Segregated specialists and nuclear culture[1]

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Introduction

Communities of nuclear workers – the engineers, technicians, scientists and technologists who developed and sustained atomic energy – evolved in distinctive contexts. They were first recruited in large numbers during the wartime Manhattan Project linking the USA, UK, and Canada to develop reactors, isotope separation plants, and atomic bombs. In the process, the participants formed distinct cadres of specialist industrial workers.[2]

The most characteristic and enduring feature of this workforce was its seclusion and secrecy. Postwar workplaces were inherited from secure wartime facilities or built anew at isolated locations. Nuclear specialists at new national laboratories were segregated and cossetted to gestate and protect their practical expertise. At Oak Ridge, Tennessee, government-vetted participants at the 'Clinch College of Nuclear Knowledge' were 'like children in a toy factory', exulted its Director, as they learned how to industrialise the use of radioactive materials. His counterpart at Chalk River, Ontario sought to establish a project 'completely Canadian in every respect', while the head of the British industrial programme chose the remote Dounreay site in northern Scotland because of design uncertainties in the experimental breeder reactor.[3]

As secrecy gradually slackened, the hidden specialists lauded as 'atomic scientists' gradually became more visible as new breeds of engineers, technologists and technicians responsible for nuclear reactors and power plants. Their workplaces and towns were configured by government objectives and commercial contractors. The occupational models and very identities of these exotic workers were exported to other countries along with American, British and Canadian reactor designs and the more stealthy weapons development programs adapted by other countries. These attributes remained largely 'locked-in' as subsequent generations continued to inhabit quarantined institutional environments.[4]

This chapter examines the experiences of nuclear specialists and the significance of their sheltered milieus. It explores how career identities were constructed by their secluded working environments in the countries that first collaborated on the development of nuclear energy, and how these models continued to inform trans-national contexts thereafter. The new experts gained varying degrees of visibility and influence in the ecosystem of professions and in their respective national cultures. My focus is on 'history from below', following the engineers and technologists rather than scientists and senior policy-makers who became visibly associated with the subject. Shaped successively by Cold War secrecy, commercial sensitivities and perceived terrorist threats, the practices of nuclear energy and its specialist workers have remained out of sight for wider publics. Initially overlooked in both popular representations and historiography, this cohort eventually came to embody the perceived successes and failures of atomic energy programmes. Their distinctive contexts reveal how the experiences of these technical workers have shaped public perceptions and their own self-identity.

Phases and forces

Secrecy made the practice of atomic energy unique in modern science and technology. The subject was framed by government policies and contract milestones and was reshaped episodically by industrial accidents. As a result, distinct public and occupational representations of nuclear workers can be discerned during the decade of postwar national experiments 1945-54; the implementation of nuclear power, c1955-69; the re-evaluation of nuclear programmes c1970-86; and the post-Chernobyl era after 1986, which seminal nuclear engineer Alvin Weinberg dubbed 'the end of the first nuclear era'.[5] Different national and institutional contexts created templates for nuclear workers during the first post-war decade, when security concerns choked off international exchanges of information, and had lasting effects for professional identity. By adopting a comparative perspective we can distinguish shared and unique features of national nuclear cultures.[6]

Throughout these periods, top-down depictions of nuclear specialists were mediated by their governments, regulatory bodies, and commercial contractors, serving optimistic rhetoric of national expertise, progressive goals, and modernization through science. These themes were equally important in the Soviet sphere, but I argue that in the Western democracies the relative prominence and status of engineers were more contested.[7] Professional identity within nuclear workplaces was also constrained by competition with other more established technical specialists.[8] I trace the corresponding engineering culture through social and cultural markers: occupational identity, defined by the categorizations and hierarchies at each site of employment; professional identity, constructed by negotiation of jurisdiction with existing professions; and, public identity depicted in popular texts and cinematic portrayals and via the agency of employers and institutions.

Wartime workers and company towns

The close association between government-directed atomic research, commercial contractors and secure sites was set early. The feasibility of a wartime atomic bomb project had been studied by academics overseen by the UK Ministry of Supply from 1940, but was expanded in the USA and Canada from 1942. The Canadian project to design a reactor started work in Ottawa and Montreal supported by engineers from Imperial Chemical Industries (ICI), but later in the war moved to Chalk River, an isolated stretch of forest on the Ontario/Quebec border. Similarly, early academic studies in New York and Chicago were quickly industrialised, quarantined and censored. Managed largely by the Du Pont Company, this led to the establishment of ever-more sequestered sites in the Argonne Forest near Chicago for a prototype nuclear reactor; at Oak Ridge, Tennessee (developing a pilot-plant reactor and methods to separate uranium isotopes), Hanford, Washington (home of three mammoth production reactors to generate plutonium) and Los Alamos, New Mexico (to develop distinct uranium and plutonium weapons). These five sparsely populated North American locations were the seeds of postwar national laboratories and associated new towns. They trialled both secret cities and Big Science, in which corporations and governments worked together to manage strategically-important technologies.[9]

Just as importantly, the locations were inaccessible working and living environments in which hybrid engineering practices were developed by, and for, thousands of technical workers. The undisclosed work – never explained to participants beyond necessity – was often mindlessly repetitive, dangerous, and demanding of close attention. The job tasks combined ignorance with personal responsibility, and information-sharing between co-workers and families was prohibited.[10]

Conflating engineers and scientists

At these sites, the new specialist engineers – drawn from the ranks of civil, mechanical and chemical workers – lived and worked in the shadow of their scientific colleagues, and their subordinate position was signalled both through occupational hierarchies and subsequent public representations.[11] The first releases of information to the public after the atomic bombings of Japan highlighted the activities of outstanding scientists and administrators while relegating engineering expertise to a secondary role. This theme was sustained by popular accounts elaborated from the Smyth report, the official American account of the Manhattan Project, over the following years.[12] Postwar historiography consequently focused on scientists as key figures.[13]

