and grass (cover)[185]. Entry was gained through a concealed tunnel below a guardhouse, designed to mimic a vernacular-styled bungalow

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[181] Although AAOR are often excluded from the ROTOR programme this thesis considers these bunker types a crucial part of the holistic operations.

[182] Cocroft, Thomas, and Barnwell, *Cold War: building for nuclear confrontation, 1946-1989*. (Swindon: English Heritage, 2003), p. 90

[183] The term 'Operations room' features heavily within Air Ministry archive documents within the 'AIR' series

[184] Services, Cut and Cover, WSP, January 2, 2021, https://www.wsp.com/en-GB/services/cut-and-cover,

[185] Cocroft, Thomas, and Barnwell, p.90. See Figure 5.5.

(which shall be explained in fuller detail later), and a single emergency escape was located at the bunker's rear. Although each bunker was required to perform a unique function, they all shared standard (near-identical) layouts. As seen in plan and section, the main corridor was set centrally on each floor, acting as a spine and circulation route with cellular rooms located perpendicular on either side, and a double- or triple-height space (known as the central operations room or operations well) that functioned as the bunker's nucleus[186]. These bunkers were interconnected with an advanced communications network and plugged into the National Grid, enabling access to electricity, water, and sewage services; the very same public utilities that simultaneously supplied modern housing, schools, and hospitals in the civil realm (see chapter 3).

Previous evaluations have perpetuated that these bunkers would be useless in the event of a real nuclear attack and continue to fuel assumptions of futility and waste. However, the design and construction of ROTOR bunkers was in fact based on scientific data gathered from primary reports at the time. Although they were designed on the limited information known at the time for the earlier, smaller yields of A-bombs, these bunkers were genuinely believed to offer the best protection against nuclear threats. Yet some of the more critical commentators have recently doubted the reliability of nuclear bunkers entirely. For instance, in describing the nuclear attack on Hiroshima, geographer Becky Alexis-Martin outlines how concrete was 'reduced to rubble' and 'underground air raid shelters with earth-covered roofs were destroyed'. However, this is not entirely true when viewed from an architectural history lens[187]. For when reading the official reports conducted three months after the atomic bombings, such as T*he Effects of the Atomic Bombs at Hiroshima and Nagasaki*, photographs show extensive damage to both Japanese cities; but there is also evidence that concrete structures (including the famous dome marking the A-bomb's detonation epicentre) and buried shelters survived and remained intact[188].

We must remember that the much more powerful H-bomb did not exist at the time of designing early ROTOR bunkers, yet they still included reinforced concrete walls, floors, and ceilings 10 to 15 feet thick to protect against A-bomb bomb blasts, heat, and radioactive fallout (as seen from the original civil engineering drawings by MHA (fig 2.2 and fig 2.3)). From a technical perspective, these bunkers were considerably thicker than most WW2 examples purposely built in Scotland or Britain, and in fact, this reinforced concrete was more similar to the U-boat submarine pens built as part of the Atlantic Wall (see chapter 1). Later analysis of the Scientific Advisors Branch (SAB) in 1960 indicated that certain ROTOR bunkers, like Barnton Quarry, provided a viable solution against nuclear ordnance[189]. For example, during Barnton Quarry's 1960s alterations, the SAB advised the SHD (Scottish Office) that the underground concrete bunker itself would sustain 'no damage' from a 10MT nuclear burst on Edinburgh [190]. However, given the peak overpressure of 17 p.s.i., which was expected with a 10MT device, it was surmised that damage might occur to the external doors and ventilation outlets closer to surface-level[191].

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[186] Ibid., See pp. 88-89, 103
[187] Alexis-Martin, p.20
[188] Home Office and Air Ministry, T*he Effects of the Atomic Bombs at Hiroshima and Nagasaki*
[189] NRS HH51/260, Request made to Scientific Advisor's Branch of the Home Office inquiring about the necessary protective factor at Barnton Quarry, 1 September 1960
[190] NRS HH51/260, SAB assessment issued to SHD, 31 October 1960
[191] NRS HH51/260, Letter to SHD from Home Office, 24 November 1960, Peak overpressure is the maximum pressure of blast waves above normal atmospheric levels

Beyond this innovative layout departing the linear pattern, the ROTOR programme's construction timeline must not be overlooked[192]. Previous research has placed less emphasis on its peacetime context; however, it is crucial to understand these bunkers within architectural history. For example, the ROTOR program not only used legitimate means of land acquisition and complied with new Town Planning stipulations, but it also contracted civilian architects, engineers, and builders and used off-the-shelf manufactured components. Firstly, as discussed later in this chapter, unlike the WW2 requisition practices, my archival research revealed that the ROTOR programme based its planning on legitimate land acquisition[193]. Like any civil architectural scheme, ROTOR bunkers were built on land legally purchased via traditional procurement instead of being forcefully taken by the British Government. Compulsory purchase powers, under the 'Defence Regulations', were only reserved for extreme situations when landowners were 'unwilling to negotiate the sale or lease of land' as discussed later in this chapter[194]. Secondly, despite previous assumptions bunkers constructed under the ROTOR programme were not exempt from new government-backed planning stipulations and were also bound by the same legal planning conditions equally imposed on other post-war civilian buildings. Thirdly, ROTOR bunkers were designed and built by carefully chosen civilian consultants and public contractors, some being pivotal figures during the post-war reconstruction under the Welfare State.

In terms of scale, it is helpful to understand the main differences between the largest and smallest bunker types within the overall ROTOR programme. For at the other end of the typological framework (from the R-type bunkers) was the hundreds of ROC posts – the smallest, shallower, and more basic by comparison. As mentioned in the literature review, these bunker types have drawn particular interest from academic and non-scholarly researchers; however, their relationship with post-war reconstruction is yet to be framed within architectural history. These bunkers, alongside their Group HQ, were a somewhat paradox when considering the classified Col War context. Not only were these bunkers constructed in a more visible location, but they featured within publicly accessible literature of the time and, as I will detail later, had a more visual presence within the civil realm[195].

Within the broader ROTOR programme, it is worthwhile to outline the two distinct variations of ROC posts that spanned from 1950 to 1970. At first, 'Orlit' style posts – closely based on earlier WW2 examples – were constructed entirely above ground to provide observers a raised vantage point for monitoring airspace[196]. These examples were assembled on-site from a series of pre-cast concrete panels transported from remote factories (fig.2.4). By the mid-1950s, however, these above-ground Orlit posts were deemed unsuitable against H-bomb threats. As a result, new concrete types were built 18 feet underground – adopting a standard model developed in partnership with the Air Ministry and Home Office in 1957**.** These claustrophobic concrete bunkers are accessed via a narrow ladderway and housed three to four ROC personnel in a dimly lit chamber measuring 19ft by 7ft, with bunkbeds, a desk, basic storage cupboards and an adjoining chemical toilet[197]. Surface traces of

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[192] Although geopolitical tensions proceeded feverishly on occasion that threatened peace, there was no official declarations of war that occurred between Britain and the Soviet Union during the Cold War

[193] TNA AIR8/1630 Restoration of the U.K. C & R System: 2nd Quarterly Progress Report 7 March 1951. Scottish sites including Barnton Quarry, Anstruther, and Inverbervie were all purchased by the Air Ministry prior to their design under the ROTOR programme

[194] TNA AIR8/1630 CRPC: Restoration of the U.K. C & R System: 2nd Quarterly Progress Report, 7 March 1951

[195] See the Civil Defence Manuals and Pamphlets published through the HMSO.

[196] Cocroft, Thomas, and Barnwell, pp. 175-176

[197] From my own fieldwork explorations, I managed to gain access to the remaining post at Tomatin – 15-miles south of Inverness

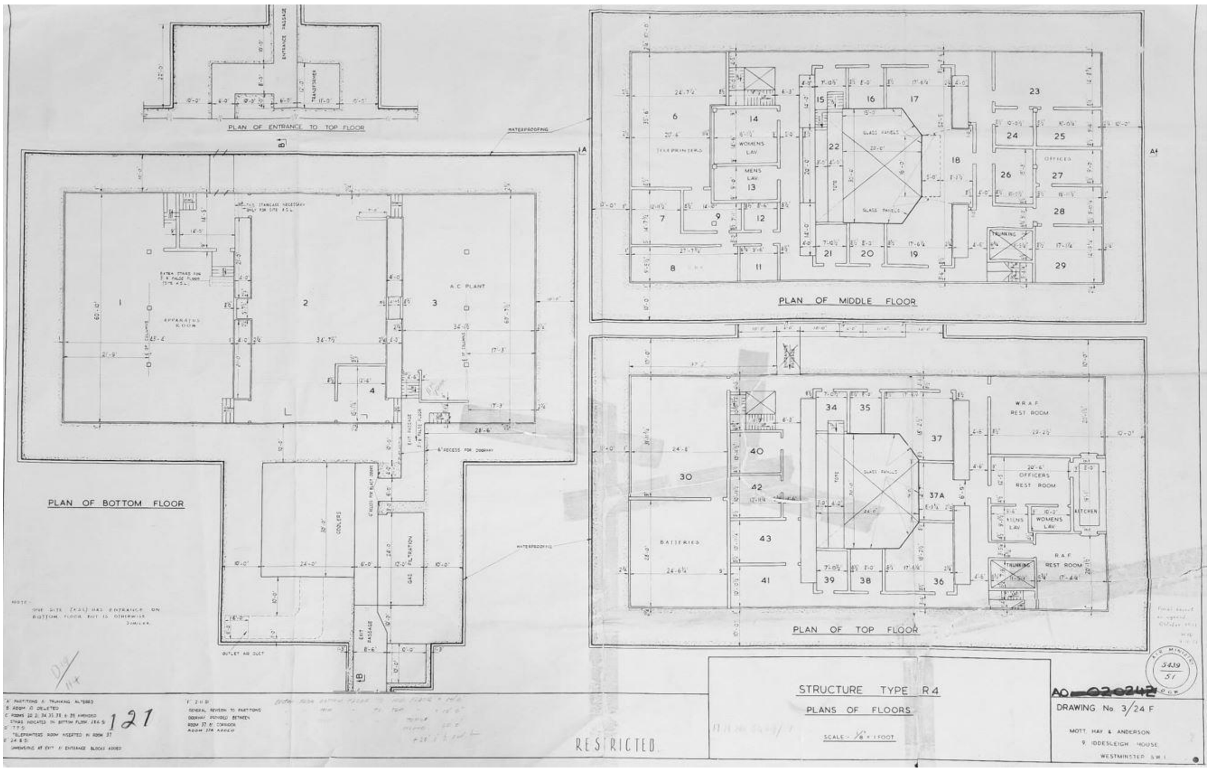

Fig. 2.2: Barnton Quarry layout plans by Mott, Hay, and Anderson (Barnton Quarry Restoration Group)

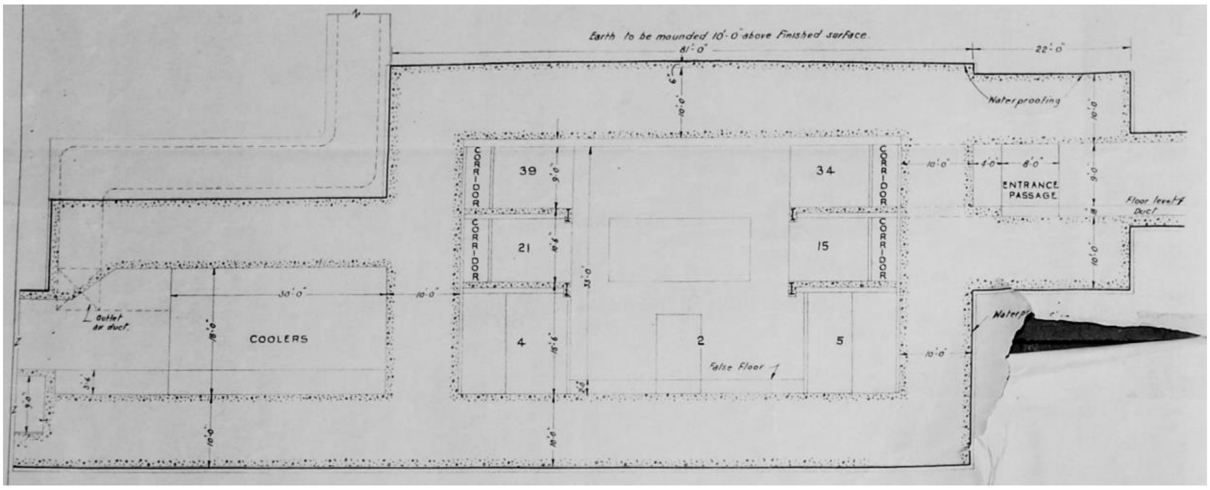

Figure 2.3: Barnton Quarry cross section by Mott, Hay, and Anderson (Barnton Quarry Restoration Group)

ROC posts are particularly well-known among enthusiast groups and academics; identifiable by their concrete air ventilation flues, access hatch, and steel mountings (designed to attach scientific equipment for measuring blast and radioactive fallout from nuclear detonations) (fig. 2.5).

What has been largely overlooked is that Orlit was also a key industry operator in Britain's post-war civil realm. Marian Bowley credited Orlit (established in 1940) as a specialist precast concreter with a notable pedigree of innovation responsible for early post-war contracts that included housing and school building programmes[198]. What is also interesting from the firm's post-war position is the

198 Marian Bowley, *The British Building Industry: Four Studies in Response and Resistance to Change* (Cambridge: Cambridge university Press, 1966), p. 215

decision to employ architect Sam Bunton as a consultant around the same period. Bunton's historical importance as an important figure in Scotland's post-war reconstruction represents a particularly exciting crossover between the top-secret ROTOR programme and broader civilian development. Firstly, in 1939 Bunton collaborated with the engineer Ove Arup to develop concrete air-raid shelters for use incorporation into housing schemes. Secondly, once he ingratiated himself with the Scottish Office and Local Authorities during Clydebank's clear-up in 1941 (after the town had been bombed by the German Luftwaffe), Bunton established the role of trusted consultant through the 1950s and 1960s[199]. His most notable contribution during this period is widely accepted as the now demolished Red Road Flats – a concrete tower block designed for the Glasgow Corporation (1962-69)[200]**.** Combined, this previous experience positioned him as a specialist in bunker architecture, which most likely influenced Orlit to appoint his services on the ROTOR programme[201].

[199] Ibid.

[200] Ibid.

[201] Miles Glendinning, "Sam Bunton and the Cult of Mass Housing" in *Rebuilding Scotland: The Postwar Vision 1945-1975*, ed. Miles Glendinning (East Lothian: Tuckwell Press, 1997), pp. 102-110


Figure 2.4: Typical above-ground 'Orlit' ROC post of the 1950s (Subbrit)

Figure 2.5: Typical underground ROC post

2.2.1: A Secret State Patronage

To expand our understanding of the ROTOR programme within the context of peacetime, we must recognise the full extent of its state-backed patronage: principally through Treasury finances and priority allocation. For at the same time money and supplies were siphoned to build bunkers the country was also pre-occupied with urgent civilian reconstruction efforts. The key funding mechanisms and allocation of scant resources, materials, and labour, during periods of extreme shortages explicitly assigned by the Central Government are still to be highlighted in architectural history.

Unsurprisingly, the innovative ROTOR programme carried a significant price tag. As detailed in chapter 1, France and Germany had both overseen large concrete bunker programmes in the 1930s and 1940s (requiring vast finances, materials, and labour), however, Britain's experience differed markedly. The Air Ministry's WW2 Chain Home radar network had only really produced two bunkers of equivalent scale in the filter and receiver blocks. On the other hand, despite being designed to standard plans, Britain's largest bunker scheme, produced in wartime conditions, was the anti-invasion defences, including costal gun batteries, and pillboxes that were much smaller structures. From this position, Britain entered the early phases of the Cold War with a lesser understanding to the onerous costs, let alone the complexities of constructing large bunkers deep underground[202].

Although the ROTOR programme quickly proved an incredible expense, we must acknowledge it was not a knee-jerk reaction at the end of WW2 but was instead sanctioned after a period of serious consideration. Rather than spawning at the immediate surrender of Japan in 1945 (after the two A-bombs dropped on Hiroshima and Nagasaki), the ROTOR programme gestated over four years. During this time, Clement Attlee's Labour government debated extensively; querying the urgency for updating and modernising air defences that would not come cheap. Historians widely acknowledge that Labour's post-war mandate promised the long overdue civil reconstruction and was extremely reluctant to sanction a move which would risk signalling regression. As much as the government hoped to focus limited State finances within the civil realm, including 'slum' clearances and new building programmes, before long, funds had to be specifically ringfenced to meet the ROTOR programme's growing demands. After Whitehall continuously rebutted earlier recommendations foregrounded by specialist Air Ministry personnel, the ROTOR programme gained formal approval in 1949.

In researching declassified archives, Nick McCamley and heritage-based archaeologists have provided a beneficial timeline to the major events influencing ROTOR programme expansion[203]. From these accounts, we know the cessation of WW2 saw Britain's defence needs drastically transition from a wartime footing into a less-urgent peacetime condition; primarily underpinned by a care and maintenance approach that required a lesser degree of financial resources[204]. Against this backdrop, the government decided to temporarily downsize its air defence system, either abandoning or decommissioning most of its chain home radar sites in favour of a more limited regional scope. As a significant result of this downsizing, Britain went from having over 200 active radar stations spread over its entire landmass which covered most of its airspace, to a more concise

[202] Fighter and Bomber Command HQ bunkers at Uxbridge and Bentley are excluded from this
[203] Including archaeologists Wayne Cocroft, and Colin Dobinson
[204] John Prophet, *The Structure of Government*, (London: Longman, 1971), p. 20: The reduced post-war air defences is also reflected in the peacetime Cabinet structure of 1919-39 - 'small enough for action but big enough its influence to dominate its party and control the House of Commons.

network. In this reduced format, this initial Cold War defence system only provided air cover to the coastal region stretching south from East Yorkshire to the Portland Bill in Dorset[205].

During this post-war reduction, the government's central defence departments conducted a series of feasibility studies from the mid-to-late-1940s. Despite 'major weaknesses' raised within the Cherry Report, recommendations for upgrading and expanding the radar network were suppressed by central government[206]. Moreover, given the military risk assessments had predicted the credible threat of nuclear war was low (since the Soviets had not yet developed nuclear capabilities), any expenditure was deemed unnecessary [207]. Politically this reluctance chimed with the more favourable peacetime promise geared towards the broader needs of the civilian population under the banner of the Welfare State. Despite the initial hesitation, however, the major reconstruction of Britain's air defences soon began. As already mentioned, the nuclear threat evolved much quicker than military strategists had first expected after a series of international events had heightened geopolitical tensions, such as the Berlin Blockade (24 June 1948 – 12 May 1949), which showed the Soviet willingness to act more provocatively.

The Treasury's importance in the story of the ROTOR programme helps explain the 'splendid isolation' Paul Hirst described (see chapter 1). Firstly, while architectural historians have recognised the funding mechanics of Britain's post-war reconstruction through the Treasury Department, their secret management of the ROTOR programme's funding is currently unknown. Secondly, although brief, archaeologists have noted the 'acute Treasury scrutiny' over new defence projects including the ROTOR programme and subsequent radar expansion schemes; but the reasons can be further understood[208]. By reframing and bridging current disciplinary boundaries, my analysis contributes to a better understanding of the push and pull effect of nuclear bunkers on Britain's post-war finances (the cuts, reductions, and cancellations). Crucially, expanding these Treasury relationships not only enables us to understand who held the purse strings but also conveys the monetary value of bunkers.

Notably, the ROTOR programme was not financed separately by an exclusive bunker budget – ringfenced from a special money pot or buoyed by American recovery funding such as the Marshall Plan but instead funded by the public purse[209]. Unbeknownst to most of Britain's population (including some senior members of parliament), taxpayer's contributions that simultaneously backed a myriad of civilian works also funded nuclear bunkers. John Prophet neatly describes the Treasury's primary role as to 'control public expenditure' of all State projects and holistically regulate the entire British economy [210]. Part of the Treasury's core duties included cross-examining all departmental costs to ensure government policy adherence and scrutinising and supervising expenditure while eliminating wastage[211].

How much did a nuclear bunker cost in 1950? Despite internal departmental politics, once approved, the ROTOR programme proceeded with an initial budget set by the Treasury to nearly £19m (or £405m in today's money)[212]. Although its rising costs over a ten-year period are difficult to trace,

[205] Cocroft, Thomas, and Barnwell, p. 118
[206] McCamley, p.72
[207] Ibid., p. 73
[208] Cocroft, Thomas, and Barnwell, p. 110
[209] The Marshall Plan was the US-backed scheme that provided over $13 billion dollars to assist European recovery running from 1948 to 1952
[210] Prophet, *The Structure of Government,* p. 134
[211] Ibid.
[212] TNA AIR2/10984 Letter from Air Ministry to Treasury, 23 September 1952

towards its latter expansion (under schemes known as 'Plan Ahead'), projected costs exceeded an untenable figure of £100m prior to being shelved[213]. To further understand the finances involved and contextualise this budget, it is worthwhile breaking down a sample of individual costs attached to the standard ROTOR bunkers. Although it is nearly impossible to decipher costs per square foot, the archival evidence does convey some overall costs. (The following figures in brackets represent the approximate costings in today's money, accounting for inflation). From the standard R-type ROTOR bunkers, the largest was the underground three-storey R4-type – of which only one was ever built in Scotland at Barnton Quarry in Edinburgh – costing approximately £1m (£21m). The second most expensive was the R3-type bunker, like Anstruther in Fife, costing an estimated £500,000 (£10.6m). While the AAOR bunkers are lesser-documented types, we can assume they were approximately £100,000 (£2.1m) based on their close similarities with War Rooms – bunkers which were part of a separate programme ROTOR[214]. Lastly, in terms of the ROC network, group headquarters reached figures of £45,000 (£0.9m), with individual posts costing up to £2000 (approximately £0.42m). These financials were not insignificant outlays – especially at the time of approval in the early 1950s.

Interestingly, when comparing these figures with civil reconstruction schemes, we can analyse costings at the time of construction to better understand the value. For instance, the second largest R3-type bunker carried around the same construction costs as hospitals and university campuses; including Britain's first post-war hospital at Vale of Leven, Dumbarton (1952-55) by Scottish firm Keppie and Henderson in conjunction with the Department of Health for Scotland (DHS) costing approximately £520,000[215]. Similarly, the new Agricultural College in Edinburgh (1948-1960), by the Scottish partnership of Alan Reiach and Ralph Cowan (initial contract valued at £350,000 but increased to nearer £575,000)[216]. Beyond these larger ROTOR bunkers, the more voluminous individual ROC posts cost slightly more than a typical flat in Sam Bunton's eight-storey housing block in Clydebank, completed by 1954, in association with DHS of the Scottish Office (priced at £1,850 per flat)[217]. Not only does this provide an essential cost comparison between ROTOR bunkers and civil realm works around the same period, but the shared timeline coincides neatly with important events of post-war architectural history. For example, in Scotland, the new Agricultural College at Edinburgh was initially designed in 1948 but was considerably delayed by six years due to 'cuts in capital government expenditure'[218]. Since an R3-type bunker was constructed at Anstruther during this period of delay, we must acknowledge that the ROTOR program directly impacted government spending.

Moreover, regarding its broader impacts across Britain, we can also reframe the ROTOR programme finances within Andrew Saint's architectural history of English schools. Here, Saint describes a series of spending cuts experienced through the Ministry of Education works between 1950 and 1952 as the 'crushing of the school-building flower just as it came into bloom'[219]. Importantly since this timeline aligns seamlessly with the peak of ROTOR programme construction, this represents yet another instance of nuclear bunkers stymying civilian construction. Had the ROTOR programme not

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[213] TNA AIR8/2033 Letter from Air Vice-Marshal G.C. Eveleigh, 7 August 1959
[214] McCamley, p. 154
[215] Hospital, *AJ*, 122 (1955), 587-604 (p. 604)
[216] Agricultural College, *AJ*, 134 (1961) 126-142 (p. 140)
[217] Buildings in the news, Flats at Clydebank, Glasgow, *AJ*, 120 (1954) 250
[218] Agricultural College, *AJ*, 134 (1961) 126-142 (p. 127)
[219] Andrew Saint, *Towards a Social Architecture: The Role of School Building in Post-War England* (New Haven: Yale University Press, 1987), p. 119

been an urgent stipulation in the face of nuclear threat, post-war architectural history may have been graced with more hospitals, universities, and housing across the 1950s.

Nuclear bunkers, including the ROTOR typologies mentioned above, have, and continue to be argued as a waste of finances. For example, one of John Beck's perennial claims is that the bunker is a 'waste of modernity that cannot be tidied away'[220]. I would argue Beck's explicit language carries the notion of unnecessary expenditure, which in many ways reflects the views held by the earlier anti-government exposes and investigations (see introduction). Despite the direct and indirect impacts mentioned earlier – either reducing or cancelling civil works programmes – the Air Ministry must be recognised for specific economic measures and fiscal scrutiny. My investigation of Air Ministry archives reveals the ROTOR programme was not financed at once, but was in fact, based on a carefully controlled masterplan. As per the aforementioned hesitation on upgrading the air defences, financial constraints limited the initial ROTOR programme to focus only on English coastal sites due to the historical invasion threat posed by Germany during WW2 and the general direction of the malevolent Soviet Union. This early work included a basic re-survey of existing radar locations by the Air Ministry 'special siting party' to assess what could be retained from leftover WW2 stations and what was needed anew[221]. The restoration was then extended to a further selection of critical seaward approaches which had been retained as part of the post-war care and maintenance phase[222].

Finally, given the rapidly changing geopolitical situation, the Treasury finally approved the ROTOR programme's expansion to be set against a series of phased sequences[223]. Phase I, for example, completed in 1953, purely dealt with restoring 28 remnant WW2 radar sites that had officially stood down in 1945[224]. In Scotland, this phase included the reactivation of three 1940s surface-level bunkers at Douglas Wood, School Hill, and Hillhead – stretching from Dundee to Fraserburgh on Scotland's east coast. These bunkers were initially constructed for Britain's WW2 Chain Home radar to protect British airspace from the German Luftwaffe [225]. Their reinforced concrete form, encased within earthen mounds, was retained unaltered. Their adaptive re-uses under the ROTOR programme were confined to new radar and communications equipment, alongside upgrading essential building services. Whereas, the later phases II, III, and IV included the construction of purpose-built ROTOR R-type bunkers and were mostly completed by the late 1950s. At first, it was specified that more 'vulnerable' areas, particularly those located on Scotland's east and north coastlines, were designated nuclear bunkers to be fully protected in concrete and built underground[226]. Meanwhile, those located in 'less vulnerable' areas were to be concrete structures built semi-underground[227]. Owing to further economic problems impacting the ROTOR programme's budget across 1952/1953, the less vulnerable types were revised considerably and eventually constructed in brick at certain locations to reduce costs[228]. Despite this extensive coverage, it is crucial to note that several other bunkers planned as part of an extended ROTOR programme were

[220] Beck, *Concrete Ambivalence*, p. 83
[221] TNA, AIR8/1630, Restoration of the C. and R. System, Note of Progress, 1 December 1950
[222] Ibid.
[223] TNA AIR20/11318 CRPC: The completion of operation rotor and phasing of individual stations 31 August 1951
[224] TNA AIR8/1630, 9th Quarterly progress report by the chairman, CRPC, 1 April 1953.
[225] See Dobinson, pp. 216-218
[226] Ibid.
[227] Ibid.
[228] Ibid.

in fact curtailed (including Wick and Skaw in Scotland), incurring considerable savings at the Treasury's request[229].

As outlined above, the genuine fear of nuclear confrontation prompted a concerned British State to not only balance expenditure between bunkers and civil projects but fast-tracked funding to ensure it met urgent completion dates. Importantly, this bunker network was not only the most expensive, largest, and most sophisticated defence scheme ever devised by Britain's Central Government, but It was also designed and constructed during a peacetime context laden with unprecedented wartime debts and civilian needs. The delayed schemes (as well as others cancelled entirely) would have likely been informed no funds could be spared given the dire economic conditions in post-war rebuilding. The secret rerouting of finances would have been kept away from as many government departments and Local Authorities as possible to avoid potential whistleblowing that would have most definitely registered in Soviet intelligence, or worse, the British press.

Thus, albeit an unpopular use of funds, when faced with the quandary of building the vast ROTOR programme as nuclear protection, the state's decision to sanction approval contradicts the widely accepted narrative of architectural history, which currently holds schools, housing, and hospitals as priorities.

2.2.2: 'Super-Priority' of Bunkers Ahead of Civilian Needs

Like much of post-war Europe, Britain was dogged with severe shortages in raw materials, plant equipment, and the skilled labour urgently required for reconstruction. Despite this backdrop however, alongside the allocation of precious Treasury finances towards the top-secret ROTOR programme, scarce material supplies and resources were also reserved in vast quantities for nuclear bunkers. More importantly, these allocations were officially approved at the highest government level under what became known as 'super-priority', which, in turn, transcended most, if not all, post-war reconstruction needs. While the super-priority scheme has been referenced within the core bunker literature, little is mentioned about its origins within state patronage, and there is yet to be a robust cross-examination of how this further impacted post-war civil reconstruction[230]. Unsurprisingly, architectural histories typically acknowledge civilian aspects as the primary architectural benefactors, including the likes of housing, schools, and hospital schemes. This next section therefore considers the secret competition of ROTOR bunkers, vying for the same scarce material supplies and resources – especially cement and steel – to reframe existing arguments of Britain's real post-war priorities.

Firstly, heritage-based archaeologists have described the ROTOR programme as 'the most ambitious military engineering project of the early-1950s'; one that demanded 'co-ordination of a major manufacturing effort' whilst absorbing a large proportion of GPO work outputs for two full years[231]. Despite other disciplines recognising the labour and raw material demands incurred by the ROTOR programme, it is equally important to begin framing these overbearing requirements within a broader context of post-war architectural history. For the same supply issues restricting the civilian industry also affected the massive task of procuring the ROTOR programme.

[229] TNA AIR2/10984, Letter from Air Ministry to Treasury, 'ROTOR and VAST', 23 September 1952
[230] See for instance: Nick McCamley *Cold War Secret Nuclear Bunkers*, and Cocroft, Thomas, and Barnwell, *Cold War Building for Nuclear Confrontation*
[231] Cocroft, Thomas, and Barnwell, p.86

In 1951, it was initially estimated that the ROTOR programme would require a labour force of 7000 personnel, 20,000 tons of steel, and more than 4000 miles of telecommunication lines[232]. However, what is particularly worth highlighting from these early estimates, is the additional quantities of cement set at a staggering 350,000 tons[233]. To better understand this figure in real terms we can draw on the Ministry of Education's annual outlays published the following year. For in 1952, the Ministry of Education, headed by Florence Horsburgh, stipulated the need of 300,000 tons of cement for school building programmes[234]. From this simple comparison, the initial cement requirements for ROTOR bunkers exceeded that tabled for new primary and secondary schools by at least 50,000 tons. Therefore, had the British Government not been so pressured by Cold War tensions and the real threat of nuclear war, it is very easy to see where the scarce materials could have been re-directed into civil rebuilding. Without the additional yet top-secret onus of building these nuclear bunkers, Britain could have the means to construct double the number of schools as part of the Welfare State's post-war rebuilding.

Marian Bowley's primary study on the post-war building industry noted a scarcity of bricks, timber, cement, and, more specifically, steel[235]. The valuable material (made from Iron Ore) became one of the most carefully guarded resources in the post-war period, so much so that the government placed it under strict rationing until 1954. Although this steel shortage is well-acknowledged by most architectural historians, there is currently a notable gap in this narrative. While the 'Steel Economy Bulletin', publicly circulated in 1952, appealed for alternative building methods (like reinforced concrete) to mitigate dire steel shortages, it explicitly noted the need to preserve steel for parallel-running 'civil defence requirements'[236]. In fact, my study reveals that Britain's post-war steel supplies (vital in bunker construction) were actually prioritised for the ROTOR programme; carrying direct impacts through civil rebuilding. For instance, such was the urgency placed on completing ROTOR bunkers that the Labour Government assigned special measures – reserved exclusively for high-priority cases – on steel allocation. Initially, it was suggested that priority would be agreed internally by the individual government departments and casually reconsidered if required[237]. However, the situation quickly changed under an increased desperation with a 'most serious' difficulty arising in the supply of reinforcing steel[238]. The Minister of Supply, Duncan Sandys, and the Minister of Labour, Aneurin Bevan, took direct action by agreeing on a joint approach to alleviate the steel supply issues[239]. For example, in 1951, a group of steel-rolling mills were effectively requisitioned (temporarily) and given exclusive government contracts to supply 4,000 tons of reinforcing steel for an unnamed ROTOR bunker[240]. Yet, when steel shortages were experienced at the same time by the London County Council Housing Committee, the committee had to purchase approximately 800 tons of steel from France to circumvent supply issues impacting the council's housing programme[241].

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[232] TNA AIR20/11318 Appendix C: Supplementary information regarding control and reporting system and details of three separate elements of the ROTOR programme – 1951. While these quantities inevitably increased given the ROTOR programme's expansion I outlined earlier, it is almost impossible to define the exact end figures.
[233] Ibid.,
[234] TNA SUPP14/1 Meeting minutes Building Committee: Economy in Educational Building 14 March 1952
[235] Bowley, *The British Building Industry*
[236] News, MOW, "Steel Economy Bulletin Published", *AJ*, 116 (1952) 279, It is important to note that although reinforced concrete construction required steel for the reinforcement rods (more commonly known as 'rebar') this method used much less quantities than alternatives in structural steel.
[237] TNA AIR8/1630 Restoration of the C. and R. system: Notes of Progress December 1950
[238] Ibid.
[239] TNA AIR8/1630 Restoration of the U.K. C & R System: 2nd Quarterly Progress Report 7 March 1951
[240] Ibid. Restoration of the U.K. C & R System: 4th Quarterly Progress Report 31 December 1951
[241] News: LCC, Steel Supplies, *AJ*, 114, (1951) 39

Likewise, in 1952, the Economic Policy Committee (tasked with managing infrastructure projects of the North of Scotland Hydro Electric Board) were formally told by the Chancellor of the Duchy of Lancaster that there was simply no steel available for further schemes[242]. These cases indicate how the ROTOR programme transcended civilian needs and forced more expensive acquisitions from overseas markets. While they are only a small sample, we must recognise similar situations occurred more widely during Britain's post-war rebuilding – especially during the peak period of the ROTOR programme.

Although the government demonstrated its willingness to put bunkers ahead of civilian needs, the ROTOR programme was not entirely immune to these industry-wide issues. As in 1951, the Control and Reporting Progressing Committee (CRPC) noted that the 'world shortage of certain materials' had impacted 'adversely' with the ROTOR programme's construction and, in turn, presented a direct threat to its entire operation[243]. Another CRPC report stated, 'It cannot be too strongly emphasised how fundamentally vital is the whole question of supply of building materials to the success of operation ROTOR as a whole'[244]. Worryingly, the CRPC committee, charged with overseeing the works, warned of a '*Periculum in mora'* (or 'danger in delay') if procurement issues were left unaddressed[245]. As predicted by the Sub-Committee on Steel Economy, defence work from 1951 through 1953 (the peak of ROTOR) required a significant supply of rebar – much more than civil schemes – which, if ignored, would delay the overall building programme, and expose Britain to potential nuclear attacks[246]. While the post-war Labour government risked negative and damaging public opinion by delaying or curtailing promised civil rebuilding, the threat posed by the Soviets caused serious concern to the viability of Scotland, and Britain's ultimate survival. These delays were considered so serious that attention swiftly turned to completing the ROTOR programme's air defence system as quickly as possible.

At first, the Ministry of Supply outlined new measures to avoid potential clashing of contracts 'either defence or especially important civil work that may conflict with rotor in any way (*sic*)' [247]. In the announcement's appendix, a letter instructed sub-contractors and suppliers to assign 'immediate preference' (a somewhat precursor to super-priority) on the receipt of any material or equipment orders for the ROTOR programme so that any orders would give immediate preference over requested goods for the home market[248]. After these incremental mitigations, all aspects of the ROTOR programme (from finances to labour) were finally assigned the top-secret government scheme labelled 'super-priority'[249]. The super-priority scheme, conceived in March 1952 by the incoming Conservative government, became fully operational in June 1952 and was underpinned by Britain's changing needs in the face of maintaining its position as a global power. Importantly, ROTOR bunkers were some of the only buildings afforded such privileges as the scheme was primarily reserved for essential aircraft, weapons, and equipment contracts[250].

To illustrate a basic understanding of the 'super-priority' protocol, I have summarised the main points quoted in a letter issued by the then Minister of Supply, Duncan Sandys. Super-priority status

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[242] TNA SUPP14/1 Cabinet meeting minutes 29 May 1952
[243] TNA AIR20/11319 CRPC: The completion of operation rotor and phasing of individual stations (MOD) 3 August 1951
[244] TNA AIR8/1630 CRPC: Restoration of the U.K. C & R System: 3rd Quarterly Progress Report 1 June 1951
[245] Ibid,
[246] TNA SUPP14/1 Report 22 Feb 1952
[247] TNA AIR8/1630 Letter from Ministry of Supply to Minister of Defence (Emanuel Shinwell) 25 May 1951
[248] Ibid
[249] TNA AIR8/1630 CRPC: Restoration of the U.K. C & R System: 6th Quarterly Progress Report 1 July 1952
[250] Ibid.

included direct access to labour, materials, machine tools, and factory capacity within Britain ahead of 'all other work of any kind whatsoever'[251]. All relevant parties using the scheme, including contractors, subcontractors, and suppliers, were instructed to prefix material orders or labour requests (from Employment Exchanges) with the codeword 'super-priority' ahead of the respective contract number[252]. All those involved (especially sub-contractors) had to be fully vetted in-line with the central government's protocols to maintain the ROTOR programme's secrecy [253]. Its use was carefully monitored to ensure there were no duplicated contracts; resources were not requested ahead of required dates; and quantities were to be accurately stipulated to avoid wastage[254]. Under the super-priority scheme, individual government departments were free to allocate its use, as and when required, through 'administrative machinery'[255]. The Air Ministry, for instance, applied super-priority to the ROTOR programme by March 1952 whilst the GPO later adopted the scheme for all telecommunications-related works; authorising equipment and cable contractors to facilitate the completion of vital landlines[256]. Although it is unclear how long this priority scheme lasted, additional archive evidence suggests it continued in principle until at least 1958, with a later report referring to a 'maximum priority'[257].

While it may strike as a potential paradox, this section has revealed that ROTOR programme bunkers shared inextricable relationships in the finances, raw materials, and labour with Scotland's (and Britain's) civilian landscape. This link proves that ROTOR bunkers were not created in a separate vacuum but competed and gorged on the same pool of resources that civil realm architectural works relied heavily upon[258]. Moreover, not only did these bunkers siphon material stocks of brick, cement, and steel, as well as significant labour forces, but they were afforded higher priority. through the state-backed patronage assigned in peacetime conditions, the ROTOR programme influenced civil architecture on a much more direct level. Given the closeness of these overlapping timelines, were allocated vital resources at critical moments in post-war reconstruction it can also be argued that the lifting of steel rationing in 1954 was a result of nuclear bunkers. Let us consider the first phase of the ROTOR defences coming online across 1953/54. This relaxation can be reframed as portraying a feeling within the Central Government that nuclear defences had achieved a crucial construction milestone and, thus, civilian needs could have more comprehensive access thereafter. Under this lens, the delayed projects – requiring steel for completion – were side-lined to ensure the ROTOR programme was a realistic endeavour within a context of dire shortages. The importance of highlighting this initial status afforded to all aspects of the ROTOR programme bunkers lies in the sudden paradigm shift in state patronage that became apparent in the 1960s (explored in chapter 4).

[251] TNA CAB-129-51-26 'Super-Priority for Certain Defence Contracts' issued by Duncan Sandys 26 March 1952
[252] Ibid.
[253] Ibid.
[254] Ibid.
[255] Ibid
[256] TNA AIR2/11604, Letter from GPO Headquarters to Air Ministry 30 April 1952
[257] TNA AIR8/2033 Air Council: Stages 2 and e of the 1958 plan for the re-organisation and re-equipment of the U.K. C. & R. system 19 December 1958
[258] Miles Glendinning, ed*., Rebuilding Scotland: The Postwar Vision 1945-1975* (East Lothian: Tuckwell Press, 1997)

2.3: Case Study: Barnton Quarry ROTOR R4-type – Sector Operations Centre

I now turn to frame Barnton Quarry as not only one of the largest bunkers within the ROTOR typological framework but, in terms of Scotland's built examples, the rarest. From approximately 200-plus bunkers constructed within Scotland, the R4-type bunker at Barnton Quarry, Edinburgh, functioned as the Sector Operations Centre (SOC) for the whole country, and while the other purpose-built R4-type bunkers were built in England (including Kelvedon Hatch, Essex) Barnton Quarry was the only example of its kind north of the border. It has recently been acknowledged for its historical value with being awarded Category A listed-building status from HES[259]. Interestingly, what is currently missing within the listing entry is that Barnton Quarry was, in fact, the first completed R4-type bunker in Britain ahead of these other English sites. As identified from my archival study, Barnton Quarry was completed on 4 February 1953, meaning it was made operational a month ahead of the closest English example at Kelvedon Hatch, completed on 9 March 1953[260]. Furthermore, owing to the efficient, standardised design processes mentioned throughout this chapter, Barnton Quarry may even have been one of the vital 'guinea pig' sites specifically chosen as a prototype bunker.

Although Barnton Quarry has endured a varied and less-fortunate lifecycle during and after its active Cold War operations, its initial role under the ROTOR programme was to act as Scotland's central nerve centre. During this operation, it was tasked with overseeing Britain's northern air defences – before assuming civil defence and govermment roles from 1960 onward (as outlined in chapter 4). Reporting directly to Barnton Quarry through a network of buried communications lines were radar sites like the R3-type bunker at Anstruther and the R1-type bunker at Inverbervie. Four ROC Group Headquarters (such as the existing bunker at Craigiebarns in Dundee) also forwarded data fed by the network of individual ROC posts. Conversely, at the opposite end of this defence network, four Anti-Aircraft Operations Rooms (such as Gairloch) received the flight data, which would subsequently programme anti-aircraft batteries, designated at the river Clyde, Forth, and Loch Ewe, for ground-to-air defence.

A secret letter to the Treasury estimated that Barnton Quarry's built cost was in the region of £1m (or £21.3m today), which suggests the bunker was perhaps one of the most concentrated loci of State funds within Scotland at the time of its construction[261]. As can be seen from the MHA site plan, the underground three-storey bunker (measuring 36.7m by 18.6m) was built into the leftover cavity of the disused quarry and later backfilled with a mound of shale and earth as shown in the black and white aerial photographs (fig 2.6). Although the RAF had previously used part of the 5.5-acre site as Fighter Command's Turnhouse Sector during WW2, the Air Ministry established a new lease agreement with the Edinburgh Corporation to cover its continued land use throughout the Cold War period[262].

Despite the quasi-urban context of Corstorphine suburbs (situated less than two miles north of Edinburgh Zoo), compared with the predominant rural settings of other Scottish (and English) ROTOR bunkers, Barnton Quarry remained undetected by both Soviet surveillance and local civilian

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[259] Historic Environment Scotland, "Former Cold War Bunker in Edinburgh gets A Listed." [259] Historic Environment Scotland. https://www.historicenvironment.scot/about-us/news/former-cold-war-bunker-in-edinburgh-gets-a-listed/#:~:text=A%20former%20RAF%20Caledonian%20Sector,Historic%20Environment%20Scotland%20 [Accessed June 12, 2021]

[260] TNA, AIR8/1630, Restoration of the U.K. C & R System: 9th Quarterly Progress Report, CRPC, 1 April 1953

[261] NRS HH51/260, Letter to J, Gibson (Treasury) 15 September 1961

[262] Ibid.

neighbours during its construction and early occupation. Although camouflaging measures included foliage cover and architectural blending of surface penetrations, there was a group of detached villas running parallel to the site's western perimeter, mere yards away (fig. 2.6). Even with the 100-plus stationed staff, bussed from domestic living quarters about four miles away at RAF Turnhouse, the site remained hidden into the mid-1960s [263]. After the 1963 Spies for Peace scandal mentioned in the previous chapter, Barnton Quarry's existence finally entered the civilian consciousness the same year for the first time (at great embarrassment to the British government). By this point of revelation, Barnton Quarry's function had shifted markedly into operating as Scotland's Central Control – the emergency government bunker. The site later experienced additional CND protests from 1963 to 1966 with the first occurring on 21 April 1963 when 150 protesters marched from Princes Street to Barnton Quarry and sang songs outside the compound's security fence[264]. A follow-up march held in April 1966 does not seem to have attracted the same public attention in the press[265].

Similar to other sites across Scotland, Barnton Quarry's fabric has experienced a considerable degree of decline since its Cold War operational use. However, it is essential to note that this decline was due to deliberate acts of vandalism and not the ills of its architecture. After it was deemed surplus to Scottish Office needs and sold in 1992, the bunker suffered years of neglect, incurring significant damage through trespassing, vandalism, fly-tipping, and near-catastrophic fires (fig. 2.8)[266]. Although commendable restoration efforts are still ongoing, my fieldwork exploration of Barnton Quarry was generously supplemented with additional archival research (as mentioned in my methodology section). This gap was primarily addressed by drawing on photographs in the *subbrit* online collections. Although a sample of key photographs, taken some time during the Cold War, depicts the bunker in its latter configuration as Scotland's Eastern Zone Control, they are still crucial for indicating how the bunker looked prior to the extensive damage.

[263] TNA, AIR8/1630, Restoration of the U.K. C & R System: 6th Quarterly Progress Report, CRPC, 1 July 1952.
[264] NRS, HH51/226/1, "Committee of 100" Demonstration in Edinburgh on Sunday, 21st April, 1963, (SHHD) 26 April 1963
[265] NRS, HH51/226/1, Loose note "C. N. D. March – 9th April", 12 April 1966
[266] Kinnear, *Reopening the Bunker,* pp.10-11

Figure 2.6: Barnton Quarry aerial photograph facing eastwards c.1953 (Barnton Quarry Restoration Group)

2.3.1: Subterranean Spaces

Not only does this site lie in a more urban context, but the main entrance to the underground bunker also differs from the standard approach taken across other ROTOR bunker locations. At Barnton Quarry, access from the surface-level compound down into the subterranean concrete bunker does not contain a vernacular-styled guardhouse, but alternative concealment is achieved through an industrial-styled brick and timber hutted structure – also housing the neighbouring WW2 RAF filter room. As seen in the rare construction site photograph (fig. 2.7), its material and form reflect innocuous workshop type building – suggesting this architectural treatment intended to masquerade as a simple remnant leftover from the site's previous quarry operations.

Beyond the steel blast-proof doors at surface level, a sloped access tunnel connects to the underground bunker's main entry point. *Subbrit* photographs show how the tunnel's concrete floor was initially overlaid with a standard Linoleum membrane (which has since melted away from the heat of the fire), providing a layer of protection and ease of maintenance. What is particularly notable here is the two different materials that combine to form the tunnel's construction. For approximately 15 meters (from the surface-level end), the tunnel has been built using *in situ* reinforced concrete finished in style typical of post-war civil projects[267]. After this concrete section, however, the tunnel abruptly shifts into a distinctive portal section of steel segments – identical to those used as tunnel linings for the Glasgow District Subway or London Underground. Crucially, this materiality provides key evidence of the super-priority protocols I discussed earlier. First, it highlights how Barnton Quarry transcended parallel running civil schemes across Scotland to procure significant quantities of scarce steel. At the same time, the likes of schools and universities were being delayed or curtailed. Second, the material shift between steel-ringed portal sections and *in situ* concrete indicates the dire extent of post-war shortages. Even with the unparalleled state patronage offered by 'super-priority' there was still a crippling shortage for the ROTOR programme. After initial design proposals specified steel, later amendments replaced this with more widely

[267] J. Gilchrist Wilson, *Exposed Concrete Finishes: Volume 1* (London: C.R. Books, 1962), pp. 101-103, See the 'rendering' featured in chapter 5

available concrete. It can be suggested that this presents a critical turning point in the ROTOR programme; when Barnton Quarry revealed that the amount of steel required would be too much of a drain if all ROTOR bunker tunnels were constructed in this standard form. While this material dialogue provides an insight into the ROTOR programme's secret narrative, I consider the reels of wall-mounted cabling affixed to both sides of the tunnel the most striking elements (see fig. 2.10). Although these conduits are no longer present, they once functioned as the main arteries of the bunker; providing essential utilities such as electrical power and telecommunications lines vital to the building operations outlined in chapter 3.

After passing the steel-ringed portal section, another set of steel blast-proof doors lay at the bottom of the tunnel. Here, a distinctive 'dog-legged' corridor (where the plan kinks perpendicularly at right angles) leads to one of the central stair cores providing access to the lower levels. Interestingly, this dog-legged feature is perhaps the oldest descendant of military fortress design and is tracible more recently to the Atlantic Wall bunkers, as discussed in the previous chapter[268]. Historically, the dog-legged feature offered protection against arms and conventional explosives by deflecting blast waves away from uninterrupted projection lines [269]. However, owing to the shifts in Cold War threats, the dog-legged junctures designed as standard across all ROTOR R-type bunkers were to protect against powerful blasts exerted from nuclear detonation; and were, thankfully, never tested.

The ceiling-mounted mechanical hoist above the central stair core was installed standard across all ROTOR bunkers for lifting and lowering goods, materials, or equipment. Should heavy radar equipment, plant, or communications systems need to be replaced with advanced technology, this simple hoist provided a vital means of future-proofing the nuclear bunker's flexibility (as I detail in chapter 3). Another interesting point is the evidence of the bunker's continued adaptive reuse across the Cold War.

[268] Hogg, *Fortress: A History of Military Defence*

[269] The dog-legged entrances integrated within Atlantic Wall bunkers were used as Killzone's to trap anyone attempting to access with machine gun emplacements providing a lethal force of active defence.

Figure 2.8: Barnton Quarry indicating fire damage and vandalism

Figure 2.7: Barnton Quarry compound looking north c.1953 (Barnton Quarry Restoration Group)

2.3.2: Central Operations Well

Architecturally, these Air Ministry bunkers were closely developed by using Britain's WW2 RAF 'filter blocks' as a starting precedent and included examples like Fighter and Bomber Command bunkers in England (as outlined in the previous chapter). While the guardhouses were vital components in camouflaging nuclear bunkers, internal architectural layouts were equally important to the optimum performance. This solution was based on simple central corridors with cellular offices and workshops offset perpendicularly and was applied as the standard design approach for most ROTOR bunkers (see fig 2.15, for example) and other 1950s bunkers of similar scale. As illustrated in *Cold War: Building for nuclear confrontation, 1946-1989* plant rooms were conveniently located at the far end of floor plans to facilitate ventilation and air conditioning systems. One of the most influential aspects underpinning the design development of ROTOR interiors was the central operations well[270]. Reviewing its plan and section (fig 2.15 and 2.16.) reveals how the central operations well served as the primary planning device for most large-scale ROTOR programme bunkers including; ROTOR R-Type, AAOR, and ROC Group HQ[271]. In short, the operations well was a two to three-storey void space that had a wall-mounted 'tote-board' and angled map table fixed to the floor. Surrounding these elements on three sides were a series of glass fronted cabins designed to have an uninterrupted view of flight data as it was presented on the tote board and map table.