Given the sparse historical narrative sanctioned by the Smyth report, the first Hollywood depiction, *The Beginning or the End* (Dir. Norman Taurog, USA, 1947), exemplified the new atomic expertise through characters playing prominent scientists (Albert Einstein, Enrico Fermi, Robert Oppenheimer, Harold Compton, Ernest Lawrence), administrators (Arthur Conant, Vannevar Bush, General Leslie Groves) and industrialists (representing Du Pont, General Electric and Union Carbide).[14] Based on such early illustrations, histories of the wartime atomic energy work in the UK, USA and Canada underplayed the growth of engineering knowledge that accompanied it. This neglect of engineering contributions was linked closely to secrecy itself.[15] The essence of the 'atomic secret' was engineering knowledge, not nuclear science, and this was preserved in an atmosphere of rising national security and commercial confidentiality.[16]

An additional contribution to the public understanding of nuclear expertise was the early role played by so-called 'atomic scientists', a term first used by headline writers but rapidly appropriated by the participants themselves. Active principally in the USA and UK and with membership drawn largely from the Manhattan Project sites, contributors to this movement sought a role in postwar policy decisions concerning nuclear knowledge and in urging peaceful applications of atomic energy. In the USA, a visible expression of the social conscience of nuclear experts was the *Atomic Engineer and Scientist*, a periodical published by the Oak Ridge Engineers and Scientists during late 1945 and superseded by the *Bulletin of the Atomic Scientists* that December. In the UK, sharing this new mixture of technical, social and policy concerns, the Atomic Scientists Association launched *Atomic Scientists' News* in 1947, expanded into the *Atomic Scientists' Journal* in 1953. During a brief window of time, their lobbying, publications and other activities gave the movement celebrity and influence in offering unmediated advice to governments and citizens.[17] But while engineers had been early participants in the movement, their public identities were subsumed within the label 'atomic scientist'.[18]

Postwar national labs

This public face for the new field was further consolidated by its postwar organisation. In the USA, the 1946 Atomic Energy Act dramatically ended collaboration with the UK and Canada, and established the new US Atomic Energy Commission (AEC) and National Laboratories. The ratio of scientists to engineers appointed as influential government policy advisors was disproportionate, leaving the technical ranks of nuclear workers voiceless and unseen.[19]

For a decade after the war, security inhibited information exchange within and between all three countries.[20] Its principal American loci were the Argonne National Laboratory (ANL) in Illinois and the Oak Ridge National Laboratory (ORNL) in Tennessee. Both had been seeded during the war by the original staff of the Metallurgical Laboratory of the University of Chicago. These segregated sites played an inordinate role in shaping both the working and public identities of their American participants.[21] Owing largely to the efforts of Argonne's first Director, Walter Zinn, American atomic expertise was neatly compartmentalised and ranked between the design sites at Argonne and Oak Ridge, on the one hand, and the engineer-dominated but subordinate Idaho Testing Station, on the other. Internal hierarchies gave a preeminent role in reactor design to Argonne, relegating Oak Ridge to separations technologies for which chemical engineers dominated the developing proficiency. A gradation of engineering expertise, inversely related to professional status, pervaded the three sites. The relatively remote Idaho and Tennessee sites accentuated this ranking, with Oak Ridge dubbed 'Dogpatch' by Monsanto workers after the 'Li'l Abner' comic strip that parodied a hillbilly community.[22] Even so, these working identities remained largely invisible in public characterisations, which continued to conflate and homogenize these specialists.

Atomic expertise in Canada, the least prominent of the three wartime nuclear allies, was restricted largely to Chalk River, Ontario, until the late 1950s. The 'Atomic Energy Project' was the responsibility of Canada's National Research Council (NRC) between 1942 and 1952. Chalk River's working hierarchies were configured differently from those across the border. As a government-funded research establishment having some similarity to national standards laboratories, the NRC had since the late 1920s developed a cohort of scientists, engineers and technicians working in relatively equitable and fluid relationships. Indeed, its Director, civil engineer C. J. Mackenzie, sought to avoid superior-subordinate relationships between technical workers as far as possible, noting that 'in classic organisational terms, the chart was kept flat and horizontal'. This institutional culture was nurtured by his successors. As summarised by the next NRC Director, chemist E. W. R. Steacie, 'the main thing to do is to develop a character and an atmosphere which distinguish the organisation from all others'.[23]

This uniqueness was recognized both internally and beyond the gates, and served to position the work of Canadian specialists publicly. The aim of Chalk River was also unique: to explore the new field of atomic energy while eschewing military applications. The NRC administrators sought to make the most of their head start to scale up nuclear research and development and, eventually, its commercial potential to serve the national interest. They had aspirations to exploit the emerging field to build the country's research infrastructure and to raise its international status. The organisation fissioned in 1952 to create Atomic Energy of Canada Limited (AECL), a crown corporation that eventually oversaw development and management of nuclear power stations and their export. A distinctively Canadian nuclear culture vaunted the domain of atomic energy and its emerging technical specialists – still sheltered at their remote site.[24]

British hopes, too, for the postwar field were developing in the last months of the war, as the Anglo-Canadian group was completing the first reactor outside the USA.[25] Beginning that autumn, seventy-one senior British engineers and scientists who had worked in Canada returned to the UK to form the nucleus of a national postwar programme.[26] In some respects falling between the two North American programmes, the British expertise in reactor technology was consolidated at two war-surplus sites, partitioned into more clearly demarcated scientific and engineering components than in the USA and Canada. The Ministry of Supply formed the Division of Atomic Energy in 1946, with the remit of developing an atomic bomb despite the country's exclusion from American collaboration. Its first centre of activity was the Atomic Energy Research Establishment (AERE) at Harwell, Oxfordshire, focusing on the science and technology of reactors and isotope separation.

Six months later, an Industrial Group, responsible for designing, building, and operating reactors and separation facilities, was established at Risley, Lancashire. Under former ICI chemist Christopher Hinton, it began to collect technical staff drawn largely from the wartime chemical industries. The first atomic workers were thus shaped by their previous working cultures, notably in how risks were handled. Hinton drew on British chemical industry practice to introduce – for the time – equitable and cautious policies concerning radiation exposure. In planning nuclear facilities and their associated lifestyles, he decided that female workers were to be actively encouraged:

> the houses there are likely to be of small modern types and will not provide full time housewifery work for wives and certainly not for daughters. It is therefore highly desirable that work for as many women as possible should be found jobs in the Factory.