As a consequence of shifting Cold War threats (see chapter 4) most of these operations wells have since been infilled, providing vital extra floorspace, and their new architectural arrangements make it difficult for us to interpret the original functions. However, a small collection of black and white photographs taken at an unknown ROTOR bunker in the 1950s, can be found online through the publicly accessible *subbrit* archive. These images appear to depict a training scenario where personnel dressed in RAF uniforms can be seen viewing the operations well from behind glass cabins (fig 2.10**)**. Similarly, what is believed to be the only surviving photograph of a standard R4-type central operations well provides an alternative perspective that partly looks into the glass cabins from the operations well (fig 2.9)[272]. Collectively, this limited series of still images help convey the physical layouts. separated hierarchy across the three-tiered levels.

John Bushby also helps understand the architecture of this space through his carefully crafted account that permits an insight to operations rooms like Barnton Quarry during active Cold War operations[273]. Referring to an unnamed site within Scotland (perhaps Saxa Vord in the Shetland Islands) during the 1970s, his autoethnographic observations helps to better understand the human interactions and activities during live operations when tracking enemy aircraft approaching British airspace. Interestingly, these flurries of activity are reminiscent of the WW2 RAF examples noted in the previous chapter (one of the best demonstrations of the central operations well is depicted in Guy Hamilton's Battle of Britain, which was filmed on location at RAF Uxbridge)[274].

In the event of a nuclear attack, the central operations well would become the beating heart and brains of the bunker where the incoming flight data was processed and disseminated to determine the most appropriate countermeasures if long-range Soviet nuclear bombers, breached Britain's airspace. The ROC network (as the main reporting body) and other ROTOR R-type bunkers (operating

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[270] Cocroft, Thomas, and Barnwell, p. 104
[271] The central operations well are also referred to as the central operations room.
[272] This image is believed to show Kelvedon Hatch ROTOR bunker in Essex, a near-identical English version of Barnton Quarry. Incidentally the operations well is no longer in the original formation as it has also been infilled.
[273] Bushby, *Air Defence of Great Britain,* pp. 9-15
[274] *Battle of Britain*, directed by Guy Hamilton (United Artists, 1969), film

as radar stations) combined as one interconnected surveillance unit. The ROC personnel would note aircraft numbers, altitudes, and flight directions before transmitting the data to their respective master post, whereby information was then forwarded to ROC Group HQ, who subsequently sent it to Barnton Quarry. Once received, the data was disseminated to assess the unfolding attack scenario and make measured, yet quick, decisions over the appropriate response[275]. The first response (or line of defence) was to scramble RAF fighter jets, based on standby at airfields located around the country for air-to-air interception. Alternatively, should this strategy fail, or time implications render this ineffective, the flight data (i.e., coordinates, direction, and altitude) would be issued to the AAOR bunkers where Royal Artillery units were to use anti-aircraft batteries as a last resort in shooting down the incoming aircraft.

Imperative to the successful handing processes, and dissemination of flight data was efficient communications. Fundamentally, Barnton Quarry's architectural design and layout of the operations well greatly assisted these efforts through a hierarchical framework of 'control cabins' strategically positioned around 3 sides of the central space – similar to the earlier WW2 Filter Rooms (fig 2.9.). By analysing the section details originally sketched by Fighter Command (part of the Air Ministry base client), it is clear the different levels containing these cabins were designed to certain heights at inverted angles to ensure an uninterrupted top-down view of the tote-board and map table (fig 2.10). The upper level was reserved for the most senior RAF personnel so they could see an an-up-to-date picture of the unfolding situation in the event of a nuclear attack[276]. The mid-level cabins were designated for the 'ground executive' radar operators and the 'air executive' who directed RAF aircraft assigned with intercepting incoming aircraft[277]. Finally, at the lower base of the operations well, highly skilled operatives updated the map table, and the tote board with information relayed from the cabins at the podium-like section[278].

[275] Cocroft, Thomas, and Barnwell, p. 104
[276] Ibid.
[277] Ibid.
[278] Ibid.

Figure 2.9: Internal view of standard R4-type Sector Operations Centre (subbrit)

Figure 2.10: Stills showing view from Sector Operations Centre cabins (subbrit)

2.4: Architects Finally Join the Bunker Club

As mentioned at the start of this chapter, in managing the ROTOR programme, the Air Ministry appointed specialist consultants and contractors to the project team which previous researchers have been able to reveal and identify as Mott, Hay, and Anderson (as the civil engineer), Sir Robert McAlpine (as the building contractor) and Marconi (as the specialist radar contractor). Despite the size, complexity, and central importance of these nuclear bunkers, however, there has been no reference nor inclination towards the involvement of architects in previous studies. Until now, the direct engagements made by RIBA architects Lesslie Kenyon Watson and Roderick Eustace Enthoven on the ROTOR programme have remained entirely unknown. My archival analysis of declassified Air Ministry files has unearthed the hidden contributions made by these two professional architects. As consultants to the Air Ministry in the early-1950s Watson and Enthoven provided vital design services on the ROTOR programme, including creative camouflage strategies; devising optimum internal layouts; producing detailed design items for fixed furniture, and planning guidance.

In contrast to the various contributions made by American architects on nuclear bunkers across the Cold War, inputs from Royal Institute of British Architects (RIBA) 'fellows', some of the most senior professionals of the industry, have hitherto remained unknown [279] . Historically, the previous utilitarian needs of the battlefield had all but consigned architects as a secondary discipline to that of engineers. in fact, Anthony Jackson, described how the British military nearly ignored architects during WW2, despite their inherent capabilities in stark contrast to engineers[280]. Jackson also explained how the RIBA 'expended much effort getting [architects] treated as favourably as engineers' during the 1940s[281]. Crucially, however, unlike the earlier, more utilitarian bunker examples, civilian architects were at the centre of developing the new nuclear bunker required for the Cold War.

To begin this section, I introduce Lesslie Watson and Roderick Enthoven as key consultants on the ROTOR programme project team by outlining the direct architectural contributions during their simultaneous involvement with the top-secret ROTOR programme. Once established, this section continues to frame additional contributions most likely made by either or both architects, such as securing planning approval that had been revolutionised under the Town and Country Planning Act (Scotland) 1947. The section concludes by suggesting surreptitious transfers of hidden contributions that can and should be recognised in a broader post-war civil context: efficient project management and design teamwork permeated through public consortiums, forums, and educational environments.

[279] Monteyne, pp. 107-142
[280] Anthony Jackson, *The Politics of Architecture: A history of modern architecture in Britain*, (London: Architectural Press, 1970), p. 78
[281] Ibid.

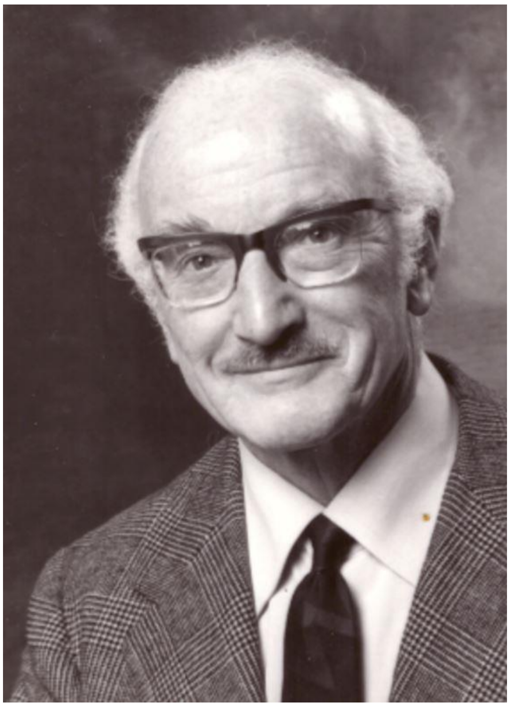

Figure 2.11: Lesslie Kenyon Watson

Figure 2.12: Roderick Eustace Enthoven

2.4.1: Lesslie Kenyon Watson and Roderick Eustace Enthoven

Before detailing their specific architectural services appointed to the ROTOR programme, it is worthwhile introducing both architects through their resumes for this overview clearly illustrates their specialist backgrounds: being mentored by highly revered architects of the twentieth century**;** acquiring frontline military experience during WW2, and sharing unique relationships with the Air Ministry. Undoubtedly, these common attributes placed both men firmly within the Air Ministry's consciousness and subsequent Cold War conversations when seeking the best, or only, suitable candidates for Britain's nuclear bunker architecture.

While Enthoven, (fig. 2.12) a somewhat stalwart of Britain's post-war professional domain (through his involvement with the AA), carries a certain presence within architectural history Watson on the other hand has largely been overlooked[282]. Despite a notable career working under famous architects, contributing several articles to the architectural press, and escaping German capture during WW2, Lesslie Watson (1906 - 1994) is a prime example of the anonymity often attributed to post-war civil servants (fig. 2.11) [283]. By analysing Watson's 'RIBA Nomination' papers we learn that after studying at the prestigious University of Cambridge and the Royal Academy in London, Watson undertook a nine-year stint from 1927 to 1936 working for the famous British architect Sir Giles Gilbert Scott (1880 - 1960)[284]. Gilbert Scott is well known in architectural history for projects like Bankside Power Station, London (1947 to 1963), now functioning as the Tate Modern art gallery, and the Forth Road Bridge (1958 to 1960). Of particular interest from Watson's time in Scott's office is that Gilbert Scott was awarded the prestigious RIBA Gold Medal in 1925 ahead of holding the prestigious position as RIBA president (1933-1934). Amongst a diverse range of projects centred mainly in England, Watson's more notable contribution lay in his involvement with the New Bodleian Library at the University of Oxford – evidenced by the watercolour held in the RIBA image collection[285]. Watson then spent two years with the architect Sir Edward Maufe (1882-1974) from 1936-1938 – who, like Gilbert Scott, was also awarded the RIBA Gold Medal in 1944[286]. Although his involvements are less prominent during his time with Maufe, Watson's RIBA nomination papers cite three projects; including a house, St. Mathews Parish Hall, and a gramophone record-making studio[287].

Vitally, after his time under Maufe's mentorship, Watson transferred to the Air Ministry Works Department (AMWD) in 1938; most certainly marking a pivotal career move that placed him in a highly advantageous position to benefit from a raft of government contracts during the frenetic post-war period – including nuclear bunkers. At the AMWD, Watson gained unique architectural experience during the construction of the RAF's new Bomber Command Headquarters at High Wycombe, 30 miles west of London [288]. The Bomber Command HQ included a three-storey subterranean concrete bunker as part of the masterplan, this orchestrated bombing missions throughout WW2 and is still utilised by the RAF today[289]. Given the site was chosen outwith London to fit the needs of concealment from aerial reconnaissance during WW2, various buildings were

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[282] Christine Wall, *An Architecture of Parts: Architects, Building Workers, and Industrialisation in Britain 1940 - 1970* (London: Routledge, 2013) Notes Roderick Enthoven's activities at the AA
[283] Mark Chalmers, "Glasshouses: Green Design", *Urban Realm*, July 27
[284] Tricia Lawton (RIBA Information Centre), email to author, October 30 2019.
[285] Ibid.
[286] Ibid.
[287] Ibid.
[288] Ibid.
[289] Royal Air Force, *RAF High Wycombe*

therefore designed in a subtle rural style of architecture to provide a degree of camouflage. For instance, the on-site RAF fire station was designed and built to resemble an innocuous village church so as to deter detection from German surveillance and espionage[290]. More importantly, however, Watson's presence within Bomber Command HQ undoubtedly provided crucial experience with the design and construction requirements of the subterranean three-storey concrete bunker. Incidentally, this would have provided Watson an invaluable insight to the challenges of working on a top-secret Air Ministry project. While unaware of this importance at the time, his presence permitted an understanding of the complexities and functional requirements specific to bunker architecture and incidentally would have positioned him as a prized government asset to the ROTOR programme in the early Cold War period.

The RAF bunker at High Wycombe was Watson's last peacetime scheme before he was released for active duties at the outbreak of WW2. Like James Stirling, another famous post-war architect, during WW2 Watson served with the Royal Artillery and was attached to the 7th Medium Regiment; rising to the rank of Lieutenant Colonel by the end of the war, commanding a group of up to 600 personnel. During the Battle of Gazala, North Africa, in May 1942, Watson was briefly captured and held as a prisoner of war by Italian forces before escaping on a further two occasions[291]. After recapture by German forces and whilst awaiting transfer to Germany, he made his final escape – spending two months on the run before returning to British lines on 22 January 1944[292]. He was later awarded an MBE for repeatedly escaping enemy recapture and returning for active service. Upon his post-war demobilisation, it appears he continued private practice on a handful of commissions ahead of his 1950s Air Ministry appointment on the ROTOR programme.

In turning to Enthoven, his historical background prior to ROTOR involvement is equally important as Watson's. Upon graduating from the Architectural Association (AA) in London, Roderick Enthoven (1900-1985) briefly taught students at the school before establishing a partnership with Pakington, Enthoven, and Gray (later reconfigured to Pakington and Enthoven) until commencing his military service at the outset of WW2. His work included an eclectic range of projects, such as housing schemes and interior fit-outs for restaurants and department stores, extending his talents to designing bespoke furniture items[293]. Considering his close links with education and the RIBA, it is no surprise that he was later described as one of the 'Modern Movement veterans'[294]. At the outset of WW2, Enthoven enlisted in the Air Ministry's Camouflage Unit, alongside architect Hugh Casson, who was most famous for orchestrating the Festival of Britain exhibition in 1951[295]. After serving active duty as a Civil Camouflage Officer from 1940 to 1944, Enthoven later transferred and became a Monuments Officer in Italy until the end of the war. Once decommissioned, he returned to lecture at the AA, where he discussed experiences as a Monuments and Fine Arts Office in Italy. Although he entered into a new partnership with Pakington and Highet for a new shop at Bournemouth (1948), his priority seems to have remained in furthering architectural education and the broader

[290] Ibid.
[291] TNA WO 373 95 43, 'Recommendations for awards', Major L.K. Watson, 9 April 1944
[292] Ibid.
[293] Enthoven's projects include House on Banstead Downs, Surrey, (1929), 12 cottages at Byfleet, Surrey, (1933), Restaurant on Regent Street, London (1937), and the Robinson and Cleaver Department Store at Regent Street, London (1938).
[294] Astragal, "Modern History", *AJ*, 175 (1982) 19
[295] Hugh Casson, Art by Accident: The Aesthetics of Camouflage, *AJ*, 96 (1944) 63-67

profession[296]. Having maintained board positions from the 1930s through WW2 (which continued into the 1980s), Enthoven was appointed RIBA Librarian in 1946. He was later elected AA president in 1948 before assuming the post of RIBA Vice-President in 1952 – sometime around his appointment on ROTOR by the Air Ministry.

While both Watson and Enthoven's careers are not widely known across post-war architectural discourse, their combined professional backgrounds and WW2 military service must be highlighted for three principal reasons. First, although Watson's career is massively overlooked within architectural history, his trainee positions at Gilbert Scott and Edward Maufe's offices must be recognised as positioning himself with mentors closely aligned with the RIBA professional sphere who produced architecture of outstanding quality. Second, given Watson's military background of commanding large groups of people, coupled with Enthoven's responsibility of rescuing monuments from erasure, they both undoubtedly possessed high skill levels of efficient management and organisation in pressurised environments. This places both men alongside other well-known post-war architects of similar pedigree who pursued notable careers after demobilising, including James Stirling and Denys Lasdun, who had also served active frontline duties. Lasdun, in particular, was stationed in the Royal Engineers and assisted with airfield construction after landing in France on D-Day[297]. Third, both Watson and Enthoven maintained a close proximity with the professional RIBA body during their appointment on ROTOR and were also of a professional maturity (with both men being in their late-40s). Thus, given these combined attributes, Watson and Enthoven were ideal candidates in providing specialist architectural services for the ROTOR programme. In fact, they may have been the only architects in Britain who met the Air Ministry demands for more advanced bunkers, suitable for the new threats posed in the unpreceded Cold War climate.

By interrogating the declassified Air Ministry files and the few remaining drawings, it is possible to establish their exact architectural services and surmise their formal appointment by the Air Ministry. From the small number of surviving drawings, it would be fair to assume that Watson provided the Air Ministry with more design input for bunkers within Scotland as well as England. For example, one of Watson's most significant commissions on the ROTOR programme was the surface-level guardhouses that concealed direct access into the subterranean bunkers. His intricate hand-drawn elevations, sections, and plans unearthed for Anstruther's R3-type guardhouse are likely the only original drawings to have survived the Cold War purges mentioned above. Since the ROTOR programme standard was strictly maintained across Britain, Watson most likely designed all the other guardhouses in Scotland and England to ensure a blanket Cold War concealment strategy. These above-ground guardhouses were deliberately designed to blend with vernacular settings and will be examined in greater detail later. Additionally, setting-out drawings for internal layouts at the ROTOR R4-type bunker at Barnton Quarry, Edinburgh – 50 miles from Anstruther – also confirm Watson's continued appointment. Similar to the standardised guardhouses, drawings found for Barnton Quarry's 'tote-board' indicate these elements would have been replicated at all the other purpose-built R4-type ROTOR bunkers within England. Beyond these drawings, Air Ministry meeting minutes also situate his involvement at Bawdsey ROTOR R3-type bunker, some 400 miles away on the south-eastern Suffolk Coast near Ipswich. Here, Watson attended a meeting that discussed

[296] Prior to enlisting and during his time at the Camouflage directorate Enthoven maintained his relationship with the AA; being a member of the AA board (1931-33), serving as Vice-President from 1940 to 1941, and was an Honorary Secretary in 1943.
[297] Calder, p. 126

detailed design elements for the internal layouts, which included optimum positioning of electrical installations, finishes, and fixed-furniture fit-outs[298].

A more limited historical account has survived within Air Ministry archives when turning to Enthoven's appointment. For example, loose RAF meeting minutes reveal how his specialist camouflage expertise was required to assess the 'value of the concealment policy' at several ROTOR sites[299]. Specifically, his knowledge of architectural camouflaging, acquired during his wartime service at the Camouflage Unit, ultimately helped determine the effectiveness of aerial concealment at nearby domestic schemes for male and female personnel stationed within these bunkers[300]. As part of his assessment, Enthoven took part in an RAF flyover covering the ROTOR sites at Sandwich and Portland, located on the English Channel, before reporting on their effectiveness[301].

What can we tell from these inputs? Firstly, this enables an accurate placement of professional architects within the ROTOR programme (alongside engineering consultants and contractors mentioned by others), which balances the wider skillset consciously acquired by the Air Ministry. Secondly, given the parallel running crossovers between civil and military realms, my study permits new insights into broader post-war architectural histories. Such as Christine Wall's discussions of architectural positions held with Central Government and Local Authorities encounters as being 'servants of the state'; during a period where employment opportunities were limited[302].

Given the high value apportioned to the ROTOR programme outlined earlier, involvement undoubtedly offered attractive fees and employment opportunities against the backdrop of post-war recovery. While there is potential for this architectural involvement to be perceived by others in the profession as unethical, particularly highlighted in the transatlantic discourse of Monteyne, the opportunity presented vital fee-paying for both architects in the early 1950s[303]. As will be explored later, this furthered Watson at least to maintain a close presence as an essential architectural consultant to Britain's government throughout the 1950s, extending into the 1960s.

Furthermore, the ROTOR programme reveals key similarities with the serial contracting measures advocated by CLASP (or the Consortium of Local Authorities Special Programme) which the Central Government later applied to broader post-war reconstruction efforts. In short, the serial contracting approach of CLASP enabled lower construction costs when appointing the same contractor on a number of projects rather than employing said contracting firm once, with no further collaboration after the works are complete[304]. When using CLASP serial contracting procedures Local Authorities shortlisted potential firms and invited tenders for a typical school build. The contractor who submitted the lowest price was subsequently awarded the opportunity of negotiating a series of additional jobs thereafter which gave firms the incentive of submitting much lower costs with a view of securing a repeated programme of works rather than single one-off jobs[305].

In combining the services of Watson and Enthoven their architectural involvement can be confirmed for at least 5 out of the 43 designated sites on the broader ROTOR programme. However, given the

[298] NRS, AIR20/8192, Minutes of meeting held in room 422 9 May 1952 to discuss electrical installations in the underground G.C.I. building 12 May 1952
[299] TNA, AIR20/8192, Confidential loose minute, 9 June 1952, Details the clearance of Enthoven to fly as a passenger
[300] Ibid
[301] Ibid.
[302] Wall, *An Architecture of Parts: Architects*, p. 22
[303] Monteyne, pp. 130-140
[304] Ministry of Education, *Building bulletin, The Story of CLASP (London: HMSO*,1961), p.23
[305] Ibid.

standardised approach honoured throughout, we must assume that both architects were further employed on a continued serial contract, similar to CLASP, for the remaining sites – as was the case with other key project team members including the engineering firm of Mott, Hay, and Anderson (MHA). Importantly, like Watson and Enthoven, MHA were civilian consultants operating across a diverse range of sectors and had established themselves as specialists in tunnelling since 1888 (through work on London railways)[306]. Moreover, projects like the deep-level shelters constructed in London during the 1940s allowed MHA to maintain ongoing relationships with Central Government through the Cold War[307]. Interestingly, the multinational engineering consultant is still operating today but has since been rebranded as Mott McDonald and grown exponentially to include a global staff of over 16,000[308].

Although McCamley briefly noted MHA general presence as part of the Air Ministry's ROTOR project team, their full appointment is further understood when investigating the firm's archival holdings[309]. My research has identified that this historical relationship continued throughout the ROTOR programme as their appointment extended to all sites across Britain[310]. Thus, using MHA's standard appointment, it is highly likely that Watson and Enthoven's architectural contracting was based on similar conditions. Watson, in particular, would have been employed to produce a series of drawing packages for the ROTOR programme beyond the guardhouses and internal joinery.

One of the more critical observations from Watson's involvement is found within the drawing's title bars (see fig 2.23). From the details inscribed here, Watson's private office address of 6 Gray's Inn Square, confirms that he produced these drawings as an independent consultant rather than a designated Air Ministry suite (like the case noted earlier?). Interestingly, this implies a degree of autonomous control in providing his specialist architectural services; considerably different from his previous position working under the AMWD at the Bomber Command bunker. This process of calling on the external civilian realm matches the Air Ministry's interwar strategies and also reflects the broader CLASP school-building initiative pushed by Government in post-war reconstruction. Firstly, the archaeological studies of Colin Dobinson, frames the famous architect, Sir Edwin Lutyens, as being appointed as a specialist consultant to the Air Ministry in the 1930s. Here, Lutyens was employed to provide key architectural advice on building elevation design as well as overseeing planning stipulations set by the Royal Commission of Fine Art; which incidentally had expressed concern with RAF architecture disturbing the quaint rural settings of countryside airfields[311]. Secondly, this contributes to our more comprehensive understanding of the Central Government's reliance on the mainstream architectural profession. Not only did the Air Ministry adopt practices of appointing external architects, but Local Authorities also applied this measure around the same period to assist in school building programmes[312].

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306 Ibid.

307 Elain Harwood, *Space, Hope, and Brutalism*, p. 311

308 Mott Macdonald, "Our Heritage", Mott Macdonald https://www.mottmac.com/about-us/our-heritage[Accessed May 2, 2022]

309 McCamley, *Cold War Secret Nuclear Bunkers*

310 Paul Bates (Commercial Manager at Mott Macdonald), telephone conversation with author, November 19 2019.

311 Dobinson, p. 126

312 Nicholas Bullock, Building the Post-War World: Modern architecture and reconstruction in Britain (London: Routledge, 2002), p.220

2.4.2: Wartime Experience and Counter Espionage

We must remember that nuclear bunkers were birthed in an entirely new climate of sophisticated Soviet espionage and counterintelligence. For example, the case of the Portland Spy Ring positioned an immediate level of threat toward ROTOR bunkers when, Michael Goleniewski, a covert Soviet mole, successfully infiltrated the Admiralty Underwater Weapons Establishment at Portland – a mere stone's throw from the ROTOR prototype bunker. Although he was finally discovered in 1960, it is believed his subterfuge had preceded undetected for some years prior. Reaching out of the military realm and appointing civilian architects Watson and Enthoven against this backdrop was not without serious consideration. At root, it was essential that the Air Ministry's carefully assembled project team worked efficiently within dangerous top-secret environments and could be trusted with highly classified information, incredibly valuable to Soviet intelligence[313]. On the other hand, this project context indicates the unique impacts this had on the architect's appointed on these nuclear bunkers.

Although the 1963 Spies for Peace incident revealed sites like Barnton Quarry (by then used as emergency government controls), the ROTOR programme, on the whole, remained publicly effectively hidden until 1973 when John Bushby, ex-RAF personnel, first mentioned the term 'rotor' in his aviation history titled *Air Defence of Great Britain*.. The sustained efforts to keep this classified project from entering the public consciousness must therefore merit further inquiry.

The palpable threat of espionage reveals the importance of maintaining an effective, top-secret environment. The strict measures that were imposed on the ROTOR programme, carried direct implications for the entire project team, including the architects Watson and Enthoven. Beyond the restricted site access, the main protocols implemented primarily centred on protecting documentation[314]. For example, as part of the above-mentioned 'super-priority' scheme, all relevant sub-contractors and suppliers were kept at arm's length over their involvement with ROTOR. As with the statutory approvals (which will be detailed shortly), those outwith the project team's inner circle were given as few details as possible in regard to the ROTOR programme. Statements simply alluded to the works being part of a vital air defence scheme required for a potential nuclear war[315]. Measures ensuring the maintaining of this party line included removing all references to individual ROTOR bunker locations, so instead of their geographical position, a three-letter cipher was used between the Air Ministry, consulting engineers, and contractors as the primary means of identification. Barnton Quarry, for example, was designated 'MHA', Anstruther was 'FAT' and Inverbervie was 'LGZ'[316].

From Peter Hennessy's archival research on government files, one of the responses to espionage threats during the Cold War was the introduction of special procedures known as 'positive vetting'[317]. Importantly, under these protocols, security questionnaires became standard for the Air Ministry by January 1952 and were used to determine the reliability of civilian staff (or 'state servants' as Hennessy describes) employed on exceptionally secret government work[318]. Owing to Watson and Enthoven's military backgrounds, coupled with prior Air Ministry relationships, it must be assumed that the robust vetting was either fast-tracked or negated for both architects and thus facilitated project management of the ROTOR programme.

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313 Trevor Royle, *Facing the Bear: Scotland and the Cold War* (Edinburgh: Birlinn Ltd, 2019), p. 204
314 Throughout my archival research most of the files were labelled as 'top-secret' or 'classified'.
315 TNA AIR8/1630 Letter from Ministry of Supply to Minister of Defence (Emanuel Shinwell) 25 May 1951
316 TNA AIR8/1630, Attachment, ROTOR Alphabetical list of identity letters 19 September 1951
317 Hennessy, pp. 96-99
318 Ibid

On the other hand, however, this placement with ROTOR inevitably placed both architects at real personal risk of Soviet espionage and subterfuge. For instance, their involvement with ROTOR bunkers undoubtedly provided architects with classified information that would be of genuine interest to clandestine Soviet agents operating in Britain. For instance, if Watson was to be compromised, not only did he know the location of Britain's nuclear bunkers; how to visually identify the defence network (based on the various surface design features, including the vernacular guardhouses) and their entry points (underneath guardhouses), but Watson also knew their inner mechanics (i.e., how to disable their vital life support systems and communications lines) and how the ROTOR programme functioned as a composite network. Anyone privy to this knowledge was inadvertently placed in the crosshairs of potential coercion or interrogation by Soviet agents. On a human level, should either of these architects wish to travel abroad to countries previously within the Soviet Union – for business or any other reason – they were likely prohibited by central government or simply reluctant to do so given the potential risks. Albeit occurring in the early 1960s, this was the reality experienced by businessman Greville Wynee, who was recruited by British Intelligence Services to smuggle top-secret documents from the Soviet Union to London[319]. Interestingly, Wynee, like Watson and Enthoven, had been carefully selected for his specific background and this permitted him to assimilate (undetected) during business trips which formed part of his cover story depicted in Dominic Cooke's 'The Courier' [320].

Additionally, the Air Ministry possibly retained both architects until the full completion of the overall ROTOR programme (around the mid-1960s) through the practice of serial contracting noted above. Serial contracting (the act of awarding multiple contracts to the same firm) is still commonly used today and is often recognised as 'framework' agreements. Where this becomes very interesting is the fact both architects ended up sharing the same office addresses at the Raymond Building, London[321]. Watson initially operated out of 6 Gray's Inn (of the Raymond Building) from at least 1952, before moving to 3 Gray's Inn during ROTOR by 1959, meanwhile Enthoven later conducted his business from the office space next door at 4 Gray's Inn from 1958. While both architects potentially crossed paths at earlier RIBA events their shared office addresses – more than ten tears after the first ROTOR placement – cannot be explained as mere coincidence[322]. Given the importance attached to the ROTOR programme and the high value of both architects, the British government may have taken active measures to protect the secrets they kept. For instance, by moving Watson and Enthoven to the same building meant they were merely 15-minutes away from the Air Ministry headquarters at 'Bush House'. Such proximity would enable Watson and Enthoven to maintain efficient consultancy (in secret) alongside keeping up appearances across the architectural profession, thus, deflecting any potential Soviet surveillance. On the other hand, by consolidating both architects within the same building, the top-secret drawings, specifications, and other sensitive materials for the ROTOR programme were ultimately secured in one central location – much easier to protect from Soviet surveillance.

[319] *The Courier*, directed by Dominic Cooke (Lionsgate, 2020), film

[320] Ibid.

[321] Both offices were part of the Grade II listed Raymond Building, a four-storey Georgian terrace of red brick that still stands today.

[322] RIBA, Annual General Meeting, *AJ*, 119 (1954) 576-577

2.4.3: Designing Vernacular Camouflage

Operating from his drawing board at Gray's Inn, Watson achieved architectural camouflaging on the ROTOR programme by designing surface-level traces of underground bunkers to match the style specific to local contexts. Most notable from the ROTOR programme were the guardhouses designed and built to resemble simple-looking bungalows. These creative approaches in concealing bunker entrances have received more sustained reference within academic and non-scholarly studies. For instance, Duncan Campbell's investigative account of 1982 was the first to explicitly reveal the ROTOR programme's guardhouse concealment practices[323]. In *War Plan UK* Campbell featured a 2D cross-section which illustrated how access to the underground operations blocks (bunkers) was gained by travelling down a sloping tunnel connected to a staircase below the guardhouses[324]. His account also featured two black and white photographs depicting standard examples of guardhouses found at ROTOR sites in England[325]. These early glimpses were eventually expanded through the later archaeological studies by English Heritage where four-regional variations of 'bungalow-like' guardhouses were identified – carefully designed to 'blend into the local vernacular'[326]. However, there has been no detailed expansion on this camouflaging for nearly 20 years, and when viewed from an architectural history perspective, there is much more to learn.

Whereby design enabled concealment by mimicking the vernacular style of architecture reflective of areas local to ROTOR sites. Firstly, I will present a detailed architectural analysis of Anstruther guardhouse elevations for the first time by using original drawings and photographic surveys (from both subbrit archives and my own fieldwork). This robust analysis serves to emphasise how expertly detailed the building was architecturally and how its high standard of construction helped the bungalow blend with its rural context. Secondly, I then frame this elevation study within Neil Leach's architectural camouflage theory of mimicry, the process of replicating surrounding landscapes for protection.

Historically, camouflage has been deployed to great effect within military applications up to WW2 as a means of hiding from one's enemy. Similarly, camouflage was also used on the ROTOR programme to avert any unwanted attention that would lead to exposure during the Cold War. For instance, ancillary buildings (housing emergency backup services and life support systems) were designed to mimic rurally styled chapels, surface-level service penetrations and ventilation stacks carefully resembled agricultural stores, or made to resemble leftover WW2 structures. However, the guardhouses were the most consciously aesthetic camouflage element; here, direct access to underground bunkers was hidden beneath a single-storey bungalow, designed, and built to match the local vernacular. These guardhouses blended into the surrounding context by using materials and construction techniques local to the area so that when viewed aerially on reconnaissance flights or seen at ground level by Soviet agents, they simply blended naturally within these contexts; whether that be lush woodland or arable countryside[327].

Watson's combined architectural and military expertise proved vital in achieving this masquerade. By cross-examining Watson's original drawings (fig. 2.13) with my own photographic survey of the as-built guardhouse as Anstruther, we can begin to further understand this vernacular camouflaging. Here, the guardhouse (fig. 2.14 and fig. 2.15) presents itself as a typical bungalow dwelling – common to its civilian neighbours. The guardhouse is L-shaped in plan with a rectangular block

[323] Campbell, *War Plan UK*, p. 238-241
[324] Campbell's first edition does not use the term 'camouflage', this was only added in the 1983 revised version.
[325] Campbell, *War Plan UK,* plates 26 and 27
[326] Cocroft, Thomas, and Barnwell, p. 108
[327] Ibid.

(housing most of the internal rooms) attached to a square section (where the stair core leads to the subterranean tunnel). The guardhouse is of traditional Scottish masonry wall construction; three elevations are bookended with steeply pitched gable ends (two of which have chimney stacks), red pantile roofs, and good quality iron guttering. Of particular note from the building's elevation is the blonde stonework, built to a significantly high standard. The craftwork continues through the four-column portico at the front entrance. The bungalow's apertures are complete with traditional banding detail around all doorways, and the timber sash and case windows. From this analysis, not only did Watson specify a high standard for the masonry, fenestration, and roofing design, but he also ensured these elements could be easily built by sufficiently skilled craftspeople local to the area, perhaps artisans also responsible for house building in Fife around the same time.

Moreover, when cross-examining alternative material specifications and construction details, further architectural nuances can be identified at Scotland's other ROTOR guardhouses, reflecting additional conditions imposed by regional variations. Although these guardhouses were based on Watson's standard design template, there are further points worth noting when comparing different examples across Scotland and England, which allude to strict adherence of regional and national variations in vernacular. For example, when comparing *subbrit* archival photographs of Anstruther and Inverbervie guardhouses, subtle details were factored into their design and construction to suit regional characteristics. Although the guardhouse at Anstruther exhibits a traditional red pantile roof – distinctly more native to Fife coastal regions – Inverbervie, was finished alternatively in a very different grey slate, flat in profile, equally more suited to the local Aberdeenshire area. Additionally, when cross-examining the two portico entrances on the main guardhouse elevations, there are subtle differences in how the columns have been detailed. At Anstruther, columns are squared at the gable ends, whereas the same columns at Inverbervie feature a stone ball (fig 2.16). These differences in architectural expression reveal that two ROTOR bunker sites with differing region-based vernacular required their own specific responses to align with vernacular styles particular to that region.

Furthermore, camouflaging these guardhouses to suit appropriate regional variations went beyond Scottish boundary lines and is also evidenced when analysing English ROTOR sites. For when comparing these examples of Scottish guardhouses with the as-built version at Wartling, England, the Scottish stonework shifts entirely to an alternative of English brick construction (fig 2.17). Interestingly, the masonry here was laid in a typical stretcher bond pattern, where each course is centred above and below by a half brick, which crucially, is not typically known for its structural strength. The material shift subsequently impacts the front portico of Wartling as due to the limitations of shaping brick compared with stonework (which is inherently more sculptural through handcrafting processes), the built result is more rigid by comparison and less organic. Likewise, the lean-to roof and column junctions expressed at Wartling are of a much more refrained design – architecturally, considered more basic in appearance[328].

[328] While these cross-border variations require further analysis, my initial assessment suggests Scottish guardhouses of the ROTOR programme were potentially of a higher architectural quality than English counterparts.

Figure 2.13: Standard guardhouse drawings by Lesslie K. Watson (Scotland’s Secret Bunker)

Figure 2.14: Anstruther guardhouse looking west c.1975 (subbrit)

Figure 2.15: Anstruther guardhouse within rural context

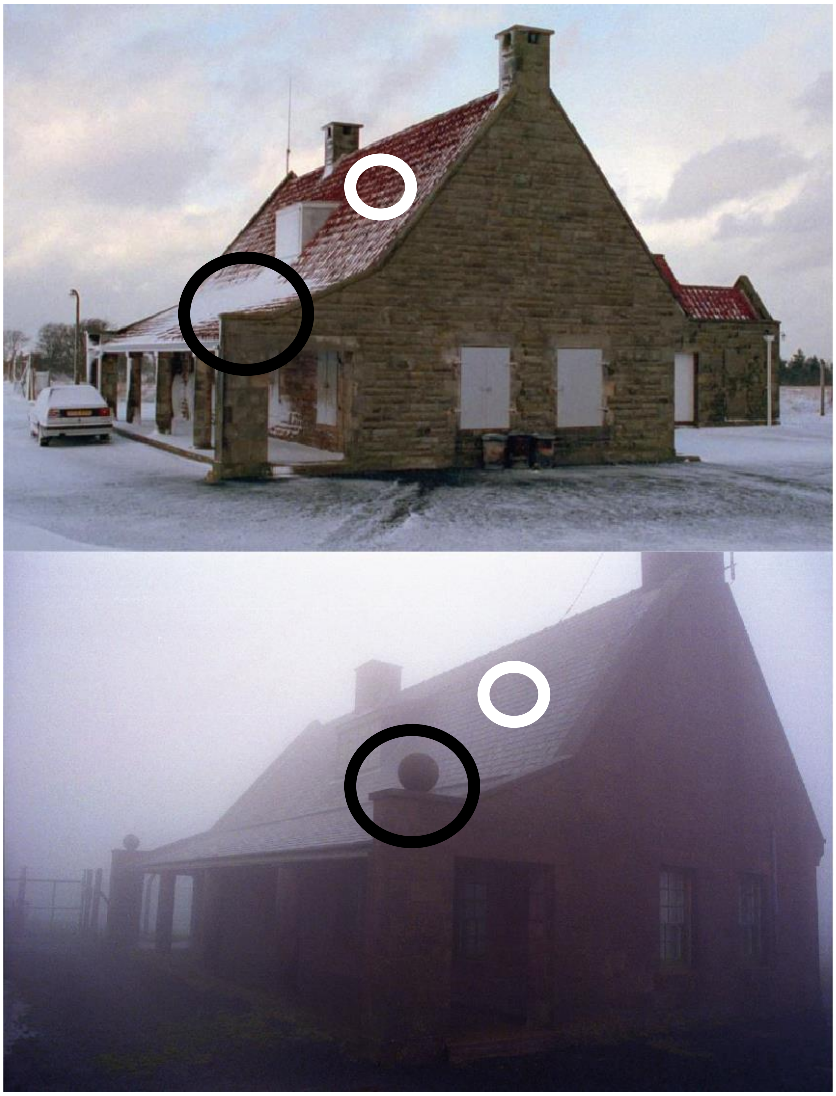

Figure 2.16: Elevational study of Anstruther and Inverbervie guardhouses (subbrit)

From the nuances of regional variations, it must be assumed that Watson conducted expanded site surveys to ascertain individual contexts; locally available materials; regional-specific details, and suitably skilled builders working in the local area. Placing this within Neil Leach's camouflage theory, highlights the importance of guardhouses designed to suit correct surroundings and in doing so charts the paradigm shift in concealment strategies compared with pre-1945 bunker examples.

Neil Leach suggests that successful camouflage can be achieved in 'producing a perfect imitation of the environment in terms of both colours and forms'[329]. By this, he argues that architecture which closely mimics its surrounding context provides a viable means of concealment and protection. In the instance of ROTOR guardhouse, architectural camouflage was required as protection from sophisticated Soviet surveillance imposed by acute Cold War geopolitical tensions. Leach also emphasises the 'strategic importance of design in facilitating the process of camouflaging[330]. From this, for camouflage to remain an effective defence mechanism, its designer – the architect – must be equipped with necessary specialist skills to ensure the imitation matches the host for if these elements were designed without due consideration to specific building types within the immediate context (structures more urban in style, for example), they may register as anomalies and thus risk detection if scrutinised in further detail by equally skilled Soviet observers. Therefore, by calling upon the architectural expertise of Watson and Enthoven, these guardhouses were designed with optimum results so as to subtly blend with their respective post-war civilian environments, in most instances, local vernacular. Once the individual site surveys were complete, standard guardhouse design and specifications could be rolled out across all ROTOR guardhouses from Shetland to Portland. Upon construction, these architectural details could be adapted to suit regional variations across all sites and tendered to selected local contractors – proficient in traditional construction techniques.

Thus, in producing these carefully crafted camouflaging applications, which paid close attention to subtleties of individual local vernacular we see another paradigm shift from previous military strategies. This new approach developed for the ROTOR programme significantly departs from the closest British predecessors (mentioned in chapter 1), where concealment solutions were much more literal or bizarre in comparison. This shift means that by the early 1950s, camouflage solutions for Cold War nuclear bunkers had superseded the WW2 strategies owing to aerial surveillance and ground-based espionage developments and ROTOR bunkers demanded more innovative architectural solutions. The pre-1945 application of scrim netting, paint schemes, and foliage cover were no longer effective.

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[329] Neil Leach, *Camouflage* (Cambridge, Massachusetts: The MIT Press, 2006), p. 74

[330] Ibid., p. 14


Figure 2.17: Guardhouse at Wartling, England (subbrit)

2.5: Nuclear Planning Targets

At this point, it is imperative to recall Edwin Heathcote (introduced at the outset of this chapter) for in his 'non-architecture' critique, Heathcote also said Cold War nuclear bunkers were 'immune from planning regulations'[331]. Given the importance of maintain the ROTOR programme's top-secrecy, as emphasised throughout this thesis, it would be reasonable to assume special concessions were afforded in keeping these bunkers classified – such as exempting them from new post-war Town Planning stipulations. Paradoxically, however, ROTOR bunkers were, in fact, required to comply with the statutory legislation also set for civilian schemes despite the misconceptions held within Malcolm Spaven's *Fortress Scotland* published in 1983. Here, Spaven (writing under the Scottish arm of CND) made baseless claims that Scotland's planning system was undemocratic, and the likes of ROTOR sites had 'no legal requirement to seek permission from the local planning authority' [332]. However, while this was entirely untrue, such misunderstandings have remained in stasis for nearly 40 years, with similar assumptions gone unchecked in the period following.

Luke Bennett, a social theorist with a background in planning law, contributed a helpful analysis of the planning efforts behind Britain's ROC posts which offered a counterargument to this planning misconception[333]. Nevertheless, there is still much more to understand by interrogating compliance with statutory planning from a robust architectural history analysis. By offering a new architectural history for the ROTOR programme, I therefore seek to revisit these nuclear bunkers and counterargue the claim that these do not reside in a separate vacuum (exempt from new Town and Planning stipulations) as Heathcote suggests, but instead convey a sense of parity with civilian post-war rebuilding of housing, schools, and hospitals[334]. The following section addresses this misunderstanding by disseminating the declassified and overlooked archival evidence to outline key examples within Scotland that prove planning obligations were honoured.

In the post-war context, significant changes to planning policy came into effect through the new legislation of the Town and Country Planning Act (Scotland) 1947[335]. Crucially, under this new Act, Local Authorities were given more power over developments for the first time and thus became a key channel for navigating the planning process and achieving key target dates[336]. For example, before any scheme commenced on site (whether it be housing, schools, hospitals, or office buildings) the relevant Local Authority had to grant approval based on a detailed review of proposals submitted in the form of building drawings, site layouts, and scaled models [337]. Given secrecy was paramount to the ROTOR programme's successful completion, full compliance with these requirements ultimately risked exposing the project's inner circle should an external Local Authority member scrutinise the bunker proposals. Therefore, this context allowed for a slight relaxation of the rigorous new planning conditions, and as this section outlines, a carefully managed process ensured statutory stipulations were honoured while also maintaining the classified status of bunkers. Unlike the previous publicity which heralded the Maginot Line and Atlantic Wall bunkers

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[331] Heathcote, 'Cold comfort form', p. 53

[332] Spaven, p. 43

[333] Luke Bennett, "Cold War Ruralism: Civil Defence Planning, Country Ways, and the Founding of the UK's Royal Observer Corps' Fallout Monitoring Posts Network*", Journal of Planning History*, 17 (2018) 205-225

[334] Heathcote, p. 53

[335] For sites located in England the legislation counterpart was the Town and Country Act (1947).

[336] Arthur J Willis and W.N.B George, *The Architect in Practice* (London: Crosby Lockwood and Son Ltd, 1952), p. 27

[337] Ibid.

during their planning phase, the ROTOR programme strived to keep top-secrecy at all costs and even kept most government departments and civil servants abreast to the ongoing bunker developments.

Subsequently, while ROTOR sites in Scotland secured planning approval, the new procedures were not without complexities. In particular, due to inter-departmental policies under the Service Land Requirement Committee (chaired by the Ministry of Town and Country Planning) considerable delays were encountered with bunker planning[338]. Furthermore, in order to obtain clearance of all land proposals, the Air Ministry and Ministry of Town and Country Planning entered a period of protracted consultations – similar to that conducted for other civilian planning proposal – which often resulted in lengthy dialogue. Moreover, should any Local Authority or central government departments raise any objections to the proposed bunker schemes it posed significant risk of delaying the ROTOR programme and subsequently miss its target dates. Therefore, to counter these delays, the 'super priority' scheme (outlined earlier) was extended in 1950 to provide an 'accelerated system' for planning approvals and urgent project completion[339]. As a result, Local Authorities had to complete a review of 'technical site' proposals (those hosting bunkers) within 14 weeks, whereas the supporting 'domestic site' proposals (accommodating personnel quarters) were to be concluded within one month[340]. In the event of 'deadlock' between the Air Ministry and any other party over land clearance, government ministers granted special powers for the ROTOR programme to 'invoke the guillotine after a period of 8 weeks from the original notification of the proposed siting' and facilitate approvals[341].

Principally it was the Department of Health Scotland (DHS) and the Scottish Home Department (SHD) of the Scottish Office who facilitated these planning negotiations for bunkers north of the border on behalf of the Whitehall-based Air Ministry. Civil servants likely based in St. Andrews House, Edinburgh, essentially acted as remote agents for obtaining these planning approvals. As they liaised with all relevant Local Authorities as far north as Shetland the Scottish Office personnel enabled sufficient cost and time savings on the overall ROTOR programme orchestrated from London[342]. Given the secrecy shrouding these sites, it is doubtful those assigned with clearing planning approvals were fully informed as to what purpose each site was to function. For example, declassified correspondence details how a formal statement was issued to Local Authorities (from the Scottish Office) that simply said these sites were of an 'urgent operational requirement' and that they pertained to a radio station 'vital for national defence'[343].

Interestingly, the Air Ministry's processes of achieving planning approval in the 1950s are distinctly similar to the systems still in place today. Although it is possible to trace the Air Ministry's securing of Barnton Quarry's planning approval (from the Edinburgh Corporation), the surviving archival record for Inverbervie reveals a deeper insight into how statutory planning permission was typically achieved for the ROTOR programme[344]. Correspondence between Kincardine County Council (as the Local Authority), Central Government departments, and the then Scottish Office details lengthy discussions in the application process for the underground bunker sites as well as the nearby domestic camp for the station staff. This compliance is important, for it was only after these discussions were complete and no objections were raised that the 'radar station' was granted

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338 TNA AIR8/1630 Restoration of the C. and R. System: Note of Progress December 1950
339 Ibid.
340 Ibid.
341 TNA AIR8/1630, Restoration of the U.K. C & R System: 3rd Quarterly Progress Report, 1 June 1951.
342 Both the Department of Health and Department of Home are present within archival records.
343 NRS DD12/1561 Letter from R.I. Hulley (Secretary of State for DHS) to the County Clerk at Ayr 4 May 1951
344 NRS HH51/260, Letter to SHD from MOW, 15 September 1961

planning permission under the Town and Country Planning Act (Scotland) 1947. Planning approval, however, was not given unconditionally. Despite the importance of Inverbervie – a vital Scottish link in Britain's ROTOR radar chain – three main planning conditions had to be met before work could even begin on site. First, Kincardine County Council stipulated that the Air Ministry was liable to cover any costs associated with the excessive maintenance measures and/or strengthening of the existing site access road[345]. Second, the Air Ministry was also responsible for covering the costs of diverting an existing field access track[346]. Third, the Air Ministry also agreed to foot any expenses should an overhead electricity line, connecting Montrose to Stonehaven (and owned by the NSHEB), require additional modifications[347].

Additionally, the RAF domestic camp (or housing scheme) proposed at Castle Terrace for accommodating the stationed personnel, 2.5-miles south of the ROTOR bunker, was also approved with one rather unusual condition. As part of planning approval, the Air Ministry had to ensure the current land tenant could secure his seasonal crops to appease the farmer after land surveyors had previously caused 'considerable damage' to his potato fields in assessing the site[348]. Against the hurried backdrop of frantic preparations against nuclear attack, these bunkers made extenuating allowance for ensuring harvest was not impeded – at the expense of subsequent delays to the ROTOR programme.

While Luke Bennett’s study of ROC posts (of which approximately 200 were constructed within Scotland) frames insightful negotiations between the Air Ministry and private landowners, he claims these posts did not require planning consent and suggested that there was ‘very little evidence of liaison with local government in the siting of these posts’[349]. My archival analysis, however, reveals how this was not the case – at least for ROC posts constructed in Scotland. For example, after lengthy discussions over sites like the ROC post at Arbroath, extensive efforts were made to comply with onerous planning restrictions fully. Not only were conditions met for an above-ground Orlit post, but the Air Ministry went to extreme and expensive lengths to satisfy the Local Authority.

Beyond the case for Inverbervie’s planning approval there is evidence to show how far the Air Ministry were willing to go to maintain compliance when faced with difficult conditions imposed by certain Local Authorities – as per the experience of Arbroath ROC post. As per the peacetime context noted at the outset of this chapter, Arbroath ‘Group 28 ‘Y.4’ ROC post was another example of legitimate site acquisition. After the landowner initially refused to sell the site earmarked for the above-ground Orlit post, however, the Air Ministry had to find an alternative location within a reasonable distance of the ROC Group HQ at Aberdeen[350]. Even after acquiring another, Arbroath Town Council impeded matters further by refusing planning permission[351]. Judging by the speedy response a mere two days later granting full planning approval, the issues appear to have been circumvented by direct ministerial action, in-line with approved Air Ministry protocols noted earlier[352]. However, it appears this relocation still carried planning issues as the final location was moved again by the end of 1955. More importantly, aside from these siting concerns, the ROC post

[345] NRS DD12/2847, Letter to Air Ministry from SHD 4 May 1951
[346] Ibid.
[347] Ibid.
[348] NRS DD12/2847, Letter to DHS from DAS 19 July 1951
[349] Bennett, *Cold War Ruralism,* p. 219
[350] TNA AIR2/19722, Letter to HQ ROC Scottish Area 21 December 1953
[351] Ibid. Letter to HQ ROC Scottish Area 17 May 1954
[352] TNA AIR2/19722, Letter from HQ ROC 19 May 1954

was also to be of 'special construction' to satisfy the Town Council's stipulations[353]. Despite these lengthy negotiations, an alternative site was purchased two years later for £25 (£775 today) to construct the below-ground ROC post, which had been prototyped at Farnham, as I will detail later[354].