But from case studies it was known that exposure during pregnancy to certain chemicals, and presumably radiation, could cause birth defects. Hinton correspondingly decided that, 'at least as an initial step' women should not be employed 'in process or other buildings where there are minor risks of exposure to mild radiation in the ordinary course of routine duties'.[27] This meant that certain environments became male preserves: process buildings, laboratories, and the Pile (reactor), Process and Separation groups. But it also altered gender roles of the period: women were excluded from laundry work, which involved a comparable radiation exposure risk from contaminated clothing. The secrecy of the British nuclear programme kept such cohorts and practices invisible to wider publics.

Early categories of expertise and representation (c1945-54)

During this postwar decade, these secure facilities explored nuclear reactor design as the fount of new phenomena and applications, and fostered the new specialists who became associated with them. Given the intellectual segregation of the sites, their administrators shaped the professional identities and portrayals of their nuclear specialists. In addition – but with no comparable attention to public representation – the USA and UK established distinct facilities devoted to the design of nuclear weapons; these amply-funded and highly secret niche activities did not become integrated into the body of knowledge that was increasingly labelled *nuclear engineering* by the late 1950s. Thus secrecy bifurcated public understandings of atomic energy.[28]

In these discrete national contexts, and particularly in the American and British establishments, as noted above, engineers attained a relatively low status and visibility in relation to scientists. The internal categorization of engineers and technicians as supporting actors in these projects was underscored by their relative obscurity in the administration of their organisations and lack of roles as spokespersons for their facilities or the field. Scientists, typically assigned to lead development groups, more frequently met reporters, explained goals and directed limited tours.

Such organisational cues flavoured a wave of popular narratives focused on pen portraits of individuals working in atomic energy, most of whom were identified implicitly as scientists. For the uninitiated reporter, the new nuclear sites could be slotted into cinematic stereotypes.[29] Typical of the genre was a Canadian reporter's description of Chalk River, where he found 'a lot of serious-minded young men slipping quietly around in white smock coats writing mathematical hieroglyphics down in books or peering into glass boxes or attentively eyeing electric needles and indicators on vast control boards'.[30] Contemporary newsreel and television images reinforced such descriptions by using unidentified white-coated nuclear workers as backdrops for voice-over commentary.[31]

More nuanced were accounts by *New Yorker* journalist Daniel Lang, who sketched the collateral population living and working at AEC towns such as Oak Ridge. Among them were seeming incongruities such as a physicist who became an ordained Episcopal deacon, and an engineer content to ask no questions about the goals of his work. Lang's narratives rehabilitated those specialists into 'latter-day Merlins... burned by the strange, inextinguishable fire they have learned to create'.[32] These sketches breathed life into lower-tier nuclear specialists but often framed them as components in a complex, concealed system, offering identities constructed from binary opposites and paradoxes. Lang's bemused perspective revealed inexplicable routine in a fairy-tale world, echoing the sentiments of senior administrator James Conant, who had described the Manhattan project as a 'rather strange journey through "Alice in Wonderland"'.[33]

Publications specialising in science teased out more subtle attributes of identity. The British periodical *Discovery* offered a steady flow of articles on the postwar technology, organisation and politics of atomic energy. Typical among them was a description of Harwell and its coy experts:

> When scientists started research on atomic bombs they took a path which was bound to lead away from the free scientific world in which knowledge knew no national frontiers… into a strange murky country of guarded laboratories and secrecy regulations... My inquiry as to the number of scientists working at Harwell was deflected, but ever so politely...[34]

Such caricatures – outcomes of secrecy – exemplified atomic specialists as enigmatic, intelligent and powerful. Yet even these unapproachable shadows contrasted with the AEC perspective presented at the American Museum of Atomic Energy opened in 1949, two years after the town of Oak Ridge was opened to civilian administration. There, visitors could learn of potential applications but almost nothing about the specialists who were behind them.[35]

There was nevertheless a noticeable taint to such representations. The early postwar years were marked by a series of political events and interpretations having international repercussions. Revelations of home-grown incidents of espionage within the Manhattan Project and postwar programmes of each country raised security procedures to higher levels; the Soviet Union followed an independent trajectory to detonate its first atomic bomb in 1949, and welcomed allied governments in China and North Korea; and American politicians claimed subversion within American institutions such as the national labs.[36] International developments raised fears of military use and suspicions about the allegiances of the American, British and Canadian specialists. Atomic culture was shaped by perceptions of weapons and secrecy, and the fears they engendered.[37] Public attitudes in each country underwent a rapid transition from representations of atomic experts as heroic geniuses to mistrusted traitors.[38] Already popularly characterised as unfathomable in terms of intellectual abilities and motivations, the atomic scientists were increasingly castigated as politically undependable and unpatriotic.[39] In the UK, staff at Harwell agonised over participation in the Atomic Scientists' Association, and the Division of Atomic Energy noted conflicts of interests for staff who were working to meet government objectives while publicly urging international openness for the field.[40]

Cinematic depictions reinforced negative interpretations of enigmatic and cloistered nuclear specialists. For example, *The Thief* (United Artists, dir. Russell Rouse, USA, 1952), starring Ray Milland as an American nuclear scientist passing secrets to foreign agents, contains no dialogue at all. For popular audiences, atomic scientists' calls for international sharing appeared both naïve and unpatriotic. An example of the fictionalization of this stance – and contemporary perceptions of it – was the film *Seven Days To Noon* (Charter Film Productions, dirs. John Boulting and Roy Boulting, UK, 1950), in which an atomic scientist steals a small nuclear weapon and threatens the destruction of London unless the Prime Minister renounces military uses. The scientist's actions, judged unbalanced and misguided, are ascribed to his having to work in isolation while carrying untenable responsibilities. Thus idealism and ideology for nuclear specialists were recast as inexplicable deviations from the norm in a period of social conformity. Guiding such readings were the suspicions engendered by confidentiality, and the worryingly impenetrable attributes of a deep intellect. Reflecting their remoteness in the postwar decade, the portrayal of atomic workers was conducted as a pantomime acted by scientists, with engineers relegated to off-stage roles or bit parts.

Visible engineers and unclassified life (c1955-69)

The staging of nuclear workers was transformed mid-decade by the Eisenhower administration's Atoms for Peace initiative (December 1953) and the subsequent UN-sponsored International Conference on the Peaceful Uses of Atomic Energy in Geneva (1955). Their outcome was fuller sharing of knowledge between countries, reshaping of the goals of national programmes towards nuclear power, and trumpeting of the expertise of nuclear specialists by their institutions and governments. For the first time, the still-sequestered nuclear engineers became visible – in silhouette, at least – as national metaphors for progress and modernity.

With new options for unclassified journals and professional representation, an American Nuclear Society (ANS) was founded in 1954 with members drawn from AEC staff and their industrial contractors. While closely linked to AEC perspectives, it offered a first glimpse of nuclear engineering as a nascent commercial field, and of specialists more aligned towards applications than research. American labour unions offered no clear identity, though: most nuclear technicians and process workers were represented after 1955 by the catch-all Oil, Chemical and Atomic Workers' Union (OCAW).

Professional recognition was more contested in the UK. Dominated by the engineering culture inherited from the pre-war chemical industry, occupational categories inhibited creation of new breeds of engineering specialist. For similar reasons, the new UK Atomic Energy Authority (UKAEA, 1954) discouraged new labour unions and curtailed disciplinary aspirations, seeking to promote specialist university training in nuclear technology only as postgraduate add-ons to conventional engineering degrees. The upstart Institution of Nuclear Engineers (INucE, 1959), attracting mainly members from the emerging nuclear power industries, trod warily between the four largest engineering professions (Civil, Mechanical, Electrical and Chemical), which collaborated to form the more prominent British Nuclear Energy Society (1960) as an interdisciplinary engineering body.[41]

The Canadian government, by contrast, encouraged unionization of Chalk River employees who, with Ministerial support, created independent unions divorced from American counterparts and vaunting high-status titles.[42] Achieving a critical mass of nuclear workers proved elusive, however, and an industry-promoting body, the Canadian Nuclear Society (CNS, 1971) emerged later without comparable professional status. In all three countries, though, unrestricted university courses were beginning to appear at the end of the decade.[43]

Despite such indications of budding academic, labour and professional representation, nuclear specialists seldom represented themselves to their peers or to a wider public. A rare self-portrait can be glimpsed in *Nuclear Engineering*, one of the first periodicals to appear during the window of optimism between the first Geneva Conference and rapidly expanding – but more taciturn – nuclear power demonstration projects. Ironically, the few pages of grim humour hint at a neglected cadre of experts stuck between dangerous working conditions and a hierarchical and bureaucratic management (Figure 1). But this was an atypical foray; nuclear engineers failed to establish an independent voice and clear identity, in part because of the corporatist arrangement of government, industry and labour cooperation. Indeed, the close identification of workers with their national projects appears to have stifled any further expression of self-identity.

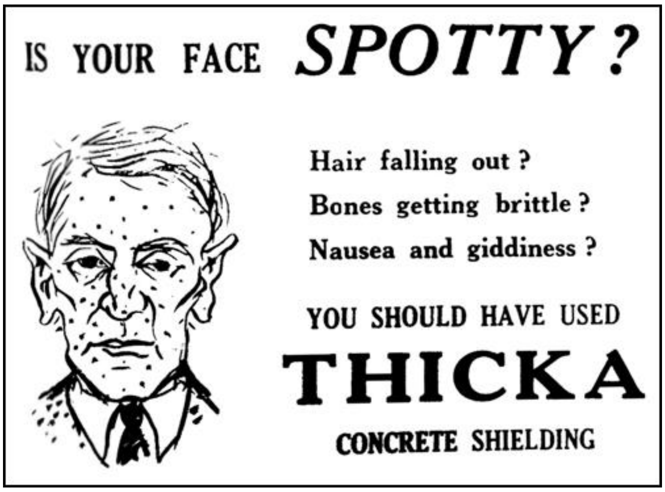
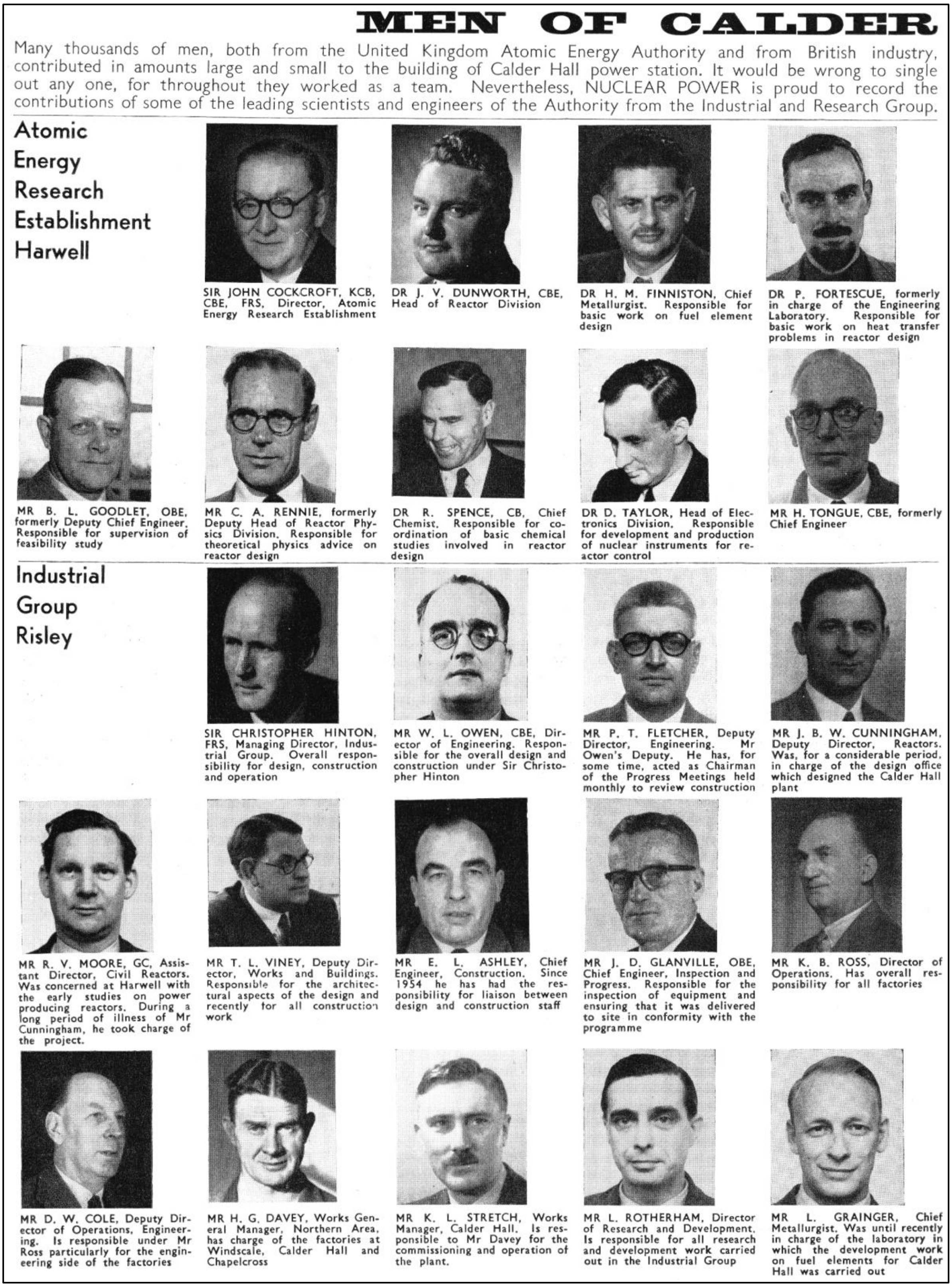