Both Inverbervie and Arbroath bunker approvals suggest the Air Ministry was willing to go to extreme lengths in appeasing potential disputes by agreeing to cover additional third-party costs in-line with the new statutory powers. Here we see a repeat of the Air Ministry's earlier worries experienced during the pre-WW2 expansion of the Chain Home radar network. As emphasised by Dobinson, the Air Ministry was acutely aware of potential issues should proposals gain any unwanted publicity and constantly checked works remained low-key[355]. I consider this adherence to new planning stipulations was part of the deep-seated ruse to ensure the utmost secrecy was maintained on the ROTOR programme. It seems the Air Ministry was willing to comply with Local Authorities over planning the ROTOR programme – at least to a point. For when impasses occurred and reserved as a last resort, the Air Ministry transcended County and Burgh Councils to streamline planning approval to maintain target completion dates. These efforts could be said to have been a calculated attempt to deflect unwanted attention from both the civilian population and the Soviet intelligence if the Air Ministry was to completely ignore planning stipulations. Nonetheless, despite the urgencies experienced during a period of potential nuclear war, this appeasement indicates a display of fairness between the Air Ministry, the landowners, and the Local Authorities.

Who was appointed to ensure ROTOR bunkers met their planning stipulations? Aside from the above services we know Watson and Enthoven provided, the Air Ministry almost certainly drew on these trusted consultants to maintain the ROTOR programme's efficiency and keep a small inner circle within the project team to ensure secrecy. In line with Willis and George's advice on good architectural practice, it was the 'architect's responsibility' to make themself 'fully acquainted with all the statutory regulations governing such work' and advise clients accordingly on the proper locating of buildings within the land[356]. Primarily, both architects were familiar with these new planning processes and thus best placed to facilitate approval with complex stipulations. Furthermore, similar to the guardhouse drawings I set out earlier, from an Air Ministry location plan for Inverbervie, dated 1951, there is evidence within the sheet annotations that highlights RIBA architects were present. At the bottom of the 1:2500 scaled 'Location Plan Site LCZ' (LCZ being the unique identity code allocated for Inverbervie to ensure project secrecy), a blank box with the wording 'ARIBA for W8' is scribed underneath[357].

Since ARIBA denotes the credentials of an associate architect and W8 was the secret cipher reserved for the Air Ministry Works Directorate AMWD, the Air Ministry and accredited RIBA architects jointly developed these drawings. As per the importance of maintaining a small, carefully vetted project team, as noted earlier, it is highly probable that Watson or Enthoven also drew these location plans. This architectural placement expands historical practices especially recognised by Dobinson, dating back to the 1930s when Edwin Lutyens was appointed to design new RAF buildings of the architectural standard to achieve approval from the Royal Fine Art Commission[358]. Most importantly,

[353] TNA AIR2/19722, Letter to HQ ROC, 12 December 1955
[354] TNA AIR2/19722, Letter to Air Ministry, 28 November 1957
[355] Dobinson, p. 208
[356] Willis and George, *The Architect in Practice*, p. 27
[357] NRS 'Location Plan Site LCZ ': Works Directorate 6/8/51 dated February 1951.
[358] Mike Osborne, *Defending Britain: Twentieth-Century Military Structures in the Landscape* (Gloucestershire: The History Press, 2004)

the above analysis reveals how Cold War nuclear bunkers were not granted a total exemption, or immunity, from new post-war planning stipulations. Despite using specific failsafe measures, the planning stipulations were generally observed with a high level of acceptance.

2.5.1: Bunkers over Boots: Restricting Industrial Developments

During these extensive planning processes, a new statutory requirement was implemented for 'safeguarding', which, interestingly, still exists in current Scottish Government Planning Circulars[359]. Initially established under the Town and Country Planning (Technical Sites) (Scotland) Direction 1951, safeguarding was to protect sites under the broader umbrella of the ROTOR programme from 'adverse developments'[360]. Relevant Local Authorities were issued with 'safeguarding maps', individual to each site, which were annotated with a series of concentric circles radiating from the site's central point that represented key boundary lines. Should any neighbouring developments fall between 600- and 2,000 yards of the ROTOR site's safeguarding boundary, Local Authorities were to directly inform the Air Ministry within 14 days[361]. Additionally, when these radar sites became operational, tractors, agricultural equipment, steel fences, and the construction of overhead (and underground) cables was strictly prohibited within a 250-yard radius of the site boundary[362]. To protect the ROTOR programme from unwanted publicity, these documents were to be protected and guarded within the smallest group possible, and 'safeguarding maps' were kept 'under lock and key' by responsible officials[363].

In maintaining secrecy, ROTOR sites were simply described as 'vital for national defence', and the Air Ministry was 'unable to give any general information on the extent and nature of restrictions to be imposed on development' [364]. Above ground, these safeguarding boundaries were installed to protect the immediate site against external radar and radio interference from civilian applications. More importantly, these safeguarded the subterranean aspects of the site to ensure no excavations disturbed (or discovered) the numerous service lines supplying the underground bunkers with electricity, water, and telecommunications. This also ringfenced suitable land should the bunker need to be extended. For example, Inverbervie's annotated safeguarding map (fig. 2.18) evidences two concentric circles radiating from the 31-acre site (indicating the 600- and 2000-yard boundaries). In regard to civil developments this safeguarding meant that no future work could fall within the nearby town without the official (unlikely) approval from the Air Ministry. Any future proposals would undoubtedly be quashed to preserve the interests of the top-secret ROTOR site [365].

Although safeguarding protocols were implemented as standard for all ROTOR bunkers in Scotland and thus carried some form of limitation, the most extreme instance of restricting industrial civil development is traceable to RAF Gailes in Ayrshire. Here, the ROTOR bunker – vital to radar coverage of the Clyde – superseded a Boots chemical factory which promised to boost the area's economic outlook. In 1947 the pharmaceutical firm, Boots Ltd, purchased 170 acres of industrial land in Ayrshire, on the west coast of Scotland, to build a new chemical factory for producing penicillin[366]. Notably, the site near Irvine had been explicitly chosen on the back of Lord Bilsland's appeal to locate the new factory in Scotland, instead of Grimsby, England, as part of the post-war

[359] The Town and Country Planning (Safeguarded Aerodromes, Technical Sites, Meteorological Technical Sites, and Military Explosive Storage Areas) (Scotland) Direction 2016, The Scottish Government, 2016
[360] NRS DD12/1561 Direction of State certificate issued by R.E. Russell (assistant secretary DHS) 1 May 1952
[361] Ibid.
[362] NRS DD12/1561 Letter from R.I. Hulley (Secretary of State for DHS), 4 May 1951
[363] NRS DD12/1561 Secret letter from R.I. Hulley (Secretary of State for DHS) to Ayr County Clerk 1 May 1952
[364] Ibid.
[365] NRS DD12/2847, Letter (marked secret and very urgent) to Angus County Clerk 2 April 1951
[366] NRS DD12/1561 Notes from meeting on RAF Station Fullarton, 28 June 1951

efforts in expanding industry developments north of the border[367]. As part of the ROTOR programme's expansion however, the Air Ministry had also earmarked 46.5 acres of land near the proposed Boots factory, which encroached considerably into the boundary line denoted on Gailes safeguarding map[368]. As a result, the Secretary of State for Air attempted to overrule Boots acquisition by claiming the site was essential for an 'important defence need'. However, both Ayr County Council and Lord Bilsland (eager to have the economic benefits of a new factory worth £1.5m) fiercely opposed the Air Ministry's proposal. Despite exhaustive searches and careful consideration, the Air Ministry later concluded that there were simply no suitable alternatives given the technical requirements of the RAF station (i.e., the underground bunker) and the Air Ministry 'must be allowed to proceed'[369]. When the decision finally ruled in favour of the Air Ministry, the ROTOR programme incurred additional not-insignificant costs.

On the one hand, this overruling meant the Air Ministry had to purchase the entire 170 acres of land instead of the original 46.5 as earmarked. On the other hand, they were obligated to reimburse Boots for £5,000 in repair costs for sterilising several coal seams on site (paid to the National Coal Board)[370]. Moreover, in addition to the ROTOR programme effectively gazumping Boots through its compulsory purchasing powers, the labour force assigned to constructing the proposed penicillin factory was also seized behind closed doors. Archives reveal that the initial construction labour – still in short supply at the time – was approved in principle for Boots in 1948[371]. However, by mid-1951, the Ministry of Labour deemed this no longer possible[372]. If we recall the 'super-priority' scheme outlined earlier, where the ROTOR programme was granted special rights to acquire labour ahead of civil works, it is plausible that the construction force earmarked for the Boots factory had subsequently been re-assigned to building the Air Ministry's ROTOR bunker – signalling a complete trumping of nuclear bunkers over parallel civilian developments.

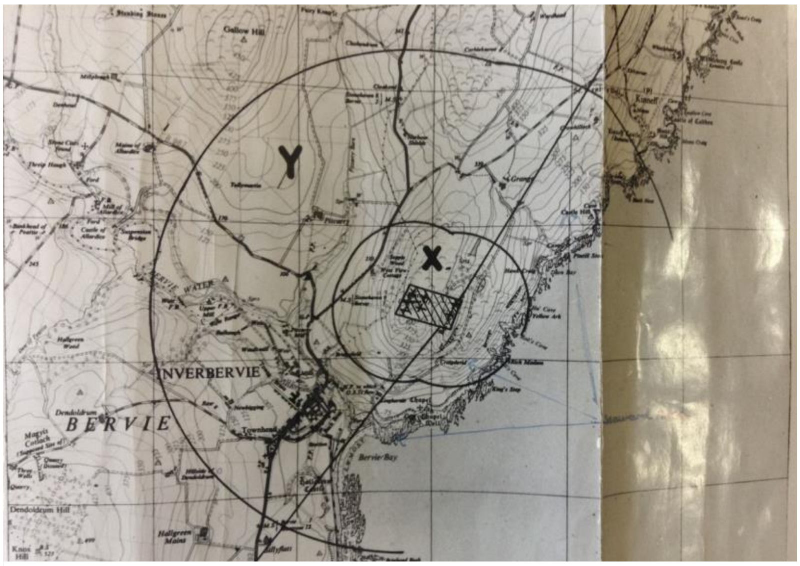

Figure 2.18: Safeguarding map for Inverberbie bunker (NRS)

[367] See John S. Gibson, *The Thistle and the Crown: A History of the Scottish Office* (Edinburgh: HMSO, 1985)
[368] NRS DD12/1561 Notes from meeting on RAF Station Fullarton 28 June 1951
[369] NRS DD12/1561 Letter issued to Ayr County Clerk from DHS 4 March 1952
[370] NRS DD12/1561 Letter issued to Air Ministry by Hulley (DHS) 14 May 1952
[371] NRS DD12/1561 Notes from meeting on RAF Station Fullarton 28 June 1951
[372] Ibid.

2.6: The Conduits of Civil Transfers

Watson and Enthoven were appointed to the ROTOR programme for their invaluable combination of wartime experience, Air Ministry relationships, and specialist architectural expertise, in turn they were also exposed to the ROTOR programme's advanced project management practices. In many ways, this advanced project management (which I detail in the next section) exceeded the standards of the broader civil realm reported at the time.

Although these cross-industry exchanges are not yet framed within architectural history, this section considers the viable means by which industry innovations transferred from ROTOR bunkers into mainstream practices. This exchange with the civil realm is considered via two primary channels: public consortium and RIBA cross-fertilisation. From analysing past issues of the architectural press, my study suggests the bunker architects, Watson and Enthoven, could have facilitated subtle innovation transfers from their unique exposure to the top-secret ROTOR programme.

Paradoxically, aspects of Watson and Enthoven was their publicly known professional engagements – simultaneous to their concealed involvement in the top-secret nuclear bunkers. Unlike other MOW architects involved in bunker projects Watson and Enthoven were far from isolated and very much at the forefront of the architectural profession. Around the time of their involvement in the ROTOR programme, both architects were primarily concerned with progressing private practice, education, architectural history, and conservation. It is vital to recall Enthoven's election as RIBA Vice-President in 1952, for this was only a year after his reconnaissance flight assessed ROTOR camouflaging. Likewise, Watson contributed to open-forum discussion at the RIBA conference at Torquay two years after ROTOR – this will be detailed shortly.

2.6.1: Public Consortiums

Firstly, by framing Watson's under-researched engagement with public works projects (external to the ROTOR programme), there is strong evidence that the same construction consortiums – borne out of bunker building – transferred directly out of these top-secret projects and were implanted within the broader civil realm. For instance, back issues of the *AJ* and *AR* reveal that beyond the ROTOR programme, the British government also commissioned Watson on a series of industrial projects across the 1950s and 1960s, particularly new post-war power stations and collieries. Such contracts included Ferrybridge B power station in North Yorkshire (1954-1960); the colliery buildings at Blyth, Northumberland (1957), Rugeley Power Station near the River Trent (1957), and Thorpe Marsh Power Station near Doncaster (1960).

Importantly, the project teams recorded across these sites comprised of the same members appointed by the Air Ministry on the ROTOR programme. For instance, Ferrybridge B power station for example, places Watson alongside Mott, Hay, and Anderson as the consulting engineers similar to Rugeley[373]. Likewise, this pairing expanded further to include the contractor Holland, Hannen, and Cubbitt for the new Blyth colliery buildings[374]. Crucially, the combined project team at Blyth Power Station (including architect Watson, engineer MHA, and contractor Holland, Hannen, and Cubbitt was essentially the same members who had been previously assembled by the Air Ministry for the Anstruther ROTOR bunker only three years earlier. Therefore, we must consider the continued paring of Watson and MHA as a direct transfer from the ROTOR programme into the civil realm. Their continued collaboration proceeded into the late-1950s which suggests the British government had identified the inherent value of the public consortium established through the ROTOR

[373] 5, Public Services, Power Station: Ferrybridge, *AR,* 115 (1954) 46-47, Noral, *AJ*, 132 (1960) 50
[374] 9, Industrial Buildings, Colliery Buildings: Blyth, Northumberland, *AR*, 123 (1958) 53

programme, which could be maintained and applied elsewhere in the wider post-war rebuilding. Thus, the shared experiences acquired on ROTOR bunker architecture were recognised and subsequently channelled into civil building programmes to nurture efficient design team collaborations and advanced project management.

Although the origins of CLASP date back to the late 1940s (through the Hertfordshire County Council school building programmes), the consortium aspect; where a group of interested local council authorities could engage and utilise a combined pool of resources and contractors, was only discussed in 1957[375]. Moreover, the first school consortium building programme did not officially break ground until 1958 with 31 commissions sanctioned by seven councils in England, amounting to a combined value of £2,870,000[376]. Crucially, according to the Ministry of Education, there were 'at the time, no precedents for a consortium of this type, and the pessimists were very sceptical about the feasibility of the whole proposal'[377]. However, given the project details outlined within this chapter, I argue that not only did the Air Ministry's ROTOR programme trump these figures (at £24m across at least 1,500 bunkers), but in fact, pre-dated CLASP given its official, albeit secret, starting date of 1949. This application of consortium also predates the later conclusions published within the RIBA *Architect and His Office*[378].

Watson's impressive career beyond the ROTOR programme is worth highlighting to better understand these professional relationships facilitated through involvement with nuclear bunkers. For instance, by the time of his appointment on the above industrial projects, Watson was working in partnership with fellow Royal Academy graduate Harold John Coates as 'Watson and Coates', however, as there is no record linking both architects prior, their historical placement on the ROTOR programme can and should be acknowledged as the point of establishment[379].

This partnership, born out of nuclear bunkers, ultimately set up their post-war statement piece; being the Headquarters building for the London Electricity Board, near Bethnal Green, in London completed in 1959. From the RIBA online photographic collection, the office building was planned on a 40-inch module with precast concrete as the main structure, and although the architectural press at the time of completion omitted reference of the external finish, photographs show an elegant composition formed in exposed aggregate concrete (fig. 2.20)[380]. Potentially Watson's most significant known contribution to public architecture after involvement with the ROTOR bunkers, the modernist office building has deteriorated and was recently signposted for demolition[381]. Thereafter, Watson became a sole practitioner for the remainder of his career and, like most others who had spent their careers with central government works, he largely remained anonymous in architectural history.

375 Ministry of Education, *Building bulletin, The Story of CLASP,* p. 14
376 Ibid., p.15
377 Ibid.
378 RIBA, *The Architect, and his Office* (London: RIBA, 1962: 168)
379 TNA AIR20/8192, Minutes of meeting held in room 422 9 May 1952 to discuss electrical installations in the underground G.C.I. building 12 May 1952, first places Watson (and his later practice partner Harold Coates) as 'architects' on the ROTOR bunkers.
380 4 Office Buildings: Offices: Bethnal Green, L.K. Watson and H.J. Coates, *AR,* 121 (1957) p.22
381 Twentieth Century Society, "Buildings at risk: Former London Electricity Board HQ, Bethnal Green." Twentieth Century Society. https://c20society.org.uk/buildings-at-risk/former-london-electricity-board-hq-bethnal-green#dismiss-cookie-notice [Accessed August 2, 2022]

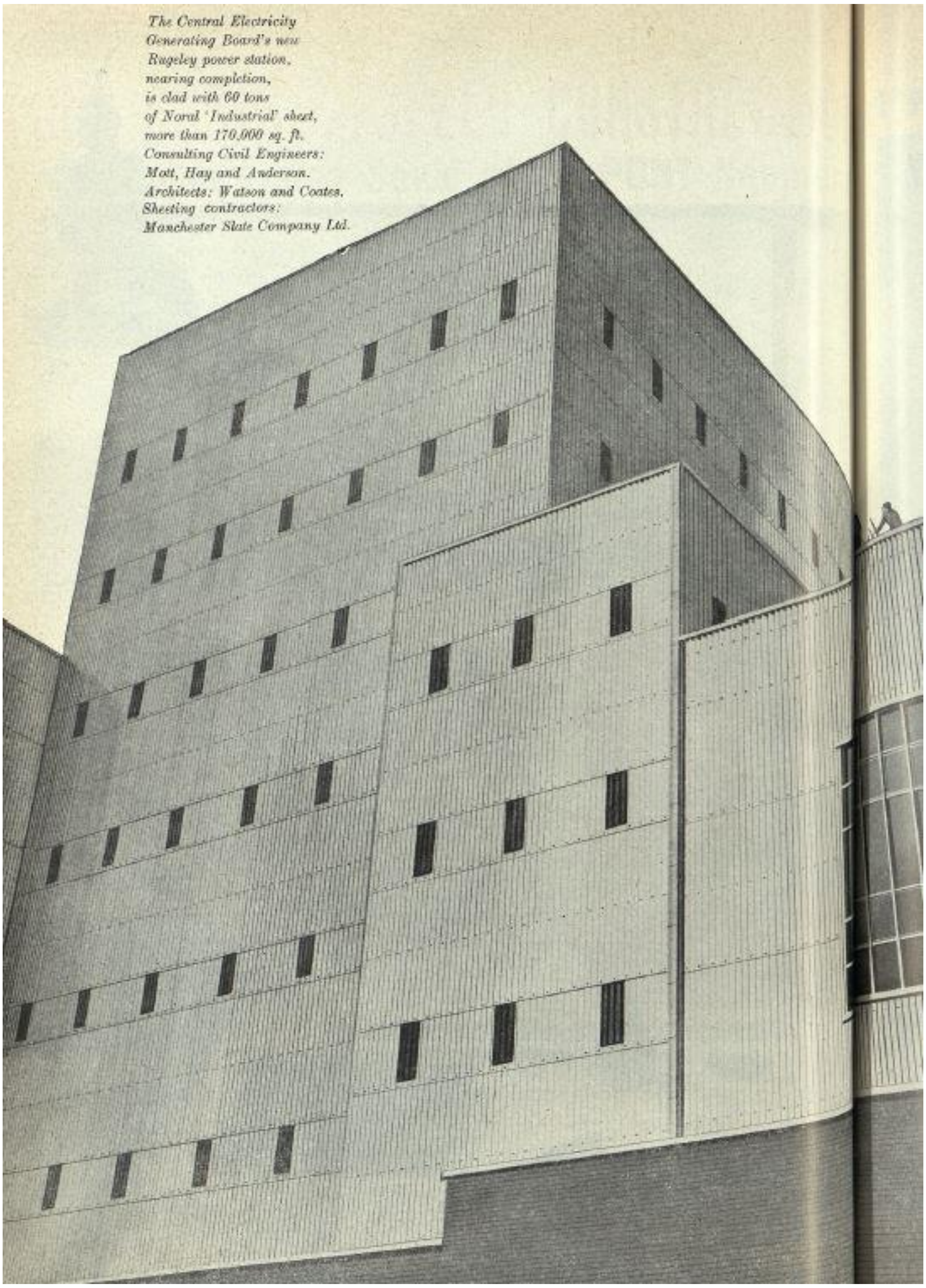

Figure 2.19: Rugeley Power Station (RIBApix)

Figure 2.20: London Electricity Board HQ, London (RIBApix)

2.6.2: RIBA Conferences

Beyond Watson's public works consortia, his personal pursuits in the post-war architectural realm indicate another more informal conduit of knowledge exchange. Throughout his career, Watson was a keen promoter of innovation and pushed new agendas for developing greater efficiency across the profession by attending plenaries and writing a series of articles published in the architectural press. One of the more exciting references to Watson's professional engagements was his presence at formal RIBA events. In 1954 for instance, Watson attended the annual RIBA Conference at Torquay, Devon, where he contributed to open-platform discussions on the value of integrated teams and the encouragement of industry knowledge exchange[382]. In responding to the difficulties of architects obtaining information on new materials and techniques, Watson provided anecdotal evidence to a crowd of over 100 attendees – working in mainstream practice[383]. The crux of his problem was the lack of a complete understanding of material properties without detailed product data[384]. Despite conducting due diligence and consulting with the Building Research Station (BRS), Watson still encountered a latent defect with a specific flooring material after the works were complete[385]. While he called for more transparency and the cross-sharing of knowledge, it was how Watson addressed this problem – using a vague reference to a 'factory' he had built circa five years prior[386]. Whether or not this was indeed a factory is beside the point. The importance of this open forum discussion resides in the potential means of innovation transfer. Given the discretion required in maintaining secrecy over the ROTOR bunkers, Watson could have equally conveyed new practices he had encountered while omitting sensitive information that would risk public exposure to these hidden bunkers.

In 1965, Watson attended the RIBA AGM where the serving president was Donald Gibson (who was also the Director of Research at the MPBW). Given both architects' fervour for bettering professional standards, it is plausible that Watson and Gibson exchanged their old experiences working at the Air

382 'A Report of the British Architects Conference, Torquay, on Materials and Techniques', *AJ*, 119 (1954) 730-735, (p. 731)
383 Ibid.
384 Ibid.
385 Ibid.
386 Ibid.

Ministry and War Office, respectively. For me, the notion of Watson offering his invaluable advice on the new Emergency Government Controls EGC bunkers (to be discussed in chapter 4), which by then, were currently under construction at Kirknewton and Cambridge, is more than enticing. Events such as these industry forums and wine-mixers provided ample opportunity for Watson (and Enthoven) to safely share the lessons learned from full-scale prototyping, advanced project management, and effective team cooperation for wider dissemination amongst the mainstream profession. This environment still retains its cross-disciplinarity sharing and fertilisation of innovative ideas in the twenty-first century.

Crucially, without jeopardising the inherent secrecy protecting nuclear bunkers from exposure, such transfers could have cross-fertilised through the discussion forums at RIBA conferences, then down into the mainstream press to be disseminated by other professional architects, engineers, and building contractors. Upon absorption, these innovations could then apply to the civil realm via a range of avenues, including Central Government Departments, Local Authorities, and private practice. Such synthesis could therefore have indirectly benefited building programmes for the likes of housing, schools, hospitals, and office both within Scotland and across the whole of Britain.

As this chapter argues, ROTOR programme architects shared close relationships with the civil realm – beyond direct engagements on Cold War nuclear bunkers. The cross-disciplinary exchanges my study has unearthed for Watson and Enthoven did not reciprocate across the planning profession, as noted by Luke Bennett. Through his detailed analysis of ROC posts, Bennett describes the professional activities of urban planners in the civil realm as evidencing 'little crossover' with those concerned with Cold War civil defence[387]. This means urban planners and civil defence planners did not cross paths which inadvertently causes a notion of disjoint. This disparity is significant, for it highlights the high degree of integrated relationships between Cold War nuclear bunkers and the civil realm currently overlooked.

[387] Bennett, *Cold War Ruralism*, p.210

2.7: Air Ministry as the Real Architectural Radicals

As outlined above, by the early 1950s the Air Ministry had acquired invaluable experience in the efficiently assembling the consultants and builders required for its specialist project team (including the architectural appointments of architects Watson and Enthoven previously outlined). This section addresses the other progressive tenets directly linked with the Air Ministry's ROTOR programme: advanced full-scale prototyping and industry-leading project management. By presenting these innovations through an architectural history lens, I argue that the ROTOR bunkers may have superseded the advanced efforts more commonly acknowledged through other government departments such as the War Office. Recognising these endeavours is essential, for they support an alternative view that the Air Ministry were perhaps the real radical force urging for better governmental architecture and proved to be just as crucial in the eventual creation of MPBW (discussed in chapter 4).

2.7.1: Full-Scale Prototyping

Thus far, I have explained how the Cold War generated significantly more pressured environments of nuclear threat, espionage, and precarious geopolitical tensions, in which ROTOR bunkers called for advanced interior conditions. For beyond the protective values, these nuclear bunkers called for physically more comfortable interiors, than the rudimentary conditions of pre-1945 bunkers described in chapter 1. Ultimately, the personnel stationed within these spaces were expected to make life-and-death decisions should the hypothetical threat of nuclear war transition to reality. Extensive prototyping was rolled out across the ROTOR programme to ensure optimum design solutions through live human trials (conducted at full-scale mock-ups and prototypes on-site to test vital building services and life support systems), which are discussed further in chapter 3.

Albeit brief, Nick McCamley's archival research traces the prototyping of ROTOR R-type bunkers as early as 1952[388]. Likewise, Derek Wood's historical account of the ROC first alluded to the prototyping of ROC post bunkers through the experiments conducted in the 1950s as the observation posts transitioned from the above ground prefabricated 'Orlit' structures to the underground in situ concrete bunkers. In *Attack Warning Red*, Wood details two separate trials, jointly conducted by the Air Ministry and Home Office, held at Farnham, Surrey, in September 1956[389]. During the last trial, the underground bunker was completely sealed from the outside world to simulate the scenario of a nuclear attack for ROC post personnel[390]. Furthermore, engineer Mark Dalton's contemporary account expands on this by outlining other experiments conducted on ROC prototype bunkers. Crucially, Dalton cites a trial held in December 1959 where the test subjects remained in the bunker for an uninterrupted period of 48 hours where the ventilation louvres were periodically closed to assess changes with internal air quality[391]. Although these previous accounts have noted this prototyping, the intrinsic architectural value – to test failures, maintain cost control, and refine iterative design solutions – has largely been overlooked. In order to understand the importance of full-scale prototyping more clearly, this section focuses on how such processes were used as a critical development tool in moulding nuclear bunker environments while maintaining a strong notion of economy.

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[388] McCamley referred to the experimental status of the ROTOR R1-type bunker at Portland, constructed in 1952

[389] These experiments involved a crew of four observers who tested the equipment and conditions within a single room living space (measuring 4.5m by 2.6m with a ceiling height of 2.3m)

[390] Ibid.

[391] Dalton, *The Royal Observer Corps Underground Monitoring Post,* p. 35

2.7.2: The 'guinea pig' Bunkers

The top-secret nature of the ROTOR programme prevented even the basic of architectural practices widely used across civil projects. For example, although other government departments such as the London County Council (LCC) architect's department and the MOW extensively used scaled-down models built from card and balsa wood to test solutions in 3D form the same could not be utilised for nuclear bunkers[392]. Drawing packages alone carried a degree of risk should they fall into the hands of Soviet intelligence, so instead of making these miniatures to develop ROTOR bunkers, full-sized mock-ups and prototyping were applied as an alternative. Unlike modern applications, which now allow for sophisticated computer- and workshop-based modelling solutions that offer instant, hyper-accurate testing, Cold War nuclear bunkers used 'live' full-scale prototypes constructed at a small collection of sites known as 'guinea pig' bunkers[393].

Declassified archives reveal how a series of live experiments were conducted at these chosen sites in the early-1950s to evaluate specific design and construction aspects. Certain guinea pig bunkers that were built in England (including Portland, Ventnor, Truleigh Hill, and Wartling) were used to conduct a series of top-secret human trials, testing ventilation, heating, air conditioning, and fire detection systems[394]. Here, efficiently tested design solutions and the iterative changes saw refinement through feedback loops ahead of broader application. For example, CRPC records reveal how advanced Minerva fire detection systems were tested and scrutinised at the full-scale prototype bunker at Wartling before the standardised solution was later installed for all sites across the entire ROTOR programme [395]. Likewise, ventilation and air conditioning trials were conducted at the full-scale prototype bunker at Portland, ahead of their scientific results influencing the twinned Scottish bunker at Inverbervie more than 500 miles north on Scotland's eastern coast.

Despite this prototyping largely traced at English sites, solutions also influenced bunkers in Scottish (and vice versa). Although there were eleven R3-type bunkers throughout Britain (including Anstruther in Scotland), only one full-scale prototype was required. Solutions and lessons learned from this prototype could then be applied to the remaining ten sites – permitting simultaneous construction sites on a national scale whilst affording economic savings. These cross-country exchanges provide a key insight into effective project management on a transnational basis. Moreover, given the same labour force was transferred to other sites in Scotland (and England) it is therefore, credible that personnel responsible for Portland were similarly involved at Inverbervie to ensure standardisation was followed.

Further evidence indicates that proactive cross-border design development occurred during the ROTOR program by comparing Barnton Quarry and the Portland 'guinea pig' bunker. Barnton Quarry's access tunnel shows a distinctive material shift from steel to concrete. Whereas Nick Catford's photographs of Portland show a similar tunnel that was instead constructed entirely in steel rings[396]. This must be recognised as primary evidence of direct impacts of the acute steel shortages and subsequent lessons learned across the broader ROTOR programme. Given the acute material shortages experienced during construction, we must assume that the Portland prototype

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[392] T. W Hendrick, *The Modern architectural model* (London: The Architectural Press, 1957)
[393] Mark Burry and Jane Bury, *Prototyping for Architects* (London: Thames and Hudson, 2016), p. 27
[394] TNA AIR8/1630 1 October 1952. CRPC correspondence details an instance where Fighter Command (as part of the Air Ministry client body) submitted a 'major modification of the internal design' following a live site trial at an unnamed R4-type bunker. Approved on the grounds of 'improved operational efficiency' the changes were then carried over to all remaining R4-type bunker sites
[395] TNA, AIR8/1630 CRPC: Restoration of the U.K. C & R System: 6th Quarterly Progress Report, 1 July 1952
[396] Nick Catford, *p 50.*

had initially planned for steel tunnels at all later bunkers, yet, as the extreme steel shortages continued, the more pragmatic and available reinforced concrete construction was adopted instead (part way through the construction of Barnton Quarry's access tunnel).

Full-scale prototyping was and is still recognised within the building industry as carrying high costs, which are either accepted by the client or another project team member – typically the contractor [397]. However, by frontloading the high costs involved with full-scale prototyping at the outset – chiefly through materials and labour – I argue the ROTOR programme produced an environment of rapid learning and streamlined industrialisation. During this early phase, vital lessons and knowledge gained from these testing sites was collated, disseminated, and communicated through the CRPC project management structure. Through this full-scale prototyping approach, the Air Ministry could also recoup some expenditure as the ROTOR programme progressed; eventually balancing out the budget spending throughout the remaining construction phases and appeasing the Treasury. After concluding these experiments and fine-tuning any necessary refinements through feedback channels, solutions were similarly applied to the remaining ROTOR programme bunkers based on an efficient model of standardisation.

2.7.3: 'Concrete Bob' Goes Nuclear

What is particularly interesting at both Portland and Ventnor prototype sites is the direct involvement of civilian contractor Sir Robert McAlpine and Sons Ltd (McAlpine) – historically known as 'concrete bob' for his synonymity with concrete construction. Although others have noted McAlpine's involvement in the Portland bunker, my investigation expands this by interrogating the firm's archival documents to reveal the contractor's wider engagement across the ROTOR programme. This thesis not only considers the efficacy of these procedures but also highlights the vital contributions made by the civilian building firm. Being assigned key contracts in the ROTOR programme's development stages provided invaluable exposure to technical concrete knowledge that would prove vital in later post-war Brutalist schemes.

Unsurprisingly, the firm's official history published as 'A Portrait of Achievement', makes no mention the ROTOR bunkers within its vast portfolio. However, under-researched company records evidence McAlpine's site presence for at least two locations in the early 1950s; during the initial stages of bunker construction[398]. For example, the company's plant register (from 1949-1951) details caravans and trailers allocated for both 'Portland' and 'Ventnor' sites in October 1951. While the archival entries are short on detail, it must be acknowledged that these dates coincide seamlessly with the early construction period of these ROTOR bunkers. It is highly likely that the caravans recorded at these sites were used as accommodation for more senior company personnel assigned to supervise on-site works or potentially provided make-shift cabins for temporary offices[399].

Before unpacking the importance of McAlpine on the ROTOR prototype bunkers, it is worthwhile introducing the contractor's position within the project team. Firstly**,** in line with the strict conditions noted earlier of maintaining secrecy, the Air Ministry's appointment of McAlpine was most certainly based on the same conditions of consultants Watson and Enthoven. Like the project architects Watson and Enthoven, McAlpine also shared an historical relationship of working on military contracts. While architectural historians typically focus on McAlpine's better-known wartime contribution in the form of the WW2 Mulberry Harbour units, deployed for ensuring supply chains

[397] Burry and Burry, p. 27
[398] UGD 254/1/4/28 Sir Robert McAlpine & Sons Ltd plant register 1950-1952
[399] Ibid.

during the D-Day landings the contractor in fact held a more long-term relationship tracible as far back as WWI. Some of the earliest RAF projects, for instance, included a series of aerodromes and repair depots constructed by McAlpine during WW1[400].

Additionally, the firm was also contracted during the interwar expansion for new RAF stations at Shawbury and Tern Hill, Shropshire, across the early 1920s. Most importantly, however, is McAlpine's presence at the Uxbridge Fighter Command HQ bunker, constructed in the build-up to WW2, alongside more than 20 new or upgraded airfields across Britain[401]. For McAlpine was contracted to build one of Britain's 'largest strategic runways' in 1948 at Boscombe Down, Wiltshire, incidentally, used for testing new jet aircraft. This long-established relationship therefore positioned McAlpine as the ideal candidate for providing vital development with Britain's nuclear bunker architecture required for the ROTOR programme.

Meanwhile, the firm maintained a busy public appearance on other civil work schemes. In managing the company's split façade of secret nuclear bunkers and public projects, it appears special in-house measures allowed both types of schemes to operate simultaneously. For example, accounting records – kept by administration staff – indicate that the Portland ROTOR bunker was deliberately concealed within the company files by its listing in 1952 as 'Portland Street'[402]. Since these records were accessible to staff beyond the company's principals, and thus outwith the small ROTOR programme cohort, this appears to be another safeguarding measure by having the scheme deliberately scribed to appear as a commercial or residential project.

Another contributing factor to McAlpine's appointment on the ROTOR programme was the contractor's key industry experience of subterranean works. Since the nineteenth century, McAlpine had established a public reputation as one of Britain's leading contractors; highly skilled in underground construction that 'pushed the boundaries of engineering convention'[403]. Amongst an expansive portfolio, McAlpine was the main contractor appointed on Glasgow's District Subway (installed between 1892 and 1894) – the company's first tunnelling project and the first ever instance of *in-situ* concrete methods applied in subway construction[404]. While the initial contract awarded a limited section of works to include some 5000 feet of track and three station platforms, McAlpine's solution proved so efficient that it was subsequently adopted as the prototype and applied to later phases of the project by other contractors[405].

Therefore, based on McAlpine's pre-Cold War construction expertise, coupled with sound government relations, we must again acknowledge the Air Ministry's progressive tenets in assembling the most adept and efficient project team to ensure ROTOR's successful execution. In McAlpine collaboration with architects Watson and Enthoven, alongside MHA as the civil engineers the project team could facilitate early prototypes to identify potential issues and thus reduce unnecessary waste across the ROTOR programme.

Like Watson (and to a lesser extent Enthoven), as detailed earlier, this somewhat lucrative appointment on the Air Ministry's ROTOR programme provided McAlpine – one of Britain's 'big six'

[400] Sir Robert McAlpine, A Portrait of Achievement, McAlpine, p. 9, https://www.srm.com/media/1729/aportraitofachievement.pdf [accessed 2 May 2021]
[401] McAlpine, A Portrait of Achievement, p. 16
[402] UGD 254/1/3/5, Staff Salaries: London Jobbing, Monthly Staff Salaries 1947-1952
[403] McAlpine, A Portrait of Achievement, p.3
[404] The Glasgow Subway, D C Thomson, 1964
[405] Ibid.

contractors – unique opportunities with far-reaching benefits[406]. For as well as benefiting from on-site exchanges at nuclear bunkers (including exposure to construction management and efficient communications, McAlpine also acquired vital experience that later transferred to post-war housing and civic schemes that included the Barbican Estate (overseen by architects Chamberlain, Powell, and Bonn (1965-82), and the National Theatre (designed by Denys Lasdun and built 1967-76).

On the one hand, McAlpine's excavating experiences at ROTOR bunker sites through the 'cut and cover' procedures was later transferred to the Barbican re-development masterplan. Although the contractor was present throughout the Barbican's entire masterplan scheme and built the last residential tower in reinforced concrete under 'Phase VA', McAlpine was initially appointed to clear and prepare the site ahead of the first works programme commencing in the mid-1960s. Oral histories and archival study reveal that the site preparations demanded the removal of over 150,000 cubic yards of rubble at an impressive daily rate of 4000 square yards[407].

Furthermore, Barnabus Calder's detailed analysis of Denys Lasdun's concrete work at the National Theatre informs us how McAlpine carefully refined a high-quality finish through the use of test in order to achieve the desired 'as-struck' board-marked concrete. To achieve this, the contractor patch-tested concrete areas that were beyond the public view, thus ensuring rough trial sections were effectively concealed in the final building. The results from these test panels allowed McAlpine to perfect the concrete aesthetic before repeating the processes on the overall building[408].

While McAlpine's reputation is still recognised today, the contractor's top-secret work on the ROTOR programme can now be integrated into the firm's historical evolution[409]. First, the company provided vital help during a period of severe concern of nuclear war (potentially putting staff at risk with the same issues noted for Watson and Enthoven). Second, their innovation enabled fast-tracked prototyping to create optimum user spaces while maintaining project efficiency and economy. Third, as all this kept McAlpine close to the Government during the post-war reconstruction, the firm was afforded super-priority access to rationed materials and labour ahead of other civilian contractors – undoubtedly providing additional benefits to alleviate the widespread shortages[410]. Lastly, it provided the contractor with unique experiences with concrete construction, which, being hidden from public opinion, essentially provided a chance to refine practice while concealing poor work underground.

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[406] C. G, Powell, An Economic History of the British Building Industry: 1815-1979, (London: The Architectural Press, 1980), p. 160

[407] Christine Wall, Linda Clarke, Charlie, McGuire, and Olivia Munoz-Rojas, Building the Barbican 1962 – 1982: Taking the Industry out of the Dark Ages, University of Westminster, The Leverhume Trust, 2012) p. 8

[408] Calder, pp. 312-318

[409] Contemporary projects include the Reid Building at the Glasgow School of Art campus designed by Steven Holl (2011-2014)

[410] TNA AIR2/11604 Loose Air Ministry minute from A.L.M. Cary 6 May 1952

2.7.4: Advanced Project Management: A 'Sophisticated' Client

While the full-scale prototyping used to develop advanced building services and life support systems signalled progressive tenets of the ROTOR programme, I now turn to frame the Air Ministry as a 'sophisticated' client through its advanced project management which was imposed across the entire ROTOR programme that the Air Ministry.

In 1965, '*Communications in the Building Industr*y' written by Dr. Gurth Higgin, and Dr. Neil Jessop described a 'sophisticated client' as having vast experience in the building process and a detailed knowledge of the contributions required from the various members of a building team[411]. The advanced project management exerted on the ROTOR programme by the Air Ministry signals crucial evidence of this sophisticated client status – ten years ahead of the broader industry recommendations. Vital to this project management was the Control and Reporting Progressing Committee (CRPC) established to coordinate phased sequencing.

As the central authority for managing the entire ROTOR programme, the CRPC was an inter-departmental committee established under the Air Ministry in 1950 to facilitate the scheme's efficient construction and final completion[412]. While the CRPC's primary role was to provide detailed progress updates for all of Britain's ROTOR sites, the committee also carried out several other vital duties. For instance, aside from orchestrating the prototyping practices outlined above, the CRPC chaired monthly progress meetings (the first of which convened on 16 October 1951), coordinated technical progress, resolved design and construction issues, and delegated tasks across the project team[413]. Additionally, if delays threatened the overall building programme, the CRPC was firstly authorised to revise the entire building timetable and divert labour or material priorities at their discretion[414]. Secondly, in maintaining this vigilance, the committee was ordered to notify the relevant party (i.e., the principal contractors) at the earliest possible moment[415]. These safeguarding measures depended on the CRPC maintaining good relationships across the entire ROTOR programme, including all the individual project team members. For if serious disruptions threatened the ROTOR programme's progress, the CRPC was to be informed as soon as possible through telephone, signal, or postagram[416].

The CRPC's practice of progress monitoring, in fact, predated broader industry standards as well as certain CLASP arrangements (widely used across state-backed school building programmes). A series of 'Quarterly Progress Reports' (QPR), which were the CRPC's principal means of communication, were issued at three-month intervals, and covered various aspects of the ROTOR programme; from overall project progress and the letting of contracts to final handovers and building occupation[417]. A small collection of these original accounts have survived the post-Cold War document purges

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411 Gurth Higgin and Neil Jessop, *Communications in the Building Industry: A Pilot Study*, (London: Tavistock, 1965) p. 16

412 TNA AIR8/1630, Although the CRPC disbanded as an organisation in 1953, all responsibilities were subsequently transferred to the latterly formed 'ROTOR Planning Team', 1st October 1953.

413 TNA AIR20/11319 CRPC note on recent points of interest in operation ROTOR: 19 February 1952. Of particular interest with these meetings is the notable increase in attendance numbers from appointed consultants, contractors, and vested government departments. Initial records indicate average 20-representatives present from the relevant parties which doubled to 40 in 1952.

414 TNA AIR8/1630 4th Quarterly Progress Report CRPC, 31 December 1951.

415 Ibid.

416 TNA AIR20/11318 Phasing Procedure, CRPC Proposals, 16 August 1951.

417 TNA AIR series spanning from 1950 to 1956: The 1st to 20th CRPC Quarterly Progress Reports issued from the Air Ministry Secretary of State

(mentioned at the outset of this thesis) which in some instances, provide an extensive commentary on the ROTOR programme's overall coordination. These QPR required all members of the ROTOR programme project team to directly issue individual updates on the 1st or 15th of every calendar month[418]. Under this protocol crucial project team members, including Watson and Enthoven (alongside MHA and McAlpine) would have submitted detailed progress reports on their respective appointments and contracts. Furthermore, as keen promoters of innovation, it is possible that in experiencing advanced project management, both architects could have subsequently transferred innovations back into broader practice through the public consortiums and RIBA discussion forums already mentioned.

Although both the CLASP Board and Working Group, carried out similar activities to the CRPC, its practice of progress monitoring was not adopted until 1957, six years after the first recorded CRPC meeting [419]. Likewise, in 1962 in the RIBA's own recommendations for architectural practice, researchers had identified there was no means of collating immediate news of workload demands for projects, which resulted in the 'duplication of tasks' and 'waste'[420].

To streamline the project progress and achieve scheduled completion dates, phased sequences were carefully applied to the ROTOR programme. Gantt charts (a relatively modern tool in the 1950s) served as construction timetables and were regularly updated and shared across the project team, assigning specific tasks to relevant parties with respective deadlines[421]. Special measures were also factored into this phased programme to permit the construction of the actual bunkers as 'rapidly as possible' to achieve completion ahead of the radar and communication phases[422]. Likewise, the installation of building services (for electricity, water, sewage, and communications) alongside life support systems (ventilation and fire detection) were separately phased from the construction of the bunker's in-situ reinforced concrete superstructure.

At a broader project management level, the CRPC supervised and co-ordinated detailed work at individual sites to ensure 'all parts of the ROTOR plan are kept constantly in phase within the approved timetable'[423]. Internal service fit-outs were to 'flow in orderly manner' to ensure that each skilled trade followed chronologically and produce the completed structure in the correct sequence[424]. Interestingly, a set of original meeting notes evidence how various tasks were individually delegated to the relevant personnel, contractors, and organisations within the project team. For instance, handwritten notes were scribed into the left-hand margins which denoted 'Action by: -'; alongside the particular staged phases; revealing how the tasks aligned with the ROTOR project team's coordination system[425].

Additional measures were quickly introduced to facilitate construction progress. For example, the CRPC dictated that if building work on the main underground bunkers was completed in advance of the scheduled technical installation, the labour force was to be immediately released and assigned

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[418] Ibid.
[419] Ministry of Education, *Building bulletin, The Story of CLASP*
[420] RIBA, The Architect and His Office: a survey of organization, staffing, quality of service and productivity, presented to the Council of the Royal Institute on 6 February 1962, (London: RIBA, 1962), p.164
[421] Gantt charts broke the overall construction programme into a definitive set of organised sequences that detailed individual project tasks and times required.
[422] TNA, AIR8/1630, Restoration of the U.K. C & R System, 4th Quarterly Progress Report, 31 December 1951
[423] Ibid.
[424] TNA AIR20/11318, MOD Working Party on Rotor, 31 August 1951
[425] TNA AIR20/11318, MOD Working Party on Rotor, 6 September 1951

to other 'important building work' rather than awaiting the sequential phase to catch up[426]. Not only did this achieve significant savings in time and cost across the entire ROTOR programme but transferring these 'fitting parties' (as they were known) elsewhere to other tasks and sites reduced 'malaise' and enabled a 'sustaining morale of the builders'[427]. Transferring a shared construction force means serial contracting – appointing multiple contracts to the same consortium of firms – allowed the invaluable labour forces to progress onto other bunkers, thus ensuring momentum and efficiency throughout ROTOR across Scotland and Britain.

To achieve this, the CRPC assigned sequential phases for individual works and planned fit-out around distinct stages: 'pre-I Day', 'I-Day', and 'Postmortem', defined below. A secret Postagram issued from Fighter Command to CRPC in June 1952; referred to meetings held with civilian consultants to discuss electrical installations in advance of the scheduled sequencing and provided a forum to mediate any identified problems[428]. In 1952, when sub-contractors raised serious concerns over the site conditions during fit-outs, the CRPC subsequently introduced a new 'pre-I Day' (or pre-installation day) meeting to be held in advance of planned installation and 'ensure the satisfaction of all interested parties and resolve potential difficulties'[429]

Additional means of maintaining construction efficiency during the ROTOR programme were the 'I-Day' (or installation-day). Here, various contractors assembled to coordinate the installation of building systems and technical services. CRPC meeting minutes recorded at Portland, Dorset, on the 8th of April 1952, explain how the 'I-Day' allowed a forum for the project team to discuss the 'integrated installation procedure'[430]. Interestingly, the success of the 'I-Day' was claimed to be the result of 'on-site co-ordination carried out by fieldwork officers [RAF], coupled with the co-operative attitude of all'[431]. On a practical level, the RAF officers assigned by the Air Ministry acted as 'technical referees' for orchestrating the contracting fit-out parties[432]. These 'agents of CRPC' (as they were called) acted as on-site micro-project managers in resolving priority conflicts during the staged construction phases[433].

Lastly, special 'post mortem' meetings provided a final feedback loop to address any problems and determine future solutions[434]. (This appears a direct remnant of interwar Chain Home radar building programme as outlined by Dobinson [435]). Such procedure was vital in knowledge transfer to the ROTOR programme labour force, which at times was in excess of 7000 personnel, all managed through a series of sub-contracts that exceeded 80 firms[436].

The phased programming and clear delegation of responsibilities outlined above evidence a high degree of efficiency, collaboration, and cooperation that was integral to the ROTOR programme. This pre-emptive stance by the Air Ministry is exciting given that later government-led reports – published in the early-1960s – began to warn the broader construction industry over serious problems when programming was neglected and subsequently impacted works – stifling efficiency

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426 TNA AIR8/1630, Restoration of the U.K. C & R System, 4th Quarterly Progress Report, 31 December 1951.
427 Ibid.
428 TNA AIR20/11319. Postagram from Fighter Command to CRPC, 11 June 1952
429 TNA AIR8/1630, Restoration of the U.K. C & R System, 7th Quarterly Progress Report, 1 October 1952.
430 TNA AIR20/11319, CRPC note of recent points of interest 23 April 1952.
431 Ibid.
432 TNA AIR2/11178 Notes from the first CRPC monthly progress meeting held 16 October 1951
433 Ibid.
434 TNA AIR2 10984 Fifth quarterly progress report 7 April 1952
435 Dobinson, p. 216
436 TNA AIR8/1630 Letter from Ministry of Supply to Minister of Defence (Emanuel Shinwell) 25 May 1951

and the economy on the one hand[437]. For example, the MOW *Survey of Problems before the Construction Industry*, conducted over two years, emphasised the criticism of inefficient project team relationships. Not only was there a severe 'lack of cohesion' across project team members, but it recognised that greater efficiency depended on the 'clearly understood division of responsibility between the various partners'[438].

In the follow-up study, published two years later as *The Placing and Management of Contracts for Building and Civil Engineering Work*, this problem was furthered exacerbated by unclear and inadequate programming of construction events, leading to inefficiency and waste[439]. As the main recommendation, the report stated that modern techniques of works programming were an 'essential prerequisite' to any construction project[440]. Based on this, the report suggested that a timetable (considering all the critical events involved within the works contract) would provide a clear schedule for all project team members. Emmerson cited a 'vast store of experience within the works directorates of Government Departments' including the Air Ministry[441]. Meanwhile, Banwell went further and listed the Air Ministry as a critical contributor in submitting evidence.

The advanced project management, prototyping, and refinement of the ROTOR programme prove that the Air Ministry was a more radical government department than previously considered. Given the evidence of CRPC documentation, the Air Ministry consciously pressed for better architecture standards within its massive nuclear bunker-building programme and displayed a willingness to draw on external practitioners to solve new problems. It might not have been Watson or Enthoven channelling these critical innovations from the ROTOR programme to share across other government departments. However, we must assume that the Air Ministry somehow transferred these practices into other building programmes – given the progressive tenets of the Air Ministry noted throughout this chapter.

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[437] Harold Emmerson, *Survey of Problems before the Construction Industry* (London: HMSO, 1962)
[438] Ibid., p. 7-8
[439] Harold Banwell, *The Placing and Management of Contracts for Building and Civil Engineering Work* (London: HMSO, 1964) p.3
[440] Ibid., p.4
[441] Emmerson, p.21

2.7.5: Laying the Civil Foundations

Government departments like the War Office are credited for driving post-war architectural innovation across both civil and military realms. However, it is vital to recognise that the first-hand experiences obtained in the ROTOR programme also enabled the Air Ministry to make secret contributions toward bettering government architecture and in turn help lay firm foundations for broader civil industry, significantly more than previously considered.

Albeit backed by similar state patronage and sharing the same inter-departmental relationships with Central Government, specific post-war projects designed or commissioned by the War Office have been acknowledged for their importance within architectural history. For instance, the Maidstone Barracks (1962 to 1964), Kent, designed by Donald Gibson (then Directorate of Works for the War Office), has more recently been posited within academic scholarship[442]. Christine Wall highlights the scheme's appraisal as published in the *AJ* upon its completion, noting how Gibson and the War Office maintained 'industrial relations' with the Local Authority throughout the works and were able to specify high-quality brickwork that required considerable skill in its laying [443]. Likewise, Knightsbridge Barracks (1959 to 1970), London, designed by Basil Spence and built by McAlpine, has also been posited within architectural history. In particular, Alexander Clement describes the adroit negotiation (between War Office, LCC, and Royal Fine Arts Commission) that eventually achieved statutory approval for the 308-feet (94m) high concrete tower – at the time exceeding height restrictions imposed upon the central London area[444]. Unsurprisingly, given these examples were built within a public, surface-level context, and thus differ significantly from the underground Air Ministry bunkers – purposely concealed from the public domain – attention has naturally been drawn to these War Office projects.

Despite these contextual differences, the Air Ministry's use of civilian architects to improve the derided quality of building work actually pre-dates these War Office projects. I have already mentioned archaeologists identified historical relationships between the Air Ministry and the architectural profession that are traced back to the 1930s. My study reveals an extension of this through Watson and Enthoven's 1950s appointments to the Air Ministry, which continued to express the desire to achieve better architecture in line with the civil realm. Drawing on archival research this section outlines the direct liaison with the professional architectural body (RIBA) was in fact maintained through direct, high-level discussions in 1957.

War Office projects are recognised ahead of Air Ministry schemes, most likely due to Donald Gibson's reorganisation in 1959. As one of the most influential architects of the post-war period, Gibson was appointed to head up the War Office during its transition to becoming a civilian organisation[445].

Driving the War Office's reorganisation was the internal 'Weeks Report' conducted by Lord Weeks between 1956 and 1957, examining the organisational effectiveness of the works department. While the *AJ* published a glowing summary of its near-instant impacts, it is vital to highlight that the full conclusions were never made public at the time of the report [446]. As a result, the glowing account published in the press had no access to the full dossier complied by Weeks, incidentally, omitting any

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[442] Public, Barracks, Maidstone, *AR,* 133 (1963) 67
[443] Wall, *An Architecture of Parts*, p. 147
[444] Alexander Clement, *Brutalism: Post-war British Architecture* (Ramsbury: The Crowood Press, 2018), p. 50
[445] Ibid, 147
[446] I.T.C Wilson, *The History of the Corps of Royal Engineers: Volume X 1945-1960* (London: Institute of Royal Engineers, 1986), p. 27 notes

criticism aimed toward War Office. Moreover, the very similar review of the Air Ministry, known as the 'Warter Committee Review', completed around the same time, has been misunderstood. Likewise, the complete account of the Air Ministry's equivalent study was also withheld from wider dissemination, yet the *AJ* based allegations on the minimal information publicly disclosed at the time.

The *AJ* reported favourably on the new War Office by passionately citing it 'one of the best architectural teams in the country' that would provide invaluable research outputs to all government departments[447]. This appraisal contrasts markedly with the article covering the Air Ministry. Instead, the *AJ* led the feature with the brutally entitled piece 'Buildings without architects'[448]. In short, the AJ lambasted the Air Ministry for its poor standard of architectural design, inadequate departmental organisation, and virtually no professional architects present[449]. While the *AJ* accused the Air Ministry of being 'wasteful' and 'outdated', the attack principally derided the appallingly bad design work in stark contrast to the new outputs of the War Office[450]. As a final insult, the *AJ* jibed, 'the Air Ministry clearly doesn't believe in advanced techniques below the stratosphere'[451].

As defamatory as this feature was, it is essential to mention the narrative centred exclusively on a small public exhibition held over 5 days at the Air Ministry, Whitehall, in January 1962 (fig. 2.21)[452]. The work displayed here included a collection of more reserved RAF schemes, such as technical training schools, medical centres, and aircraft hangers. However, for obvious security reasons, the top-secret architectural work that had recently been completed under the ROTOR programme did not feature in this public exhibition. Therefore, the Air Ministry's exhibition could not share the fine examples of vernacular guardhouses executed in creative military camouflage (allowing nuclear bunkers to be carefully and sympathetically integrated within their immediate contexts, by reducing or removing their visual impacts). Nor did the exhibits reveal the sophisticated climate-controlled underground environments (that are examined in chapter 3). Undoubtedly, had these elements been permitted to feature, it would have been difficult for the press to critique them so harshly.

[447] The Editors, "Rockets for the Air Ministry", *AJ*, 135 (1962) 165
[448] Building's Without Architects, *AJ*, 135 (1962) 164
[449] Ibid.
[450] Ibid., p. 165
[451] Ibid.
[452] Air Ministry, Exhibition, *AJ*, 135 (1962) 100

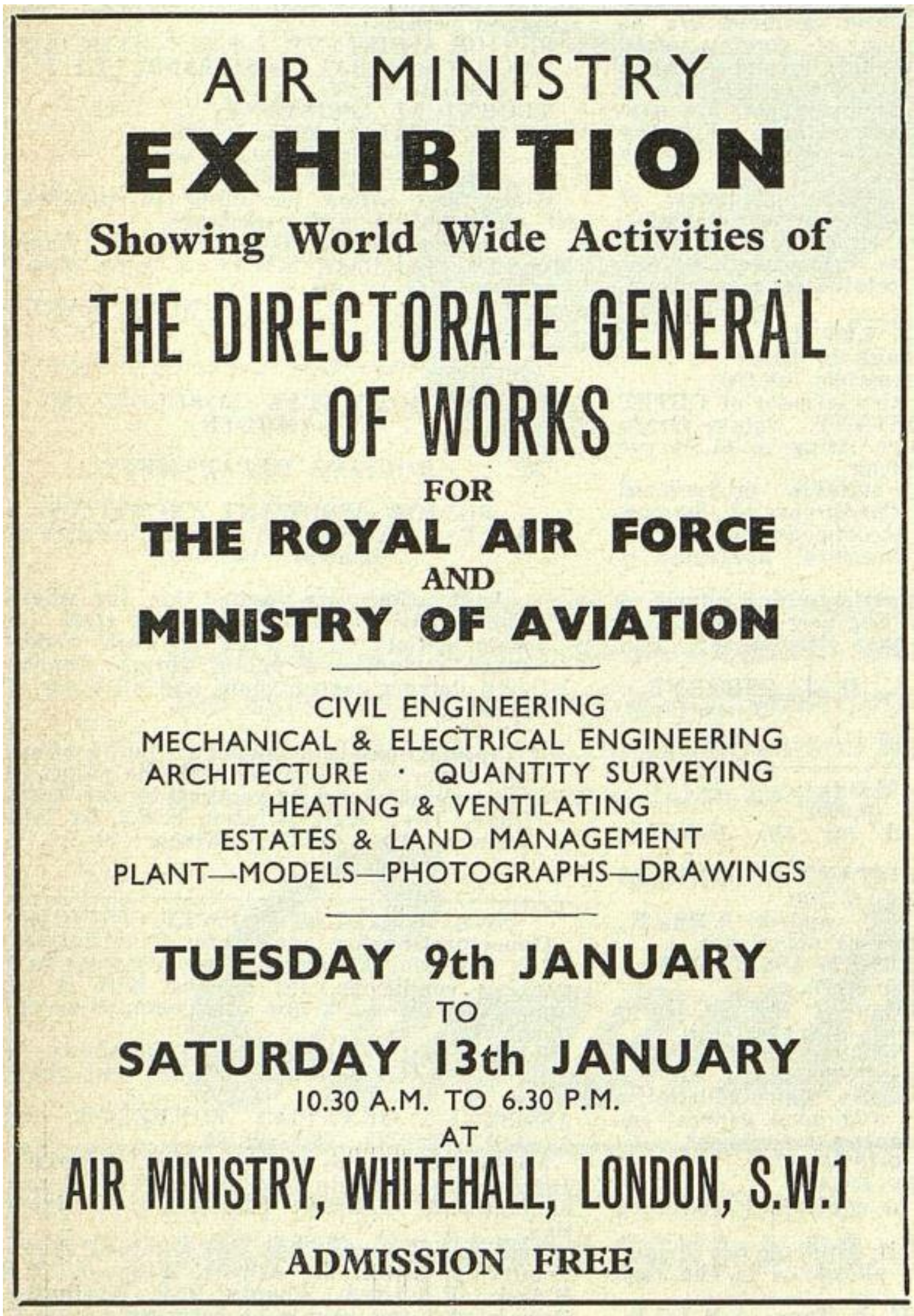

Figure 2.21: Air Ministry Exhibition advertisement 1962 (AJ)

2.7.6: Revisiting Water's Committee

By interrogating the now-declassified Warter Committee documents, my study reveals the conclusions published within the original report and offers a long-overdue counter to the original press critique of the time. In November 1956, Nigel Birch (the then Secretary of State for Air under the Conservative Prime Minister Anthony Eden) commissioned the Warter Committee to review the current and future needs of the Air Ministry Directorate General of Works (AMDGW). Previously named the Air Ministry Works Directorate (AMWD) – the newly formed AMDGW was responsible for all RAF construction requirements, both within Britain and its overseas territories, as well as the later bunker additions to the ROTOR programme[453]. Led by the industrialist Sir Phillip Warter, the committee centred its investigation on the oral testimonies gathered from military personnel and civilian staff experienced with Air Ministry works [454]. The committee conducted 26 meetings with various government departments and also visited Bomber Command, which, as we know, was a key project in Lesslie Watson's earlier architectural career[455].

Interestingly, alongside including primary evidence from various organisations beyond the RAF's inner circle, the committee also called upon the RIBA to seek essential advice on the position of employing professional architects[456]. The RIBA recommended the AMDGW appointed more architects and emphasised the need to establish a 'chief architect' as an independent head of the department[457]. Importantly, however, one of the bigger misinterpretations of the Warter Committee, as published by the *AJ*, was that the Air Ministry had outright rejected these suggestions[458]. Vitally missing from the *AJ* article at the time of print was that the Air Ministry had in fact acknowledged the RIBA's advice but had instead opted to continue their long-term, cost-effective, practice of appointing civilian architects as independent consultants as and when required[459]. Incidentally, this matches the earlier appointment of architect Edwin Lutyens dating back to RAF works in 1934, and it also frames the appointments of architects Watson and Enthoven as essential design consultants for new bunker types required by the Air Ministry in the Cold War.

Like the Air Ministry exhibition, this review, conducted five years earlier, does not refer to the work completed under the ROTOR programme. Despite their proximity to RIBA professional affairs, even if Watson and Enthoven had wanted to publicly defend the Air Ministry's honour, it would most definitely have breached Section two of the Official Secrets Act (see conditions noted in chapter 1) and risked treason. They could, however, anonymously transfer their bunker design and construction experiences alongside the advanced project management within the broader civil industry. For instance, while secrecy would have remained paramount, both men could have found means of channelling lessons learned through the dialogue and liaison headed by the then RIBA president, Professor Leslie Martin, during the Water Committee data collection.

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[453] TNA AIR/13321 'Report of a committee appointed to review the organisation of the Air Ministry Directorate General of Works' April 1957

[454] Ibid.

[455] Notable Government departments included the Treasury, the Ministry of Transport and Civil Aviation, and the Ministry of Works.

[456] TNA AIR2/13321 22 March 1957, RIBA Memorandum of evidence on the position of architects in the air ministry directorate general of works

[457] Ibid.

[458] Building's Without Architects, *AJ*, 135 (1962) 164

[459] TNA AIR2/13321 22 March 1957, RIBA Memorandum of evidence on the position of architects in the air ministry directorate general of works

2.8: Conclusion

I introduced this chapter by outlining the urgent need of challenging the misconceptions that nuclear bunkers were 'non-architecture'. After investigating the various areas of interest, this chapter has revealed that nuclear bunkers were distinctly more architectural in their disposition than previously considered and more importantly, through inextricably linked relationships with the civil realm, did not reside in a totally isolated vacuum but experienced the same push and pull effect – or a pendulum swing – as both worlds passed by in the shadows.

This has been emphasised within this chapter through the unparalleled state-patronage secretly assigned to nuclear bunkers which ultimately placed these buildings ahead of all other civilian requirements and at times, saw nuclear bunkers skip the long queues awaiting scarce material, labour, or precious financial resources. Despite public works projects, such as housing, schools, and hospitals, currently acknowledged within architectural history as top priorities, this chapter has shown how nuclear bunkers in fact transcended these works and caused a significant delay, alteration, or cancellation of these civil schemes. This chapter has also revealed that as a result of new engagements with civilian architects nuclear bunkers were able to rapidly evolve to suit impending new Cold War threats of nuclear attack and espionage simultaneously, opening a transfer channel that cross-shared innovations at government level and ultimately benefitted the mainstream post-war landscape. Lastly, I have demonstrated that the fact Scotland was not attacked with nuclear weapons we must acknowledge these bunkers were both commissioned under the pretence of genuine nuclear threats and were testing grounds for broader post-war innovations.

CHAPTER 3. BRINGING NUCLEAR BUNKERS INTO THE MEGASTRUCTURE ARGUMENT

3.1: Introduction

The previous chapter indicated the colossal scale of the ROTOR programme as it spread across the entire British landscape; physically connecting the remote Islands of Shetland and Orkney all the way down through London and beyond to the southern English coastline. The complexity of the ROTOR programme has and continues to make it difficult to fully understand, define, and categorise, even when narrowing the scope to focus only on Scotland's bunkers. The tendency of other disciplinary approaches to frame nuclear bunkers thematically, rather than adopting robust architectural taxonomies, often exacerbates this misunderstanding. To address this problem, the following chapter therefore considers nuclear bunkers within the post-war architectural discourse of Megastructure theory as a 'legitimate way to order massive, grouped functions'[460]. By applying the firmer typological framework for the ROTOR programme as defined in chapter 2, the following chapter is arranged in two parts. Part one considers the massive scheme of ROTOR bunkers and their connected infrastructure as one consolidated network, or the 'permanent frame' of Megastructure theory. I outline this aspect as the macro-Megastructure narrative, which enables us to understand how vital building services and life-support systems were secretly installed across the country; siphoning Mains power, water, and telecommunications from the same sources of the civil realm. After establishing this national framework, part two then turns to the individual bunkers as the 'plug-in' units of Megastructure theory. I define these plug-ins under a micro-Megastructure narrative and conduct analyses on the architectural quality of interior bunker climates and investigate the importance of specific component parts as the second stage 'plug-in'. This will cross-examine the smaller units within bunkers and frame their similarities with Brutalist aesthetics.

[460] Fumihiko Maki, Investigations in Collective Form (St Louis, 1964), 4-13 "quoted in" Reyner Banham, *Megastructure: Urban Futures of the Recent Past* (New York: Harper Collins, 1976), p 71

3.2: Defining Megastructure

What exactly is meant by the term Megastructure? In an architectural history context, Megastructure was a theoretical concept that rose to prominence during the post-war period, and was primarily discussed by various practitioners, critics, writers, and academics operating within the architectural realm. The term has, however, since become more widely adopted by other disciplinarians outside of architecture, including military historians and battlefield archaeologists, and has become synonymous with popular television documentary series like National Geographic's Nazi Megastructures. As a result of this expanded application, the architectural definition of Megastructure has lost its original meaning and more often than not reverts to an oversimplified term for describing engineering projects that are massive in scale. Yet when revisiting the origins of Megastructure theory there are additional considerations that must be acknowledged before assigning the Megastructure status. For Reyner Banham, the well-known post-war architectural critic and historian, who held a firm understanding of Megastructure, a building's size did not immediately qualify it as a Megastructure but was instead potentially a Megastructure upon achieving a much more complex set of criteria [461].

In *Megastructure: Urban Futures of the Recent Past*, Banham outlines certain criterion which are vital to bringing nuclear bunkers into the Megastructure argument. Aside from Britain's bunkers neatly aligning with Banham's point that Megastructure clients were almost always central governments we can extract more pertinent ideas worthy of serious consideration[462]. For in charting the etymological origins of the term 'Megastructure' (as it was first coined by the Japanese architect Fumihiko Maki in 1964) Banham borrows Maki's definition of Megastructure as a 'large frame in which all the functions of a city or part of a city are housed'[463]. Likewise, from the opening argument in *Megastructure,* Banham also quoted Ralph Wilcoxon's definition as published in 1968, stating a Megastructure was as a 'structural framework into which smaller structural units…can be built – or even 'plugged-in' or 'clipped-on'[464]. In expanding Maki and Wilcoxon's similar takes on Megastructure Banham further adds that Megastructures typically adhered to the notion of a 'permanent and dominating frame containing subordinate and transient accommodations'[465].

Few would disagree that Reyner Banham established a bedrock for understanding and expanding Megastructure discourse[466]. While his book, *Megastructure: Urban Futures of the Recent Past*, remains an invaluable source detailing the roots and evolution of Megastructure theory, Banham also conducted a series of lesser-known lectures presented at the AA during the 1970s which discussed elements published within *Megastructure* at greater length[467]. I have therefore decided to hold Banham's works as an analytical template for assessing ROTOR bunkers within Megastructure discourse. Therefore, by combining the above criteria I argue the ROTOR programme qualifies as Megastructure to which hundreds of separate nuclear bunkers collectively plugged into a national framework of subterranean building services. the permanent framework of ROTOR bunkers as a

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[461] Reyner Banham, *Megastructure: Urban Futures of the Recent Past* (New York: Harper Collins, 1976), p. 7
[462] Banham, *Megastructure*, p. 8, p. 11
[463] Ibid
[464] Ibid
[465] Ibid., p. 9
[466] See for example, the recent scholarship of Douglas Murphy, *Last Futures: Nature, Technology, and the End of Architecture* (London: Verso, 2016)
[467] These lectures can be viewed at AA School of Architecture, YouTube, https://www.youtube.com/user/AASchoolArchitecture [Accessed February 10, 2022]

Macro-Megastructure with individual bunkers performing as the plug-in units, or Micro-Megastructure, and thus will be centrally maintained throughout this chapter.

Part one.

3.3: Macro Megastructure: From Shetland to Portland

To begin placing nuclear bunkers within the Megastructure argument (as a Macro-Megastructure) we must borrow and combine three central aspects outlined by Reynar Banham in *Megastructure*. Firstly, although Banham rejected the theoretical 'Comprehensive City' from the Megastructure argument describing the project as 'ludicrous' there are merits worth extrapolating[468]. Proposed in 1967 by architects Mike Mitchell and Dave Boutwell, images illustrated the 'Comprehensive City' as a single, uninterrupted unit that spanned the entire width of North America, from New York to San Francisco – an unrealistic distance for one continuous building. However, albeit at a shorter length, by re-framing the ROTOR programme within a similar lens to that of Mitchell and Boutwell, I argue that this concept of a Megastructure spanning significant distances was not only plausible but was partially achieved in this bunker network before these ideas began circulating within architectural discourse. Whilst not expressed as a linear formation (as envisaged by Comprehensive City), the ROTOR programme physically spanned from Saxa Vord in the Shetland Islands and meandered downwards to cover Scotland's landmass of 77,900 km² all the way south of the border to Portland, Dorset on the English coast. In this sense a macro-Megastructure that connected into more than 1500 nuclear bunkers tasked with monitoring Britain's entire airspace.

Secondly, in the same publication, Banham also draws on the theoretical work of architect Louis Kahn's proposed but unbuilt 'Civic Center Project'. Designed in 1952 for the city of Philadelphia, Kahn's scheme comprised a series of massive cylindrical parking towers, which to Banham, were not Megastructures on their own, but when considered holistically, their 'total effect was megastructural'[469]. Albeit Banham's analysis of the Civic Center Project pertains to a smaller metropolitan scale with surface-level components, the same idea of individually dispersed structures representing a Megastructure can also be expanded to include the more extensive ROTOR programme network. Thirdly, in expanding the 'Civic Center Project', it is important to also draw on Banham's appraisal for the theoretical 'plug-in city' concept (fig. 3.1) developed in 1964 by Archigram group member, Dennis Crompton[470]. Plug-in city: national network (1964) adopted the form of a series of clustered nodes' where 'industry, offices, dwellings would all enmesh, but the heavier, slower-changing units would near the base'[471]. Fellow Archigram member, Peter Cook, described how this concept of 'plug-in' could expand across the wider British landscape 'linking the existing centres of population and affecting, eventually, a total city of them all'[472].

By combining the above Megastructure discussion, this section conveys how these ROTOR bunkers, spanning the length and breadth of the country plugged into a comprehensive framework of National Grids supplying mains power, water, and the GPO landline telephone communications, which, collectively, also supplied public utilities to Scotland's general civilian population.

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[468] Banham, *Megastructure,* p.197
[469] Ibid., p. 39
[470] Ibid., pp. 96-97
[471] News, "ADG – Plug-in cities", Timothy Cochrane, AJ, 142 (1965) 1208-1209 (p. 1208)
[472] Peter Cook, "Plug-in", in Archigram, ed. Peter Cook (New York: Princeton Architectural Press, 1999), p 39

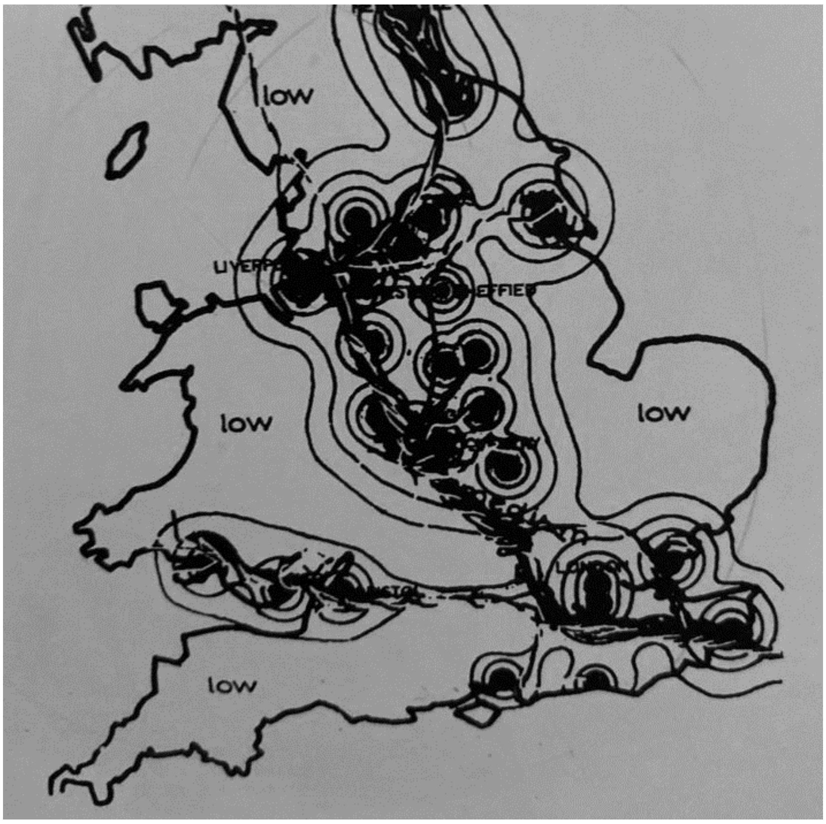

Figure 3.1: Archigram 'Plug-in city: national network' (Cook, Archigram, 1976)

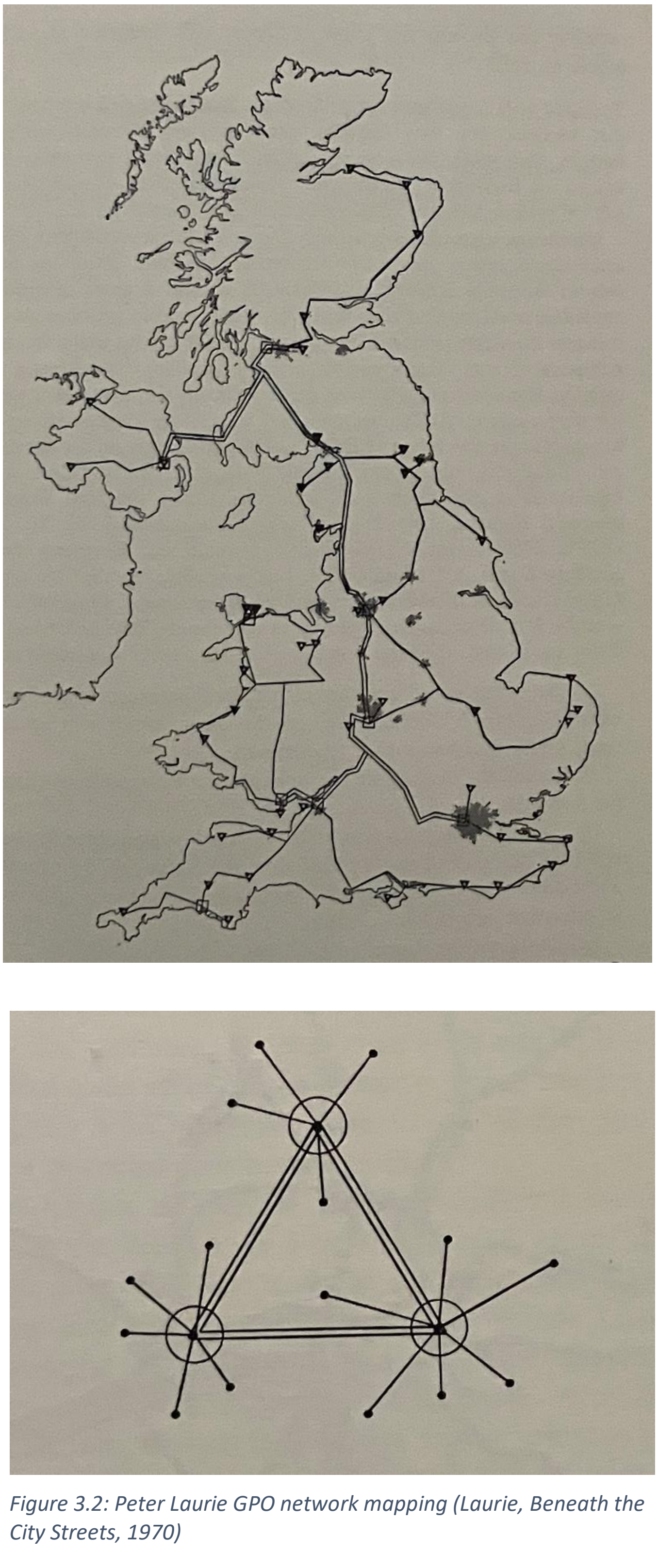

Figure 3.2: Peter Laurie GPO network mapping (Laurie, Beneath the City Streets, 1970)

3.3.1: National Grid Connections

Whilst the massive post-war expansion of public utilities provided a network of mains services for the civilian population, these very same National Grids, spanning huge countrywide distances, also powered and connected Britain's top-secret nuclear bunkers (as Megastructure units). Based on the fieldwork observations of Hiroshima and Nagasaki (see chapter 1), the British Government believed that similar nuclear attacks on Britain would incapacitate the mains power National Grid, leaving most of the population without electricity for up to two weeks[473]. Principally, without electricity, and the dependent water and communications systems, these bunkers were essentially useless concrete carcasses. Although ROTOR bunkers were designed to function autonomously in the event of a nuclear attack (which shall be detailed shortly) by using diesel-powered generators, their normal operating function heavily relied on being physically connected to a series of key building services. In drawing on the broader ROTOR typological framework, I consider as a Macro-Megastructure, my research has revealed that Scotland's nuclear bunkers, were in fact connected to the same public utilities serving the civilian population. For example, the Inverbervie ROTOR bunker directly connected into the National Grid by plugging into the North of Scotland Hydro-Electric Board's network[474]. Likewise, the East Kilbride AAOR bunker (fig 3.3) directly connected into the National Grid, by plugging into the South of Scotland Electricity Board's power network [475].

Importantly, plugging these individual nuclear bunkers (as the Megastructural units) into the National Grid (as the Megastructural framework) was not cheap nor were these connections known to the general publicly. In fact, although these connections were vital in supplying the required power that operated the sophisticated building services and life-support systems, they soon proved to be incredibly expensive. For example, Barnton Quarry's electricity bill cost around £7,500 per month (or £190,000 today) to keep the bunker in a constant state of readiness[476]. These bunkers were thankfully never used during a real nuclear attack; however, they were kept operational 24 hours a day, seven days a week, and they were regularly used in Britain's simulated war game exercises in response to genuine Cold War threats. Even in a reduced stand-by mode, given these windowless spaces were devoid of any natural daylight, or cross-ventilation, an artificial environment was constantly maintained that carried significant costs.

Not only did these bunkers secretly siphon precious energy supplies from the National Grid during the busy period of rebuilding Britain, but the State also afforded them priority ahead of other civilian needs (see chapter 2). Progress reports held in TNA outline discussions held between the Air Ministry and the Ministry of Fuel and Power over the electricity required at ROTOR bunkers in which the Air Ministry emphasised the urgency in providing power supply to ROTOR sites ahead of any other civilian demands[477]. These RAF stations consumed enormous amounts of electricity for the radar equipment and building systems. This unknown relationship is interesting when famed alongside Barnabas Calder's research in *Raw Concrete*. In short, ROTOR bunkers were provided Mains power by the same utility boards that supplied millions of domestic households with vital

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[473] Home Office and Air Ministry, T*he Effects of the Atomic Bombs at Hiroshima and Nagasaki*, Section "damage to public services" outlines how electricity cables were severely damaged in Nagasaki that disrupted Mains power supply for at least two-weeks prior to post-attack restoration.
[474] NRS, NRS DD12/2847, Letter to Air Ministry 'Services Land Requirements' from SHD 19 April 1951; Before privatization and a 1998 merger creating the now *SSE*, the NSHEB was a public sector utility provider established in 1943 and contributed greatly to the government's post-war expansion of the National Grid.
[475] NRS, HH51/351, Force Level Assessment – SHHD, East Kilbride 14 August 1979
[476] Ibid.
[477] TNA AIR8/1630 CRPC: Restoration of the U.K. C & R System: 9th Quarterly Progress Report, 1 April 1953

electricity used for the basic necessities of lighting, heating, and cooking. Not only were these customers unaware of secret nuclear bunkers, siphoning energy from the same power network, but they were equally unaware that as taxpayers, they also funded bunkers' utility bills, and therefore in-directly contributed to their active operations. If an alternative situation saw no bunkers constructed then it is interesting to consider where these services might have been redistributed to the civil realm, subsequently altering Scotland's architectural history.


Figure 3.3: Barnton Quarry incoming service connections to Mains Grids (subbrit)

3.3.2: Crossed Wires: Sharing the General Post Office Telecommunications

Beyond Mains power connections, another critical element in this Macro-Megastructure was that all ROTOR bunkers had to maintain adequate and timely communications during and after a nuclear attack. Regardless of how well they were planned, designed, and constructed, if bunkers could not ensure fundamental communications across the full ROTOR programme, then the core functions of the air defence network were significantly impeded. Ultimately, if Soviet bombers breached Britain's northernmost airspace but vital information of the inbound attack failed to reach Scotland's key sites like Barnton Quarry, or was even delayed, the appropriate defence decisions could not be made in time, with potentially devastating consequences.

Drawing again on the findings from Hiroshima and Nagasaki, Cold War emergency planning anticipated that telephone lines would likely be incapacitated for an indefinite period of time after a nuclear strike on Britain [478]. In response, sustained efforts ensured the vital GPO telecommunications lines were extensively laid across the country and were buried as an optimum protective measure. Crossing the length and breadth of the nation, physically connecting Scotland's bunkers to one another and in turn plugging into Britain's extensive network, these communications (as a Megastructural framework) sidestepped major population centres, such as key cities and large towns, to mitigate catastrophic damage and thus increase the megastructral network's overall survivability[479]. While Derek Wood's historical account on ROC infrastructure chronicled the GPO's establishment of these telecommunications lines during WW2, it is prudent to recognise how the Air Ministry later spearheaded similar efforts to install miles of new underground cabling; vital for an emergency Cold War telephone network[480]. My archival research has revealed a significant GPO presence throughout the construction of the ROTOR programme, given the GPO was predominantly occupied with the installation of new lines for telephone and teleprinters which had hit 'full tilt' by March 1952[481]. Importantly, in maintaining an economically viable model, Britain's telecommunications network doubled to serve both civilian population; secretly piggybacking during peacetime but would handover complete control to the government and military in the event of a nuclear strike[482].

When recalling Peter Laurie's maps and diagrams (fig. 3.2) of suspected communications lines crossing Britain, we must acknowledge they not only strike similar connotations of Megastructure theory but are equally reminiscent of Archigram's illustrations which were also beginning to circulate within architectural discourse around the same time. Mallory and Ottar's account also featured an artistic impression of the Maginot Line, with axonometric drawings showing a sectional cut-away of the subterranean defences (fig 3.6). Albeit the Maginot Line was part of the pre-1945 military fortresses when comparing this with Archigram's imagery, influential figures such as Banham must have been intrigued by the parallels across the military and civil realms. Despite this tentative probing, however, the inherent secrecy ultimately impeded any opportunity of linking these research silos. In the end, another chance was missed during lively debates of positing this Macro-Megastructure into discourse. For in reality during these communications frameworks (spanning Shetland to Portland) remained top-secret and were thus obscured from more comprehensive

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[478] Home Office and Air Ministry, T*he Effects of the Atomic Bombs at Hiroshima and Nagasaki*
[479] NRS HH51/260, Letter from SHHD to Lady Tweedsmuir, 20 August 1963
[480] See Derek Wood, *Attack Warning Red: The Royal Observer Corps and the defence of Britain 1925 to 1975* (London: Macdonald and Jane's Publishers, 1976)
[481] TNA, AIR8/1632, Letter from Scottish Home Department to Air Ministry 'Services Land Requirements' GPO installation commences March 1952, 7 April 1952.
[482] Ibid.

dissemination at the time. While the Spies for Peace expose had briefly introduced a basic awareness of these nationwide frameworks in 1963, and the subsequent CND protests held at Barnton Quarry signalled this GPO network at least expanded north to Edinburgh, the full extent of this classified network was a carefully guarded secret the government strived to keep throughout the remainder of the Cold War[483]. A tangible sense of this massive, connected telecommunications network would only emerge in the early 2000s through the archive-based mapping work by archaeologists at Historic England. By this point, however, Megastructure no longer held the same elevated status within the architectural realm as it had done so in the 1960s and 1970s. It is only now, with the broader declassification of Cold War nuclear bunkers that we can begin to visualise the Cold War telecommunications framework as a retrospective, yet worthy, example of the Megastructure argument.

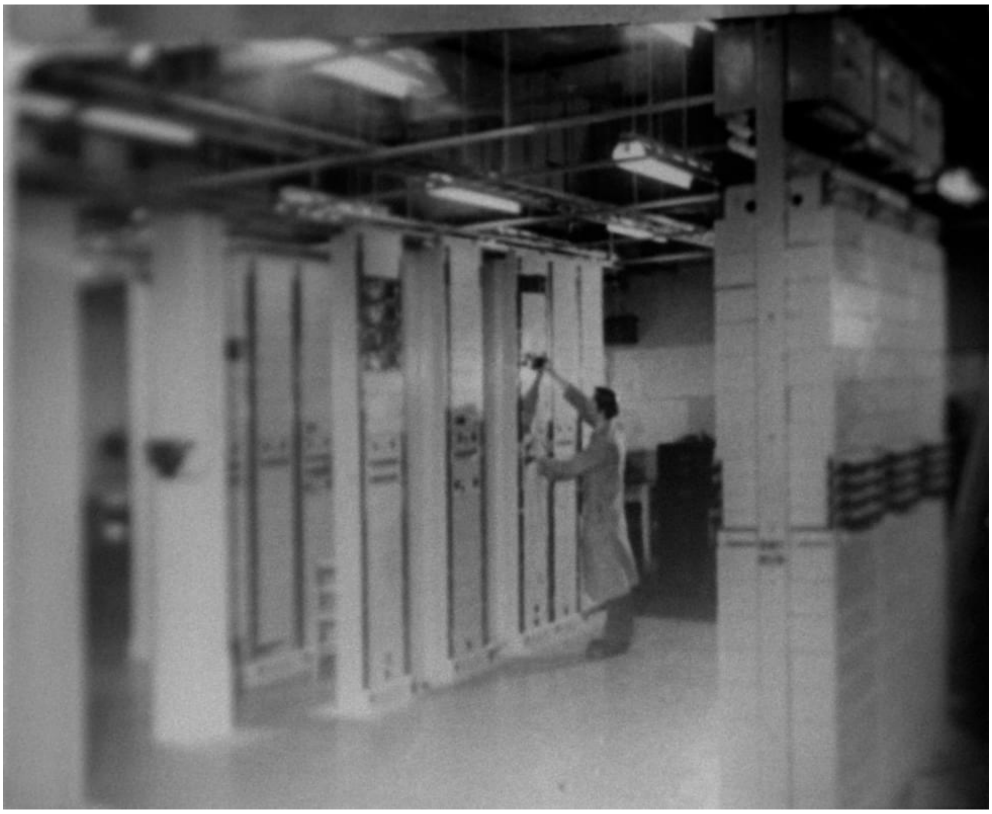

Figure 3.4: GPO technician services telephone exchange in an unknown ROTOR bunker (subbrit)

[483] NRS, HH51/276, House of Commons extracts, SHHD, 1 May 1963

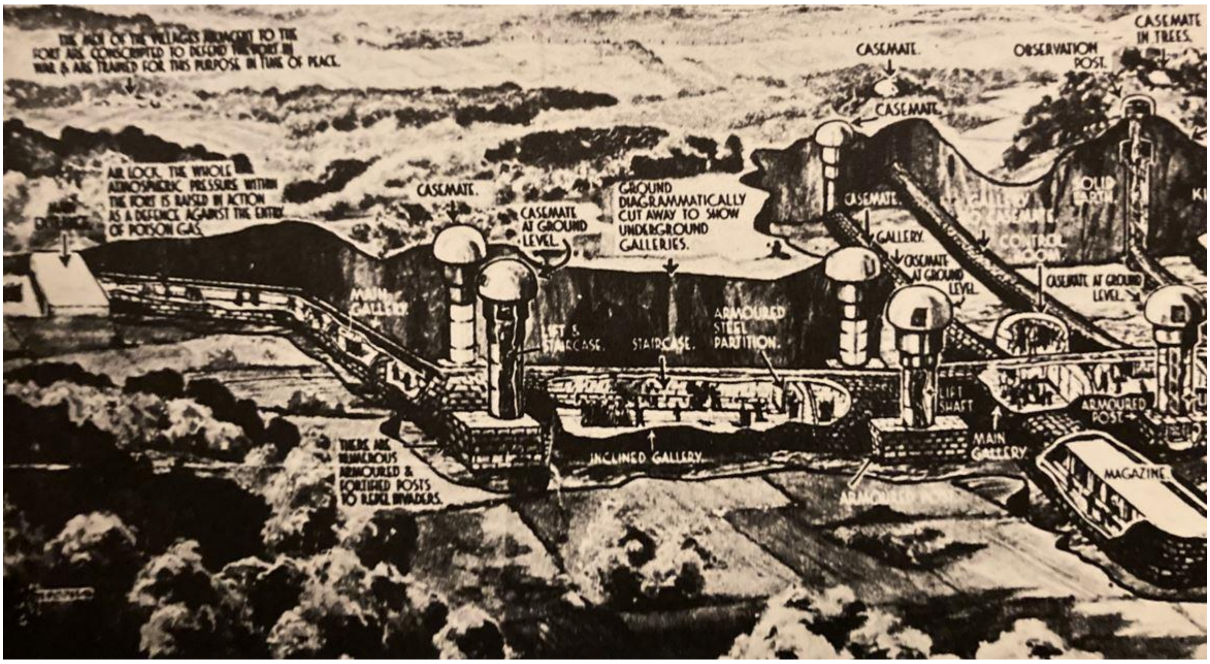

Figure 3.5: Maginot Line axonometric (Mallory and Ottar, Architecture of aggression, 1973)

Part two.

3.4: Micro Megastructure: Protection Against Extreme (Nuclear) Environments

Part 1 outlined the various services installed across the entire ROTOR programme as the macro-Megastructure components of the 'framework', where the vast networks of electricity, water, and communications lines effectively created a National Grid for individual bunkers to 'plug-in'. I now turn to assess the individual nuclear bunkers through the micro-Megastructure lens as the replaceable 'units' that plugged into the main structural framework.

My analysis here is framed under Reyner Banham's Megastructure criterion of insulating buildings against thermally extreme environments whereby I consider a nuclear blast and radioactive atmosphere as the ultimate, most extreme, 'megastimulating' condition[484]. According to Banham's take on thermally extreme environments he sets out three fundamental conditions of the extreme as experienced within the civil realm; heat, cold, and wet. First, Banham draws on Wladimir Gordeef's theoretical 'Cite-paquebot' scheme published in 1956, in which Gordeef proposed a 'sealed and self-contained' solution to cope with the 'hostile' environments of the Sahara Desert, scorching heat during the day contrasted with freezing cold at night[485]. Second, Banham outlines how Canadian universities in the 1970s were similarly designed to protect occupants against the extremes of cold weather climates[486]. Third, he cites Cumbernauld Town Centre in Scotland within by claiming the building offered an interior space sheltered from both the 'frequent rain-squalls and the lively winds that drive [the rain] up the slope' [487]. However, based on this rationale, what if we went further and suggested that a nuclear attack would introduce an unthinkable condition more extreme than the combination of all of the above?

Within this new light, ROTOR bunkers like Barnton Quarry mark a significant departure from pre-1945 examples by affording optimum interior conditions as part of the protection against extreme nuclear environments. In the event of imminent attack, the steel blast-proof doors would shut to provide occupants with an autonomous, self-contained, controllable climate. As the activities and tasks orchestrated from within these sealed bunkers required decision-making that literally amounted to life and death, maintaining the well-being and efficiency of stationed personnel was therefore paramount. Unlike earlier military examples, ROTOR bunkers were designed not only to provide the fundamental conditions for basic survival but, for the first time, extended to give personnel much more pleasant environments. In stark contrast to the exposed concrete of Atlantic Wall bunkers, or the damp cave-like interiors of the Maginot Line (see chapter 1), ROTOR bunkers featured decorative elements such as Linoleum flooring, dado railing, and painted walls. However, beyond these internal finishes, the Air Ministry consciously designed these bunkers for a definitively better quality of living and working by enabling building users the ability to configure temperature and humidity levels tailored to individual comfort. Although these elements were much more complex than previous bunkers, the ROTOR programme's highly efficient consortium of contractors were suited to installing these advanced building systems which ultimately plugged these bunker units into the Mains framework.

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[484] Banham, *Megastructure*, p. 43
[485] Ibid., p. 50
[486] Ibid., p. 144
[487] Ibid., p. 172

3.4.1: Domesticating the Nuclear Bunker: Optimum Comfort Needs

In the nuclear epoch bunkers could no longer rely on internal conditions evidenced in pre-1945 bunkers and from the 1950s they became more domesticated as they, for the first time, were required to provide optimum levels of comfort. Unlike typical domestic buildings of the civil realm Barnton Quarry, Anstruther, and Inverbervie bunkers were constructed underground at depths of 60-100 ft and therefore had no windows to provide a basic means of naturally ventilating the bunker's interior environment. Instead, sophisticated mechanical systems were installed which provided hermetically sealed environments with artificial ventilation, heating, and air conditioning. The artistic impressions and floor plans featured within English Heritage's *Nuclear Bunkers* provide a basic understanding of the mechanical ventilation strategy designed for ROTOR bunkers. Cutaway drawings for instance, show how air conditioning was fully incorporated within the bunker's fabric to cool the electrical equipment (including radar screens, telephone racks, and electronic data processors) whilst providing comfortable and controllable temperature and humidity levels for the station personnel[488]. Achieving this required large ventilation shafts which protruded above ground and permitted external air to flow vertically down into bunker's huge intake fans and pass through a series of filters designed to remove any external pollutants and radioactive fallout dust. Once cleaned the air then entered into the plant room where a mechanical ventilation system distributed the fresh air throughout the bunker's internal spaces via lengths of steel ducting mounted at ceiling level and fixed below the suspended floors. Finally, the stale air was extracted to the surface level via an alternative system of vertical ducts.

Although this system was carefully designed, this ventilation strategy quickly emerged as a primary concern during the early phases of construction after issues were identified with internal temperature and humidity levels; posing an unforeseen risk to the comfort factor and working conditions within the bunkers. The underground concrete spaces not only created naturally warm and humid environments, but the interior environment was further exacerbated by the additional heat produced by the bunker's plant machinery and clunky radar equipment[489]. In 1952, a top-secret note sent by RAF air commadore Hubert Chapman, expressed that a heat increase of 15 degrees above the ambient temperature was wholly 'unacceptable' for RAF personnel and pressed for an efficient means of securing 'reasonable working conditions' for the entire ROTOR programme [490]. Similarly, RAF group captain Douglas-Jones warned that the 'efficiency of the crews' – ultimately responsible for Britain's nuclear defences – would be severely impacted under these conditions,[491]. In response to these concerns, Ronald L Phillips, the then chair of the CRPC, placed an immediate urgency to resolve such issues economically and without any further disruption on the overall ROTOR programme progress[492]. Importantly, what must be noted here is that the working conditions advocated by senior RAF officers strike immediate resonance with the later state-backed research conducted by the MOW into modern building services. Although the MOW studies centred on domestic civilian conditions, it placed similar dictated that 'the maintenance of a good standard of mental and physical health' was hugely dependent on factors of heating and ventilation[493].

From 1952 to 1954 the Air Ministry rigorously tested and carefully refined internal bunker climates to ensure that optimum environmental conditions were constantly achieved. It is worthwhile

488 Ibid.
489 Cocroft, Thomas, and Barnwell, pp. 88-89
490 TNA, AIR2/10984, Loose note from Air Commodore H. H. Chapman to CRPC, 3 July 1952
491 Ibid.
492 TNA, AIR2/10984, Loose note from Air Commodore R. L. Phillips (CRPC Chairperson), 14 July 1952
493 Ministry of Works, *Heating and Ventilation of Dwellings* (London: HMSO, 1956), pg. 13

recalling the full-scale prototypes detailed in the previous chapter, for these enabled fantastically efficient and economic design development of mechanical ventilation systems. Although the prototypes were mostly located in England, as the ROTOR bunkers were part of a standardised building programme, the mechanical ventilation system also matched those built within Scotland. As per the prototyping process, these mechanical ventilation systems were carefully tested, fine-tuned, and developed through a series of secret on-site human trials (using continuous feedback loops), and once the optimum solution had been achieved, the mechanical ventilation was then installed in nuclear bunkers across Britain[494].

The first of these live experiments was the full-scale air conditioning test conducted at the prototype ROTOR R2-type bunker at Truleigh Hill, south of London, on 2 April 1952. Here, RAF medical officers and members of the Institute of Aviation Medicine observed a cohort of 40 RAF men and women partaking as human test subjects as they simulated a typical work shift. The military participants were clothed in full woollen battledress uniforms (males wore jackets, shirts, and trousers, with females donning jackets, blouses, and skirts), with civilian GPO staff wearing shirts, trousers, and overalls[495]. By combining the oral feedback and scientific data recorded from inside the bunker during this trial optimum climate conditions were noted for both summer and winter extremes. For instance, when simulating tasks that were expected for the main operations room, test subjects claimed that whilst 14-17 degrees Celsius was 'comfortable' an optimum temperature between 18-20 degrees Celsius with a relative humidity of 50-55 percent was more favourable[496]. Vitally, this experiment raised two points. Firstly, it was noted that when manually lowering the temperature by thermostat controls, internal conditions led to an 'improvement of mental alertness' which chimes with the above-mentioned concern over RAF personnel effectiveness[497]. Secondly, rather than typical military settings, these optimum temperature and humidity levels fell squarely within the recommended government standards for domestic dwellings – particularly communal spaces such as kitchens and living rooms[498]. Additional tests, replicating these same simulation parameters, were later conducted to further fine-tune and refine the bunker's internal environment conditions[499].

The second live experiment followed in May 1952 at the prototype ROTOR R1-type bunker at Portland, Dorset, on the southern English coast. Interestingly, within the report's introduction it stipulated that the findings were to be read in conjunction with the previous experiment held at Truleigh Hill a month prior which incidentally supports my argument of the advanced levels of the Air Ministry's project management (detailed in chapter 2)[500]. The Portland experiment involved nearly double the number of test subjects and altered the test parameters to simulate a busier working environment. Here, 76 RAF personnel (including 70 male and 6 female crew) constantly moved throughout the various rooms in the underground bunker[501]. These differing conditions were to reflect the constant circulation of staff, switching between off-duty rest and active roles so as to replicate, as close as possible, the frantic movements that were expected in the event of a nuclear

[494] TNA AIR2/11604, Appendix 'A' to Air Ministry minute dated 10 July 1952, details all 11 ROTOR R3 structures were to be fitted with the same heating and ventilation plant by contractor Matthew Hall & Co Ltd
[495] TNA AIR20/11319, Report on the first human trial of a CHEL (R2) Structure by Group Captain J.F. Sandow O.B.E and Flight Lieutenant W.J. Allen H.Q., Fighter Command and RAF Institute of Aviation Medicine', 2 April 1952.
[496] Ibid.
[497] TNA AIR20/11319 'CRPC Note on Recent Points of Interest in operation ROTOR', 23 April 1952.
[498] Ministry of Works, *Heating and Ventilation of Dwellings,* p. 19
[499] TNA AIR20/11319 Postagram from CRPC to Fighter Command, 3 June 1952
[500] TNA AIR20/11319 'Report on the first human trial of an R1 building', May 1952.
[501] Ibid.