Figure 1: Black humour from a fraught occupation: cartoon from the 'Unclear Times' feature in the Christmas issue of *Nuclear Engineering* 3 (1958), 527.

This communal laryngitis can be attributed to the enduring inaccessibility of nuclear workers and their sites. In each of the three countries, national and corporate facilities remained the primary sites for the developing field. Employment of nuclear specialists was a near monopoly, being limited to posts at the national labs or their commercial contractors. Employment itself continued to be vetted by security protocols, thus filtering the cohort of participants in the field even further. Education and training of the first generation of nuclear specialists originated there, and moved to universities only in the late 1950s as secrecy relaxed sufficiently. Thereafter, government initiatives to encourage national nuclear industries attempted to square the circle, combining efforts to create export industries while limiting proliferation of nuclear weapons capabilities.

This State-managed environment also allowed for an unusual degree of positive rendering, however. Unlike defence industries centred bluntly on nuclear weapons, nuclear power could be depicted in ways that valorised at least some aspects of the expertise of their engineers. With the advent of nuclear power programmes, engineers in each of the original three countries became identifiable as distinct from scientists, and collectively symbolised ideals akin to those first popularised in the Soviet Realist art of the 1930s: dedication, reliability, modernity, teamwork and even bravery.

This unveiling of national experts was best exemplified in Britain, where the Calder Hall nuclear power station was lauded as an international first. Unlike the Manhattan Project accounts of a decade earlier, senior engineers of the UKAEA were praised publicly along with scientists (Figure 2). Popular books and newsreels began to depict more nuclear engineers and technicians than scientists, shifting the field towards a more engaging public portrayal.[44]



MEN OF CALDER

Many thousands of men, both from the United Kingdom Atomic Energy Authority and from British industry, contributed in amounts large and small to the building of Calder Hall power station. It would be wrong to single out any one, for throughout they worked as a team. Nevertheless, NUCLEAR POWER is proud to record the contributions of some of the leading scientists and engineers of the Authority from the Industrial and Research Group.

Atomic Energy Research Establishment Harwell

SIR JOHN COCKCROFT, KCB, CBE, FRS, Director, Atomic Energy Research Establishment

DR J. V. DUNWORTH, CBE, Head of Reactor Division

DR H. M. FINNISTON, Chief Metallurgist. Responsible for basic work on fuel element design

DR P. FORTESCUE, formerly in charge of the Engineering Laboratory. Responsible for basic work on heat transfer problems in reactor design

MR B. L. GOODLET, OBE, formerly Deputy Chief Engineer. Responsible for supervision of feasibility study

MR C. A. RENNIE, formerly Deputy Head of Reactor Physics Division. Responsible for theoretical physics advice on reactor design

DR R. SPENCE, CB, Chief Chemist. Responsible for co-ordination of basic chemical studies involved in reactor design

DR D. TAYLOR, Head of Electronics Division. Responsible for development and production of nuclear instruments for reactor control

MR H. TONGUE, CBE, formerly Chief Engineer

Industrial Group Risley

SIR CHRISTOPHER HINTON, FRS, Managing Director, Industrial Group. Overall responsibility for design, construction and operation

MR W. L. OWEN, CBE, Director of Engineering. Responsible for the overall design and construction under Sir Christopher Hinton

MR P. T. FLETCHER, Deputy Director, Engineering. Mr Owen's Deputy. He has, for some time, acted as Chairman of the Progress Meetings held monthly to review construction

MR J. B. W. CUNNINGHAM, Deputy Director, Reactors. Was, for a considerable period, in charge of the design office which designed the Calder Hall plant

MR R. V. MOORE, GC, Assistant Director, Civil Reactors. Was concerned at Harwell with the early studies on power producing reactors. During a long period of illness of Mr Cunningham, he took charge of the project.