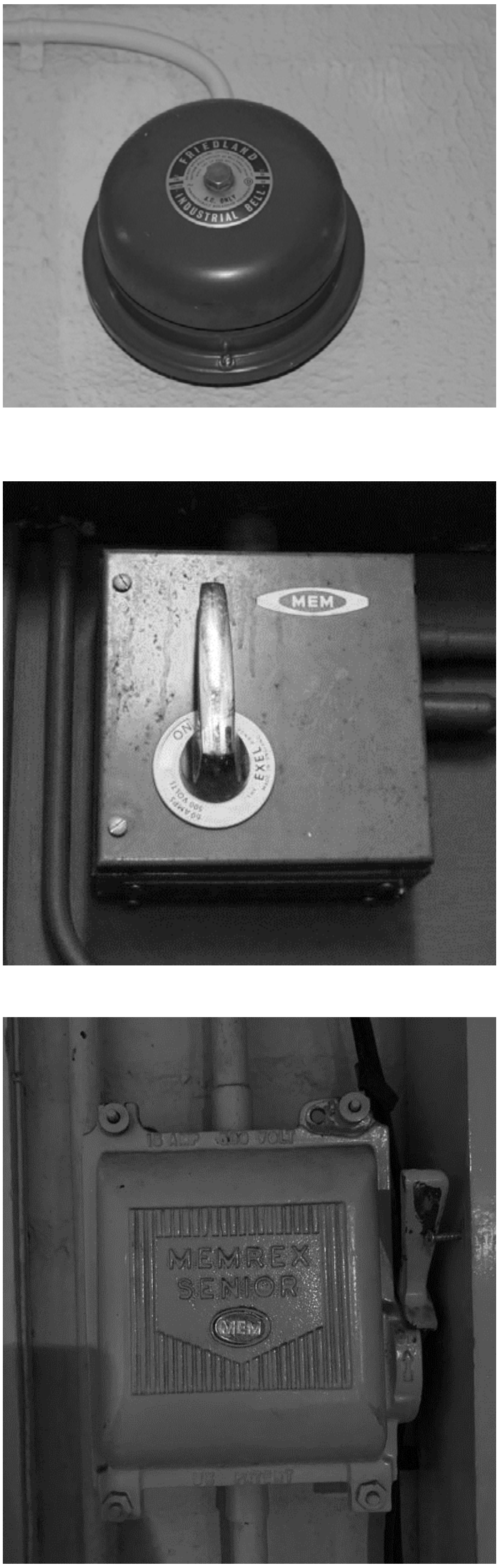
attack. Interestingly smoking was also permitted to determine how quickly tobacco dispersed inside the sealed environment[502]. Additional thermostats were also installed at Portland to give users more control over the internal climate. For example, isolated thermostats in the GPO workshop permitted civilian staff to manually adjust the room's specific temperature without affecting the bunker's other areas used by the RAF[503]. At Portland, consideration was also afforded to testing emergency scenarios in the catastrophic event of a full system failure (including breakdown of the back-up power systems). It was observed that whilst the environment would induce mild headaches and breathlessness of the bunker's occupants, the hermetically sealed climate was safe without air for at least 24 hours in a total shutdown[504]. Further air conditioning tests were also conducted at various other ROTOR bunkers in 1953 to simulate gas attacks and record the impacts on station personnel with reduced oxygen levels[505]. These experiments suggest the mechanical ventilation systems were thoroughly tested and calibrated under simulated conditions of a nuclear attack, which importantly, correlates with the parallel-running Scientific Advisors Branch experiments detailed in Melissa Smith's research, which I will return to in the next chapter.

These advanced climate-control systems installed within ROTOR bunkers of the early 1950s not only transcended the utilitarianism of pre-1945 military bunkers but afforded some of the more comfortable working environments in post-war Britain, well ahead of general civilian standards in domestic architecture. Firstly, if we compare these more domestic-like temperature and humidity conditions, which closely paralleled civilian housing typologies, nuclear bunkers were much more geared towards human comfort than any of their closest military precursors outlined in chapter 1. Consider, for instance, the basic ventilation systems installed across the Maginot Line and Atlantic Wall. These served purely utilitarian purposes of expelling smoke and gunpowder fumes from bunkers whilst protecting troops against gas attacks, but they were never designed to account for occupants' comfort. Although air conditioning systems were integrated within sections of the Atlantic Wall bunkers, they were only limited to a series of functional spaces, such as ordnance and munitions stores, rather than troop accommodation quarters[506]. Secondly, when placing the ROTOR bunkers into Banham's chronological timeline, they represent some of the first examples of post-war buildings to incorporate mechanical air conditioning systems. Moreover, given that Barnton Quarry was operational by 1953, it is worth highlighting that the bunker was one of the earliest buildings in Scotland to incorporate advanced artificial environmental controls. Through this predating of broader uptake in civil projects, the 1950s ROTOR bunkers we must therefore reconsider Miles Glendinning suggestion that nuclear bunkers constructed within the later Cold War period (as in toward the 1980s) exhibited the most 'elaborate' examples[507].

Had these advanced climate-control systems integrated within ROTOR bunkers been publicised at the peak of Megastructure discourse, I argue they would have undoubtably registered an interest with figures like Reyner Banham. In *The Architecture of the Well-Tempered Climate*. Banham appraises air conditioning as providing 'almost total control of the atmospheric variables, temperature, humidity…', which in turn 'demolished almost all the environmental constraints on design'[508]. Thus, when considering nuclear bunkers under this lens, air conditioning systems equally

[502] Ibid.
[503] Ibid.
[504] Ibid.
[505] TNA AIR8/1630, Tenth Quarterly Progress Report, by CPRCP, 1 July 1953.
[506] Partridge, *Hitler's Atlantic Wall*
[507] Glendinning, *The Architecture of Scottish Government,* p. 297
[508] Reyner Banham, *The Architecture of the Well-tempered Environment* Second Edition (Chicago: The University of Chicago Press, 1984), p. 187

removed, or at least mitigated, the unique constraints of designing windowless spaces, that were insulated against the most thermally extreme Megastructural environment of nuclear attack. Although these bunkers were never occupied during an actual nuclear conflict, they did experience extensive operational use in peacetime. For after a period of constantly monitoring airspace these buildings subsequently remained in an active state of readiness and hosted a series of governmental and military exercises (commonly dubbed “war games”) to simulate, under the most authentic conditions, how a nuclear attack would impact a building’s performance. Crucially, it was through a combination of defence drills and on-site occupancy that enabled mechanical ventilation systems to be tested, developed, and refined throughout the Cold War, which may have potentially influenced their later integration within civilian buildings.



3.6: Standard electrical components installed within Anstruther bunker

3.4.2: Fixtures and Fittings: A Standard 'Kit of Parts'

Crucial to the reliable functioning of these essential life support systems was the ability to control the interior climate within the hermetically sealed environment. From fieldwork surveys lengths of surface-mounted conduit is omnipresent throughout bunkers, spanning walls, floors, and ceilings, leading to an array of mass-produced fuse boxes, toggle switches, plug sockets, and distribution panels. Collectively these numerous fixtures and fittings provided the bunker occupants with an interface which enabled an advanced climate control and refined comfort levels. Although my early photographic surveys first identified recurrent manufacturers of fixtures and fittings (see fig. 3.6) inside both Scottish and English bunkers, the deeper analysis conducted by this thesis reveals this kit of parts is inherently more important in a broader architectural sense [509]. Despite being previously overlooked, in tracing these architectural histories for the first time, we can better understand how nuclear bunkers were economically designed for initial setup and long-term maintenance by using reliable parts, procured through bulk-buying, with the Megastructure concept of future servicing kept in mind.

Unfortunately, owing to the vandalism of Barnton Quarry during its post-Cold War period of neglect, most of the original component parts have since been deliberately destroyed or stolen by illegal trespassers[510]. Although a small collection of s*ubbrit* archival photographs evidence some of the original fuse boxes and switchgear still in situ, it is imperative to draw again on similar sites constructed as part of the broader ROTOR programme to fill these gaps. With this in mind, and whilst of a different bunker type, the ROTOR site at Anstruther can be used analogously to supplement Barnton Quarry's missing evidence.

By combining my fieldwork observations with archival photographs, I have curated the most definitive catalogue of Britain's nuclear bunker kit of parts to date. In cataloguing this kit of parts, a series of industrial warning bells and fire alarms made by the 'General Electric Company' (GEC), 'Friedland', and 'Gent of Leicester' (Gents) were identified through a cross-sample of Scottish and English bunker sites, alongside a plethora of switchgear, including distribution fuse boards and control panels made by 'Bill', 'Dennis', and Midland Electric Manufacturing (MEM). The following segments consider this standard kit of parts, via three principal grounds: bulk buying; off-the-shelf civilian applications, and 'piecemeal' policy in specifications.

3.4.3: Bunker Bulk Buying

The multiple building services and life-support systems widely installed across ROTOR bunker sites throughout Britain required significant quantities of component parts. Importantly, these voluminous demands for parts were not only required for initial construction but given the projected post-nuclear attack scenario were also essential for future servicing strategies. The Air Ministry was therefore highly dependent on an efficient yet economical supply chain that could feed contractor fit-out parties with a steady stream of mass-produced component parts. Key to this procedure was bulk buying, which being recommended as early as 1947, was the process of placing large orders at the same time so as to ensure timely procurement of items in significant quantities[511]. Furthermore, the 'super-priority' protocols exclusively afforded to ROTOR bunkers over civilian projects to mitigate chronic post-war material shortages (see chapter 2), also maintained an uninterrupted bulk buying supply chain. Importantly, this bulk buying approach was actively adopted by the Air Ministry

[509] Kinnear, *Reopening the Bunker,* p. 16
[510] Ibid., pp. 10-11
[511] Essex County Council Schools, AJ, 105 (1947) 273-280

as standard practice well ahead of other known cases identified within architectural history civilian applications. For instance, bulk buying strategies adopted in the ROTOR programme pre-date the procurement efforts of certain Local Authorities and public works schemes like the GPO building programme[512]. Considered chronologically, the Air Ministry's bulk buying approach perhaps even influenced and developed the 1960s civilian practices from the critical lessons learned through the ROTOR programme. As it was possible to transfer the benefits of this industry practice through the architectural conduits of Watson and Enthoven given their placement within professional practice outlined in the previous chapter.

Servicing proposals in Megastructure theory can be found in ROTOR bunker construction and maintenance strategies, principally through installing, repairing, and replacing industrial components. By using a coordinated bulk buying process, ROTOR bunkers evidence a credible means of servicing the 'plug-in city' concept. By reframing ROTOR bunkers within the prism of 'plug-in city', I argue that the conceptual servicing can be viewed in a realised built form via a combined strategy of construction, maintenance, and bulk-buying processes.

Archigram's 'plug-in city' concept, which Reyner Banham considered part of the Megastructure criterion, highlighted the strategies for providing future servicing, maintenance, and replacement of obsolete parts (or 'units') in the larger 'structural framework'[513]. Archigram's take on the 'plug-in city' similarly considered a 'large-scale network structure, containing…essential services', applicable to any terrain, and having units 'planned for obsolesce' plugged into a said network[514]. Crucially, Archigram predominantly conceived this servicing and unit replacement through the application of mobile craneways, lifts, underground goods tunnels, and feeder 'tube systems', illustrated by a series of detailed architectural drawings[515]. These 'cartoon' sections that depicted the plug-in City's servicing mechanics, were later credited by Banham as being the first drawings 'from which one could construct a working model'[516]. When these drawings were initially circulated in the mid-1960s, the *AJ* compromised to accept the plug-in City concept on grounds of a technical possibility[517]. However, the idea was ultimately rejected on financial grounds given the astronomical costs required to realise the concept in built form and was labelled 'economically unrealistic'[518].

Firstly, while the prototype bunker at Portland was the only ROTOR bunker originally fitted with a passenger lift, ceiling-mounted mechanical hoists were installed as standard across all new ROTOR sites. Vitally, these hoists, carefully positioned at stair cores, allowed heavy parts to be winched in or out of the bunker when replacements were needed. When plant, telecoms, or radar equipment broke down or was rendered obsolete new units could be transported underground and ultimately plugged into the bunker – in this instance, the structural framework. These mechanical hoists thus provided a small yet credible manifestation of Archigram's 'plug-in City' craneways to insert the plethora of parts purchased in bulk.

Secondly, we must recall the contractor fit-out parties (outlined in chapter 2), which, as we now know, efficiently coordinated services installations across ROTOR bunkers. Under careful guidance of the Air Ministry project management, these gangs of contractors moved from task to task within individual bunkers and then once completed went from site to site across Britain. These contractors,

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512 MOPBW, Prefab post offices, *AJ*, 136 (1962) 1200-1201
513 Cook, "Plug-in", p. 39
514 Ibid.
515 Ibid., p. 38
516 Banham, *Megastructure,* p. 102
517 Astragal, "Plugging Plug-in", *AJ*, 140 (1964) 784
518 Ibid.

appointed through serial tenders, were supplied with plentiful component parts, I argue that they be considered as the real-life manifestation of Archigram's crane-ways and railway shuttles featured in their conceptual drawings. Subsequently, these consortia (of civilian architects, engineers, and contractors) became adept with installing (or plugging) these individual 'unit parts' into the micro-Megastructure framework, in turn, connecting the individual bunkers into the broader macro-Megastructure network, spanning from Shetland to Portland.

Thirdly, as these factory-made component parts were mass-produced, it was possible for them to be stockpiled within bunker storages to provide an ample supply of replacement parts for future maintenance under nuclear conflict. For under the sealed conditions of a nuclear attack, these bunkers had to function autonomously with no assistance from the outside world. In such conditions, should any part become damaged, it would need to be easily replaced by the personnel and tools already inside, thus, facilitating quick replacement of 'plug-in' units. Moreover, given the bulk contracts negotiated with manufacturers and suppliers, future generations of product ranges effectively ensured bunkers could easily integrate newer versions of the parts within the bunker's long-term evolutionary cycle.

Figure 3.7: Friedland industrial bell advertisements (AR)

3.4.4: Off-the-Shelf Civilian Applications

Interestingly, the mass-produced components discussed so far were not bespoke, items made exclusively for ROTOR bunkers but were instead sourced directly from manufacturers who also supplied parts for civilian applications. By taking a sample of the most recurrent off-the-shelf manufacturers identified through fieldwork surveys and archival study, I have established new historical links which directly link components installed within top-secret nuclear bunkers and an array of civil architectural schemes.

Paradoxically, although operating in top-secret conditions, the ROTOR programme specified off-the-shelf components made by some of the most prevalent manufacturers active within Britain's post-war construction industry. For instance, the fittings that were installed throughout bunkers featured heavily within widely circulated architectural magazines during the 1950s and 1960s. Some manufacturers, like GEC, who made electrical switchgear, lights, and toggle switches, were even industry leaders; with mass-produced components extensively supplied for installation within banks, offices, and homes. Others, like Gents, who made industrial alarm bells and clocks, also supplied the time-keeping system for the original Royal Festival Hall, designed by Robert Matthew in 1951[519]. Likewise, Minerva, who specialised in fire detection systems, were also specified for all three buildings within London's Southbank Centre[520].

Of these civilian applications, it is undoubtably MEM who represent one of the more intriguing relationships connected with nuclear bunkers. For MEM, who specialised in electrical switchgear, widely marketed a range of off-the-shelf components in post-war Britain that were 'ideal for schools, hospitals, and other public buildings'[521]. For obvious reasons, however, the secrecy surrounding the ROTOR programme prohibited MEM from publicly announcing that they had also been contracted for one of Britain's largest, most important, post-war projects for nuclear defences. Interestingly, an early MEM advertisement for consumer control units featured within the *AJ* in April 1951, which, as we know from chapter 2 signals a busy period of crucial design development for Britain's bunker programme[522]. A later MEM advertisement published in 1954 by the *AR* heralded 'Lower building costs are here!...' (fig. 3.8), the full-page spread claimed that by specifying MEM equipment afforded 'considerable savings here and now on the electrical installation of any building project'[523]. The feature continued that 'every item conforms to the highest standards in the industry yet is priced well below most others'[524]. Accordingly, this economy was due to their in-house production having 'one of the most efficient factories in the world' [525]. From this marketing sample, MEM appears to have provided a viable supply chain to meet the ROTOR programme's bulk buying demands within the strict budgetary conditions imposed by the Treasury. Crucially, ROTOR bunkers were not the only buildings to take advantage of such economic incentives offered by MEM. For although the Southbank Centre has since undergone extensive renovations (which has included the replacement of building services and plant equipment), my photographic survey revealed an original MEM 'fireman's (*sic*) switch' still mounted on the external concrete structure (fig. 3.10). [526] Therefore,

[519] Gents' of Leicester, *AJ*, 113 (1951) 1xii
[520] Building illustrated, Concert Halls: Queen Elizabeth Hall and Purcell Room, AJ, 145 (1967) 999-1018 (p. 1018), Building illustrated, Royal Festival Hall extension, AJ, 141 (1965) 477-487 (p. 487)
[521] MEM, *AR*, 123 (1958) cvi
[522] Brian Grant, Technical Section, "The Industry", *AJ*, 113 (1951) 839
[523] Midland Electric Manufacturing Co. LTD, Lower building costs are here!..., *AR*, 115 (1954) Iviii
[524] Ibid.
[525] Ibid.
[526] These specialised switches enable firefighters to quickly disconnect power from dangerous building components in the event of emergencies.

despite the prevalence of MEM within the civil realm, the Air Ministry's need for affordable, reliable off-the-shelf parts – of a high standard – suggests a calculated risk in potentially exposing the bunker network was carefully observed throughout.

Interestingly, this relationship between MEM and the Air Ministry appears to have been established well in advance of the Cold War. At this point, we must recall the Uxbridge Fighter Command HQ introduced in chapter 1, as my visit and photographic survey of this WW2-era bunker identified very similar MEM switchgear components. Discovering this switchgear is hugely significant on the grounds that Uxbridge was constructed in 1939 and as this predated the earliest ROTOR bunkers by at least ten years, indicates a much longer relationship existed with the manufacturer. Thus, by featuring MEM on exclusive tender shortlists the ROTOR programme facilitated more efficient and economical bulk buying given the arduous and lengthy vetting processes (mentioned in chapter 2) had already been addressed, establishing an advanced degree of trust with the Air Ministry.

Although MEM undoubtedly offered the Air Ministry cost-saving incentives on the ROTOR programme, in a time of desperate need, the civilian firm most likely benefited in equal measure. MEM appears to have enjoyed a sustained period of commercial success after its first involvement with Britain's nuclear bunkers. Shortly after the ROTOR programme's first phase was made operational, MEM considerably expanded its industry presence through a series of key takeovers, that included the purchase of electrical component maker J.H. Tucker & Co. Ltd, Birmingham, in 1955[527]. Another merger with Kersons Manufacturing Co. Ltd in 1957 expanded MEM to put, as the press quoted, '…100 years of electrical experience at your service'[528]. This formidable industry position is also evident through a series of key civilian contracts that followed in the 1960s. For example, as well as the firefighter's cut-off switch noted at the Southbank Centre, MEM switchgear was also installed at the Lee Chapel social housing scheme at Basildon, Essex, in 1961[529]. Additionally, MEM control units for underfloor heating were installed on new multi-storey tower blocks in Birmingham a year later [530]. In fact, by 1962, extensive marketing boasted how MEM had grown its industry experience to serve a broad product range suitable for 'public building, schools, hospitals, hotels, offices and in the home'[531]. (Although beyond the scope of this thesis timeline, it is worthwhile noting that MEM also supplied consumer control units to the Robinson College at the University of Cambridge, designed by Scottish architects Gillespie, Kidd & Coia in 1981[532]). Therefore, we must acknowledge that the bulk buying contracts with MEM, for off-the-shelf components, secured an advantageous position for the ROTOR programme on two main grounds. First, by specifying these widely available off-the-shelf components at a fever pitch of post-war rebuilding ensured a steady supply chain both during the British-wide bunker construction as well as an emergency stockpile. Second, it neatly placed innovation alongside future bunker expansion, for amongst firms like MEM, there was a constant industry-wide press in hugely competitive markets for continued product development. So, while components mainly catered for more efficient and economic workspaces in civilian applications, they equally provided the same benefits to top-secret nuclear bunkers.

527 Announcements, Trade, *AJ*, 122 (1955) 722
528 Great News!, "MEM, Tucker, Kerson merger puts 100 years of electrical experience at your service…", *AR*, 121 (1957) iii
529 Midland Electric Manufacturing Co. LTD, "For Basildon New Town in Essex", AJ, 133 (1961) 127
530 Midland Electric Manufacturing Co. LTD, "in new Birmingham flats, *AJ,* 133 (1962) 96
531 Midland Electric Manufacturing Co. LTD, 'Gridswitch Range', AJ, 136 (1962) 85
532 Building Study, Robinson College, Cambridge, *AJ*, 174 (1981) 241-261 (p. 261)

Figure 3.8: Midland Electric Manufacturing advertisement 1954 (AR)

Figure 3.9: Midland Electric Manufacturing Switchcraft brochure 1954 (AR)

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Figure 3.10: Midland Electric Manufacturing Fire-fighting switch located at South Bank

3.4.5: A Classified 'Piecemeal Policy'

Achieving this extensive fitout was considerably more complex given the secrecy surrounding the ROTOR programme. However, a classified 'piecemeal' policy of component specification and installation may have been the solution to circumvent this issue. To understand the origins of this piecemeal policy, we must return to the WW2 timeline where Marconi was appointed the principal radar contractor on Britain's Chain Home radar network, the air defence network which was the precursor to the Cold War ROTOR programme. Crucially, the Marconi company's official history published in 1970, outlines a unique wartime 'policy of piecemeal manufacture', that was jointly conceived between Marconi and the British Government [533]. Centrally, this policy was devised as a means of preserving the 'maximum amount of security' for military contracts by concealing the mass production of radar and radio components installed within the fleets of RAF aircraft [534]. Rather than a traditional linear production process, whereby components were consolidated and assembled at a single geographical location (largely by one main manufacturer), the various individual elements were shared between a number of different contractors across several disparate sites [535]. As a result of this separation, the efficient linear-based assembly line – direct from factory to site – was broken and therefore individual manufacturers did not know the full nature of the products being made, nor could they easily determine their final destinations [536]. Collectively this approach assisted concealment from potential breaches in security from active German espionage and surveillance.

By adopting a similar approach of this WW2 piecemeal policy into the ROTOR programme and breaking the supply chain provided an additional means of keeping secret bunkers hidden both during their initial construction and ongoing maintenance. Having already established the previous involvement of contractors Marconi and McAlpine, as well as the architect Lesslie Watson on Air Ministry projects it is highly likely that this consortium would have agreed to adopt similar piecemeal policies for the ROTOR programme – during a more heightened state of Cold War secrecy amid sophisticated Soviet spying and intelligence gathering. As observed in my photographic surveys of ROTOR bunkers across Scotland and England, there is an unusual fitout of multiple component manufacturers. For example, the electrical switchgear installed throughout a typical bunker used an array of mass-produced components made by MEM, Bill, and Dennis, rather than procuring all necessary switchgear under a single contract. Similarly, rather than specifying the one type of alarm bell for all ROTOR bunkers there were multiple variations installed which included models made by GEC, Gents, and Friedland. In tracing these company histories there is no reason why one single manufacturer could not provide a consolidated contract for all the required electrical switchgear or alarm bells. MEM, for instance, had both the production capacity, and off-the-shelf product range to supply all switchgear elements required for ROTOR sites like Anstruther yet the final as built architectural fittings reveals the switchgear was split between three or four separate firms. This somewhat convoluted specification suggests that a similar piecemeal policy was adopted across the ROTOR programme, whereby a range of competing firms, with overlapping capacities, were used to break the linear production line and therefore assist the overall secrecy.

Furthermore, when considering the geographical spread of these manufacturers identified in the supply chain, we must acknowledge the vast distances covered; particularly as Scottish sites included the most remote locations across the whole ROTOR programme (see chapter 1). For example, components found within Scottish bunkers were dispatched from factories predominantly located in

[533]W.J, Baker, *A History of the Marconi Company* (London: Methuen and Co Ltd, 1970), p. 307
[534] Ibid.
[535] Ibid.
[536] Ibid.

England; including MEM in Birmingham, Friedland in Cheshire, GEC in London, and Minerva in Surrey. This means that the Minerva fire detection system, installed at Saxa Vord bunker in Shetland, was shipped some 800 miles away from a factory in Surrey, rather than procuring a similar alternative manufacturer within the Scottish mainland. Therefore, the kit of component parts (including smoke detectors and units) needed to be driven hundreds of miles by lorry then ferried north to reach the remote ROTOR site. Crucially, this cross-border supply chain also included distribution channels that saw Scottish factories similarly contributing to the fit-out of bunkers in England. For instance, refrigeration machinery for the air conditioning system installed at Kelvedon Hatch bunker outside Essex, was manufactured by L Sterne & Co Ltd based in Glasgow, over 400 miles away. In recalling the Treasury's financial scrutiny throughout the ROTOR programme (see chapter 1) it is important to acknowledge that these geographical spreads significantly contradict the economics of shipping. Instead of carefully sourcing manufacturers closer to individual bunker sites and reducing associated logistics expenditure, it appears another level of the piecemeal policy was adopted to further increase security and secrecy. This vast distribution across Britain and the various contractors' contributions made on both sides of the border were vital in creating this functioning Megastructural bunker network.

In conclusion, this section reveals how nuclear bunkers as Megastructures represents another missed opportunity of serious consideration within architectural discussion at the time due to their top-secret status. For instance, while ROTOR programme architects, Lesslie Watson and Roderick Enthoven (introduced in the last chapter), were both actively engaged with broader architectural discourse when the Megastructure debate emerged, they were duty bound by the Official Secrets Act. Even if they had identified and disclosed the strong parallels shared between nuclear bunkers and Megastructure theory, they were ultimately at risk of being charged over treason, as was the case with Duncan Campbell (see chapter 1). Although further connections between nuclear bunkers and Megastructure theory later emerged during the 1970s, they were siloed within a very different context of investigative research (conducted after the Spies for Peace expose in 1963) and remained outside architectural discourse. For example, the illustrated maps and diagrams published in Peter Laurie's *Beneath the City Streets* evidenced clear similarities with the famous Megastructure images that would appear seven years later in Banham's writings. Laurie's maps not only resonate with Megastructure drawings and diagrams, but the fact that he also brought the GPO Tower into his analysis well ahead of Banham's account reflects the disciplinary limitations imposed. The fact that Banham includes the WW2-period Shivering Sands Fort, near Kent (built to protect the River Thames against Luftwaffe raids), indicates that if these Cold War nuclear bunkers were not held within the shadows, Britain's architectural history would have seriously considered these structures within their discussion[537]. Only now, by unpacking declassified files and exploring decommissioned sites, can this nationwide bunker network be brought into the Megastructure argument for the first time.

537 Banham, *Megastructure,* p. 28

3.5: Brutalist Tendencies: Services Exposed

ROTOR bunkers not only used the same mass-produced components ahead of their later appearance within historically important Brutalist examples, but they also evidenced similar tendencies of exposing building services prior to broader uptake in civil architecture. Although I discuss Brutalism in more detail throughout the next chapter, it is important to first outline the additional Cold War-specific reasons as to why exposed building services were also specified for Britain's Cold War nuclear bunkers as part of this micro-megastructure lens.

Like Megastructure, Brutalism was and still is a popular area of interest for architectural historians (among others) since its scholarship expanded considerably in the early-2000s. The first mention of Brutalism within a British context is widely credited to Reyner Banham's 1955 essay 'The New Brutalism' published in the *AR*; where, similar to Megastructure theory, Banham outlined a criterion he deemed worthy of acknowledgement as Brutalist tendencies[538]. As part of Banham's definition, he included the importance of 'valuation of materials 'as-found'' and used the Hunstanton secondary school, designed by the famous post-war architects Allison and Peter Smithson, as a key case study[539]. In Banham's detailed appraisal of Hunstanton (completed in 1954 after lengthy delays incurred by steel shortages) he noted that 'wherever one stands within the school one sees its actual structural materials exposed, without plaster' and highlighted how the 'electrical conduits, pipe-runs, and other services are exposed in equal frankness'[540]. This Brutalist tendency of exposing building services, rather than concealing them from view, was reiterated by Banham in his later analysis of James Stirling's Leicester Engineering Building (1959-63). So much so that the 'magnificent exposed water pipes' which are equally worthy of Banham's 'as-found' criteria, have been highlighted in the more recent scholarship of architectural historian Barnabas Calder. In *Raw Concrete*, Calder emphasises how the exposed building services of Stirling's Leicester Engineering Building bear the 'hallmarks of Brutalism'[541]. The rationale of exposing services at these civil schemes has been extensively debated since with views predominantly citing either economic necessity or stylistic design choices. However, when reframing nuclear bunkers within this discussion what additional circumstances were at play in exposing a building's services?

Interestingly, ROTOR bunkers adopted the same exposed building services around the same time as Hunstanton and 10 years ahead of the Leicester Engineering Building. From detailed surveys of ROTOR bunkers the suspended ventilation ducting, exposed plumbing, and wall-mounted electrical conduit are all but identical to that shown in the early post-completion photographs of Hunstanton. Furthermore, the lengths of wall-mounted conduit that led to the range of abovementioned fuse boxes, toggle switches, alarm bells, light fittings, plug-sockets, master clocks, firehoses, and a variety of sundry services, express a similar aesthetic in bunkers to that designed into both educational buildings. Importantly, this marks a distinct shift from other Air Ministry construction standards of the same period such as domestic accommodation for RAF personnel. For despite the industrywide post-war material shortages, the Air Ministry design specifications for the flagship barracks block at Boscombe Down, England, did not expose building services as would be expected. Instead, photographs published in the *AJ* reveal how contrary to ROTOR bunkers, water and waste pipes

538 Reyner Banham, "The New Brutalism", *AR*, 118, (1955) 354-361
539 Ibid., p. 361
540 Reyner Banham, *The New Brutalism: Ethic or Aesthetic* (London: Architectural Press, 1966), p. 19
541 Calder, pp. 180-181

were encased within additional ducting, and thus, produced a cleaner, yet more expensive aesthetic which concealed building services from view within the finished architectural space[542].

As much as exposing services in ROTOR bunkers permitted valuable savings (principally in cost, material, and labour) to assuage the Treasury's fiscal scrutiny, the 'as-found' Brutalist tendencies also afforded these nuclear bunkers another measure of functionality in life preservation. For leaving building services exposed ultimately enabled a practical means of repair and maintenance during and after a nuclear attack. Given these bunkers were to be sealed off from the outside world for an indefinite period of time, should any building services fail, or components require replacement, delays posed extreme risks to those dependants sheltering inside. Therefore, by exposing the conduit, pipe-runs, and ducting instead of concealing these behind partition walls or plasterboard linings facilitated easier access, for the repair crews inside these bunkers as all components and parts were relatively free from obstruction. While the 'as-found' exposed building services may hold similar visual comparison with other civilian Brutalist buildings they were equally underpinned by a somewhat ominous nuclear functionalism.

[542] Barracks for the RAF, *AJ*, 110 (1949) 711-713 (p. 713)

3.6: Conclusion

This chapter has highlighted the suitability in organising large networks of interconnected nuclear bunkers within post-war Megastructure theory. Had it not been for the restrictions imposed by the State, the valid claims held by nuclear bunkers in achieving Megastructure status, may well have been identified within post-war architectural discourse for serious consideration. As evidenced through his book review of *The Architecture of Aggression*[543] Reynar Banham expressed significant appraisal of Mallory and Ottar's research into military architecture and WW2 bunkers such as the Atlantic Wall bunkers and forts of the Maginot Line in France. Importantly, Mallory and Ottar's account featured a detailed insight to the autonomous climates within the underground spaces and tunnel systems of the French Maginot Line which was established in chapter 1 as an important precursor to nuclear bunkers. Additionally, this architectural study also included sectional drawings cutting through the Maginot Line to reveal their underground workings that look strikingly similar to the Megastructure-like images that circulated within timely architectural discourse. Therefore, had the ROTOR bunkers been available to study during this frantic period of Cold War tensions and theorisations, the sophisticated environmental conditions, servicing strategies of replacement parts would most likely have caused greater intrigue of nuclear bunkers than the outmoded WW2 examples. Lastly, within more immediate architectural histories, had these networks of secret nuclear bunkers been integrated with the Megastructure argument they may have predated the Megastructure status offered Cumbernauld Town Centre, commissioned by the Cumbernauld Development Corporation (1963-67), described by Banham as the 'nearest thing yet to a canonical Megastructure that one can actually visit or inhabit'[544].

[543] See Reyner Banham, Architecture of Aggression, *AJ*, 158 (1973) 1014, Interestingly Mallory and Ottar are equally commendable of Banham's 'fresh' approach to architectural history.
[544] Banham, *Megastructure,* p. 105

CHAPTER 4. BRUTAL COLD WAR SHIFTS

4.1: Introduction

Towards the end of the last chapter I argued that Brutalist approaches to exposing services 'as-found' were not wholly applied in bunkers purely as a stylistic aesthetic but were instead underpinned by the need to protect and preserve building systems in the event of a nuclear attack. Beyond the 'as-found' aesthetic nuclear bunkers are also located in Brutalist discourse on the grounds of their synonymous relationship with concrete as held by the likes of Garrett and Klinke[545]. On the other hand, however, Beck implies this relationship as being more detached from Cold War nuclear bunkers and argues they 'are more about the inside than the outside'[546]. Clement emphasises the historical complexities around Brutalism as an architectural style, as despite certain architects deliberately avoiding association with the movement, they still captured the 'essence of Brutalism' [547].

Therefore, by providing a detailed analysis of the concrete form and aesthetics of Kirknewton and Cambridge bunker extensions in 1960, this chapter counters expands this relationship with Brutalism by considering the notable shifts in 1960s government bunkers alongside the changes in concrete aesthetics[548]. This chapter firstly investigates the shifts in state-backing, priority status, and the political jousting behind Scotland's government bunkers. Then I conduct a detailed decoding of the concrete to further explore the changes required for nuclear protection, public concealment, and the post-nuclear civic functions envisaged for their continued use as the Nuclear St Andrews House to surviving remnants of the Scottish Office. This decoding also reveals the critical contributions made by civilian architects that positioned nuclear bunkers alongside other public realm works. Lastly, this decoding reveals how Kirknewton was a key architectural prototype for developing Cambridge's more prestigious setting and testing exposed aggregate finishes to expand concrete technical knowledge to benefit broader civil applications.

545 Garrett and Klinke, *Opening the bunker: Function, materiality, temporality*, p. 1066
546 Ibid., p. 224
547 Clement, p. 171
548 Under this typological framework The Scottish Central Control (SCC) served Scotland whilst the Regional Seat of Government (RSG) operated in England and Wales.

4.2: Fiscal Issues: The Pendulum Swing of State-Backing

Towards the end of the ROTOR programme's scheduled completion, the continuously shifting geopolitical situation was, again, recast, forcing yet another drastic rethink of Britain's nuclear defences. Although this shift pushed for a revised defence strategy, nuclear bunkers of the first building programmes were not simply cast aside. Instead, they were allocated a host of new functions as the British government came to terms with the genuine possibility of nuclear attack paired with a growing awareness to bunker costs. By the time of this paradigm shift, finances had to be constantly balanced between the threat of nuclear conflict and fulfilling the post-war promise of civilian rebuilding as the State were all too aware of the inflating costs required in bunker architecture.

As we know from chapter 2, the Air Ministry's ROTOR programme – in terms of an air defence system – was rendered obsolete by the late-1950s. Chronologically, this redundancy principally due to Soviet developments in nuclear weaponry and their delivery systems as they transitioned from long-range bombers to ballistic missiles. For example, Nick McCamley attributes the 1955 disbandment of Anti-Aircraft (AA) Command as a direct response to the Soviets achieving Hydrogen bomb (H-bomb) status in 1953. Given the H-bomb carried greater yields, much more potent than the earlier atomic devices, it was surmised that if AA flak had struck airborne Soviet bombers, there was a high risk that the nuclear payloads could inadvertently explode and cause catastrophic damage before the ordnance was even released [549]. Therefore, the AAOR bunkers of the ROTOR programme were no longer suited to their original defence function. Shortly after the disbandment of AA Command, the Soviet's successfully tested their first inter-continental ballistic missile (ICBM) in 1957, which meant that nuclear payloads could be delivered at unprecedented supersonic velocities without the need for pilots. These new speeds immediately transcended the tracking and monitoring capacities of radar technology operating within ROTOR bunkers and utterly outclassed the human response times of the ROC monitoring network. Thus, the system of interconnected ROTOR bunkers and ROC infrastructure (outlined in the previous chapters) could no longer detect and report incoming Soviet threats within adequate reaction times. As a result of these combined factors the Air Council decided to close Britain's Sector Operations Centre (SOC) in 1959; transferring detection, monitoring, and warning roles to the more advanced BMEWS site at Flyingdales in North Yorkshire (beyond the scope of this thesis)[550]. Crucially, these defence shifts matter for in 1962 the world experienced the Cuban Missile Crisis – widely accepted by historians as the closest escalation of tensions that nearly triggered a full-blown nuclear conflict and real need for these buildings. Thus, this first period of nuclear bunker building not only evidences a tangible necessity for this architecture but also how quickly the context could change and the resulting financial implications.

It is important we must acknowledge that bunker architecture was not to blame for the ROTOR programme's redundancy. The issues contributing to its sudden demise largely resided with advances in radar equipment and weapons technology, so although human operators and observers could no longer relay attack information quick enough, the physical bunkers themselves were not the issue. As a testament to its robust architecture an official report issued in late-1961 revealed how Barnton Quarry had been kept in such good condition it was constantly ready for immediate use should the country transition to a nuclear war footing[551].

[549] McCamley, *Cold War Secret Nuclear Bunkers*
[550] Ibid., p. 91
[551] NRS HH51/260, Letter to J, Gibson (Treasury), 15 September 1961.

Against this changing backdrop, Scotland's defence priority was recalibrated. Its principal role under the ROTOR programme had centred on marshalling vital air monitoring of Britain's northernmost frontline, by the turn of the 1960s however, this shifted to preparing an emergency outpost in the event of a nuclear attack. Should Britain's central government be disturbed or entirely incapacitated in the period after a nuclear strike, Scotland (alongside other home nations and English regions) depended on these outposts to function autonomously 'with the maximum degree of devolution' while awaiting the restoration of central government administration[552]. Previous multidisciplinary research outlines how the earlier War Room strategy was subsequently revised to provide a viable system of Emergency Government Control (EGC) bunkers. Political historian Matthew Grant, for instance, has emphasised that alongside conventional government duties, this emergency administrative system would help maintain control in the aftermath of a nuclear attack and prevent Britain from descending into an 'anarchy of looting, violence, and social decay'[553]. For McCamley, these EGC bunkers were essentially 'Whitehall in microcosm'[554]. The archaeology fieldwork of Historic England has supported this mini-Whitehall concept of a mini-Whitehall by tracing and recording the various government departments assigned to these bunkers, including the Treasury, revealing who were formally assigned a place and tasked with major contributions in this post-nuclear administrative structure[555]. This EGC programme amassed an interconnected network of 13 top-secret bunkers dispersed throughout Britain; including the Scottish Central Control (SCC) for Scotland, and the Regional Seats of Government (RSG) for England and Wales. Together this dispersed system was to work in conjunction with the main alternative seat of government at Burlington, London (also known as Corsham) which provided shelter for 1500 staff as well as Britain's Prime Minister.

As with the ROTOR programme, it would be helpful to firstly outline a basic typological framework for the SCC administrative structure and highlight the key differences evidenced between Scottish and English contexts. Across the broader EGC system the RSG carried an 'administrative meaning' instead of defining a particular type of nuclear bunker. While kirknewton may share certain similarities with Cambridge bunker, it assumed a very different purpose. Peter Laurie first alluded to Scotland's unique hierarchical system of the SCC supported with zones, instead of the ten regions within England, yet the architectural importance of this is still to be fully understood[556]. At base, Scotland was to be overseen by a Scottish Central Control (SCC) functioning as the main post-nuclear government centre of operations, with a further three subservient 'Zones HQ' bunkers providing vital support with the help of individual 'Group Controls' assigned to each council region. Importantly, each Zone was designated a separate bunker, which, architecturally, was equal to the individual English RSG bunkers (fig 4.1). Secondly, while the English RSGs covered their respective regional constituents, the SCC was actually responsible for the entire population of Scotland; a a huge landmass of approximately 78,000 km² (almost twice as much as Cambridge's 40 km²). Lastly, while a Regional Commissioner headed English RSGs, the SCC was instead run by the Secretary of State for Scotland, which given their status of second only to the Prime Minister, represented distinctly more important political figure[557].

[552] Grant, p. 138
[553] Ibid., p. 140
[554] McCamley, p. 161
[555] Wayne Cocroft, Cambridge Regional Seat of Government: Survey Report, (Cambridge: English Heritage, 1997), p.12
[556] Laurie, p. 112
[557] Jane Morton, Scottish Office: Regional Rule, *New Society*, (10) (1967) 392-395 (p. 392)

Having established this new hierarchy, it is interesting in how the EGC programme evolved and the State shifted from its previous stance on the ROTOR programme to re-assess its backing. Like most departments involved with creating the ROTOR works programme, the Treasury had entered the Cold War largely unaware of the impending construction costs (see chapter 2). By the early-1960s, however, the fiscal body was painfully more conscious of the soaring outlays associated with building expansive networks of robust and technically advanced concrete bunkers, specially designed for nuclear protection. In response, the Treasury became less willing to finance nuclear bunkers and began to draw its battle lines to limit government expenditure and stem the haemorrhaging of the public purse[558]. By 1961 the Treasury declared they would no longer fund 'custom-built accommodation for Regional Seats of Government in England and Wales and Scottish Central control and Zone controls in Scotland' [559]. This signals a sea change in State-backing as the balance between nuclear bunker architecture and public works spending had to be checked for the first time. Although the British government had already spent more than £20 million of taxpayer's money had already been spent by and thousands of tons in valuable materials such as steel, concrete, and bricks had already been set, these bunkers could not simply be mothballed or written-off as complete losses. The outmoded ROTOR programme instead provided an extensive building stock that was to be reused for the rest of the Cold War.

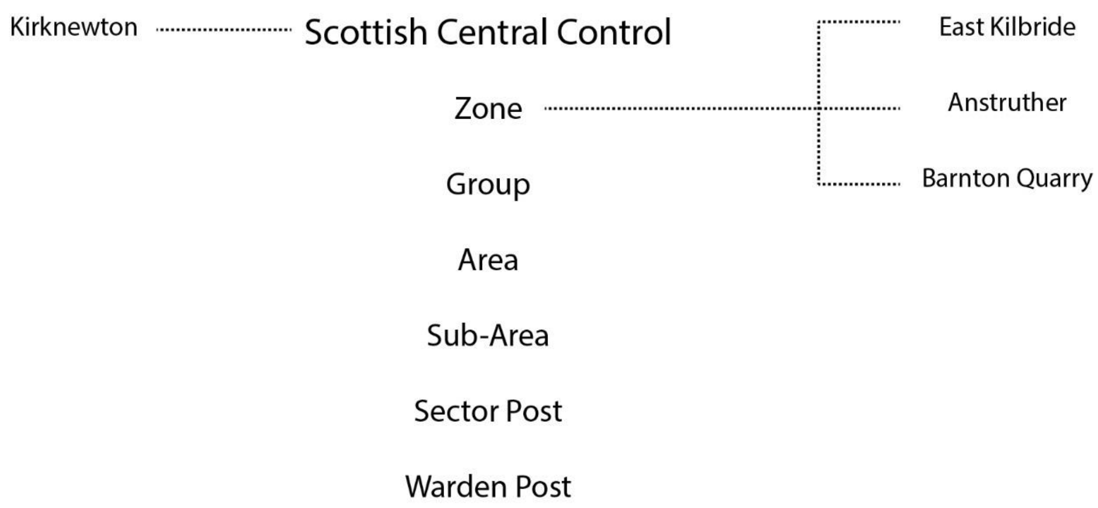

Figure 4.1: Hierarchical framework for Scottish Central Control c.1965

[558] NRS HH51/260, Letter from SHD to Air Ministry, 11 January 1961
[559] Ibid.

4.2.1: Push for Adaptive Reuse

Reuse policy has been referenced in previous studies, but the core rationale requires expanding, for this reveals the central government's sudden pendulum swing in state-backed patronage. With new purpose-built bunkers vetoed by the Treasury an alternative policy of adapting and reusing existing stocks from the 1950s was fervently pushed. This brutal shift in government policy meant existing buildings had to be found and 'adapted to meet the needs of those controls and suitably protected to give them a protective factor against radiation' [560]. In Scotland, four of the largest nuclear bunkers built during the 1950s were granted extended lifespans under Emergency Government Control (EGC) plans noted above. While the ROTOR programme bunkers at Barnton Quarry, Anstruther and East Kilbride (alongside the War Room at Kirknewton) no longer suited their original defence functions, they all secured vital new roles in the 1960s defence reorganisation. For instance, in 1961, Barnton Quarry was given the vital role of SCC; Anstruther served the Northern Zone control; East Kilbride assumed the Western Zone control, and finally, Kirknewton became the Eastern Zone control[561]. This cost-cutting exercise in turn dictated new uses for Britain's largest, most technologically complex, and expensive bunkers and therefore were far from wasteful as some have and continue to suggest.

Under the SCC typological framework, Scotland also required Group Controls to assist the hierarchical organisation (fig.4.1.). Although significantly smaller, these facilities still required protection against radioactive fallout and had to ensure a communications network that was capable of connecting the command chain after a nuclear strike[562]. Whilst carrying lesser costs, the Treasury similarly discouraged purpose-built Group Controls on financial grounds. As Britain's Local Authorities were responsible for these subservient controls the onus was on councils to locate and reuse leftover 'protected service premises' – especially the remnant ROTOR programme bunkers [563]. Local Authorities that had no such bunkers within their regions, were instead permitted to integrate Group Controls within the basements of existing structures or alternatively, new buildings already going through design stages[564].

4.2.2: Peter Womersley's Group Control

An example of a Group Control being integrated into a new building already under design is tracible to Peter Womersley's offices for Roxburgh County Council (1966-68), which, is incidentally more recognised within Scotland's architectural history. The administration block was built as the first phase of a larger masterplan, predominantly using *in situ* reinforced concrete with an 'as-struck' finish (fig 4.2). The plans published by the *AJ* upon its completion indicate that 'strongrooms' and 'radio rooms' were designed into the building's monumental 85ft tower, but civil defence facilities were also incorporated within the basement as per the Treasury's directive[565]. Given that the County Council office block was completed in 1966 and since it served Scotland's Eastern Zone civil defence, Roxburgh would have been a focal point of contact for the Local Authority if nuclear war had broken out with the Soviet Union. Using allocated Treasury financing, the Scottish Office was willing to cover the additional costs of incorporating the Group Control within the office block to a value of £5,000 (or £155,000 in today's money)[566]. Factoring this subsidy into the final costs of the office scheme

[560] Ibid.
[561] Changes later saw Barnton Quarry and Kirknewton swap roles and an additional 'deputy' headquarters was installed at a reused WW2 bunker in Inverness. Note: there were no zone controls assigned for the south.
[562] NRS HH51/194, Letter from Western Civil Defence Zone Controller to (SHD) 24 January 1961
[563] NRS HH51/194, Letter from (SHD) 22 July 1960
[564] Ibid.
[565] Building study, "County offices by Peter Womersley", *AJ,* 148 (1968) 933-946, p. 946
[566] NRS HH51/194, Letter from Western Civil Defence Zone Controller to (SHD), 24 January 1961

(approximately £300,000) suggests this contribution represented around 1.5% of the overall project value [567]. In this case, however, the monetary values are not as important as project delays incurred by the shifting defence architecture. Although Womersley's design was initially commissioned in 1960, the office block did not commence on-site until six years later[568]. While the AJ generally attributes to this delay being caused by several shifts in the client brief, it falls short in revealing these changes were partly impacted with incorporating nuclear bunker architecture.

Figure 4.2: Peter Womersley's Roxburgh County Council offices (RIBApix)

As detailed in chapter 2, the ROTOR programme regularly jostled with civilian projects over precious public funds throughout the 1950s – albeit within the Cold War shadows, known only to a selective few government officials. Not only did this tussle continue into the 1960s but given the extended requests for financial aid across the whole of Britain, the Treasury became even more brutal surrounding the financing of bunkers as mentioned above. Around the same time that the Scottish Office was planning its emergency government controls, other urgent needs emerged from the civil realm and tended to be more successful in prizing funds from the Treasury. It is important to acknowledge that the Central Government subsidy schemes that provided financial aid to the likes of Roxburgh County Council offices also had to be shared with Britain's countless other civilian needs,

[567] Building study, "County offices by Peter Womersley", *AJ,* 148 (1968) 933-946, p. 946
[568] Ibid.

especially the likes of new social housing[569]. Albeit Roxburgh was afforded a small government grant, some civil projects received full funding from the Treasury, as evidenced at the Hutchesontown C (1958-65) housing blocks, designed by Basil Spence for the Glasgow Corporation (fig 4.3). Interestingly, the individual flats of Hutchesontown C were originally price-capped at £2,800 per unit, yet, when design development exceeded the approved budgeted cost in 1958, an appeal was launched[570]. This subsequently saw the Glasgow Corporation pressure the Scottish Office (a devolved department dependant on central Treasury finances), for additional funds. Crucially, the Scottish Office eventually conceded and, in the end, approved the extra expenditure for this well-known example of Scottish post-war architectural history.

This shift in state-backed patronage is important, for although Scotland's emergency government bunkers still remained a closely guarded secret, the finances were ultimately drawn from the exact same Treasury budget bankrolling the likes of Hutchesontown C, as well as a raft of other public schemes under the expanding Welfare State banner [571]. In a period of continued economic frugality, State spending required a careful balancing of budgets, which incidentally created a Cold War dilemma over precious finances, for the government could not afford to finance nuclear bunkers as well as massive civil building programmes that had been promised to the people. In this light, shifting funding away from public works programmes towards nuclear bunkers – that may or may not be required in future conflicts – was most unpalatable. Had this secret been publicly exposed, it would have been incredibly damaging to the Conservative government. Therefore, the Scottish Office sanctioning precious funds towards Hutchesontown C can and should be acknowledged as a more direct instance where civilian demands outmuscled nuclear bunkers. Further yet, it is an interesting thought that had the Scottish Office been aware of the impending costs attached to Barnton Quarry's alterations and Kirknewton's extension, Hutchesontown C might have fared differently if the requests to increase the project's budget had been denied. Nonetheless, this Scottish case study outlines the Treasury's firm, and at times brutal, shift in sate patronage. As the purse strings tightened, nuclear bunkers were swiftly losing their priority status that had previously placed them ahead of all other civil works. In this new 1960s context it became policy to locate suitable examples for reuse from the country's existing stocks.