MR T. L. VINEY, Deputy Director, Works and Buildings. Responsible for the architectural aspects of the design and recently for all construction work

MR E. L. ASHLEY, Chief Engineer, Construction. Since 1954 he has had the responsibility for liaison between design and construction staff

MR J. D. GLANVILLE, OBE, Chief Engineer, Inspection and Progress. Responsible for the inspection of equipment and ensuring that it was delivered to site in conformity with the programme

MR K. B. ROSS, Director of Operations. Has overall responsibility for all factories

MR D. W. COLE, Deputy Director of Operations, Engineering. Is responsible under Mr Ross particularly for the engineering side of the factories

MR H. G. DAVEY, Works General Manager, Northern Area, has charge of the factories at Windscale, Calder Hall and Chapelcross

MR K. L. STRETCH, Works Manager, Calder Hall. Is responsible to Mr Davey for the commissioning and operation of the plant.

MR L. ROTHERHAM, Director of Research and Development. Is responsible for all research and development work carried out in the Industrial Group

MR L. GRAINGER, Chief Metallurgist. Was until recently in charge of the laboratory in which the development work on fuel elements for Calder Hall was carried out

Figure 2: The hierarchy of a profession: the 'Men of Calder', with the Harwell Research group 'over' the Risley Industrial group.[45]

The qualities associated with nuclear workers expanded to suit the new rhetoric of atomic energy as an important ingredient in national status and prosperity. British contributors could now be portrayed by their government and editorialists as world-leading, tenacious in their dedication and forward-thinking. Such rhetoric could be enriched by the sacrifices imposed by the country's exclusion from American collaboration, and the resource limitations demanded by the dire postwar British economy. Emphasising different national themes, Canadian successes justifiably cited the NRX (1947) and NRU (1957) reactors which produced unmatched neutron intensity, and the commercialization of the 'cobalt bomb' (1951) which democratized medical radiotherapy and vaunted peaceful applications.

Heroism, too, became an evanescent attribute of nuclear workers. The audacity of world firsts was underlined by public admission of engineering accidents. While the earliest incidents were played down or went unmentioned, a problem at Britain's Windscale reactors in the spring of 1955 involving a broken fixture and stuck fuel elements was recounted a year later in a series of newspaper articles as a combination of courageousness, cool thinking and British pragmatism.[46] Similarly, the selfless role of 'atomic engineers' in disarming a nuclear test at the Nevada Proving Ground thrilled readers of *Life* magazine in 1957.[47] This representation of nuclear workers as calmly and even heroically competent fitted neatly with the serious nature of safety concerns surrounding radiation, and the security concerns that still restricted dissemination of knowledge. Nuclear specialists would serve as wise protectors to build, design and repair nuclear facilities, with C. P. Snow's *New Men* in the guise of engineers or, indeed, as the technocratic elite envisaged between the world wars by American antecedents such as Thorstein Veblen and Howard Scott.[48]

To a wider American public, the roles of nuclear engineers could be portrayed more subliminally. With official underpinning, *Our Friend the Atom*, launched as a 1957 Walt Disney book and television film, beckoned to a world transformed by the atomic age.[49] The original cartoon project, initiated by the United States Information Agency, was produced with the cooperation of General Dynamics (responsible for the *USS Nautilus* nuclear submarine) and the US Navy, and was followed by an atomic submarine ride in the new Tomorrowland attraction at Disneyland. The collaboration proved profitable for Disney and simultaneously promoted a beneficent public image of applied (and commercialised) atomic energy and its associated (but still shadowy) specialists.

Such depictions also served a new generation of young people's books communicating the adventure of this new field as a modern profession, ranging from nuclear technologists to research engineers.[50] For young American men, the more pragmatic texts such as *Atomic Energy in Industry* offered a first glimpse of the variety of craft trades and technician jobs becoming available. It highlighted the current shortage of labour, the adaptability of existing skills to the new field, and the practical facts of radiation exposure in the pragmatic way that the dangers of electrical current had been described to earlier generations.[51] By the early 1960s the UKAEA, too, sought to present nuclear power as a career that was modern, accessible and exciting for young Britons. One career guidance book led its adolescent readers through a visit to an industry exhibition, convincing its fifteen year-old principal character to leave school to pursue industrial apprenticeship combined with college courses to become 'Alan Martin, Reactor Engineer.[52] It reiterated the British slant on nuclear expertise as a practical add-on rather than a discipline in its own right. From Christopher Hinton's wartime experiences in industrial organisation, then, children of the baby boom generation were being shaped for a British industry that was both new and old.[53]

The cultural attributes of nuclear workers traced above also became evident to other professionals. The sociologists behind a 1962 American study suggested that professionalization would be promoted by the 'element of awe', 'apprehension' and 'aura of mystery' which set nuclear workers apart in the eyes of the general public, and suggested that the specialists would attain high status akin to that of airline pilots. They argued that the 'halo of secrecy' and 'professional secrets' would be the key to the special esteem anticipated for nuclear workers.[54] Oak Ridge Director Alvin Weinberg later reiterated such views, characterising nuclear engineers as a 'fully professional, elite cadre that carries a heavy burden of responsibility'.[55]

Sequestered environments and mistrusted specialists (1969-)

This mantle of responsibility and social distance assumed growing importance in public representations during the cultural peak of nuclear energy, and ironically became central to subsequent critical reassessments of nuclear specialists in each country. As the era of exploration in atomic energy was replaced by more economically-oriented development of nuclear power, contention dogged the barely-established specialists. The first decade of nuclear power revealed unsuspected engineering complexities and rising costs. During the 1970s public perceptions of inadequate operational safety and lack of planning for nuclear wastes came to the fore.[56]

Public concerns about radiation dangers, reactor safety, and nuclear waste now more frequently castigated nuclear engineers than scientists as accomplices in shadowy policies. Cinematic depictions reflected these new themes. *The China Syndrome* (Columbia Pictures, dir. James Bridges, USA, 1979) depicts the quandaries of a compliant engineer within a bureaucratic system in which violations of safety procedures are routine and a conspiracy of silence is part of the institutional culture. The coincidence of the film's release weeks before the Three Mile Island accident undoubtedly reinforced American popular interpretations. Similarly, *Silkwood* (ABC Motion Pictures, dir. Mike Nichols, USA, 1983) the story of a whistle-blower at an Oklahoma plutonium processing facility, underscored corporate conspiracy, worker paranoia, and the insidious dangers of radiation. Such cinematic renderings served as templates for real-world events, providing rules of thumb to guide public understanding of what was still largely a hidden world.[57]