[569] Miles Glendinning and Stephan Muthesius, *Tower Block: Modern Public Housing in England, Scotland, Wales, and Northern Ireland* (New Haven, Connecticut: Yale University Press, 1994) offers a more detailed analysis of Government subsidy schemes during this post-war period.
[570] Miles Glendinning, "From Genius Loci to the Gorbals" in Basil Spence Architect, ed., Philip Long and Jane Thomas, (Edinburgh: National Galleries of Scotland, 2008), pp. 87-95.
[571] Calder, p. 312. notes similar issues experienced with Treasury budgets at Denys Lasdun's National Theatre building at London's Southbank

Figure 4.3: Hutchesontown C housing scheme by Basil Spence (RIBApix)

4.2.3: Purse Strings and Political Manoeuvres of the Scottish Office

Even these adaptive reuse policies proved difficult in reality given the historical inter-departmental frictions between the devolved Scottish Office and central British government. With the changing geopolitical landscape and tighter purse strings emerging in the 1960s, securing funds and sign-off for nuclear bunkers required a certain guile from the Scottish Office. The financial implications of constructing and maintaining nuclear bunkers had already taught the British government brutal economic lessons. As a means of both justifying previous expenditure, and limiting ongoing overspend, Britain's existing bunker stocks of the 1950s were not simply handed over to the Scottish Office for continued reuse. Instead, these sites were subject to intense scrutiny and underwent lengthy due diligence processes once they had been earmarked for inclusion within the new EGC network. By analysing the complex and protracted negotiations behind the Barnton Quarry acquisition, only now, we can understand the manoeuvres required by the Scottish Office to pivot the restrictions imposed by the central government. In maintaining a firm economic astuteness, the Scottish Office inadvertently translated these efforts into the civil realm for the betterment of broader civil post-war rebuilding.

As per the structural framework outlined above Scotland urgently needed a suitable host for establishing the country's first Scottish Central Control (SCC). Initially, given the high likelihood Edinburgh was designated a prime target for a Soviet nuclear attack the Scottish Office was initially unwilling to house the SCC at Barnton Quarry on geographical grounds[572]. A direct strike on Scotland's capital – perhaps at Waverley Station or Princes Street – would be within a mere 5 miles of Barnton and thus threatened the existing ROTOR bunker's entire survivability. Under this rationale the Scottish Office appealed to the Treasury in August 1960 arguing that the Barnton Quarry bunker was 'too close to a possible target to be suitable to house a Control as important as the Scottish Central Control'[573]. The Scottish Office made it clear that its preference lay in acquiring a new purpose-built facility, that was suitably protected from radioactive fallout and could accommodate an enlarged occupancy of 'operational' and 'government' personnel (at an estimated cost of £200,000 to £300,000 (or £5m to £7.5m today))[574]. Less than six months later, however, the Scottish Office's firm stance shifted entirely, and despite the earlier concerns over proximity, it conceded to the Treasury's pressure by accepting to adaptively reuse the existing ROTOR bunker at Barnton[575]. This swift U-turn after months of discussion, suggests the Scottish Office suddenly came to the realisation that no matter how long it resisted the adaptive reuse option, the Treasury was unwilling and unlikely to budge. In fact, had they continued their protracted negotiations in favour of a new purpose-built SCC bunker, the Scottish Office would be conscious that further protests would jeopardise any financial approval within the allotted budget year.

Even after reluctantly accepting Barnton Quarry as the designated SCC the Scottish Office's problems with Whitehall were far from over. While minor issues arose in establishing the other interconnected Civil Defence Zone Controls at Anstruther, Kirknewton, and East Kilbride, negotiations for Barnton Quarry proved much more challenging and incurred further delays. As outlined in chapter 3, the Treasury were already aware of the significant investments Barnton had absorbed by the 1950s (including installing sophisticated life support systems, telecommunications networks, and National Grid connections). But so too were the Air Ministry. For in considering this transfer of assets from an Air Ministry perspective, this three-storey underground bunker in Edinburgh was the largest and one

[572] NRS HH51/260, Letter to R.E. Hill of Air Ministry from Elliott-Binns (SHD), 21 June 1961
[573] Ibid.
[574] Ibid.
[575] Ibid.

of the most technically advanced examples from their entire Scottish estate. At a time when geopolitical tensions were increasing yet again, it is understandable the Whitehall-based departments were particularly reluctant to part with this invaluable asset.

As mentioned in chapter 2, part of the Scottish Office's post-war responsibilities included discharging planning stipulations with the Local Authority on behalf of the Air Ministry's ROTOR programme. Interestingly, when clearing the statutory matters for Barnton Quarry in the early-1950s, the Scottish Office (through the SHD) was simply informed the secret site was required for continued RAF use – the nature of its exact functions was withheld at the time. Supplying Local Authorities with intricate detail of the classified radar network carried legitimate risks of exposing the site to prying Soviet surveillance[576]. Yet, upon formal site handover from the Air Ministry to the Scottish Office in 1961, under instruction from the Treasury department the Ministry of Works (MOW), demanded that the SHD inform the Edinburgh Corporation and the Lord Provost (as head of the Local Authority) of all proposed changes[577]. Moreover, the Treasury even withheld further financial support post-handover until it had received written assurance that the land lease agreement had been ratified with the Edinburgh Corporation[578].

This disclosure strikes as odd. For similar to the earlier 1950s ROTOR programme, 1960s EGC bunkers were also afforded special security measures to help keep them within the shadows. It is therefore surprising that such a formal demand was made to the Scottish Office, for divulging top-secret information to the Edinburgh Corporation ultimately risked Barnton Quarry's exposure. It must be remembered that during this period of negotiation, very few government officials – and likely no Local Authority members – were privy to this hidden bunker network[579]. Moreover, the disclosure stipulated for Barnton was not even standard procedure across all EGC acquisitions. For instance, when the Scottish Office acquired East Kilbride AAOR bunker from the War Office to be reused as the Western Zone Controls, strict instructions prohibited any mention of the alteration works required for its reuse. Project details were especially kept secret from the East Kilbride Development Corporation stationed nearby and the 'covert action only' directive was ordered; meaning any survey of the existing bunker was prohibited unless careful measures were taken to conceal such investigations[580]. (As a side note it is worth mentioning that Torrance House, as the HQ for East Kilbride Development Corporation, was earmarked for emergency requisitioning during a nuclear attack, but these plans were also kept secret from the Development Corporation and never divulged[581].)

From this cross-examination, it would appear that deep-rooted friction between Whitehall-based departments and the devolved Scottish Office administration paralleled a friction that has already been detected within the civil realm. In the broader political sense, Hanham previously claimed the Treasury harboured a 'long-standing' dislike of the 'very existence of Scottish Office' as a new political entity[582]. He asserted how this dislike was manifest in the 'pernickety' manner in which the Treasury continued to exert fiscal control long after the Scottish Office had been establishment,

[576] NRS, HH51/260, Letter to SHD from MOW, 15 September 1961
[577] Ibid.
[578] Ibid.
[579] Barnton Quarry's existence was first revealed in 1963 with the Spies for Peace expose
[580] NRS HH51/260, Meeting notes, Central Government Controls in Scotland, 14 November 1961
[581] Ibid.
[582] H.J. Hanham, "The Development of the Scottish Office" in Government and Nationalism in Scotland, ed. J.N. Wolfe (Edinburgh: Edinburgh University Press, 1969), p. 68

underpinned by a reluctance of changing the 'old-fashioned bureaucratic flavour' [583]. Ultimately, as outlined in this section, the thorny relationship between the Treasury and the Scottish Office indicates the impacts of inter-departmental friction were paralleled within Scotland's Cold War nuclear bunkers. Just like their frustration over new houses, schools, and hospitals within Scotland's civilian real, this dislike was projected onto Barnton Quarry.

Against this complicated backdrop it is therefore prudent to highlight the counter-manoeuvres facilitated by the Scottish Office during the acquisition process. In the formal site transfer of Barnton Quarry (as well as the RAF's station at Anstruther in Fife) from the Air Ministry to the Scottish Office, not only were the immediate bunker alterations covered by the Treasury, but onerous future care and maintenance costs were also passed to the Whitehall-aligned MOW[584]. Importantly, this arrangement deftly secured by the Scottish Office meant the MOW became responsible for expensive building overheads (such as heating, lighting, and air-conditioning) alongside any future construction work packages.

After official handover, Barnton Quarry urgently required upgrades to the existing communications systems and various structural alterations at 'considerable cost' prior to becoming operational as a new SCC bunker[585]. The three-storey command space (a leftover from the outmoded ROTOR air defences) was infilled with a steel-framed platform to provide additional floor space for seating the designated civil servant staff. Ventilation systems were also upgraded with expensive blast dampers, a replacement standby generator was installed, and extra blast-proof doors were fitted to the surface-level outbuilding[586]. Crucially, while the Scottish Office agreed to cover around £4,500 per annum for essential site security it successfully managed to ringfence £39,000 from the Treasury to cover the major construction work, with a further £7,500 from the MOW to settle the site's annual maintenance bill[587]. Through this tactical manoeuvring the Scottish Office carefully avoided bearing the bulk of the costs, and ultimately freed up a sizeable portion of funds to be distributed elsewhere in the wider civil realm.

This previously unknown political jousting sheds new light on the multi-faceted operations conducted by the Scottish Office during post-war rebuilding, extensively covered by the DOCOMOMO research published in 1997[588]. Moreover, the deft pivoting displayed by the Scottish Office contributes towards countering certain negative perceptions levelled at the devolved government department within more recent scholarship[589]. Some architectural historians, for example, have suggested the Scottish Office was 'weak and reactive' throughout the long period of Conservative rule (1951-1964) particularly in regard to providing greater social housing[590]. When considering these bunker acquisitions around this same time, however, we must recognise that it was the Scottish Office who secured already built, highly sophisticated bunker assets for Scotland's nuclear defences and therefore must acknowledge these top-secret endeavours by positing them

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583 Ibid.

584 NRS HH51/260, Letter to R.E. Hill (Air Ministry) from J. Utterson (SHD) 7 September 1961

585 NRS HH51/260, Letter to R.E. Hill (Air Ministry) from Elliott-Binns (SHD), 21 June 1961

586 Ibid.

587 NRS HH51/260, Letter from Elliott-Binns (SHD) 17 October 1961. Four wardens were employed to monitor Barnton Quarry 24 hours a day, seven days a week.

588 Glendinning, *Rebuilding Scotland*

589 For example: Stefan Muthesius, and Miles Glendinning, *Towers for the Welfare State: An Architectural History of British Multi-storey Housing 1945-1970* (Edinburgh: The Scottish Centre for Conservation Studies, 2017) and Glendinning, ed., *Rebuilding Scotland,* outline a comprehensive account on the Scottish Office architecture.

590 Muthesius and Glendinning, *Towers for the Welfare State*

alongside other significant Scottish Office achievements, like securing formal approval for the Forth Road Bridge (1958-64) as Britain's first estuarine road crossing[591].

4.3: New Civil Services for Nuclear Bunkers

During Barnton Quarry's 1960s alterations the Ministry of Works (MOW) was reformatted into a new government department called the Ministry of Public Building and Works (MPBW). Within a civilian architectural context, the MPBW is historically known for its role in overseeing the central governments' building programme alongside managing the conservation and preservation of Britain's heritage sites such as castles and stately homes[592]. The MPBW, however, is yet to be acknowledged for its vital Cold War role with nuclear bunkers. As throughout this next chapter, from 1963 to 1970 the MPBW was not only charged with alteration works outlined above for Barnton Quarry but oversaw all bunker extensions and entire new-builds throughout Britain[593].

Labelled the 'new monster' by the *AJ* in 1962, the MPBW combined the previous construction responsibilities of four government departments (incorporating the building programmes of the Air Ministry, War Office, Admiralty, and the MOW) into a single, consolidated entity[594]. Under this departmental reform, the MPBW hierarchical framework was headed by Geoffrey Rippon as Minister, with the famous post-war figure of Sir Donald Gibson as the director general of research and development. Despite being responsible for a broad spectrum of work the department is more commonly associated with Britain's General Post Office (GPO) schemes, which is unsurprising given how the GPO served as the 'bread and butter' of MOW (ahead of its reorganisation as the MPBW) contracts[595]. Undeniably, within the MPBW extensive portfolio, the most famous of projects was the GPO Tower, London (1961-65) located in the central district of Fitzrovia[596]. What is particularly interesting with this landmark scheme is the decision of locating the GPO here was taken as early as 1952. While architectural historian Elain Harwood, notes that the GPO Tower's site was chosen on the base of its status as 'the hub of London's telecommunications system', from the vast cable laying mission outlined in chapter 2, we also know this was deeply underpinned by Britain's defence preparations for nuclear attack[597].

However, it is beyond London where this new service closely links with nuclear bunkers. For additional projects conducted by MPBW architects based in Scotland (including as the glass houses for the Royal Botanic Garden, Edinburgh (1965-67) (fig. 4.6), and the Post Office Savings Bank complex at Cowglen, completed in 1970) share an inextricable connection with the Kirknewton bunker that must be highlighted. Similar to my detailed analysis of Watson's hand drawings (see chapter 2), when unpacking Kirknewton's drawing title bar, we can establish for the first time that civilian MPBW architects George Albert Henry Pearce and John Johnson were directly responsible for Scotland's government bunkers as well as the aforementioned Royal Botanic Garden greenhouses

[591] Gibson*, The Thistle and the Crown*, p. 125, This was achieved by the shifting responsibility for roads and bridges from the Central Government department of Ministry of Transport to the SHD.
[592] Simon Thurley, *Men from the Ministry: How Britain Saved its Heritage*, (New Haven: Yale University Press, 2013) provides a comprehensive account to the conservation and heritage perspective of the MPBW
[593] By 1972 these responsibilities transferred to the Property Services Agency (PSA) until its dissolution in 1996.
[594] The Editors, "The New Monster", *AJ,* 136, (1962) p. 1003. The MPBW was later absorbed into the Department of the Environment (DOE) by 1970
[595] Francis Walley, "From bomb shelters to postwar buildings: 40 years' work as a civil engineer in Government" *The Structural Engineer*, 79 (2001) 15-21 (p. 18)
[596] This is now known as BT Tower and has since been awarded Grade II listed building status by Historic England
[597] Harwood, *Space, Hope, and Brutalism*, p. 25

(fig 4.4)[598]. There was even a letter issued to the Scottish Office by the MPBW addressed from the 'Royal Botanic Garden, Edinburgh (fig 4.5) in regard to Barnton Quarry's BBC Studio Control Room[599]. This correspondence suggests work may have been conducted under the cover of a temporary site office in central Edinburgh, which, if true, marks another considerable departure from the MOW top-secret working conditions noted for the 1950s bunker building programmes. Despite the significance of architects Watson and Enthoven's earlier consultancy to the Air Ministry on the ROTOR programme, MPBW architects Pearce and Johnson convey a significant shift in architectural responsibility of nuclear bunkers by the early-1960s. Under the new MPBW organisation, there was an improved culture of efficiency alongside affording 'full responsibility for aesthetics to the architect'[600]. Under Gibson's new civil service, we must acknowledge that Pearce and Johnston carried higher authority and control over Kirknewton's design and construction, signalling another critical paradigm shift in nuclear bunker architecture, and thus indicating a watershed moment that will be further explored in this chapter.

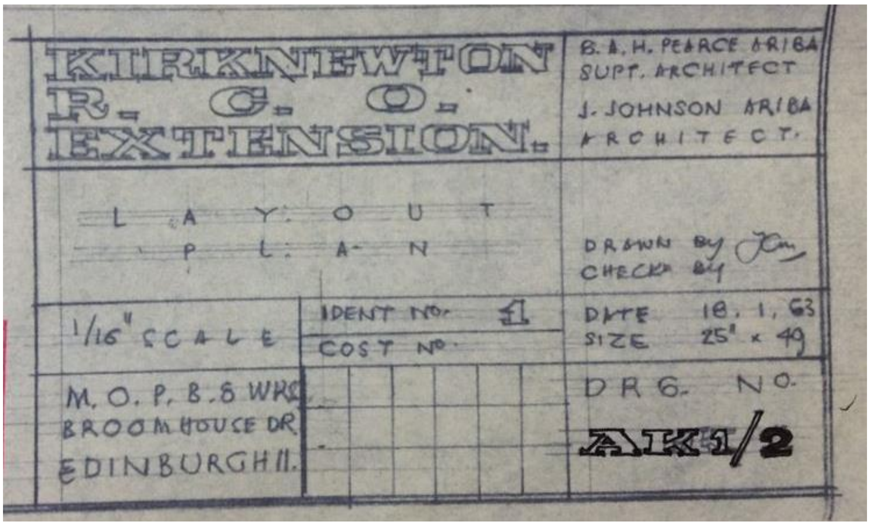

Figure 4.4: MPBW drawing title bar from Kirknewton 1960s extension (NRS)

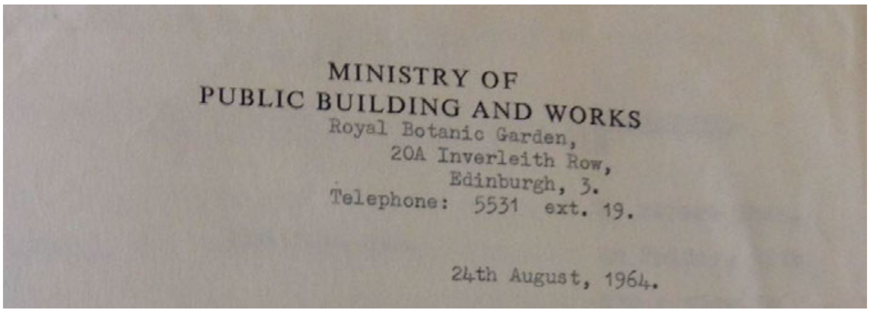

Figure 4.5: MPBW correspondence addressed from Royal Botanic Garden (NRS)

[598] Glendinning, *The Architecture of Scottish Government*, p. 197
[599] NRS, HH51/296, Letter to SHHD from MPBW, 24 August 1964
[600] Wall, *An Architecture of Parts*, p. 147

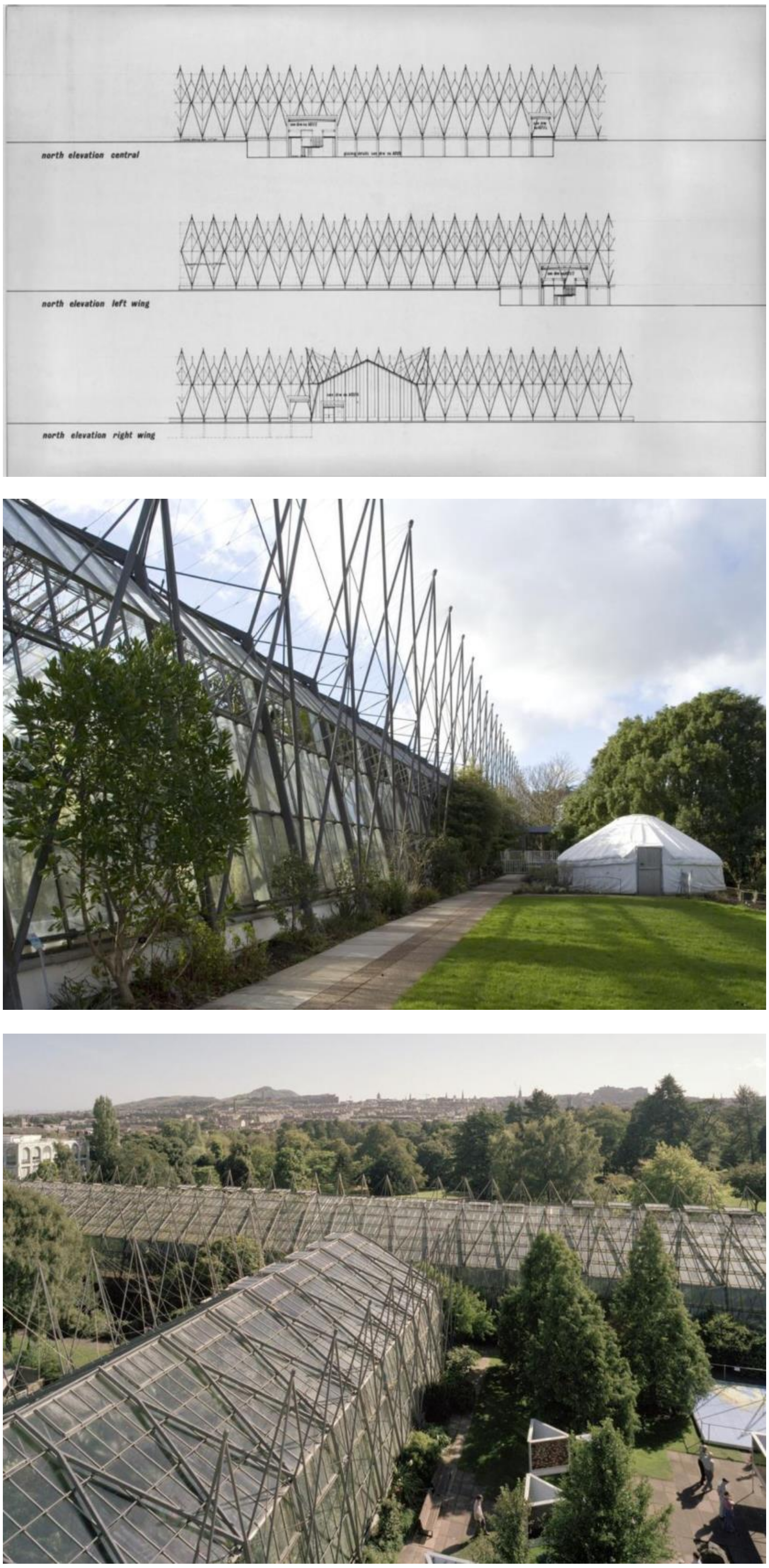

Figure 4.6: MPBW Royal Botanic Garden glasshouses (Canmore)

4.4: Case Study: Kirknewton – Scottish Central Control

In returning to the SCC, we must remember that while the Scottish Office fell short in gaining Treasury approval for a new purpose-built bunker during a brutal shift in financial priority, it did manage to negotiate the successful acquisition of Barnton (see above) to operate as a stopgap measure. In tandem with this achievement, the Scottish Office also managed to secure Kirknewton as a longterm solution through the procurement of another existing bunker that had previously operated as Scotland's Eastern Zone War Room during the 1950s. Before unpacking my detailed analysis of Kirknewton's elevation and 'decoding' its concrete composition, it would be helpful to provide a brief contextual background to Kirknewton's origins.

A simple yet important fact which links Britain's nuclear bunkers with civil realm is that similar to Barnton Quarry's 1950s acquisition, Kirknewton's site was also legitimately purchased in a peacetime context rather than being requisitioned as per WW2 procedures. In July 1953, the War Department paid £1650 (or £51,000 today) for 52 acres of land 12 miles southwest of Edinburgh which at the time was being used by St Cuthbert's Co-operative Association for farming purposes[601]. Here, at the 'Raw Camps' estate, Scotland's Eastern Zone War Room was established providing a key bunker for post-nuclear civil defence[602]. Strangely, given the secrecy attached to these sites, the land was well within view of the public road and contained a minimal measure of natural terrain and foliage which offered a partial concealment of the War Room's lateral projecting two-storeys (see fig 4.6 & 4.7).

Like the ROTOR programme, the Regional War Room system of bunkers was based on a standard design brief issued by the Home Office. A group of carefully vetted MOW staff were allocated a secure drafting suite where they produced architectural drawings for these War Room bunkers in complete isolation from other Home Office projects [603]. Additionally, the construction make-up of these War Room bunkers was similar to contemporaneous ROTOR bunkers given they were formed using an in situ reinforced concrete superstructure at 5ft thick (1.5m). The War Rooms however, possessed a crucial difference when compared to ROTOR bunkers in that most of their external concrete envelope existed above ground which therefore resulted in (albeit crude) surface-level architectural elevations. It is difficult to put an exact construction cost on these bunker types, but archives indicate the Home Office required £100,000 (or £3.5m today) of taxpayer's money per individual War Room.

As mentioned at the start of this chapter, when the Soviets surpassed British military projections by developing their own H-bomb in 1953, a further paradigm shift was also experienced in the War Room bunker system. In short, the more powerful H-bomb was calculated to cause much greater devastation and fallout than earlier A-bombs, meaning the War Rooms were too small to host the personnel and equipment required for operating immediate post-nuclear attack rescue and recovery efforts to the surviving public[604]. As a result, the entire War Room programme shifted with a view of establishing a more practical civil defence approach; one that would effectively 'oversee and guide the process of recovery' for the ensuing months or years[605]. Across the rest of Britain this new EGC system would be administered through 12 RSGs, but in Scotland, the SCC controlled matters north of

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[601] NRS SOE25/1, Land Disposition, 1 July 1953
[602] NRS SOE25/1, Letter from Elliott-Binns (SHD) 23 October 1961
[603] Campbell, *War Plan UK*, p. 263
[604] McCamley, p. 155
[605] Ibid.

the border, receiving vital support from 3 additional Zone Controls (which in turn, marshalled all of Scotland's regional areas).

Since the existing internal area of the 1950s War Rooms was insufficient for an enlarged staff capacity, its double-height 'operations well' was firstly infilled before a new two-storey extension was constructed alongside. This effectively doubled the building's size and housed most of the new facilities required by the staff base of 450 personnel [606]. Kirknewton's extension was of a relatively simple geometric form, executed in a box measuring 140ft by 100ft. The bunker's main rectilinear mass contained male and female dormitories and rest facilities on the upper level, with offices and plant on the lower level. The taller section (stretching an extra storey in height) housed the bunker's ventilation systems (see fig 4.11). Interestingly, Kirknewton's extension was initially based on a twinned site located in Cambridge and was thus issued early sketch plans and accommodation guides produced by the London-based MOW department[607]. Like the bunkers under the ROTOR programme, Kirknewton was also connected to the mains grid for water, electricity, and wate drainage[608].

Relocating the Scottish Central Control a mere 12 miles away from Edinburgh was not simply a new postal address, but was a move that was ultimately taken to 'improve the chances of survival'[609]. We must remember that by the time of Kirknewton's extension, the newly developed H-bomb transcended the deadly threats posed by the early A-bombs; carrying much greater blast and heat effects. Furthermore, the H-bomb arrived with an increased danger from radioactive fallout; significantly more lethal than reported in the post-attack fieldwork at Hiroshima and Nagasaki (see chapter 1). In responding to this shifting threat, military and government planners agreed that whilst bunkers could no longer be built to withstand a direct strike, they should still maintain a sufficient thickness as protection against radiation[610]. In this new context, Kirknewton's design accounted for a protection factor (PF) against Gamma radiation of 450 to 1, resulting in a reduced concrete wall thickness of approximately 12inches (300mm). This shift in wall thickness removed nearly 4ft (1200mm) of concrete per individual wall, which resulted in a concrete aesthetic more similar to Roxburgh County Council Offices than pre-1945 bunkers (which is explored below)[611].

Before proceeding with Kirknewton's in-depth analysis, it is worth recalling the inter-departmental friction previously mentioned between the Scottish Office and Whitehall-based departments. For similar to the ROTOR programme's origins, Kirknewton's early design development also depended on cross-border collaboration between Scottish and English-based branches of the MOW[612]. However, when the Scottish Office requested design information from the twinned-Cambridge site there was a distinctively terse tone expressed by the MOW and the Home Office, who were somewhat reluctant to fully comply with Scottish interests[613]. While both countries had engaged to

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606 Ibid.

607 NRS, HH51/296, Correspondence between SHD and MOW November 1961. (Unfortunately, the initial sketch design was omitted from the archival file)

608 NRS, SOE25/1, See Scottish Office correspondence over disposal procedures for Kirknewton

609 NRS HH51/260, Letter from SHHD to Lady Tweedsmuir 20 August 1963

610 McCamley, p. 164

611 Building PF is defined by the radiation dose-rate at which a person is exposed whilst inside a protected building compared to the dose-rate of a person out in the open. A PF of 100 to 1 means the dose-rate for someone inside would receive 1/100th of the dose-rate to someone outside in an unprotected environment.

612 Although the MOW was initially appointed to design Kirknewton's extension partway through its development, all work was incidentally absorbed into the MPBW by 1962

613 NRS, HH51/296, Correspondence between SHD and MOW November 1961

produce the earlier ROTOR bunkers through a harmonious relationship this dialogue appears to have markedly shifted by the turn of 1960.

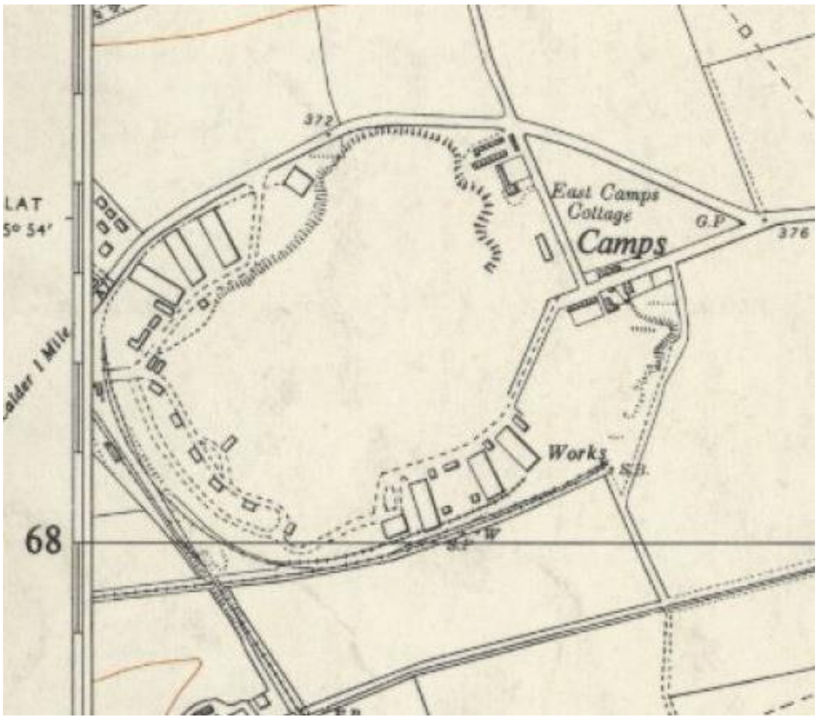

Figure 4.7: Kirknewton location map 1968 (National Library Scotland)

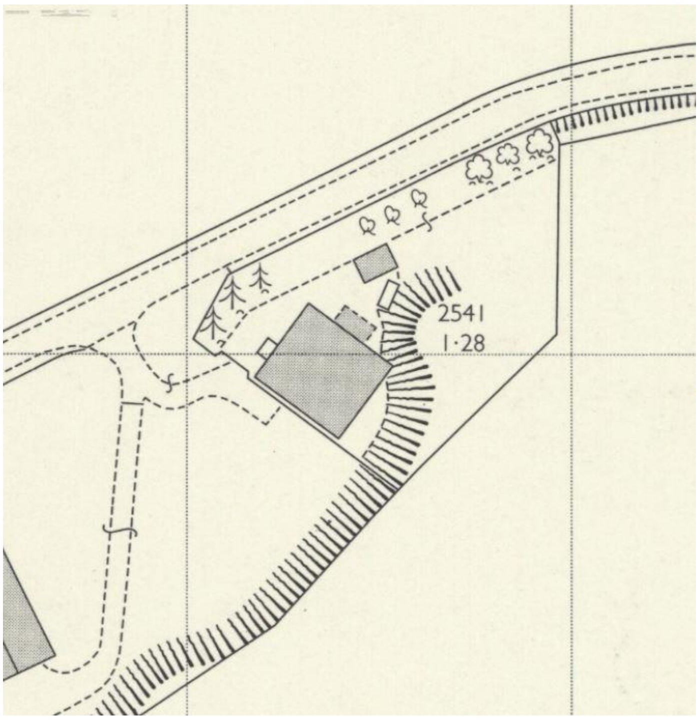

Figure 4.8: Kirknewton site map 1968 (National Library Scotland)

4.4.1: Decoding Concrete: The Nuclear Brutalism

The following section is concerned with analysing the concrete form and finishes expressed in Kirknewton's external aesthetics as a direct response to the shifting nuclear threats of the 1960s. This assessment not only migrated bunker architecture more in-line with Brutalism but enabled key innovations to migrate into the civil realm. While Scotland's longterm SCC at Kirknewton was partly an extension, its execution represents a significant shift in nuclear bunker architecture through a series of major deviations in concrete construction that migrated towards conscious Brutalist aesthetics. Archaeological fieldwork by Wayne Cocroft first identified this design shift by noting how Kirknewton's elevations (alongside its twinned bunker at Cambridge) were 'unusual in the degree of architectural embellishment in the contemporary Brutalist style'[614]. To better understand this statement, I have broken down the concrete elements of Kirknewton and conducted a detailed analysis in-line with architectural historian Barnabus Calder's decoding. This section argues that this external concrete required a much more expensive and refined treatment than typically achieved through standard in situ construction techniques as evidenced in earlier nuclear bunkers and pre-1945 military examples. This analysis begins with outlining how the bunker's basic forms departed a purely functionalist approach and then turns to framing the exposed aggregate finish designed for a unique fallout protection purpose. Thereafter, in combining the overall composition, I argue that concrete was consciously designed as a special post-nuclear civic aesthetic for the Scottish Office, which in turn, provided a vital working prototype for the more refined setting of its Cambridge twin.

In decoding post-war aesthetics Calder highlights two critical aspects that can simultaneously help, and hinder, our ability to better understand concrete compositions. First, he speaks of a love for the 'subtle details' in alternative concrete finishes that provide a means to visually 'decode' surfaces and then decipher the 'ingenious efforts' required to successfully achieve the construction techniques[615]. Second, he suggests that concrete assumes a notion of 'camouflage' whereby the non-specialist layperson is typically unable to 'distinguish between high-quality and low-quality concrete work'[616]. While Calder's subtle concrete details and camouflage theory are used to study Brutalist works within the civil realm, I argue these analytical tools can also be applied to similarly decode top-secret, parallel-running, nuclear bunker schemes.

As mentioned, while the two-storey extension abutted the existing War Room to link both bunkers internally, we must firstly recognise this addition as a building in its own right to better a clearer architectural understanding. For upon completion, there were four new elevations, additional roofscapes, and entirely different façade compositions. Albeit Kirknewton was demolished in 2003, photographs taken by bunker enthusiasts, sometime in the 1980s, permit a basic reconstruction of the bunker's concrete forms and finishes which are no longer physically extant for detailed interrogation.

Although the comparison has not yet been made, Kirknewton's overall form is strikingly similar to the protected GPO repeater stations that were created to operate Britain's emergency communications after a nuclear attack. Interestingly, the surviving example at Uddingston (30 miles west of Kirknewton) was designed in the 1950s by the MOW, which was eventually absorbed into the newly formed MPBW by the time of Kirknewton's extension. Nick McCamley notes how these repeater stations were set to a simple rectilinear form which included a taller 'concrete ventilation

[614] Cocroft, Thomas, and Barnwell, p. 205
[615] Calder, pp. 25-26
[616] Ibid., p. 337

tower' at the front end; providing air intakes to cool the internal spaces for the GPO staff[617]. While Kirknewton's overall form shares a degree of similarities with these GPO repeater stations, several key deviations force a departure from a purely functionalist approach. For instance, like repeater stations, a taller concrete section was also designed into Kirknewton's main elevation to provide air intake for the building's ventilation systems. However, rather than being squared, Kirknewton's concrete ventilation tower adopts the profile of an inverted butterfly (resembling the letter V). Visually, this strikes immediate hints of the angular extrusions present at other Brutalist schemes constructed around the same period, such as the galleries incorporated into London's Southbank Centre, dubbed 'culture bunkers' by architect and Archigram co-founder Warren Chalk in 1967[618]. When I return to this analysis later in this chapter, my decoding reveals how these angular profiles not only carried additional costs, skills, and labour but were also designed for more ominous purposes in nuclear defence.

Figure 4.9: Kirknewton northwest elevation (subbrit)

Another point to note in Kirknewton's shifting concrete aesthetics is a departure from the previous reliance on monolithic construction, which was acutely observed by Paul Virilio during his explorations of the WW2 Atlantic Wall bunkers [619]. For example, archival photographs evidence distinctive 'construction joints' (fig 4.10) incorporated into Kirknewton's elevations that show two deep horizontal recesses wrapping around the building's façade; splitting the main volume into three unequal bands: top, middle, and bottom. Vitally, these construction joints are indicative of the multiple assembly stages and therefore reveals the concrete was not formed by one continuous 'single-pour', but was instead, assembled through separately phased construction sequences.

As well as the evidencing the separate pouring stages these construction joints also indicate the procedures involved and the efficiency of the labouring force[620]. For the impressions left on the

[617] McCamley, p. 237
[618] Mallory and Ottar, *Architecture of aggression,* p. 122
[619]Virilio, *Bunker Archaeology*
[620] John, G Richardson, *Practical Formwork and Mould Construction* (London: C.R. Books Ltd., 1962), p. 67

façade indicate where the concrete walls stopped, the shuttering carefully removed, and then repositioned upwards for the next lift (likely done by using scaffolding to allow labourers to reach the desired height), permitting the pouring processes to be efficiently repeated for the remaining sections. This is important, as technical literature published at the time of Kirknewton's extension strongly advised that 'the most efficient method of [concrete] construction would be the monolithic casting of the complete structure'[621]. Rather that pouring Kirknewton's mass in a single full-height mould, which was the common approach with pre-1945 bunkers, this alternative assembly required skilled gangs of concreters to carefully form the concrete in a series of layers. Paradoxically, in deviating from a monolithic concrete approach and incorporating construction joints, the MPBW elevational design contradicts the Treasury's financial reluctance (noted above) and also suggests a conscious application of architectural ordering. This design shift chimes with broader changes in concrete design as written by architectural historian Catherine Croft who quotes Louis Kahn's view on concrete joints as signalling the 'beginning of ornament'[622]. Therefore, Kirknewton's 1960s extension was significantly different than earlier nuclear bunkers in that it adopted more complex and expensive building assemblies in search for more desirable aesthetics, and therefore departs from the pure functionalism synonymously recognised in military architecture. In shifting Kirknewton's concrete away from wartime precursors (see chapter 2) the nuclear bunker subsequently adopted similar construction techniques as those employed in civil projects like Womersley's Roxburgh Council offices, ultimately, signalling a conscious move towards a better elevational design and architectural ornamentation.

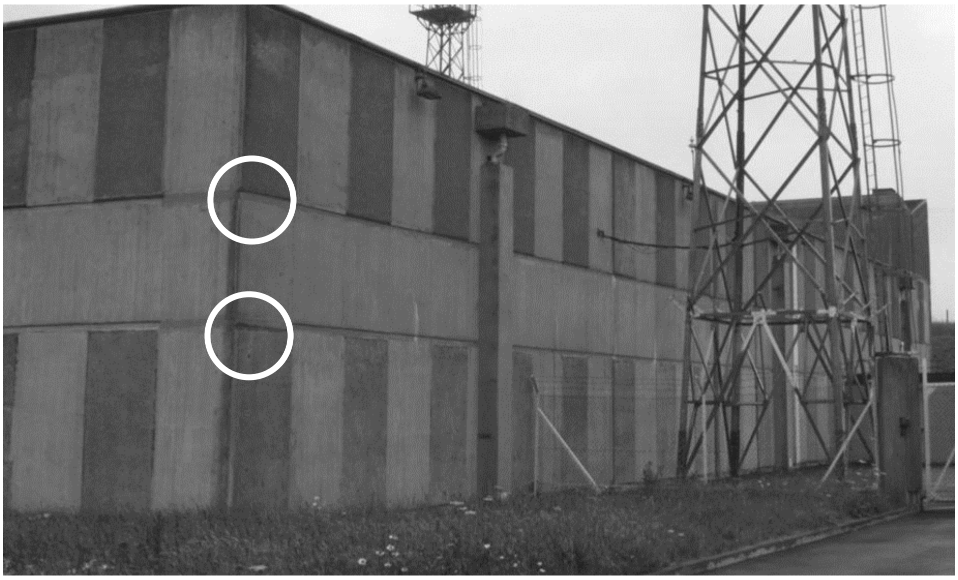

Figure 4.10: Kirknewton elevational study (subbrit)

[621] Ibid.
[622] Croft, C., *Concrete Architecture*, (London: Laurence King, 2004) quote from 'This Business of Architecture'. Lecture at Tulane University New Orleans, 1955, p. 20

Much alike the deviation in construction joints, precast concrete elements identified within Kirknewton's elevation also signal another noticeable shift in bunker architecture. For this is most certainly the first time precast concrete was incorporated into nuclear bunkers as separate elements rather than having the entire bunker cast in situ[623]. As shown in (fig 4.11), there are three extrusions projecting outwards to cover the air intakes and extracts linked with the building's ventilation system[624]. Instead of being cast in the simpler and cheaper way as part of the main structure, the elements were instead formed separately – most probably cast in timber moulds off-site within a controlled factory setting, to be hoisted into position, and affixed at the designated apertures. Crucially, integrating these separate precast elements into the main in-situ structure required additional design, manufacturing, construction management, skill, supervision, and above all else, a capable contractor to ensure successful execution of these separate assemblies.

Further evidence of this shift can be found when turning to surface aesthetics as this decoding process reveals that Kirknewton's finish was much more refined aesthetically than typically expressed in nuclear bunker architecture. Unlike previous examples, Kirknewton's main building mass adopted two distinctive approaches in its concrete treatment that architect Michael Gage identified in 1970 as 'direct' and 'in-direct' finishes[625]. Whereby the 'direct' finish simply accepted the resultant concrete texture upon removing the formwork; usually leaving visible lines and indentations of the timber's grain[626]. Whereas the 'in-direct' finish required an additional 'operation' to add or remove from the concrete in search of a richer aesthetic, and in Kirknewton's case, this saw the outer layer of cement removed to reveal the coarse aggregate from within[627]. However, from the vertical lines expressed in the elevations, we can deduce that Kirknewton predominantly used concrete with a 'direct' finish. This more standard concrete construction method is widely acknowledged in Brutalist discourse as 'beton brut', which translates as 'rough concrete', and was first cited by Reyner Banham in his 1955 essay 'The New Brutalism' [628]. Prior to this however, similar uses of beton brut techniques had become the default preference in military architecture from the late nineteenth century through both World Wars – primarily owing to its defensive capabilities in protecting buildings against blast and heat. Although beton brut is often traced to its use in Le Corbusier's Unite d'Habitation at Marseille on economic grounds, as Brutalism developed and began to gain favour across Britain, this approach became a much more expensive and carefully tailored finish, resulting in detailed architectural specifications and the need for equally skilled concrete workers.

[623] I have excluded the early Orlit posts constructed as part of the ROTOR programme given their simpler assembly of precast components was cruder in comparison.
[624] Cocroft, Thomas, and Barnwell, p. 205
[625] Michael Gage, *Guide to Exposed Concrete Finishes* (London: The Architectural Press, 1970)
[626] Ibid.
[627] Ibid.
[628] Banham, "The New Brutalism"

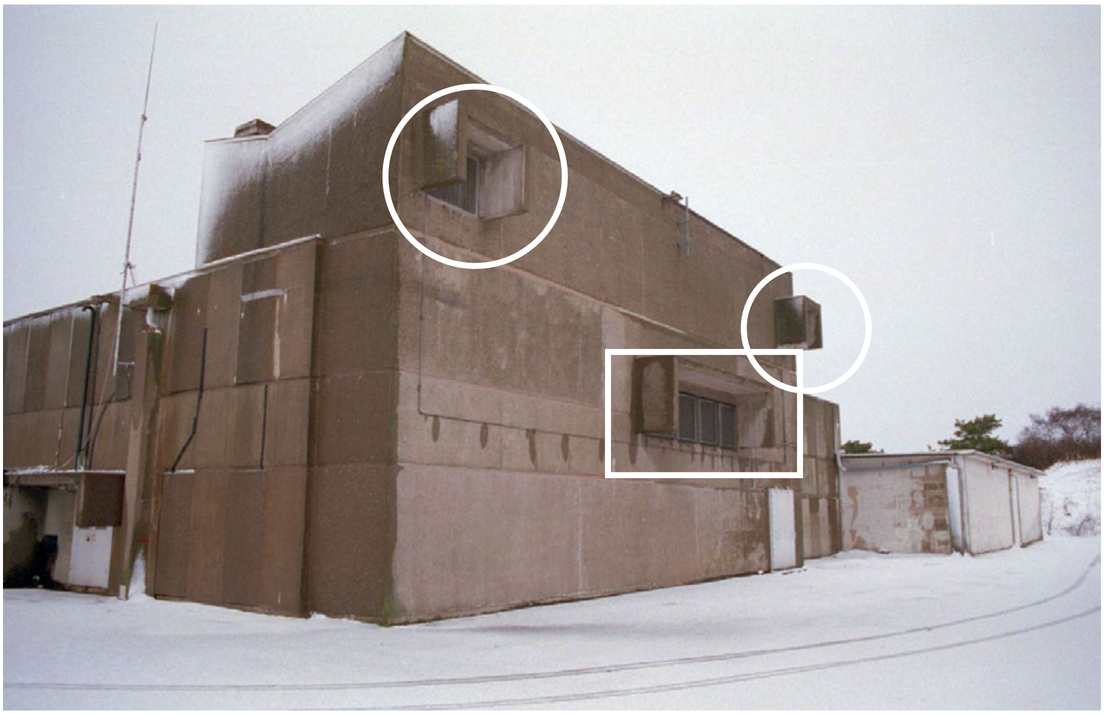

Figure 4.11: Kirknewton southeast elevation (subbrit)

4.4.2: Design Specifications: Exposed Aggregate for Nuclear Fallout Protection

As much as the construction joints, and precast clip-on hoods reveal significant design deviations from pre-1945 bunkers, projecting concrete panels at Kirknewton reveal a more unusual shift in bunker architecture with the application of 'in-direct' finishes. For on these panels, the outer layer of cement was carefully removed to expose the inner aggregate, thus signalling the most important migration towards civil-like aesthetics at the turn of the 1960s. Although exposed aggregate finishes are widely recognised in the concrete of other civilian Brutalist works, their presence at nuclear bunkers is incredibly scarce. While HE has previously highlighted this architectural treatment a more detailed breakdown of these elevations can further our understanding as exposed aggregate finishes were typically specified for a more favourable aesthetic alongside additional technical advantages for preserving against future weathering and exposure. In this section, I present a new case that argues this approach was taken to protect against nuclear attack.

Firstly, before decoding Kirknewton's exposed aggregate finishes, it is crucial to acknowledge they were chosen by the MPBW during the design stage based on the variations in pencil rendering (the as-struck sections identifiable through thin vertical lines, the exposed aggregate panelling shown through dot-work) in (fig 4.12) evidenced in the hand-drawn elevation by MPBW architects Pearce and Johnson. As these elevations were dated January 1963, is it also important to recognise the industry knowledge on this specialist concrete treatment available at the time, for under Donald Gibson's forward-looking vision (noted above) it is likely that all MPBW projects would be pressed into making the best use of such information. By 1963 concrete experts, such as J. G. Wilson, the architectural consultant to the Cement and Concrete Association (CCA) and John Richardson, who lectured MPBW staff about concrete, were actively sharing technical knowledge on practical applications and had compiled early data sheets that were made available architects considering an exposed aggregate finish[629]. Importantly, Wilson admonished designers (and clients) that achieving a high-quality finish heavily relied on skilled labour and close supervision to prevent any unwanted 'imperfections' that could spoil the final outcome[630]. Similar warnings had also been raised by engineers Hagnal-Konyi and Tottenham, who from 1948 to 1958 were among some of the earliest figures to note that any exposed aggregate finish principally required 'very skilled labour' and 'strict supervision' when considering the specification[631]. What is particularly interesting is that despite an industry awareness to the additional costs, requirements in skilled labour and supervision, the exposed aggregate finish was still approved by the Treasury during the 1960s period of imposed fiscal scrutiny. Therefore, Kirknewton's exposed aggregate finish represents one of the first and rarest instances of Scotland's Cold War nuclear bunkers considerably deviating from the more common, cheaper 'as-struck' concrete that were historically employed in bunker architecture.

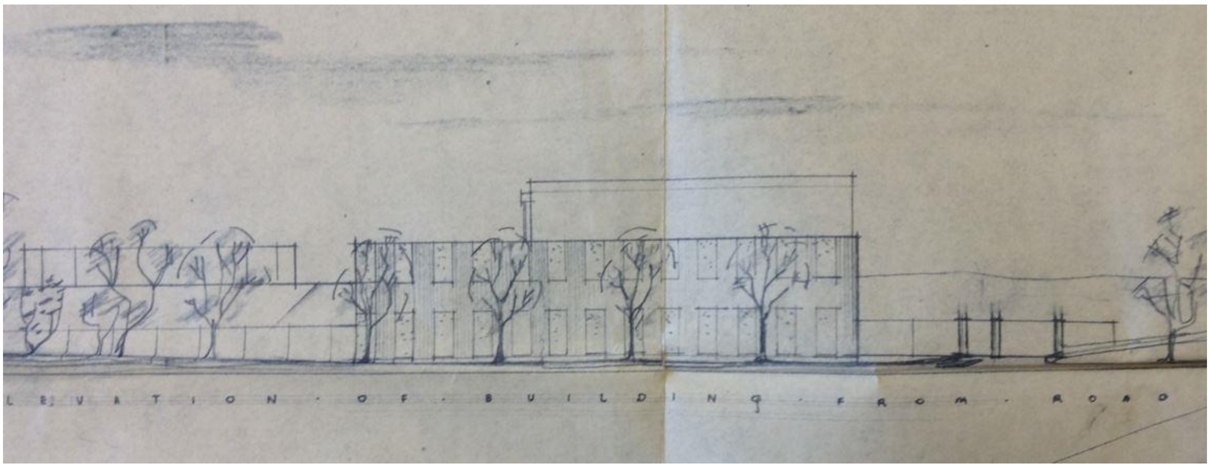

Figure 4.12: Kirknewton northwest elevation as drawn by MPBW 1963 (NRS)

[629] The Cement and Concrete Association (CCA) was established in 1937 and provided a free consultation service to industry throughout the post-war period.
[630] Wilson, *Exposed Concrete Finishes*, p. 71
[631] K. Hajnal-Konyi and H. Tottenham, "Concrete", in new ways of building, ed., Eric de Mare, (London: The Architectural Press, 1958), p. 40

As mentioned above, Wayne Cocroft highlighted the uniqueness of this exposed aggregate finish to nuclear bunkers by 1997. However, when revisiting this from a robust architectural history perspective, it is crucial to know exactly how this was realised in practise. For it was not achieved by inserting or clipping separate precast concrete components onto the main building – as per standard industry practice – but was instead cast *in situ* as part of the building mass. In principle, precast concrete methods permitted greater flexibility in their formation as operatives tended to work in controlled factory setting. These sheltered off-site environments, enabled considerable savings in time, labour, and building costs. Photographs published in Wilson's account demonstrate how precast concrete panels could have their aggregate exposed much more efficiently as operatives could freely move around a fixed mould on the factory floor and remove the outer layer of cement much easier than if the same procedure was done on-site, working at heights, under time constraints, and in uncontrollable weather conditions (fig 4.14).

Although Nick Catford's photographs of Kirknewton confirm that this exposed aggregate finish was integrated within the elevations, the distance at which these were taken limit the ability to scrutinise finer as-built details. To mitigate this research problem, I used survey photographs of similar concrete panels taken during my fieldwork exploration of the similar bunker at Cambridge. Fortunately, the Cambridge twin (located on Brooklands Avenue) still exists in fantastic condition as part of English Heritage's estate and has more recently assumed reuse as a remote campus for the University of Cambridge. As seen (fig 4.13) at Cambridge, areas of exposed aggregate extrude outwards from the main elevation by approximately 50mm; not enough to qualify as a substantial projection but just enough to create visual and physical tectonics. Importantly, these projected areas of concrete subsequently required more complicated formwork and resulted in more awkward junctions for the carpenters to negotiate when assembling the timber shuttering as the wet concrete mix could leak from any unwanted gaps or weak points. What made this aesthetic even more complex was that these sections alternated with 'as-struck' finishes that were achieved by using thinner widths of vertical timber board as formwork. Given these different concrete treatments, the shuttering had to be removed at specific isolated sections while the concrete was undergoing its curing process. Once the timber sheets were carefully removed at these designated zones (allowing the neighbouring vertical timber boards to remain in situ), they were placed aside, washed, then stored for later reuse at other sections[632]. To limit this problem of intricate formworks, a combination of skilled operatives and close supervision ensured a collective precision and tolerance when assembling the formwork's outline.

As recommended by John Richardson in 1962, *in situ* such concrete forms that required complex shuttering like Kirknewton's elevations should instead seek out the alternative approach of clipping on secondary precast wall panels[633]. Interestingly, these recommendations remain within today's matured concrete industry, where specialist contractors often favour precast concrete over in-situ methods when producing similar exposed aggregate finishes. Whilst preference is largely based on cost and labour, health and safety considerations are now also emphasised[634].

[632] Richardson, *Practical Formwork and Mould Construction*, pp 82-83
[633] Richardson, *Practical Formwork and Mould Construction,* p. 17
[634] Barry Quinn (Pre-Construction Manager at Careys), interview with author, 18 October 2020

Figure 4.13: Existing concrete detail at Cambridge RSG

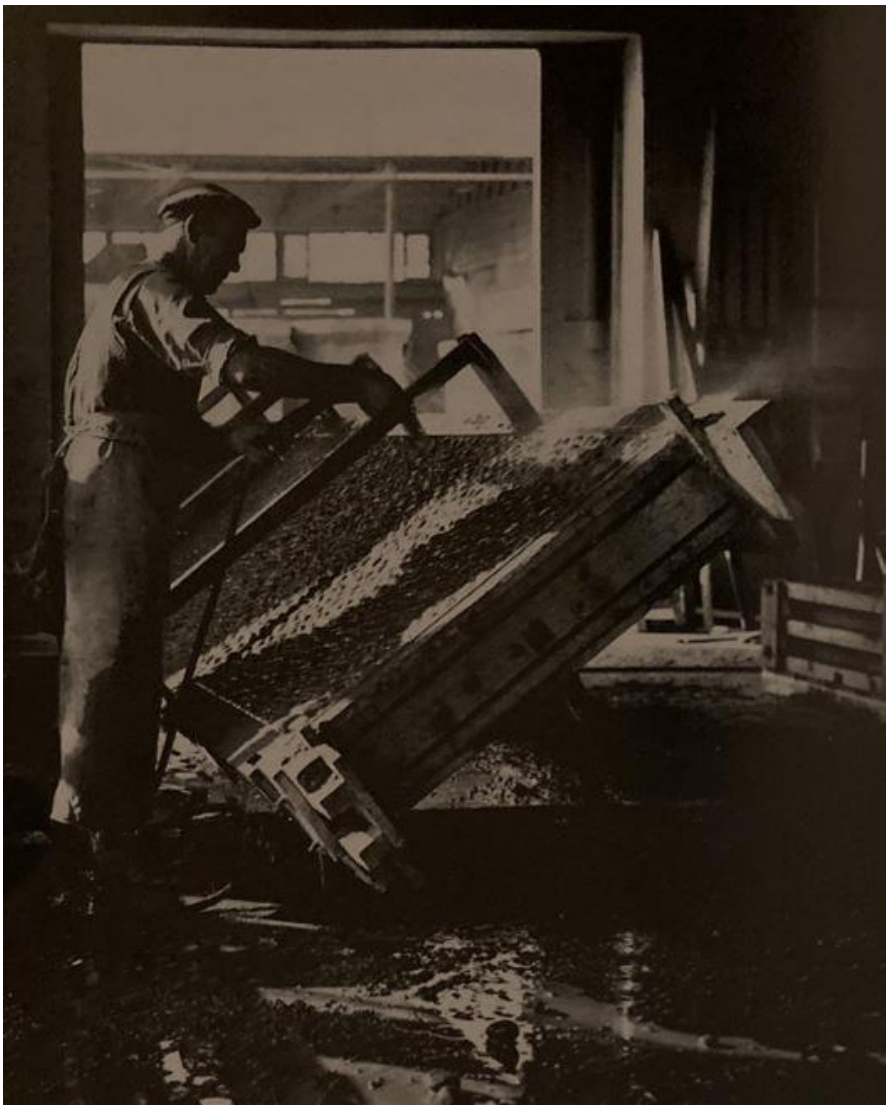

Figure 4.14: Exposed aggregate of precast concrete panel (Wilson, Exposed Concrete Finishes, 1962)

While Wayne Cocroft has suggested the aggregate was exposed by simply washing away the top layer of cement, based on the technical knowledge available within industry at the time, it is more likely that the cement was removed through an additional process of brushing[635]. This 'in-direct' brushing and washing technique also required extra craft, skill, and close supervision to ensure the outer layer of cement was both removed to an even depth across the desired area and completed within a specific timeframe before the concrete hardened. Firstly, Wilson emphasised that the 'greatest care' was required in removing the minimal amount of cement (about 15mm), for if concreters brushed or washed too vigorously, any faults were irreversible, and the mistakes would be clearly visible in the finished surface[636]. Moreover, operatives the brushes were kept clean throughout this process as cement could clog the bristles and spoil the overall aesthetics[637]. Lastly, Wilson repeatedly stressed the urgency of removing the top layer as quickly as possible, stipulating a timeframe of 16-18 hours after the wet concrete mix had been poured[638]. Outwith this period, the concrete would harden beyond the capabilities of washing and brushing, and more expensive and tooled methods, such as bush hammering (widely used at the Barbican Estate and Glasgow University Library), were the only alternative solutions for removing the cement[639]. From Kirknewton's elevations, I have calculated that this complex treatment required washing and brushing procedures to be repeated a total of 86 time for 43 panels at both ground and upper levels. This would have demanded a highly skilled group of operatives working closely together to ensure all instances looked the same from top to bottom across 4 elevations.

Importantly, this exposing *in-situ* concrete aggregate by brushing and washing is not presently identified elsewhere in Scotland. In fact, the nearest like-for-like example of this finish is tracible to the elevations of Basil Spence's 'Thorn House' (1955-59); a fifteen-storey office block and showroom in central London (fig 4.15)[640]. Prior to Thorn House, earlier examples are even more limited to a series of 1950s CCA experiments prototyped in Wrexham and published by the *AJ*[641]. Interestingly, when expanding this criterion further, the closest examples resembling Kirknewton's concrete are crucially not found with in-situ construction but are instead evidenced in precast concrete. For instance, the exposed aggregate finishes featured throughout St Peter's Seminary (1961-66), Cardross, by the firm Gillespie, Kid, and Coia, were precast units affixed to a separate concrete frame (as were the exposed aggregate finishes at Hutchesontown C housing scheme). However, the exposed aggregate found within precast units tends to be bigger when compared to Kirknewton's finer sized grain. For example, Diane Watters presents photographs that show how aggregate used at St Peter's Seminary was of a larger, more rounded pebble[642]. Therefore, given the lack of other comparable examples (around the same time period) which achieved exposed aggregate finishes though in-situ concrete, it must be assumed the MPBW was acutely aware of the wider requirements in additional labour, skill, supervision, cost and above all the need to secure a suitable and capable contractor. Yet despite these expensive outlays, it is interesting that the Treasury still signed-off the financial approval for this specified aesthetic.

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635 Wayne Cocroft, *Survey Report: Cambridge Regional Seat of Government,* (Cambridge: English Heritage, 1997), p. 7

636 Wilson, *Exposed Concrete Finishes*, pp.72-73

637 Ibid.

638 Ibid.

639 Ibid.

640 Wilson, *Exposed Concrete Finishes*, p. 7: Unfortunately, the expressive in-situ exposed aggregate concrete columns at the main entrance were clad over during the building's recent transformation.

641 Technical Section, 'Surface Treatment of Concrete', *AJ,* 113 (1951) 773

642 Watters, *St Peter's, Cardross: Birth, Death and Renewal*

Economist, Marian Bowley, was one of the first to highlight these additional requirements in exposed aggregate finishes through her 1960s concrete research, which actually pre-dated Wilson's later warnings over their additional outlays in skilled labour and costs[643]. Importantly, Bowley noted how these finishes were 'too recent for a tradition to have grown up', because 'few firms have adequately trained craftsmen (*sic*) and the technical knowledge' required to achieve this aesthetic[644]. By this she meant the aesthetic was still in its infancy and was yet to be mastered on a broader level. However, the new tendering procedures established by the MPBW undoubtedly ensured the most experienced, and thus highest paid contractors were rightly appointed. The selective 'contractors' list' introduced in 1963 permitted eligible firms (already involved with Air Ministry, MOW, or War Office construction programmes) an exclusively opportunity to price bids for MPBW contracts[645]. From the ROTOR programme contractors cited in chapter 2, we know that McAlpine and Peter Lind were later retained by the MPBW during this crucial period of 1960s bunker building. Firstly, from Glendinning's architectural investigations we can place McAlpine's continued appointment with the MPBW through a series of Scottish tax centres in the 1960s[646]. Secondly, CCA publications noted that Peter Lind was commissioned on the aforementioned GPO Tower, London, that also shared a construction timeline as Kirknewton[647]. Therefore, it is highly likely that McAlpine and Peter Lind, who had since propelled themselves as key industry operators by the mid-1960s, were subsequently brought back into the fold to maintain a consistent relationship already established. On the other hand, this agreement may have offered financial incentives to both contractors if they could facilitate the prototyping, completion, and transfer of concrete knowledge back into the civil realm whilst maintaining the secrecy of bunker sites.

[643] Marian Bowley, *Innovations in Building Materials: An economic study* (London: Gerald Duckworth & Co, 1960), p. 256
[644] Ibid.
[645] MOPBW, "Contractors' List", AJ, 137 (1963) 711
[646] Glendinning, *The Architecture of Scottish Government: From Kingship to Parliamentary Democracy*
[647] Peter Mandell (Operations Director at Peter Lind), email to author, 27 May 2020

Figure 4.15: Exposed aggregate of in-situ column by washing and brushing, Thorn House, London (RIBApix)

Given my above decoding of concrete, we must ask the question as to why this in-situ approach was taken for applying exposed concrete aggregate? At the time of Kirknewton's design the standard industry practice was to affix precast concrete panels to a separate structural frame. However, other sources of primary data clearly indicated that a precast panel approach was wholly unsuitable for bunker architecture given the structural and material observations from the 1945 nuclear attacks on Hiroshima and Nagasaki. In recalling the report outlined in chapter 1, the *Effects of the Atomic Bombs at Hiroshima and Nagasaki*, it was noted that blast forces from both A-bombs had caused severe distortion and deflection of concrete frames and resulted in the collapse of concrete columns and floor slaps as evidenced in the report's photographs taken on-site[648]. Francis Walley, a MPBW structural engineer who had been sent to Japan by Britain's Home Office, stated how concrete panels had 'bowed' as a result of the enormous blast pressures exerted by the unprecedented nuclear explosions [649]. More terrifying, was the invisible and lethal gamma radiation which passed through buildings and materials of 'considerable thicknesses', exposing occupants to fatal doses of radiation[650]. Standard technical details for affixing precast concrete panels onto a structural frame were published by the CCA in 1961, and clearly indicate weak points occurring at the intersection of panel joints. In the civil realm these 'bridges' risked weather penetration of wind, rain, and snow, but for bunker architecture these gaps invited lethal radiation to leak through into the building envelope[651]. While these precast approaches offered a more economical means of producing exposed aggregate finishes, we must acknowledge that fixing separate panels into a main structural frame in a similar fashion was entirely unsuitable for nuclear bunkers.

Secondly, in the preamble to Kirknewton's design, the British government sanctioned top-secret tests in line with the above threats posed to buildings by radiation. Melissa Smith's research on the Scientific Advisor's Branch (SAB) civil defence experiments details an upsurge in assessing 'the new threat of fallout' after the first H-bomb test in 1952 produced significantly more quantities of lethal radioactive dust than earlier A-bombs[652]. In particular, Smith highlights a series of studies conducted across the 1950s and 1960s that assessed how nuclear fallout may have interacted buildings. For example, she notes two specific experiments from 1959 and 1963 which analysed if radioactive fallout dust would dispense and reduce when exposed to rain and wind. These live trails used a non-contaminated 'fine grit' to simulate the behaviour of fallout dust, as mock buildings were hosed down with water, or exposed to windy conditions to determine the potential behavioural patterns of the fallout particles in response to the simulated weather conditions[653]. Interestingly, not only does this experimental timeline match the design and construction of Kirknewton, but SHD correspondence regarding the short-term use of Barnton Quarry under the EGC programme references these trials as ongoing that would impact modifications of the bunker's roof construction[654]. These experiments are essential because they neatly tie in with the architectural awareness of the technical advantages raised in 1960. Bowley, for instance, noted CCA experiments at Wrexham, Wales, and how these benefits afforded concrete buildings a more pleasant

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[648] Home Office and Air Ministry, T*he Effects of the Atomic Bombs at Hiroshima and Nagasaki*
[649] Walley, *From bomb shelters to postwar buildings*, p. 16
[650] Home Office and Air Ministry, T*he Effects of the Atomic Bombs at Hiroshima and Nagasaki*, p. 16
[651] J. G. Wilson, *Concrete facing slabs*, (London: CCA, 1961)
[652] Mellissa Smith, "Architects of Armageddon: the Home Office Scientific Advisor's Branch and civil defence in Britain, 1945-68" *British Society for the History of Science*, 43(2) (2009) 149-180 (p. 168)
[653] Ibid.
[654] NRS, HH51_260, Request made to Scientific Advisor's Branch of the Home Office inquiring about the necessary protective factor at Barnton Quarry 1st September 1960

weathering as the ‘rough spread the moisture’ with raised profiles acting ‘as drips from which the moisture may fall clear’[655].

From this extensive research and development, we must assume that, despite the more expensive and labour-intensive approach, in-situ casting was deemed the only way an exposed aggregate finish could be practically achieved to serve all defensive requirements: blast and heat resistance, penetrating radiation, and latent fallout. In this light, the MPBW architects almost certainly designed the concrete form and finish as a means to assist the wicking away of radioactive dust from the building envelope. The concrete hoods covering the air intakes, provided a further barrier and limit air contamination. The inverted butterfly roofscape allowed contaminated rainwater to flow down and collect away from the parapets to prevent overspill onto the building’s users below, and the exposed aggregate facades were less likely to splash and instead retained radioactive fallout within the rough surface textures.

At this point, it is worth recalling Francis Walley, the MPBW structural engineer who in witnessing the A-bomb impacts on concrete first-hand, had become an expert to the British government on nuclear resistant design. For alongside Walley’s engagement with civic works throughout the 1960s he was also deeply involved with top-secret government and military projects that ran concurrently. In the mid-1950s, for example, he was responsible for civil defence structures at Britain’s A-bomb trials in Australia; observing the effects of blasts experienced on concrete and steel. He was also responsible for carrying out key development work for the missile defence system at Spadeadam in Cumbria, England[656]. However, it was a 1961 secondment to the Scottish MPBW office as superintendent engineer on the Royal Botanic Garden glasshouses in Edinburgh that positioned him conveniently close to Kirknewton[657]. For it is entirely possible Walley’s presence in Edinburgh saw him supervise experiments (similar to those outlined above) on assessing concrete finishes as fallout protection. If tests at Kirknewton projected that exposed aggregate was a viable means of fallout protection then under Walley’s instruction would be subsequently allocated to Cambridge, following closely behind in the building programme. interestingly, such cross-border collaboration between the Scottish outpost and the central London office fits squarely with Donald Gibson’s mandates of knowledge exchanges aimed toward standardised MPBW design approaches for building components[658]. Thus, indicating another paradigm shift away from the previously siloed attitudes of the old MOW department.

Beyond fallout protection, another possible rationale for the expensive concrete specification could be rooted in better concrete aesthetics. Although Boyd and Linehan hold bunkers as ‘tight functionalist alignment of form following ordnance’, which may ring true with pre-1945 examples (and some of the earlier ROTOR bunkers), Kirknewton’s elevations also suggest there was more consideration for aesthetics rather than purely protecting against nuclear attack[659]. For example, in 1962 Richardson suggested architects in search of a particular aesthetic could ‘take advantage of the techniques of exposed aggregate work to provide ruggedly textured finishes[660]. Likewise, at the same time, Wilson outlined how exposed aggregate finishes weathered more attractively in

[655] Bowley, *Innovations in Building Materials*, p. 255
[656] Walley, *From bomb shelters to postwar buildings*, p. 20, R, F, Hughes, “Profile: Dr Francis Walley”, The Structural Engineer 76 (5) (1998) 91-92 (p. 91)
[657] Walley, *From bomb shelters to postwar buildings*, p. 20
[658] News, MOPBW, “Donald Gibson: Director-General”, *AJ*, 136 (1962) 1098
[659] Gary A. Boyd and Denis Linehan, “Becoming atomic: the bunker, modernity, and the city”, *arq*, 22 (2018) 241-25 (p. 253)
[660] Richardson, *Practical Formwork and Mould Construction,* p. 16

comparison with regular 'as-struck' concrete (which did not expose the aggregate). He claimed that when exposed concrete aggregate finishes, executed to a good standard, provided a 'sense of homogeneity and quality of surface'[661]. Importantly, when cross-examining the concrete evidenced within Kirknewton (and Cambridge) against the surfaces at London's Southbank, it must be noted that there are far fewer blemishes and spalling evident within bunker elevations. I therefore argue that the concrete form and finish displayed at these Cold War nuclear bunkers may have also been consciously designed for ornamental reasons beyond mere functionalism. While the 'as-struck' beton brut concrete broadly used across other bunkers may owe its origins to utilitarian protection, the quality of finishes within these 1960s nuclear bunkers signal that a superior crafting was consciously and deliberately applied. In combination with the aforementioned construction joints and precast hoods bunker architecture indicates further migration towards Brutalist examples more present within the civil realm.

Furthermore, the dimensional coordination of the exposed concrete panels integrated within Kirknewton's elevations also support the argument that conscious aesthetics began transitioning into Scottish nuclear bunkers by the 1960s. In short, dimensional coordination was the practice of designing to a range of 'preferred increments' which was underpinned by a need of efficiency and economy[662]. Although three elevational drawings are missing from Kirknewton's extension, I have reconstructed the main façade, which would have anchored the site's approach and entrance, using a combination of surviving floor plans and archival photographs. Additionally, given its near-identical composition to that of Cambridge twin, we can also draw on Wayne Cocroft's measured survey which sized the exposed aggregate panels at approximately 8ft high by 4ft wide[663]. As British industry standards for timber sizes at the time of design, we can assume the concrete shuttering was assembled using 8ft by 4ft sheets of plywood (or similar boarding). Vitally, when dividing the north-western façade (fig 4.16) by 4ft wide increments the elevation allows for 26 equal segments. This architectural approach would have enabled an efficient and economical solution to placate the Treasury's financial pressure, whilst also compromising better bunker aesthetics through the ornamental-like patterning.

Importantly, this seamlessly aligns with the new MPBW mandate on achieving efficiency with large building programmes. For around the period of Kirknewton's design the *AJ* claimed dimensional coordination had been prepared for 'building programmes directed and supervised by government departments'[664]. Additionally, during a radio interview aired on the BBC Third Programme at the outset of the new MPBW, Donald Gibson stated that a primary objective was aimed at leading by example to show Britain's industry what is buildable not just in one building but an enlarged programme[665]. By 1966, after the completion of Kirknewton (and Cambridge) it was further announced that all government building departments had agreed on the standard policy of 'dimensionally co-ordinated (*sic*) building components'[666]. The closely-knitted timelines shared between these Cold War nuclear bunkers and the British government's wider architectural development suggests the two separate realms were secretly collaborating in search of a mutually beneficial industry progression.

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[661] Wilson, *Exposed Concrete Finishes,* p. 72
[662] News, MPOPW, "Dimensional co-ordination of industrialized building", *AJ*, 137 (1963) 378-379
[663] Wayne Cocroft, *Survey Report: Cambridge Regional Seat of Government,* (Cambridge: English Heritage, 1997), p. 7
[664] News, MPOPW, "Dimensional co-ordination of industrialized building",pp. 378-379
[665] Ibid.
[666] News, MOPBW, "Government support for open systems", *AJ*, 144 (1966) 1404

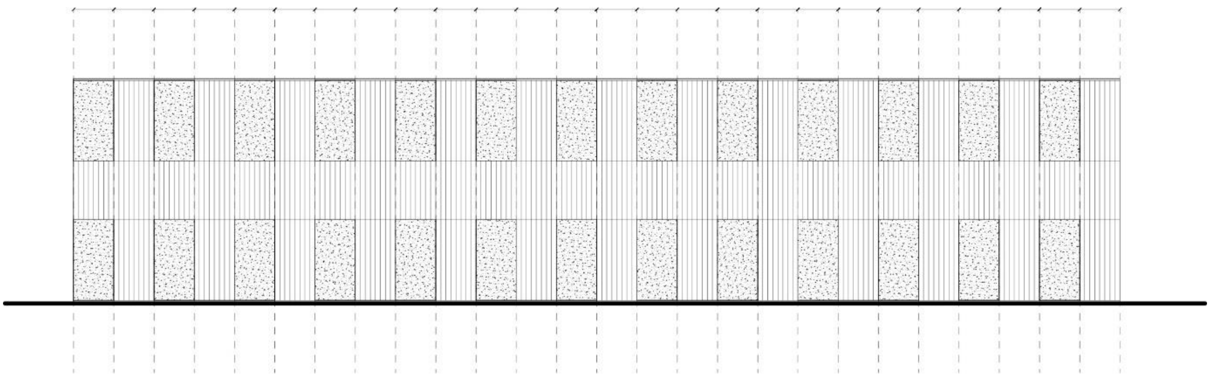

Figure 4.16: Kirknewton main elevation – dimensional coordination

Figure 4.17: Boston City Hall (RIBApix)

Lastly, there is additional scope beyond a British context to align Kirknewton (and Cambridge) bunkers with American architectural histories. For this aesthetic resonates with David Monteyne's architectural analysis of Boston City Hall (1962-68), a key example of American Brutalism also constructed in 'as-struck' reinforced concrete around the same time as Kirknewton (fig 4.17)[667]. While Boston City Hall was initially designed as the city's civic centre, had nuclear war occurred in the 1960s, the building also offered protection against radiation, contained a fallout shelter for nearly 20,000 citizens, and included an Emergency Operating Centre for elected public officials to continue government administration[668]. Albeit on a much larger scale and within a very different American Cold War context, we can still acknowledge key parallels with Kirknewton which indicate the transatlantic similarities in the British and American government responses to the 1960s nuclear threat. For example, Monteyne describes how the upper elevational section, containing the administrative offices, was ordered by a series of 'repetitive concrete grids' that were 'marked by an expressive exterior treatment'[669]. Although Kirknewton's alternating exposed aggregate finishes are of more reserved aesthetic, it is undeniable its architectural composition shares a similar rhythm with Boston City Hall.

While urbanist Stephen Graham writes that the Brutalist architecture of the western cities (1950-70) was built to 'directly imitate the functionalist and aggressive concrete of WW2 military bunkers' my thesis argues how Cold War nuclear bunkers were also an integral part of this narrative [670]. By using the expressive concrete examples presented within this chapter instead of the pre-1945 examples found in the Atlantic Wall, we can begin removing some of these misconceptions rooted in functional and aggressive concrete. Albeit these nuclear bunkers were created in top-secrecy and thus concealed from architectural dissemination, the more aesthetically pleasing expressions at Kirknewton (and Cambridge) are much closer in comparison with well-known examples of Brutalism than WW2-era precursors. In fact, I would go so far as to argue that by 1960 nuclear bunkers had discarded their historical dependency on military-grade monolithic concrete and leaned into the same Brutalist forms and aesthetics as evidenced in the civil realm. Likewise, this more ornate concrete at Kirknewton (and Cambridge) can and should be recognised within Calder's definition of 'high-brutalism'; crucially as both bunkers were constructed around the same timeline Calder defines (1958-75) that espoused an 'outburst of architectural creativity' and 'extraordinary technical progress[671]. Had the post-war architectural canon been able to gaze upon nuclear bunkers – without risking accusations of treason – more direct correlations would have been drawn with Brutalist discourse instead of commentators reverting to cite pre-1945 examples. By decoding Kirknewton's elevation and thus understanding the hidden values attached to its specification and skilled construction, we must acknowledge that the building's overall composition does not reside within John Beck's definition of concrete 'implacable blankness'[672].

My study of Kirknewton's elevation argues that this concrete composition was by no means accidental. Firstly, the newly established MPBW afforded its architects greater authority by the time of Kirknewton's design, which expands on Wall's argument of additional responsibilities under Donald Gibson's tutelage of maintaining professional authority[673]. Secondly, the architects also had

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[667] See #SOSBrutalism. "Kallman McKinnell & Knowles/Campbell, Aldrich & Nulty: Boston City Hall." #SOSBrutalism. https://www.sosbrutalism.org/cms/15891257 [Accessed June 14, 2022]

[668] Ibid., p. 232

[669] Monteyne, p. 235

[670] Graham, *Vertical,* p. 357.

[671] Calder, p 16

[672] Beck, *Landscape as weapon*, p. 143

[673] Wall, *An Architecture of Parts,* p. 147

broader access to the technical and aesthetic possibilities, as well as the financial implications, chiefly through the CCA[674]. With all this in mind, the single-casting approaches used extensively during WW2 were no longer the only option available to the Kirknewton bunker architects Pearce and Johnson. This shift in concrete specification shows another critical milestone in the nuclear bunker's migration away from military precursors towards a civil disposition.

To conclude this section, how do Cold War nuclear bunkers fit within the Brutalist discourse of architectural history? Design historian Alexander Clement prefaced his revised version of *Brutalism* by outlining how the term Brutalism 'seems to mean different things to different people[675]. Although Clement suggests that recent research interests tend to focus almost exclusively on the aesthetic side of the argument, this thesis posits nuclear bunkers exhibiting the same Brutalist tendencies in concrete finishes through conditioning of nuclear threats and emergency government plans of the Cold War[676].

[674] The CCA produced a collection of booklets and pamphlets, offered free consultancy advice, and provided lectures and workshops.
[675] Clement, p. 6
[676] Ibid.,

4.5: Fit for the Scottish Office: Nuclear St. Andrew's House

It is vital that we acknowledge Kirknewton's specialist concrete finishes – typically reserved for prestigious civil buildings – for it strengthens a deeper understanding of the bunker's overlooked political and architectural importance. For alongside incorporating fallout protection, it is highly likely that the aesthetic concrete carried the additional purpose of adorning Kirknewton's elevations with civic-like ornamentation. In regard to typology and function, previous research has all but assumed that Scottish Cold War nuclear bunkers simply mirrored what has been uncovered for England. Aside from Laurie's earlier acknowledgment, Kirknewton has and continues to be generally accepted as another RSG from the 13 within Britain's EGC network[677]. However, this is an oversimplification, as Kirknewton was more significant than just a typical RSG bunker. Rather than managing government administration on a regional level, Kirknewton was, in fact, the country's 'highest level of control' in a war-time scenario and operated as the main headquarters (formally identified as Scottish Central Control (SCC)) for the entire Scottish Office[678]. Ultimately, if Britain had entered into a nuclear conflict with the Soviet Union, Kirknewton was to become the official 'war time (*sic*) St Andrews house on a wider scale' and with a micro-government of selected civil servants, military heads, and key civilian staff, would have overseen the maintenance of administration in the aftermath of a nuclear attack[679].

Unlike the earlier ROTOR bunkers, the 1960s induced another paradigm shift in the operational requirements with Kirknewton being allocated an increased capacity of 500 staff, 90% of which consisted of the Scottish Office civil servants taken from departments based in St. Andrews House (Edinburgh) rather than military personnel[680]. Crucially, as part of its core staff base, Kirknewton was also to shelter the Secretary of State for Scotland, who, during this period of British politics, was second only to the Prime Minister[681]. As Scotland's capital and centre of devolved political powers, Edinburgh was identified as a prime target of a possible Soviet nuclear attack on Britain. Therefore, similar to the emergency procedures for dispersing Britain's main government to the Burlington bunker, evacuation plans were also drafted to whisk a skeleton crew from the Scottish Office out of Edinburgh[682]. Should a nuclear attack be detected, the order would have been issued to evacuate the Secretary of State for Scotland accompanied by approximately 450 specially chosen civil servants within a limited timeframe, leaving most of their colleagues behind[683]. As St. Andrews House was less than 5 minutes from Waverley train station, it is likely this small, exclusive cohort – restricted to carrying small travel bags and briefcases – would have walked down Waterloo Place and, in an orderly fashion, passed through the station to muster on a designated platform. Boarding a steam train – requisitioned purely for the Scottish Office (which by then would have been on a wartime footing) – the group would have headed west on the more scenic commuter rail route via the Shotts Line and disembarked 12 miles away at 'Midcalder' station (now named Kirknewton). Alighting the train, staff would have hurriedly made the final 5-minute leg of the evacuation north to the SCC, potentially their last experience of Scotland's pre-nuclear landscape ahead of imminent devastation and radioactive fallout.

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[677] Laurie, p. 112
[678] NRS, HH51/260, Report issued from SHHD February 1965
[679] NRS, HH51/260, Letter from Elliott-Binns (SHD) 17 October 1961
[680] NRS, HH51/591, Letter to Elliott-Binns of Scottish Home Department, 25 September 1963
[681] Jane Morton, Scottish Office: Regional Rule, p. 392
[682] Hennessy, pp. 188-189
[683] Morton, Scottish Office: Regional Rule, pp. 392-395, notes how Scottish Office staff were well known and liked among Scotland's Local Authorities

Amongst the historical critique levelled against Britain's efforts in nuclear defence, some researchers have queried the viability of bunkers, like Kirknewton, to function in an effective manner after a nuclear attack. Paul Hirst, for instance, describes the idea of civil servants 'passing one another memos, while trying to carry on the futile business of governing a nuclear wasteland' as 'truly laughable'[684]. However, we must acknowledge that civil defence planning at the time was based on scientific data and genuine beliefs that a post-nuclear Scotland could operate from a designated headquarters supported with a hierarchical network of sub-centres. After evacuating from Edinburgh and entering Kirknewton, William 'Willie' Ross (Secretary of State for Scotland from 1964-70) was to undergo a unique transform. As noted by the SHHD in 1965, Willie Ross (fig. 4.18) would have been immediately promoted to Commissioner for Scotland with the 'ultimate control of all life saving (*sic*) operations and all services necessary to survival in Scotland'[685]. Had Willie Ross orchestrated Scotland's post-nuclear recovery as planned, he would have presided over these duties alongside a range of devolved peacetime matters for at least 21 continuous days sealed within Kirknewton until, and only if, connections were re-established with Britain's central government in London[686].

Figure 4.18: Willie Ross, Secretary of State for Scotland 1964-70 (National Portrait Gallery)

[684] Hirst, *Space and Power*, p.222
[685] NRS, HH51/260, Report issued from SHHD February 1965
[686] These devolved matters included agriculture; forestry; Mains electricity/water supply; education; housing; healthcare; Scotland's roads, and extend to overseeing Local Authority administration, finances, and architecture. As well as presiding over building conservation the post-war amendments to Town and Country planning legislation also afforded Willie Ross the task of co-ordinating all of Scotland's planning developments

Figure 4.19: St. Andrews House, Edinburgh, Secretary of State's Office (Canmore)

Figure 4.20: Typical office at Anstruther ROTOR bunker converted to Northern Zone Control (Subbrit)

Figure 4.21: St. Andrews House, Edinburgh, conference suite (Canmore)

Figure 4.22: Conference suite at Anstruther ROTOR bunker converted to Northern Zone Control (Subbrit)

However, should such reconnection be delayed indefinitely, Kirknewton was to supersede Whitehall and operate as Scotland's central governmental, running day-to-day matters, such as maintaining social order and governmental administration, as well as orchestrating the country's long-term recovery. If the post-nuclear wasteland was as bleak as featured within Peter Watkins infamous *The War Game*, architecturally, Kirknewton, needed to be recognisable and representative of the political power it protected within. Therefore, as per other RSG bunkers in England, the visually impressive (and expensive) concrete aesthetics outlined above were considered an appropriate means of impressing 'visiting government ministers or local leaders and dignitaries'[687]. To ensure the building's monumental facades were of sufficient quality, build costs appear to have been balanced with a more reserved treatment of the bunker's interior finishes. For example, although the internal design of St Andrews House, was designed to include luxurious office suites complete with 'sumptuous' walnut panelling and cushioned leather chairs, Kirknewton was much humbler in comparison[688]. Although the bunker featured industry-leading building systems walnut panelling was swapped for barefaced brick and concrete masonry alongside plasterboard-lined partitions, sometimes coated in a beige emulsion, with exposed industrial fixtures and fittings, and ceiling-mounted ducting and lighting.

Additionally, given his high-status as the head of the house, Willie Ross would have also swapped his panoramic Edinburgh views for wall-mounted scientific charts and maps of Scotland that were to be annotated with the expected devastation following a nuclear attack. Without windows, at least he would be spared the unease of visually seeing the irreparable destruction wrought upon the Scottish landscape. Although Willie Ross would have to live without access to natural daylight and worked in more basic surroundings, he still had the sole privilege of being assigned a double pedestal desk and an armchair while the remaining civil servants sat at standard MPBW writing desks and chairs[689]. Surviving hand-drawn sketches held in NRS archives provide an insight into Kirknewton's interior spaces that were to be shared by Scottish Office and military personnel. Surprisingly, these layouts indicate a sense of extreme cluster as the packed floorplans include desks, filing cabinets, cupboards, tables, and chairs. Bizarrely, hat and coat stands were afforded prime space within the tight plan, yet circulation paths around the furniture, are disproportionately less generous, which had the potential of generating an uncomfortable working space in the expected chaos of post-nuclear recovery[690].

The other Whitehall outposts established in Scotland have been recognised for their architectural and historical importance, yet the Kirknewton bunker has been largely overlooked from this discussion. As the first official building for the Scottish Office outside London, St. Andrew's House (1933 -39) has been highlighted as one of the most important milestones in the pursuit of greater Scottish devolution. Professor H.J. Hanham, for instance, claimed it provided a seat of government for Scotland for the first time since the eighteenth century and ultimately established a 'full-scale Whitehall department' [691]. He continued that this new system 'provided a flexibility' that could facilitate a future transition to a more autonomous rule, one increasingly detached from London's central government[692]. Others view the underlying reasons behind St. Andrews House with more

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[687] Historic England, "Regional Seat of Government, Government Buildings. Historic England https://historicengland.org.uk/listing/the-list/list-entry/1390526?section=official-list-entry [Accessed May 2, 2020]

[688] Glendinning, *The Architecture of Scottish Government,* p. 273

[689] Letter from John Utterson (SHHD) to A Hardie (MPBW) 3 November 1964

[690] NRS, SOE25/1, Loose sketches, 'Scottish Central Control', undated

[691] Hanham, *The Development of the Scottish Office*, p. 67

[692] Ibid.

scepticism, with Gibson suggesting this was a crafty means of Britain's Central Government in securing further control beyond London, describing St. Andrews House as merely 'an outpost of Whitehall stationed in Scotland for reasons of administrative convenience'[693]. What is particularly interesting with both theories is that in the scenario of nuclear war, where the Scottish Office managed to seek effective shelter, Kirknewton would have conducted an unprecedented measure of a devolved – even independent – Scottish Government. If nuclear strikes had entirely decimated London, the onus of maintaining order and continued political machinery in the unpredictable socio-political aftermath transferred from Edinburgh and fell squarely with those sheltered in Kirknewton and its supporting Zone Controls had to exercise a flexibility, that met Hanham's criteria of a facilitated transition to more autonomous rule. In this light, Kirknewton must be recognised in the same discourse as St Andrews House owing to its important architectural history value.

4.5.1: Kirknewton: The Brutal Prototype

From the contempt expressed towards the Scottish Office by both the Treasury and the MOW departments Kirknewton's official sign-off may have been approved on the proviso it was ultimately a working 'high-fidelity' prototype for the Cambridge RSG bunker[694]. According to architects Burry and Burry a high-fidelity prototype (or mock-up) is a means to physically test architectural design elements at full-scale ahead of construction; permitting an opportunity to rectify any issues or mistakes to ensure a premium-build quality was achieved in the final product and gain a sound understanding of the phased sequences to facilitate construction. Just as the Air Ministry's ROTOR programme had extensively adopted prototyping (detailed in chapters 2 & 3), it is likely that the MPBW, upon inheriting the AMWD (responsible for ROTOR prototyping), maintained similar methods. As such, Kirknewton's rural location in Scotland's central belt provided an ideal setting that could conceal the prototype bunker ahead of its Cambridge twin positioned within a much more urban and publicly visible context.

Letters sent by Elliott-Binns (on behalf of the Scottish Office) suggest that Kirknewton's early design proposals were initiated by at least November 1961, with on-site works scheduled to start the following, which was slightly ahead of Cambridge's parallel construction timeline[695]. By planning Kirknewton's extension in advance of Cambridge would have given the MPBW enough time to rectify key lessons learned; any mishaps encountered at Kirknewton could be identified, rectified, and translated to the MPBW project team assigned to Cambridge. Staggering the construction phases would have enabled contractors to test the overall buildability of Kirknewton by understanding how to best deal with; awkward concrete pouring stages; integrating separate pre-cast concrete elements within an in-situ superstructure; setting construction joints; refining dimensional coordination, and lastly, perfecting the exposed aggregate finishes outlined in detail within this chapter.

At this stage, it is important to note that although my previous research suggested both bunkers were almost identical in form and aesthetics, there are however specific architectural nuances that, when further investigated, indicate that Kirknewton was much more rudimentary[696]. For example, in decoding Kirknewton's elevations and cross-examining them against Cambridge, additional variations are present which collectively indicate testing conducted on aspects of concrete. In using

[693] Gibson, *The Thistle and the Crown*, p.69
[694] Burry and Burry, *Prototyping for Architects*, p. 27
[695] Upon completion, Kirknewton was to assume the role of SCC and in turn transfer Eastern Zone Control to Barnton Quarry as part of the exchange.
[696] Kinnear, *Reopening the Bunker*, p. 15

photographic surveys, I have identified three critical areas of difference from the roofscape, through the elevations, down to the baseline. (Kirknewton, as shown on the left of fig.4.23) with Cambridge opposite)

Firstly, Kirknewton's V-shaped roof is of a cruder construction. The concrete ventilation tower shows evidence that two separate concrete pours formed the upper roof section, contrasting to Cambridge's visually neater single pour that achieved a much more continuous form and finish. Secondly, Kirknewton's horizontal construction joints are much thicker and recessed, which results in three prominent elevation bands of unequal width. In contrast, Cambridge's much more subtle joints are of equal separation. Thirdly, the overall quality of concrete finishing is lower at Kirknewton. For instance, the 'as-struck' vertical lines at Kirknewton are much less impressive than Cambridge, which incidentally, evidence a high-quality of finish in keeping with the concrete surfaces found in the Southbank case studies visited in fieldwork. Heavily leans towards prototype.

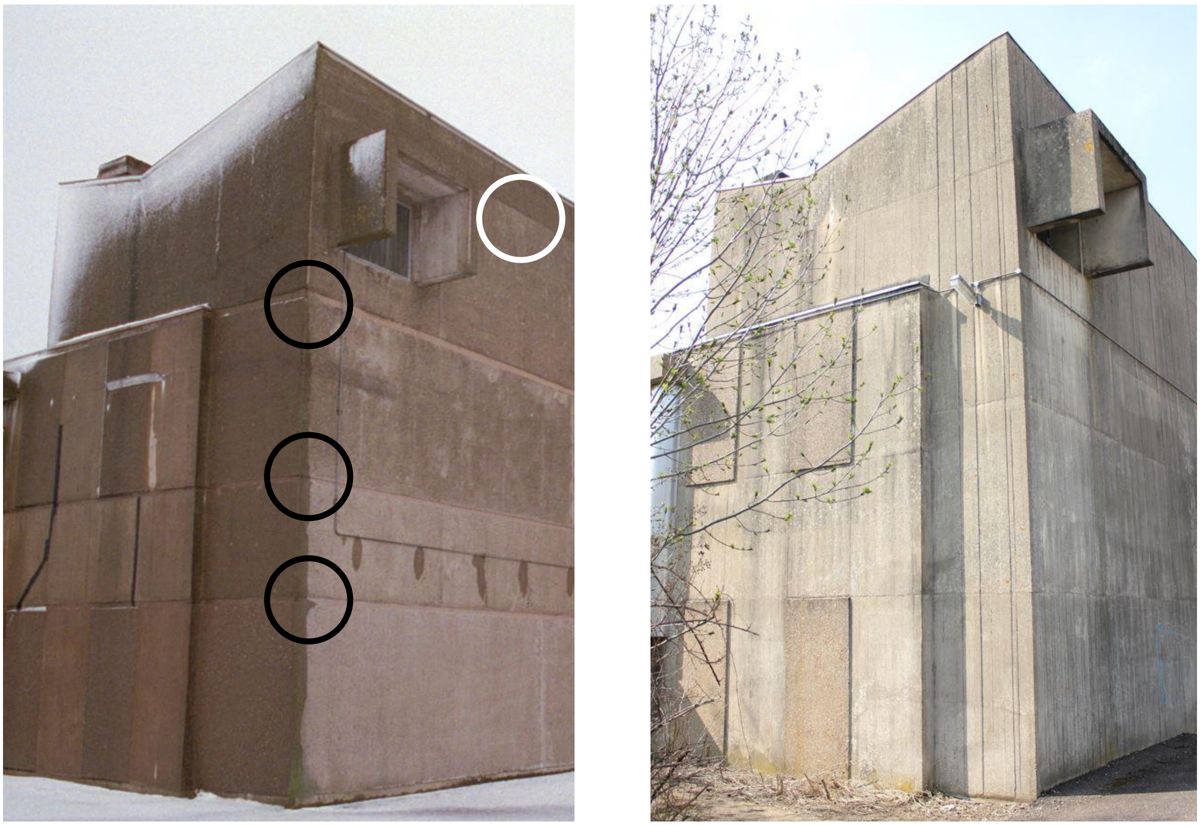

Figure 4.23: Elevational comparison of Kirknewton and Cambridge concrete detailing

Given that Kirknewton and Cambridge were both conceived as part of a more extensive building programme intended to be rolled out across the country this trialling of concrete construction suggests planned construction was to continue further. Matthew Grant's archival research reveals this network of EGC bunkers was scheduled to include at least 6 new 'bespoke RSG buildings' costing £2m over a two-year construction period[697]. Incidentally, this figure matches the estimated costs (up

[697] Grant, p. 180

to £300,000) originally requested for Kirknewton[698]. As noted at the start of this chapter, however, the pendulum swing of Treasury finances shifted government spending away from bunker building back towards civilian projects[699]. The 1960s extensions to Kirknewton and Cambridge are rare examples of these officially sanctioned schemes being realised in built form[700]. Although the Cambridge bunker was of a higher quality in comparison with Kirknewton, its construction was still being refined in tandem with the concrete prototyping approach. For example, when analysing photographic surveys of Cambridge, the interior view of a ventilation air intake clearly shows construction joints of a poorer quality than those visible externally and uneven surfaces where variations of timber planks and sheets of differing widths have been used in formwork (fig. 4.26). This concrete detailing suggests that the tower element was potentially factored into an earlier sequence in the construction programme to allow for testing the buildability at key junctions. By pouring this internally concealed section, the contractors could understand the quality of concrete required on the principal elevations along Brooklands Avenue ahead of final approval by the MPBW architects. In this respect, the areas hidden within ventilation shafts provided the contractors similar test panels like those trialled by McAlpine at the National Theatre [701].

Moreover, beyond these top-secret bunker projects, it is also possible that this prototyping both assisted and influenced concrete construction in the broader post-war civil industry, primarily channelled through the CCA and MPBW. First, it is interesting to note how elements of the CCA's technical advice as published in the early-1960s, were significantly revised by Michael Gage's 1970 update titled *Guide to Exposed Concrete Finishes.* From this revised account, Gage's emphasis shifted to recommend that the 'uniformity of the finished surface depends to a very great extent upon the degree of supervision at all stages on the job, and it cannot be overemphasised that a high standard of workmanship (*sic*) is essential for an acceptable finish'[702]. Given the interconnected relationships and shared timelines I argue this shift was in part owed to the top-secret work conducted at nuclear bunker sites like Kirknewton and Cambridge. Such knowledge exchange was entirely possible given the historical relationships between the British government and the CCA. In historian Edwin Trout's research paper *Concrete Air Raid Shelters, 1935-1941* he traces this relationship as far back as 1935, when close collaboration with the Home Office elevated the CCA 'as the champion of the air raid shelter[703]. When Britain transitioned towards WW2, the CCA subsequently assumed the role of principal consultant, influencing policy and promoting the use of concrete in constructing bomb-proof shelters. Furthermore, the oral account from MPBW engineer Francis Walley's extends this relationship through the late-1950s, when the CCA was appointed consultants over the Spadeadam Blue Streak rocket site[704]. Additionally, my own archival research has revealed that such engagements were maintained through the 1980s in the civil defence 'protection in buildings against nuclear attack'[705].

Parallel to these top-secret engagements, the CCA also maintained a public presence through direct involvement with well-known Brutalist works. For example, the civil engineer, Ove Arup utilised the CCA's free consultation service to test the various concrete surfaces which were specified

[698] Ibid.
[699] Ibid., p. 181
[700] Although Nottingham was the third RSG bunker to be approved within this programme it is currently beyond the scope of this thesis.
[701] Calder, pp. 312-318
[702] Gage, *Guide to Exposed Concrete Finishes*, p. 121
[703] Edwin Trout, "*Concrete Air Raid Shelters*, 1935-1941 Construction History", 32 (2017) 83-108 (p. 84)
[704] Walley, *From bomb shelters to postwar buildings*, p. 20
[705] NRS, HH51/285, Letter to Home Office from R.M. Tiller (CCA – Advisory Division) 10 April 1980

throughout the Southbank Centre[706]. Likewise, before Chamberlin, Powell, and Bon (CPB) had finalised their proposals for the Barbican development, Elain Harwood notes how the architects travelled to Norway with the CCA in 1960 to inspect concrete construction and finishes[707].

In returning to the MPBW, it is important to note Donald Gibson pressed for the government department to 'secure the widespread dissemination of the best modern practices'[708]. This is vital, for the concrete aesthetics evidenced in the now demolished New St. Andrews House (completed in 1975), Edinburgh, evidenced striking parallels with Kirknewton's elevational treatment. Constructed by McAlpine, a contractor we know to be present in the ROTOR bunker framework, the Brutalist complex included the St. James Centre, a multi-storey car park, a hotel, and new civil servant offices for the expanding Scottish Office departments[709]. Importantly, not only did the design of New St. Andrews House begin in the mid-1960s – around the time of Kirknewton's completion date – but the MPBW architects appointed to the bunker's extension also worked in collaboration with Edinburgh City Council in designing New St. Andrews House [710]. Owing to this shared timeline, it is entirely possible that MPBW architects and engineers assigned to Kirknewton either transferred directly to New St. Andrews House upon the bunker's completion or alternately, provided critical feedback on an advisory level. Nonetheless, the intensive labour, supervision, and skill involved with exposing aggregate from in-situ concrete as outlined in this chapter, had by then revealed the associated costs, which in turn would be economically unviable on a building the size of New St. Andrews House. Full-page photographs led Dan Cruickshank's critical piece adorned 'the image crumbles' showed similar exposed concrete aggregate finishes as those outlined within Kirknewton's elevational study [711]. The vital difference however, being these Brutalist-styled facades adopted the more commonly applied precast concrete panels fitted within a concrete structural frame, in-line with the early 1960s industry standard.

[706] A. C. Powell, "Rough concrete on site", *The Arup Journal*, July (1966) 1-15 (p. 7)
[707] Elain Harwood, *Chamberlin, Powell & Bon* (London: RIBA, 2011), p. 47
[708] News, MOPBW, Donald Gibson, AJ, 136 (1962) p. 1098
[709] Ibid. p. 288
[710] Glendinning, *The Architecture of Scottish Government*
[711] Dan Cruickshanks, Edinburgh, the image crumbles, *AJ*, 159, (1974) 100-108 (p. 100)

4.6: Mimicry: Brutalism as Quasi-Urban Camouflage

A final point to note on this relationship of concrete form and finish, lies in how Brutalism assisted architectural camouflage by mimicking built environments to conceal government bunkers from Soviet surveillance.

By the 1960s not only did increasing threats continue to influence the secret design and construction of nuclear bunkers similar to the 1950s building programmes, but the geopolitical situation became so precarious, that the British government worried that visible construction of bunkers would ultimately 'raise international tensions and the likelihood of war'[712]. Amid this shifting landscape and with more sophisticated surveillance measures, the MPBW (which by 1964 had absorbed the AMWD previously tasked with concealing ROTOR bunkers) were pressed into developing a new architectural camouflaging technique that carefully disguised emergency government bunkers as unassuming examples of Brutalism. In chapter 2, I introduced Neil Leach's theory on architectural camouflage by using the ROTOR bunker guardhouses as an example of how surface-level elements were carefully designed to match the local vernacular for concealment. The following section recalls Leach's theory to highlight how both Kirknewton and Cambridge bunkers respectively mimicked their 'endlessly adapting' rural and urban environments respectively in order to successfully 'blend' their 1960s extensions into a developing environment of Brutalism[713].