The morale of the profession itself, as mirrored in the declining ranks of the American Nuclear Society and Institution of Nuclear Engineers, flagged in the face of growing public suspicion of reactor safety and declining reactor orders. The management of nuclear engineers' professional identity by government and industry played a significant role in this downturn.[58] If Three Mile Island consolidated public attitudes about nuclear specialists in the USA, the Chernobyl (May 1986) and Fukushima (March 2011) accidents exported them to other countries.[59] A public face for such decaying cultural optimism was the cartoon series *The Simpsons* (1987-) and its central character, Homer, a poorly trained and bumbling nuclear engineer. Nuclear specialists, by turns invisible, progressive, heroic and mistrusted, had been reduced to a joke.

This account of shifting identities over seven decades – the span of merely two or three working careers – underlines the significance of their security-bound contexts. Nuclear workers have experienced enduring definitions of 'otherness', keeping their experiences and practices at the margins of societal awareness and acceptability. The cultural valuation of nuclear expertise – markedly different in the USA, UK and Canada – mutated under the influence of institutional templates, shifting national goals and unforeseen engineering errors, but remained strongly flavoured by its segregated origins.

Bio

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Notes

[1] This work was supported by ESRC grant RES-000-22-2171.

[2] There was a 'prehistory' of industrial radioactivity surrounding the purification and sale of radium from the turn of the twentieth century but involving microgram, rather than kilogram, quantities of radioactive products. See, for example, Xavier Roqué, "Marie Curie and the Radium Industry: A Preliminary Sketch," *History and Technology* 13, no. 4 (1997) and Maria Rentetzi, "The U.S. Radium Industry: Industrial in-House Research and the Commercialization of Science," *Minerva* 46 (2008).

[3] Alvin M. Weinberg, *The First Nuclear Era: The Life and Times of a Technological Fixer* (New York: AIP Press, 1994), pp. 38-9; C. J. Mackenzie to Walter Zinn, letter, 17 Apr 1946, Library and Archives Canada (Ottawa) [henceforth LAC] RG77 Vol 283; Christopher Hinton, "Unpublished Memoirs Chap XVI: The Reasons Why", Institution of Mechanical Engineers archives (London) Hinton A.4.

[4] Two other countries were significant in the postwar development of atomic energy and distinctive environments for nuclear workers: the USSR and France. See David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-1956* (New Haven, CT: Yale University Press, 1994); Paul R. Josephson, *Red Atom: Russia's Nuclear Power Program from Stalin to Today* (New York: W. H. Freeman, 1999); Sonja D. Schmid, *Producing Power: The Pre-Chernobyl History of the Soviet Nuclear Industry* (Cambridge, MA: MIT Press, 2015); Gabrielle Hecht, *The Radiance of France: Nuclear Power and National Identity after World War II* (Cambridge MA: MIT Press, 1998).

[5] Weinberg, note [3]. Related unpublished materials were consulted at the Weinberg archives (Children's Museum of Oak Ridge, and the Modern Political Archives, Howard H. Baker Jr Center for Public Policy, University of Tennessee, TN).

[6] On appropriate scales of analysis, see Lewis Pyenson, "An End to National Science: The Meaning and the Extension of Local Knowledge," *History of Science* 40 (2002); Erik Van den Vleuten, "Toward a Transnational History of Technology: Meaning, Promises, Pitfalls," *Technology and Culture* 49 (2008).

[7] On the cultural role of engineers in the Soviet sphere, see Paul R. Josephson, "Atomic-

Powered Communism: Nuclear Culture in the Postwar USSR," *Slavic Review* 55, no. 2 (1996); Dolores Augustine, *Red Prometheus: Engineering and Dictatorship in East Germany, 1945-1990* (Cambridge, MA: MIT Press, 2007); and, Schmid, *op. cit*.

[8] Andrew D. Abbott, *The System of Professions: An Essay on the Division of Expert Labor* (Chicago: University of Chicago Press, 1988).

[9] Sean F. Johnston, *The Neutron's Children: Nuclear Engineers and the Shaping of Identity* (Oxford: Oxford University Press, 2012). On Big Science by the nuclear engineer who coined the term, see Alvin M. Weinberg, *Reflections on Big Science* (Cambridge,: MIT Press, 1967) and Peter Galison and Bruce William Hevly, *Big Science: The Growth of Large-Scale Research* (Stanford, Calif.: Stanford University Press, 1992).

[10] Peter B. Hales, *Atomic Spaces: Living on the Manhattan Project* (Urbana: University of Illinois Press, 1997); Barton C. Hacker, *The Dragon's Tail: Radiation Safety in the Manhattan Project* (Berkeley: University of California Press, 1987).

[11] On social definitions of the roles of engineers and scientists see, for example, E. T. J. Layton, "Science as a Form of Action: The Role of the Engineering Sciences," *Technology and Culture* 29 (1988); on conflation of these two technical groups, see Fiona Clark and Deborah L. Illman, "Portrayals of Engineers in “Science Times”," *IEEE Technology and Society*, no. Spring (2006); Sean F. Johnston, "Making the Invisible Engineer Visible: Du Pont and the Recognition of Nuclear Expertise," *Technology and Culture* 52, no. 3 (2011).

[12] Department of Reconstruction (Canada), "Scientists Who Probed Atomic Secrets" Government of Canada, http://www.cns-snc.ca/history/history.html/1945Aug13PressReleasePart2; Henry D. Smyth, *Atomic Energy for Military Purposes: The Official Report on the Development of the Atomic Bomb under the Auspices of the United States Government, 1940-1945* (Princeton, NJ: Princeton University Press, 1945).