There is nothing striking about the Kirknewton site located off the B7015 road, 12 miles southwest Edinburgh. As shown in Nick Catford's photographs there was simply a raised grassy knoll with groupings of trees that had partially surrounded and concealed the existing 1950s War Room bunker. While there are neighbouring industrial yards and a new housing scheme today the 1960s landscape was representative of Scotland's post-war greenbelt. Despite this typical rural setting however, it is vital to draw on historian Alexander Clement, who writes that Brutalist architects often 'took great pains' when integrating schemes, even those within less-urban sites[714]. This is important when considering James Stirling's Andrew Melville Halls (1964-67) at St Andrews in Fife, nearly 50 miles northeast of Kirknewton, which was formed using a daring assembly of precast concrete panels. Black and white photographs depict the rough grey concrete of these student halls, anchored in an extensive landscape of trees and grassland that at the time bordered St Andrew's western periphery (prior to the town's modern expansion present today). Although Stirling distanced himself from Brutalism, the building has been widely accepted into Scotland's post-war architectural discourse under the Brutalism banner[715]. According to Stirling, the scheme was designed into a 'non-contextual' site using an 'abstract' architectural vocabulary[716]. In chapter 1, Kirknewton was never considered within architectural discussions, either during its Cold War operational timeline, post decommissioning, or even after its subsequent demolition in 2003. However, given the site layout, the integration of concrete and ruralness, Kirknewton can and should now be considered alongside the same abstract thinking referenced at James Stirling's Andrew Melville Halls.

This is important when turning to Cambridge's very different contextual setting, for unlike Kirknewton the English twin was situated much closer to a populated city centre, and thus required a more refined architectural response to mimic the quasi-urban built environment and conceal its

[712] Laurie, p. 120
[713] Leach, *Camouflage*, p. 79
[714] Clement, p. 172
[715] See #SOSBrutalism. "James Stirling: Andrew Melville Hall, University of St. Andrews." #SOSBrutalism. https://www.sosbrutalism.org/cms/17036028 [Accessed June 14, 2022]
[716] James Stirling, 'Lecture '81', in Architecture in an age of scepticism, ed. Denys Lasdun, (London: Heinemann,1984), p. 194

existence from public view. The bunker on Brooklands Avenue lay on the southern periphery of the University of Cambridge's campus, which incidentally, experienced a sizeable expansion over a 10-mile radius throughout the 1960s, including a new printing press in the architectural style of modernism diagonally opposite. Crucially, the architectural literature published at the time of the Cambridge bunker construction declared how new buildings within this micro-region harnessed the 'best concrete design in British architecture'[717].

In Adrian Forty's analysis of London's Southbank (developed from 1961 to 1968) he notes how the LCC architects designed the buildings to 'disappear' against their contextual backdrops[718]. According to Forty the continuous concrete surfaces of these buildings allowed them to 'merge into a generic urban infrastructure'[719]. Therefore, if we consider the Southbank treatment as an adequate form of urban camouflage, then under the lens of Leach's mimicry, we can expand this concept further by how the concrete elevations blended bunkers into other contemporaneous Brutalist examples. For instance, the quality of board-marked concrete applied on Corpus Christi College by Arup (1965), New Hall by Chamberlain, Powell, and Bonn (1965), and St. John's College by Powell and Moya (1967), all bear a striking resemblance to the Cambridge bunker's concrete detailed above. Beyond similarities in architectural finishes, similar building forms; such as the extruding air flu on the boiler house at Churchill College by Sheppard, Robinson, and Partners (1962) appears a near-identical example to the Cambridge bunker's concrete ventilation tower. Likewise, the 'jumble of pre-cast and in-situ concrete beams' which Banham described at Churchill College resonates with Cambridge's abovementioned concrete composition[720]. The geographical proximity and timeliness of civil concrete examples across Cambridge thus provided an ideal setting to conceal the bunker's expansion without the risk of escalating geopolitical tensions. Furthermore, to accurately mimic this quasi-urban environment and produce a convincing Brutalist aesthetic, an equally high-quality of concrete construction was required at Cambridge to match the surrounding civil examples. Given Kirknewton was set within a more concealed, rural context, I argue that the Scottish bunker was surreptitiously used as a suitable testing bed to achieve high-quality concrete. Ultimately, if mimicry was not effectively achieved in the architectural aesthetic, then the Cambridge bunker risked detection from Soviet surveillance, or direct-action groups linked with CND activities that would also risk greater exposure. Under this lens, Kirknewton was used as a working prototype ahead of Cambridge.

Beyond the concrete materiality the concept of Cambridge as bunker camouflage can be expanded through its considered urban planning as well as mimicking public works to fuel cover stories. Like Kirknewton, Cambridge's extension was to join and merge with the existing 1950s War Room to provide a larger bunker capable of accommodating an increased staffing capacity. From the initial design brief, the new concrete block was to abut the existing structure on the western side, however, aerial photographs taken some time after completion of construction reveal this was not in fact the case[721]. Instead, Cambridge's extension was relocated to adjoin the south elevation and as a result generated a much more symmetrical building plan than the irregular footprint of Kirknewton as evident from above (fig. 4.25). This revised orientation permitted the bunker to seamlessly nestle into the surrounding fabric which was pre-defined by the (now demolished) single-storey government office blocks along Brooklands Avenue. With this in mind if Soviet surveillance had

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717 George Perkin, Concrete in Architecture (London: Cement and Concrete Association, 1968), p. 5
718 Forty, *Concrete and Culture*, p. 282
719 Ibid.
720 Reyner Banham, Criticism, Churchill College, Cambridge, *AR*, 136 (1964)174-179 (p. 178)
721 NRS, HH51/296, Secret Letter to MOW from SHD, 17 November 1961

detected this extension, it is possible the works would have been explained away as a harmless new wing of the neighbouring government offices or alternatively a simple expansion of the collegiate campus. Additionally, since the new University of Cambridge printing press underwent construction around the same time adjacent to the bunker, the timely overlap would have provided ideal cover to conceal the building works as the two building programmes shared vast quantities of traffic and labour forces and material deliveries.

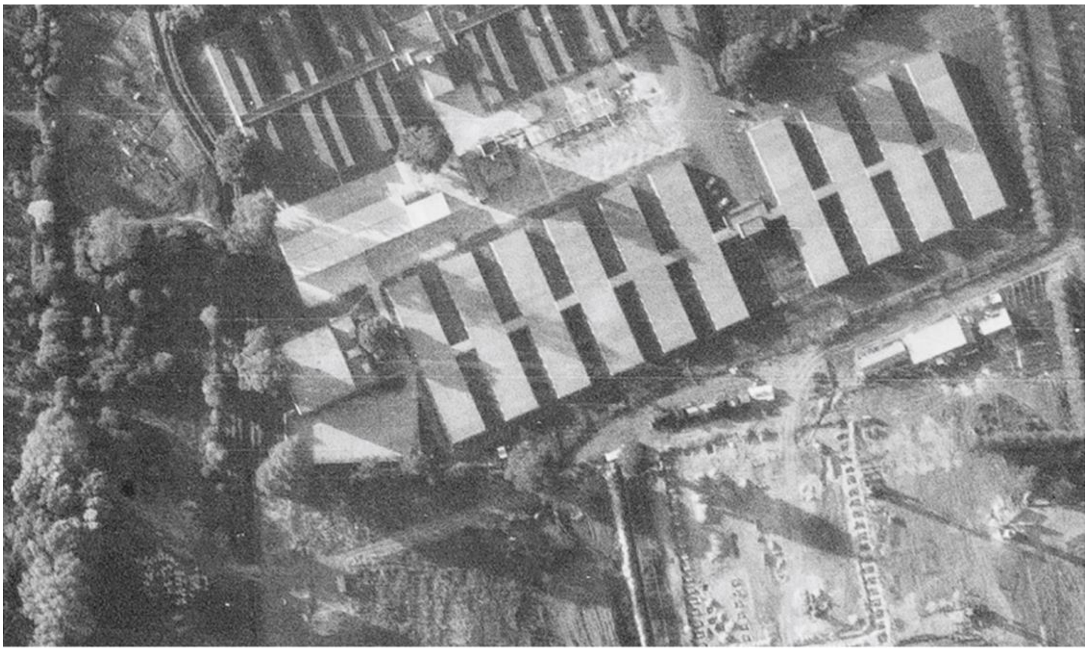

Figure 4.24: Aerial view of Cambridge site layout 1953 (HE)

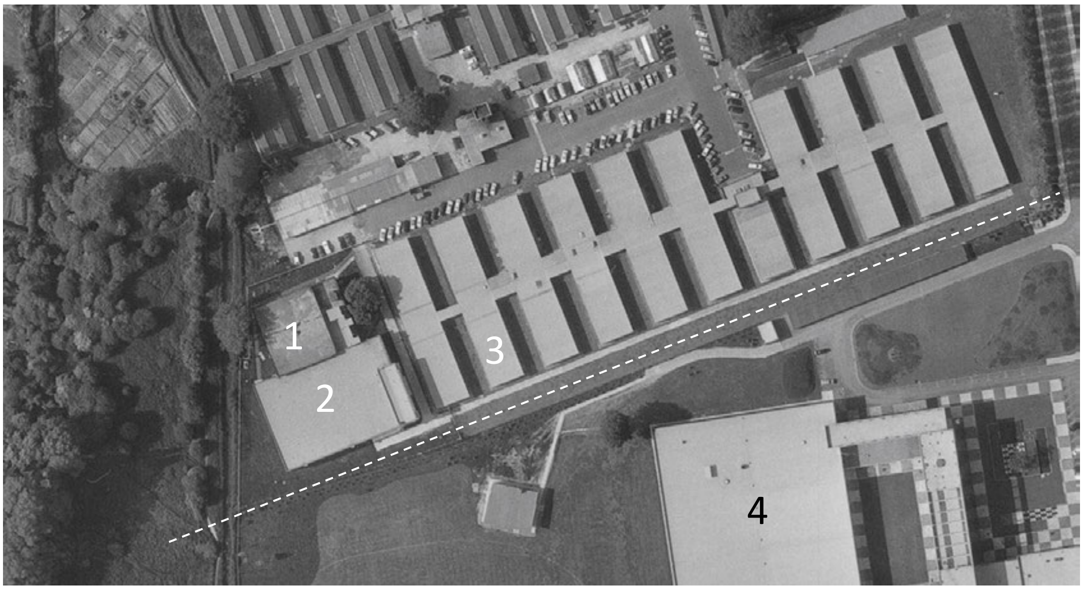

Figure 4.25: Aerial view of Cambridge site layout 1967 (HE)

1950s War Room (1)

1960s RSG extension (2)

Existing government huts (3).

1960s University of Cambridge Printing Press (4)

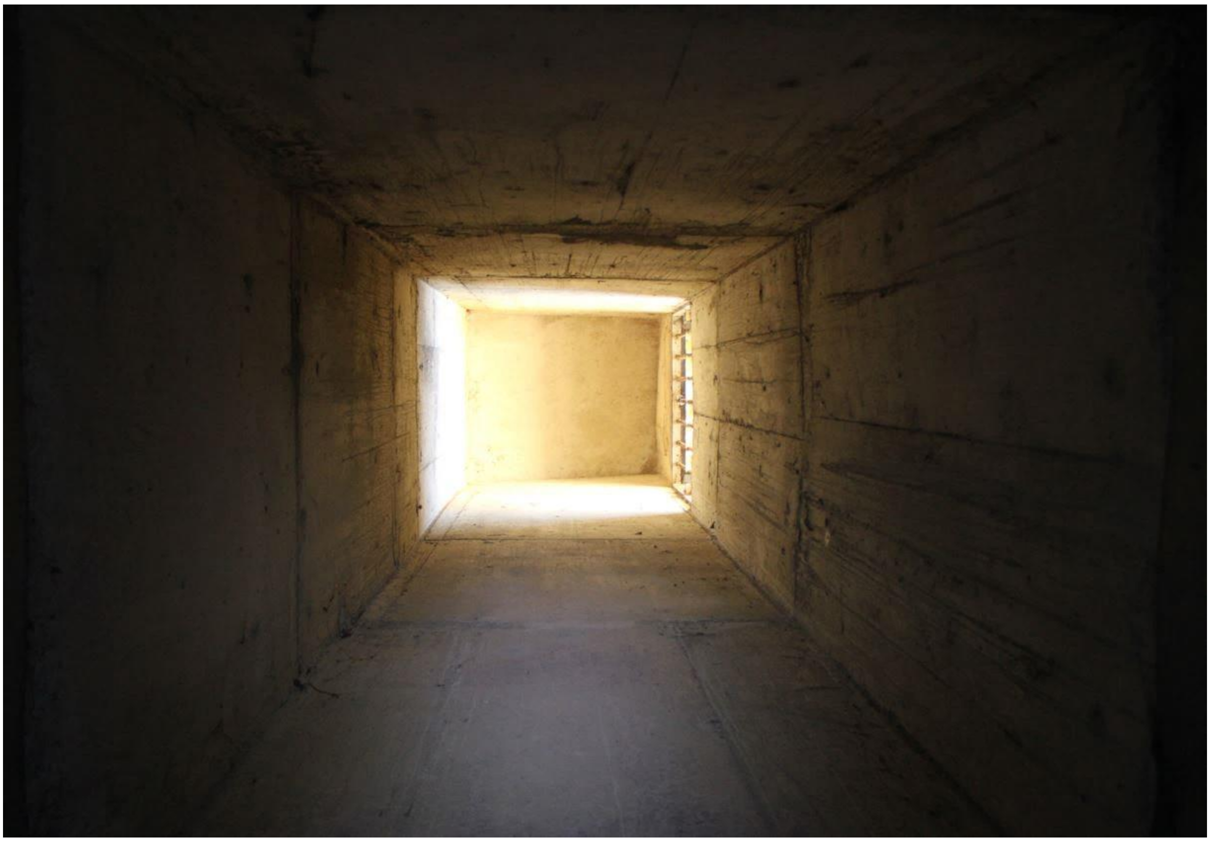
Figure 4.26: Cambridge concrete 'test panels' within air ventilation towers

Lastly, as well as refined Brutalist aesthetics and considered urban design, cover stories also supported the concealment of Cambridge's secrecy. Like the government's primary refuge at Burlington (introduced earlier), Cambridge also appears to have entertained a similar ruse to maintain its secrecy and avoid public detection. As historian Matthew Grant outlines, concealing Burlington's top-secret location was assisted by a series of carefully crafted 'cover stories' from the late-1950s onwards to ensure a plausibility would discourage unwanted civilian curiosities into the site's real purpose. For instance, it was initially given vague cover that the MOW was conducting general clearances ahead of preparation as flexible, protected, government accommodation amid increasing anxieties over nuclear war. When work expanded and on-site activity increased, the cover story was amended, and the bunker was subsequently masqueraded as a vital GPO facility for enabling wartime communications during and after a nuclear attack on Britain[722]. As we know from chapter 2 the extensive presence of the GPO during the 1950s ROTOR programme, it is possible that the MPBW was attuned to the effectiveness such rumours offered, and therefore encouraged their further incorporation to the camouflaging strategy. Importantly, in drawing on Peter Laurie's earlier investigations, he described the Cambridge bunker as a 'massive concrete block' that 'may well protect a trunk-telephone exchange'[723]. Crucially, this was totally plausible as not only was the MPBW responsible for designing such telephone exchange buildings, as well as nuclear bunkers, but the MPBW were also busy nearby in a genuine civilian capacity extending the GPO sorting office at 'Parker's Piece'[724]. Had it been more generally assumed to be another telephone exchange by Cambridge's population is likely the public would have ignored it, and the Soviets would have bypassed it to focus resources elsewhere.

I therefore argue that this specialist architectural blending of Cambridge into the quasi-urban landscape through careful mimicry of Brutalism defines a keystone moment in camouflage development. For in 1944, architect Hugh Casson, doubted that architectural camouflage would forever retain an 'adolescent' status, never to reach a 'maturity'[725]. Casson based this projection on spending four-years at the Air Ministry's Camouflage Unit during WW2, developing paintwork patterns and decoy sites. However, much like other aspects of technological advancement it is clear that the Cold War had eclipsed the infancy of WW2-period camouflaging. Therefore, using carefully designed architectural aesthetics and form in conjunction with rumour and fictional cover stories these bunkers merged more seamlessly with the civil realm – achieving the camouflage maturity Casson doubted. Although this section has centred on the Cambridge bunker, I argue its convincing camouflage as Brutalist architecture is indebted to Kirknewton's role as a prototype site.

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[722] Grant, p. 139
[723] Laurie, p. 250
[724] Philip Booth and Nicholas Taylor, *Cambridge New Architecture* (London: Leonard Hill Books, 1970), p. 94
[725] Hugh Casson, "the aesthetics of camouflage", *AR*, 96, (1944) 63-68

4.7: Epilogue: Architectural Afterlives

The post-Cold War life cycles of both Kirknewton and Cambridge bunkers reveal two very different outcomes. As noted in my previous research paper, owing to sustained analysis and timely studies spearheaded by English Heritage, including the archaeological reports and publications cited within this thesis, Cambridge was awarded Grade II listed building status in 2003 (approximately equivalent to Category B within the Scottish listing system)[726]. Shortly after achieving listed building status the Cambridge bunker further survived an imminent demolition threat during the construction of the nearby Orcadia housing scheme and since 2020 has been adapted for reuse as a collections unit by the University of Cambridge's Museum of Archaeology and Anthropology. Paradoxically, in this new function the bunker's climate control has dramatically shifted from its initially conceived Cold War purpose. While it was historically designed to keep out the external environment of a nuclear blast and radioactive fallout, it now strictly retains the specialist internal environment conditions, crucial in protecting the fragile artifacts[727].

Kirknewton, on the other hand, experienced an entirely different architectural afterlife and following its decommissioning and failed reuses it was finally demolished in 2003. In the late-1980s the bunker was stripped of its function as Scotland's central headquarters and Kirknewton's political powers were subsequently transferred north to Cultybraggan in Perthshire. Although it falls beyond the scope of this thesis, the entirely new Regional Government Headquarters (RGHQ) bunker at Cultybraggan had been constructed by Magaret Thatcher's Conservative Government amid renewed Cold War threats. In losing its status as the post-nuclear hub for the Scottish Government the building was subsequently placed on a care and maintenance basis until the end of the Cold War. In 1992, and in stark contrast to its historical importance, the Scottish Office went further with a full decommissioning; facilitating the bunker's immediate disposal as the building was no longer required by the government and since 1984 had incurred a significant financial drain on public funds through its maintenance bill cited at £12,000 per month[728].

Paradoxically, and in stark contrast with its recognised importance during the Cold War, the Scottish Office were surprisingly anxious the bunker would struggle to sell and as a last insult it was officially deemed 'not very valuable'[729]. Such statements may ring true within a commercial argument, for not only were demolition costs deemed unfeasible at the time, but the extensive underground services prohibited any new surface development of the site, thus limiting the bunker's reuse for any prospective buyer[730]. While it is crucial to note that the Scottish Office did explore the building's potential reuse and even offered the site to the National Galleries of Scotland as storage facilities (in a similar fashion to Cambridge's new function), but upon failing to find willing State tenants Kirknewton eventually went to public auction in 1993[731]. After a period of advertisement within local newspapers that featured crass headlines such as 'Grim Nuclear Secret: Cold War thaw forces sale of bunker hideaway' the bunker was sold to a private firm for £67,000 (or £125,000 today)[732]. Prior to its final demolition the building experienced a brief spell as 'the bunker' nightclub venue (pictured in fig 4.27). Interestingly, an archival image shows how the street-facing elevation subsequently served as the main façade and the first point of arrival for the visiting crowds. Despite the building being

726 Kinnear, *Reopening the Bunker*, p. 14
727 Michael Vanoli, Cambridge Nuclear Bunker, CFCI Webinar, March 10, 2021
728 NRS, SOE25/1, Letter from Scottish Office finance department to HHD 29 September 1992
729 NRS, SOE25/1, Letter to Lothian Council July 1992
730 Ibid., Mains connections are seen in the MPBW drawing 'Drainage and Water Service'
731 NRS, SOE25/1, Letter to Scottish Office 15 September 1992
732 NRS, SOE25/1, The Lothian Courier 8 January 1993

painted white in an attempt to conceal the original 1960s concrete aesthetic the projected sections of exposed aggregate, which had served as a key prototype function during the Cold War, are still visible. In this instance, Kirknewton migrated into Scotland's civil built environment as a unique, yet short-lived nightclub experience, and not the post-nuclear governmental block feverishly prepared during the Cold War.

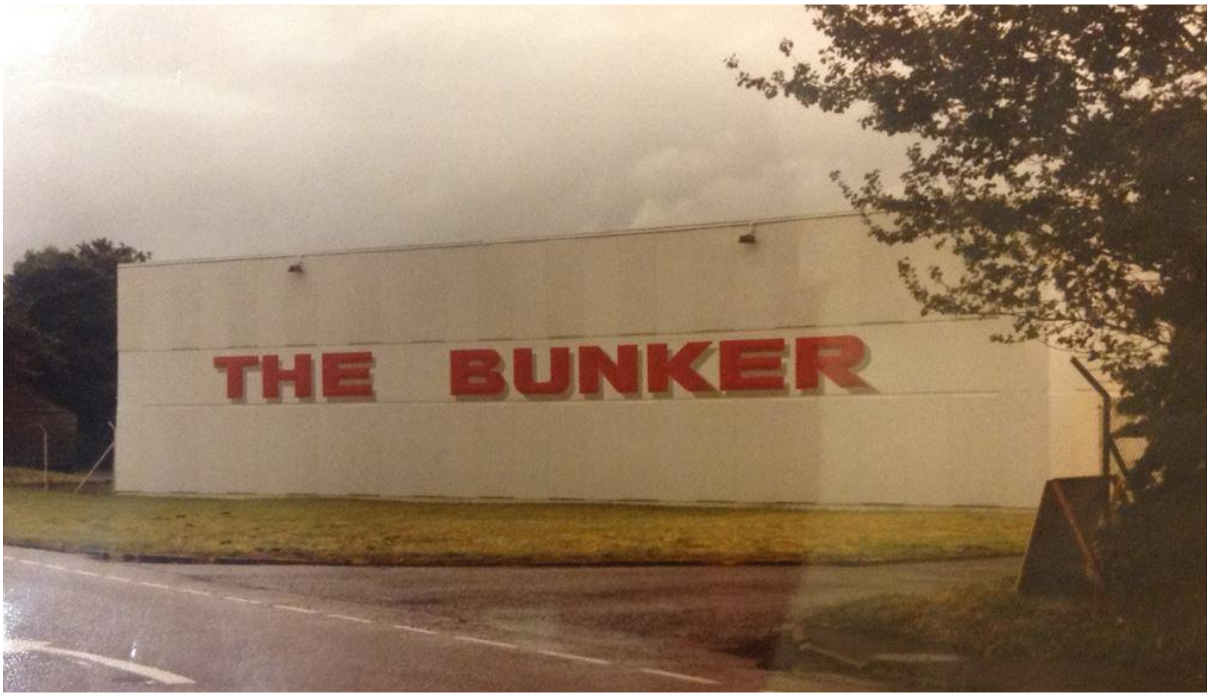

Figure 4.27: Kirknewton as 'The Bunker' nightclub (NRS)

In a seismic shift of global narratives, the previous nuclear threats posed to Kirknewton through blast, fire, and radiation, were, in the end, replaced with threats of deliberate demolition, or as Cairns and Jacobs ascribe it; 'architecture's mortal enemy'.[733] From a heritage and conservation perspective what is crucially important about Kirknewton's demolition is that it was conducted in full accordance with statutory Scottish planning legislation[734]. Unlike its surviving twin at Cambridge, Kirknewton was never deemed historically significant enough by anyone to be suggested for listed building status and was thus never assigned heritage protection. Although its architectural and historical importance were eventually noted within an unpublished thematic review produced by HES in 2007, its afterlife had already been curtailed before having the opportunity of garnering any serious attention, either publicly, through professional practice, or academically[735]**.** Therefore, when Kirknewton's post-Cold War owner decided to demolish the building in 2003, there was no community group defiantly arguing its case for retention or restoration, as per the afterlife of Gairloch and Barnton Quarry bunker as outlined within this thesis. This epilogue thus aims to serve a warning to the detrimental and irreversible impacts of demolishing Scotland's last remaining Cold War nuclear bunkers. The only way of preventing future loss under Scotland's current heritage framework is by furthering more in-depth studies through a combined methodology of fieldwork and archival analysis – as per the case studies within the previous chapters. By doing this we can expand broader awareness to the importance of these buildings. As a first step, this thesis contributes a template and platform for further research to assist placement within formal architectural history and will be outlined within the conclusion through three main recommendations.

Figure 4.28: Cambridge façade within the modern-day residential housing scheme

[733] Cairns and Jacobs, p. 196
[734] Kinnear, *Reopening the Bunker*, p. 14
[735] Devon DeCelles (Designations Officer at Historic Environment Scotland), email to author, October 13, 2017.

CONCLUSION

5.1: Full Circle: Far-reaching Fallout

As we know, the grave concerns and global threats raised at the start of this thesis did not materialise and thankfully, there was no nuclear attack on Scotland, Britain, or anywhere else[736]. However, this should not deflect from the fact these nuclear bunkers were extensively used throughout the Cold War in both simulated rehearsals as well as remaining in constant states of full readiness for the unthinkable event of nuclear conflict. Although their mortal enemy now lies with decay, vandalism and more threatening issues of forced, yet unnecessary, demolition they continue to demonstrate an ability to survive their individual post-Cold War afterlives and carry an influence over the civil architectural realm. Damaging misconceptions of waste should not detract their architectural merits when assessing building histories for future preservation and expanded study. For unlike other examples of poorly constructed Brutalist schemes across Britain, which have since been demolished out of necessity, some nuclear bunkers have long outlasted civil buildings that were constructed during the very same period. As evidenced through the examples of reuse, conservation and restoration outlined within this thesis, Scotland's Cold War nuclear bunkers convey a concept of going full circle with many more far-reaching impacts than previously considered.

By bringing nuclear bunkers out of the shadows, this thesis presents the first authoritative account which reveals they should no longer be considered examples of 'non-architecture' 'immune from planning regulations' as claimed by previous critiques cited within this thesis (see chapter 2). Rather these nuclear bunkers were a new architectural typology, specifically generated in response to the nuclear threats borne out of Cold War tensions. Furthermore, this typological evolution experienced between 1950 and 1970 saw the nuclear bunker depart from the rigidity of its historical military precursors and migrate towards buildings more aligned with the civilian realm that brought with it an unprecedented flexibility—one which not only enabled their continued repurposing both during and after the Cold War but have since adopted diverse functions beyond the in-situ museum. For instance, while Kirknewton (and its Cambridge twin) and Barnton Quarry permitted continuous recycling during the paradigm shifts of changing Cold War threats, their architectural flexibility has also enabled these nuclear bunkers to be adapted as nightclub venues, specialist artifact storage units and creative restoration communities. Boyd and Linehan's critique describe bunkers as the 'antithesis of modernity', underpinned by an 'architecture of stasis' and expressed 'continuation without development'[737]. However, the detailed case studies presented within this thesis counters this by conveying an inherent ability of nuclear bunkers to maintain their architectural development and ensure continued use both during and after the Cold War.

By bringing Scotland's nuclear bunkers out of the shadows and positing them alongside civil architecture for the first time, this thesis highlights the tangible, yet secret, relationships that ultimately shaped and influenced both narratives. Whether it was in-direct or direct influences, with every push and pull of nuclear bunkers, there were, in turn, ripple effects experienced through both nuclear bunkers and civil architecture. As a result of this tussle, public works (including housing, schools, hospitals, and universities) across Scotland were either delayed, reduced, significantly altered, or cancelled entirely. The broader impact of this relationship can be extended to larger narratives. It is particularly interesting for example, that the removal of steel rationing across Britain in 1954 seamlessly aligned with the first phase of the ROTOR air defences becoming operational to protect Britain from long-range Soviet bombers. Other examples are found in shifting government

[736] This is not to detract from the harmful and long-lasting impacts from the years of atmospheric nuclear weapons testing highlighted in the research of Becky Alexis-Martin

[737] Boyd and Linehan, *"Becoming atomic*", p. 253

patronage from one extreme to another, where nuclear bunkers and civil architecture continued to tussle over priority. Part of this secret balancing act saw nuclear bunkers transition from high-ranking military priorities (assigned scarce materials and labour ahead of civilian needs) to becoming side-lined and shelved.

In response to the complex issues presented by Cold War threats, nuclear bunkers were initially assigned the highest priority (ahead of all civilian needs) by the British Government to facilitate the completion of vital defences. By bringing nuclear bunkers out of the shadows, this thesis highlights how key innovations from nuclear bunker creation inadvertently transferred to public works. More significantly, some of these innovations were used in nuclear bunkers ahead of well-known systems within the civil realm. Such as the forging of consortiums (between professional RIBA architects, contractors, and consulting engineers) to develop specialist expertise in concrete construction and advanced project management.

Lastly, this far-reaching fallout of nuclear bunkers also offers under explored avenues for a broad spectrum of other disciplines that have yet to encounter these sites. Enthusiasts, academics, non-scholars, and those with personal interests in history can share fruitful discoveries and contribute new knowledge to various fields. Despite the apparent disparity of female voices cited within this thesis it is essential to highlight that these avenues are open for multiple demographics and in a shared resonance with Luke Bennett we should not assume 'bunkerology' is a practice of exploring nuclear bunkers exclusive to men[738]. As noted within the introduction, there were very few women accredited to being involved with nuclear bunkers at the time of creation. Crucially, this is not a fair reflection of the actual contributions made by women civil servants but is typically reflective of the wider male-orientated historical narratives, which must continue to be redressed. Importantly, in terms of Cold War nuclear bunker research there is a notable growth in interest from women as evidenced through the *subbrit* fieldwork and study groups I have engaged with throughout this thesis. Therefore, Cold War nuclear bunkers should be recognised for offering rich hunting grounds for anyone, of any gender, interested in the history of construction project management, construction, politics, and economics, as well as the more focused sub-genres within architectural history including concrete material histories, Brutalism and Megastructure discourse, town and country planning,

In summary, nuclear bunkers represent some of the most important architectural fabric of the Cold War whilst proving vital in the broader development of Scotland's (and Britain's) post-war rebuilding. The proximities shared across the built examples and mainstream architectural scholarship are incredible. Understanding this previously unknown relationship is paramount to further developing invaluable knowledge called upon by heritage-based investigations, when reviewing policy frameworks on protective measures, and enabling creative adaptive reuse opportunities.

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[738] Luke Bennett, Who goes there? Accounting for gender in the urge to explore abandoned military bunkers, *Gender, Place & Culture*, 20 (2013) 630-646

5.2: Recommendation I: Robust Recording

While this thesis has established a series of previously overlooked parallels and channels of influence between Scotland's nuclear bunkers and post-war civil architecture, further inextricable connections that simultaneously lassoed both realms are yet be revealed. As an optimum solution, this expanded study would facilitate the broadening of historical understandings of these architectural assets to ultimately secure heritage protection against future threats of erasure through listed building, or scheduled monument status. It must be acknowledged, however, that achieving heritage protection for any building in Scotland is a complex and often lengthy process that in some cases may not result in a successful outcome. Additionally, while formal heritage designation provides a better degree of protection than unlisted buildings it does not render a building entirely immune to erasure through decay, vandalism, or demolition. Alternatively, robust recording can serve a more feasible and immediate approach until more radical changes to Scotland's heritage framework provides better long-term viable options for these building types. By employing a combined methodology of comprehensive fieldwork surveys and detailed archival study, as utilised in my research approach, we can continue to bring Scotland's Cold War nuclear bunkers out of the shadows.

Given the timely nature of the threats posed to the survival of these buildings an urgent review is first required on Scotland's existing Cold War nuclear bunkers to both categorise and determine the more precarious sites at risk and their current state. Such categorisation could adopt a simple grading system to identify basic parameters; for example, ranking the rarity of an existing site as well as noting the condition of its architectural fabric (grading bunkers from excellent to poor). Importantly, this process must be conducted in close alignment with the similar research interests from an English context, as this will enable cross-border identification of rare and at-risk sites across Britain. For instance, if a bunker in Scotland demonstrates an historical and architectural rarity for the whole of the U.K. then this status must be reflected in its record. Likewise, if its condition is recorded as being poor or very poor this should facilitate different priority levels. Once sites have been identified and graded their existing fabric can then be recorded using detailed photographic surveys, measured drawings, and archaeological excavations alongside curating a more complete factual record from the available archives. Moreover, forging new relationships with private bunker owners, government departments and third parties can facilitate this recording process by obtaining permissions with site access to overcome the previously identified research problems. Similarly, by working closer with the likes of heritage professionals and archaeologists (amongst others) through a multidisciplinary, transnational lens, integrating architectural history research can positively assist recordings and bridge some of the identified research disparities between Scottish and English work. Crucially this will use the previous work completed within the English context along with an updated review of the abovementioned (unpublished) HES desktop survey as a baseline.

Although this thesis has made positive inroads to deciphering the now-declassified records of Scotland's Cold War nuclear bunkers, and navigating the defunct government departments that were responsible for their creation, operation, and disposal there is much more to be disseminated from central depositories held at the likes of the National Archives and National Records of Scotland; the primary records noted in the following reference section provide a useful starting point. For example, overview analysis should be conducted for the ROTOR type bunkers using the Air Ministry files held in the National Archives to establish a more extensive framework for Scotland's Cold War nuclear bunkers within the British-wide network.

In short, the above processes should centre on the principal aim of bettering our architectural history of Scotland's Cold War nuclear bunkers and thus facilitating listed building status as and where required. However, in the event this approach fails, and site(s) are signed off for demolition, as a last resort we should attempt to conduct a comprehensive physical and digital record prior to erasure. By focusing this recording on the identified areas of interest bunkers can be efficiently and feasibly preserved in the digital sense to enable future studies and analysis once the physical fabric is no longer there.

5.3: Recommendation II: Heritage Policy Review

As outlined in the introduction, Scotland's overlooked Cold War heritage is not due to a lack of interest or an unwillingness of its heritage bodies to expand further research but is instead found at a higher policy level with which the devolved Scottish Government now administers. Therefore, any means of furthering this research must be addressed by revisiting the current policy, and while parliamentary budget constraints carry very real issues and limitations, several intermediate steps can assist these efforts until more long-term policy changes are ratified.

At a more feasible level we can begin removing some of the more complex misconceptions of inherent violence, ambivalence, and repulsion previously attached to these sites and reconstruct more accurate perspectives. This insight goes some way to alleviating any implication that Scotland's nuclear bunkers are enmeshed with traumatic issues of slave labour, foreign occupation, and physical conflict only associated with other sites, that can hamper successful designations. I therefore call for these buildings to be re-considered on the firmer architectural history grounds as presented in this thesis. If we elevate these nuclear bunkers as being closely aligned with civil architecture, there is significantly more potential for broader recognition without the risk of valorising sites with dark pasts.

5.3.1: Broader Bunker Engagement

In the meantime, there is reasonable scope to begin revisiting the current heritage frameworks and integrating overlooked architectural histories to engender more cross-disciplinary opportunities. For example, knowledge exchange and wider awareness of these buildings can be achieved through avenues including public talks, workshops, conferences, guided tours or large-scale informative events like the Doors Open Days (successfully applied at Barnton Quarry's restoration in Edinburgh). From this wider community engagement, we can encourage insightful education to the architectural and historical importance of Cold War nuclear bunkers. Collectively, by assembling these varied, yet shared research efforts, we can establish a more robust platform that can be widely used across Britain's Cold War nuclear bunkers and demystify the previously misplaced implications.

Specialist consultants can also be employed to provide vital research assistance and contribute toward facilitating this broader bunker engagement between architectural historians, archaeologists, and heritage-based professionals. Not only is this consortium of Cold War nuclear bunker experts largely missing from discourse, but glaring gaps evident with Scottish research contexts, calls for a more urgent catch-up to gain parity with the work already completed by English-centric studies since the early-2000s.

5.3.2: Emergency Action

By amending the current policy underpinning Scotland's heritage frameworks, more statutory measures can be taken at government level to enable proactive surveying and more robust recording of targeted sites to assist future listed building designations. Extended powers made available to HES for example, could serve as emergency action reserved for certain situations. Through these statutory powers we could protect Scotland's Cold War nuclear bunkers in situations where they faced serious risk of demolition and removal. In addition to Kirknewton's sanctioned demolition, the bunker at Gairloch also faced peril in the early days of the project. For instance, the AAOR type bunker encountered issues during the initial procurement after it was placed on the open property market by the Highland Council. Despite requests to have the building listed until the community trust had secured funding, the application was rejected by HES on the rationale the similar Category B listed AAOR bunker at Craigiehall, Fife, was sufficient enough for Scotland's heritage portfolio. As a compromise, Gairloch was subsequently placed 'at risk' on the Scottish Buildings at Risk Register – the online database for buildings of architectural and historical importance facing existential threats[739]. Crucially, unlike the 'Building Preservation Notice' which offers temporary protection of an unlisted building to delay demolition or drastic alterations, the Buildings at Risk Register holds no legal powers whilst HES conduct the required assessments for listed-building consideration[740]. In the meantime, more specialist Cold War nuclear bunker research can and should be encouraged within discourse until the required changes are implemented at national policy level[741]. Fortunately, Gairloch evaded potential erasure and has since developed into an invaluable community centre and museum, but this positive outcome is not always guaranteed,

5.3.3: Component Pools

Lastly, aside from these more ambitious proposals less-onerous measures can also be implemented at ongoing and future bunker restoration projects. As per the Barbican's parts exchange scheme noted by Barnabas Calder, where residents can share original fixtures and fittings to maintain the architectural character, similar schemes can also provide assistance on a manageable level. Specific support grants like those currently offered by HES would take time to establish given the bureaucracy of national heritage policy, but less-formal component pools could be setup in the meantime[742]. For although the original product ranges of fixtures and fittings as installed within nuclear bunkers are no longer in production, the likes of Friedland bells and MEM switchgear, matching original specifications have found in backstock or salvaged from other buildings of the civil realm owing to their off-the-shelf availability outlined in chapter 3. These are still available for affordable procurement through online marketplaces like eBay[743]. A specialist component pool curated for Cold War nuclear bunkers would not only help ensure historical authenticity at faithfully restored sites and thus satisfy HES designation criteria, but it would also further sustainability credentials in recycling old parts (otherwise destined for landfill) rather than purchasing newly made items.

[739] Dr. Karen Buchanan (Curator at Gairloch Heritage Museum), email to author, June 31, 2017.
[740] Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997, https://www.legislation.gov.uk/ukpga/1997/9/section/3 [Accessed May 2, 2022]
[741] Kinnear, *Reopening the Bunker*, p. 14
[742] Calder, p. 117
[743] During my thesis research I have procured original component parts: including Friedland Industrial bells that can be installed as per original interior fit outs for the 1950s and 1960s nuclear bunker programmes.

5.4: Recommendation III: Adaptive Reuse Credentials

As outlined in this thesis, Scotland's nuclear bunkers have continued to function through varied post-Cold War adaptive reuses of civilian configuration, primarily due to the typological shift in configuration outlined above these reuses include opportunities well beyond prosaic Cold War military museums.

Given the historical importance of the ROTOR programme, it is worth highlighting the nuclear bunkers of this specific typological framework that have subsequently seen successful reuse. For instance, although the AAOR at Gairloch initially served the nearby anti-aircraft batteries in Loch Ewe, this building was never actually used in a real scenario of conflict. Upon the dissolution of anti-aircraft command in 1955, however, the bunker continued to be utilised as a part of Scotland's civil defence network before it was eventually absorbed by the Highland Council for use as the road's department storage unit[744]. After lying dormant and deemed surplus to requirements, it was publicly sold and has since been successfully repurposed as Gairloch Museum; a vital multi-purpose community hub including a heritage centre, gallery space, archive, library, film theatre, and remote learning facility for students at the University of Highlands and Islands.

Gairloch Museum is a strong case for evidencing how community trusts can rally and save these buildings from the scrapheap whilst also demonstrating how monolithic constructions can be adapted with careful concrete coring, removal, and plugging of leftover service penetrations. Despite some assumptions, this reuse approach is far more financially viable than demolishing the building and constructing anew. Moreover, these alterations to the existing concrete were achieved through a shared philosophy across the entire the project team to maintain as much of the original structure as possible. Not only were the original blast-proof doors retained in situ, but the sections of exposed raw concrete are also left in a fantastic 'as-found' Brutalist-like expression. The standardised off-the-shelf components, surface mounted throughout via lengths of electrical conduit, serve a worthy companion to the exposed services initially installed for protection against nuclear attack[745] .

If we recall for a final time the National Grid connections maintained across these sites, there may be additional opportunities for harnessing renewable energy. For instance, there is further scope to repurpose some of the larger facilities as solar energy farms by installing Photovoltaic (PV) cells; either on the open grass mounds surrounding the rural sites or on top of bunker roofs – currently being developed at Gairloch. Not only could this strategy generate clean electricity to power these sites, which is often the most onerous overheads in bunker museums, but it could also feed back into the mains supply for distribution to the civilian population.

Other ROTOR programme sites, such as the R3 bunker at Anstruther, has been open to the public as a successful visitor attraction since 1994. Although its primary museum function serves *Scotland's Secret Bunker,* the building is also available for various function hire[746]. On the other hand, the R1 bunker at Inverbervie is now a private dwelling and offers an equally diverse set of functions. For instance, it offers a unique Airbnb experience of sleeping in the old guardhouse bungalow (with an inclusive tour of the underground bunker offered to guests). The subterranean bunker space operates as the 'Bervie Brow Research Station', described as a 'home, research centre, stage for creative work, and source of inspiration' while extending availability for professional photography

[744] Dr. Karen Buchanan (Curator at Gairloch Heritage Museum), email to author, June 31, 2017.
[745] Kinnear, *Reopening the Bunker*, p.13
[746] When inquiring about booking the bunker as a venue for my thirtieth birthday party I was informed the base hire price (excluding catering, entertainment, etc.,) came in at £2000 – a considerable price undoubtedly influenced by its expensive overhead costs for hosting large groups of people.

and filming opportunities[747]. Likewise, the Craigiebarns ROC Group HQ in Dundee is also used as a filming location as means of generating vital income for supporting the ongoing restoration and maintenance costs. It is important to note that further examples of repurposing can be found outwith the ROTOR programme. For instance, the East Kilbride War Room bunker (which was awarded Scheduled Monument Status in 2004) that initially functioned alongside Kirknewton 1950s bunker network, is currently exploring reuse opportunities with planning proposals tabled for converting the Cold War nuclear bunker into a contemporary office building.

Going beyond Scotland, we can draw again on the repurposing of Cambridge bunker by the University of Cambridge. Given these types of structures can be feasibly reconfigured with modern technology to provide advanced climate control systems required for storing fragile artefacts or art. On the other hand, given robust concrete construction, are also ideally suited for the likes of secure data storage facilities or a range of other valuable collections. Vitally these solutions can be made with minimum alterations and, at times, virtually no loss of architectural character[748]. Ultimately, had this expansive reuse potential been wider known at the time of Kirknewton's demise, it may have saved the building from demolition.

Lastly, from this architectural perspective these recent examples can and should be recognised as catalyst projects – especially given the current climate crisis. Instead of being perceived as 'awkward' hindrances, these nuclear bunkers should be recognised as core assets, especially under the government's aim of reducing carbon emissions (given how concrete is better kept and reused than being demolished) and thus I argue the for retaining more bunkers for sustainable redevelopment instead of wasteful demolition and increased carbon emission.

Figure 5.1: Gairloch AAOR before adaptive reuse

[747] Harry Willis Fleming, "Bervie Brow Research Station." HWF. http://www.hwf.co.uk/research-station/index.html/ [Accessed March 2, 2022]
[748] Kinnear, *Reopening the Bunker*, p.13

Figure 5.2: Gairloch Museum during construction

Figure 5.3: Gairloch Museum rooflight cored into concrete

Figure 5.4: Gairloch Museum 2020 (Ross-Shire Journal)

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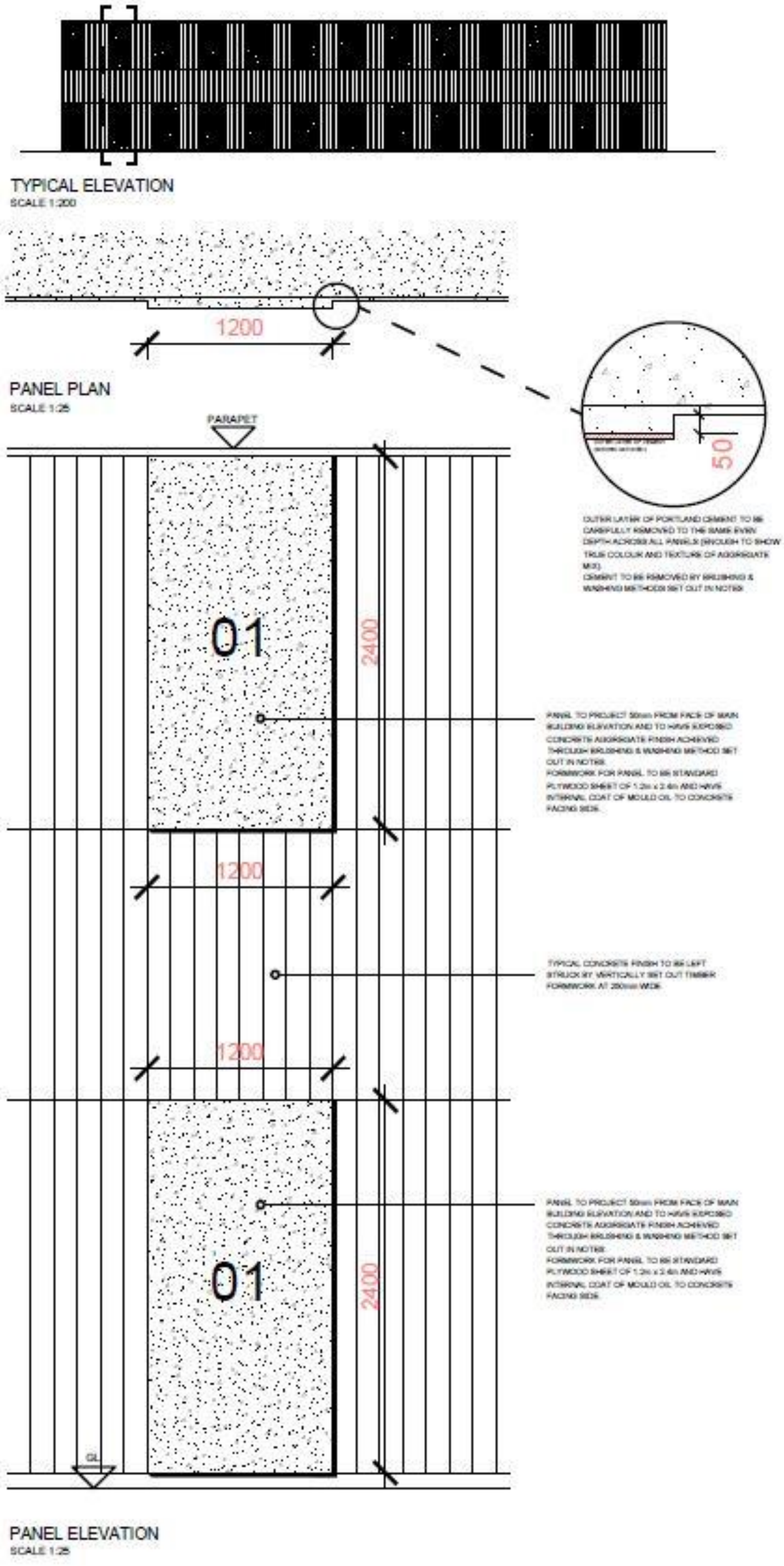
Appendix



01

BRUSHING & WASHING METHOD

STIFF BRISTLE (SCRUBBING) OR WIRE BRUSHES TO BE USED IN REMOVAL OF OUTER LAYER OF CEMENT STARTING FROM THE BOTTOM OF PANELS AND WORKING UPWARDS.

THE DEPTH OF CEMENT REMOVED SHALL BE ACHIEVED AT THE BOTTOM OF THE PANEL WILL BE MAINTAINED ACROSS REMAINING PANEL SURFACE AND REPEATED AS NECESSARY (8-10 TIMES FOR PANELS ACROSS ALL ELEVATIONS)

CARE IS TO BE TAKEN WHEN BRUSHING SO THAT CEMENT IS REMOVED TO A MINIMAL DEPTH AND ISOLATED AREAS ARE NOT EXPOSED UNEVENLY THROUGH VIGOROUS BRUSHING. THE DEPTH OF CEMENT REMOVED SHALL BE ENOUGH TO REVEAL THE TRUE COLOUR AND TEXTURE OF AGGREGATE TO AN EVEN FINISH ACROSS WHOLE PANEL AREA.

DURING THIS PROCESS OF CEMENT REMOVAL THE BRUSHES ARE TO BE CONSTANTLY CLEANED IN A BUCKET OF WATER TO ENSURE THE BRISTLES ARE NOT CLOGGED WITH THE WET CEMENT.

ONCE THE CEMENT HAS BEEN CAREFULLY REMOVED TO A CONSISTENT DEPTH AND THE AGGREGATE IS EXPOSED EVENLY ACROSS THE PANEL THE SURFACE AREA IS TO BE SPRAYED WITH WATER AND LIGHTLY BRUSHED WORKING FROM THE TOP OF THE PANEL TO THE BOTTOM TO CLEAR ANY REMAINING MORTAR.

NOTE: THE ABOVE BRUSHING AND WASHING PROCESS IS TO BE CARRIED OUT AS SOON AS POSSIBLE AFTER THE REMOVAL OF SHEET PLY FORMWORK AND TO BE COMPLETED WITHIN 18 HOURS BEFORE THE CONCRETE IS CURED. FAILURE TO DO SO WILL NOT PERMIT BRUSHING AND WASHING METHOD TO BE EMPLOYED.

AS SOON AS THE GROUND FLOOR SHUTTERING PANELS ARE REMOVED THEY ARE TO BE CAREFULLY CLEANED OF ANY RESIDUAL CEMENT OR DEBRIS. PANELS ARE TO BE STORED IN A DRY PLACE UNTIL REQUIRED FOR ASSEMBLY IN FORMWORK OF UPPER LEVEL.

Exposed Aggregate Finish Study

1960s Brushing and Washing Method