[13] E.g. Arthur Holly Compton, *Atomic Quest: A Personal Narrative* (Oxford: Oxford University Press, 1956); Robert Jungk, *Brighter Than a Thousand Suns: A Personal History of the Atomic Scientists* (San Diego: Harcourt Brace, 1956); Leslie R. Groves, *Now It Can Be Told: The Story of the Manhattan Project* (New York, N.Y.: Harper & Row, 1962). On scientists as heroes, see David K. Hecht, "The Atomic Hero: Robert Oppenheimer and the Making of Scientific Icons in the Early Cold War," *Technology and Culture* 49, no. 4 (2008).

[14] Such accounts focused on the narrative of participants who marshalled the countries' scientific and industrial might – several of whom were consulted by the script writers. ‘The Beginning or the End'' correspondence, LAC MG30-E533 vol 1.

[15] Sean F. Johnston, "Security and the Shaping of Identity for Nuclear Specialists," *History and Technology* 27, no. 2 (2011); John Krige, "Atoms for Peace, Scientific Internationalism and Scientific Intelligence," *Osiris* 21 (2006).

[16] Gregg Herken, ""A Most Deadly Illusion": The Atomic Secret and American Nuclear Weapons Policy, 1945-1950," *Pacific Historical Review* 49, no. 1 (1980). The dominance of engineering tasks in the design of the first atomic weapons is also noted in Lillian Hoddeson et al., *Critical Assembly: A Technical History of Los Alamos During the Oppenheimer Years, 1943-1945* (Cambridge: Cambridge University Press, 1993).

[17] See the sympathetic study by Alice Kimball Smith, *A Peril and a Hope: The Scientists' Movement in America, 1945-47* (Chicago: University of Chicago Press, 1965), and Donald A. Strickland, *Scientists in Politics: The Atomic Scientists Movement, 1945-46* (Lafayette: Purdue University Studies, 1968) on its factionalism and ideological conflict. For a layperson's view of the Federation of Atomic Scientists, see Lang, Daniel, 'The unscientific lobby', in: Daniel Lang, *From Hiroshima to the Moon: Chronicles of Life in the Atomic Age* (New York: Simon and Schuster, 1959), pp. 53-65.

[18] On the differentiation of technical specialists, see P. Whalley and S. R. Barley, "Technical Work in the Division of Labor: Stalking the Wild Anomaly," in *Between Craft and Science: Technical Work in U.S. Settings*, ed. S. R. Barley and J. E. Orr (Ithaca: ILR Press, 1997), and L. Perlow and L. Bailyn, "The Senseless Submergence of Difference: Engineers, Their Work, and Their Careers," ibid. , pp. 23-52 and 230-43, respectively.

[19] Richard G. Hewlett and Jack M. Holl, *Atomic Shield, 1947-1952* (Berkeley: University of California Press, 1969), pp. 15-42; Richard G. Hewlett, "Beginnings of Development in Nuclear Technology," *Technology and Culture* 17, no. 3 (1976); Pap A. Ndiaye, *Nylon and Bombs: Dupont and the March of Modern America* (Baltimore: Johns Hopkins University Press, 2007), Chapter 4.

[20] Reactor engineering arguably held a 'Goldilocks position' in terms of security, being more secretive and hence more regionally delineated than other new forms of nuclear knowledge that had wider application, and yet less secure than weapons development. On the relatively open parallel development of expertise in radioisotopes for medical and other applications, see Néstor Herran, "Spreading Nucleonics: The Isotope School at the Atomic Energy Research Establishment, 1951-67," *British Journal for the History of Science* 39, no. 4 (2006).

[21] Johnston, note [9].

[22] Leland Johnson and Daniel Schaffer, *Oak Ridge National Laboratory: The First Fifty Years* (Knoxville: University of Tennessee Press, 1994).

[23] G. Bruce Doern, *Science and Politics in Canada* (Montreal: McGill University Press, 1972); quotations pp. 42 and 43.

[24] Sean F. Johnston, "Creating a Canadian Profession: The Nuclear Engineer, C1940-1968," *Canadian Journal of History* 44, no. 3 (2009). See also Wilfred Eggleston, *Canada's Nuclear Story* (Toronto: Clarke Irwin, 1965); Robert Bothwell, *Nucleus: The History of Atomic Energy of Canada Limited* (Toronto: University of Toronto Press, 1988); D. G. Hurst and E. Critoph, eds., *Canada Enters the Nuclear Age: A Technical History of Atomic Energy of Canada Limited as Seen from Its Research Laboratories* (Montreal: Atomic Energy of Canada Ltd, 1997); Gerald Wynne Cantello, "The Roles Played by the Canadian General Electric Company's Atomic Power Department in Canada's Nuclear Power Program: Work, Organization and Success in Apd, 1955-1995" (MA, Trent, 2003).

[25] S. G. Bauer and J. Diamond, "Note on Piles for the Production of Useful Power", 4 Jun 1945, LAC RG77 Vol 283.

[26] "1944-1945 Montreal Laboratory: Questionnaire to UK Staff on Postwar Movements", National Archives (Kew) [henceforth NA] AB 1/152.

[27] 'Factory planning for production pile 1947', NA AB 7/284. Female nuclear engineers remained as uncommon as in other engineering professions, however, for broader cultural reasons and overt sexism. When the first female graduate member joined the INucE, the announcement of her entry was accompanied by the information that 'this charming and attractive scientist in our midst is already married' ['From the Secretary', *Journal of the Institution of Nuclear Engineers* 13 (1972): 34].

[28] The sites dedicated to weapons development included Los Alamos National Laboratory (New Mexico, 1942), Sandia Laboratory (New Mexico, 1945, designated a National Lab in 1979), Atomic Weapons Research Establishment (Aldermaston, Berkshire, 1950) and Lawrence Livermore National Laboratory (California, 1952). On their specialists, see Michael Parfit, *The Boys Behind the Bombs* (New York: Little and Brown, 1983); Debra Rosenthal, *At the Heart of the Bomb: The Dangerous Allure of Weapons Work* (Addison-Wesley, 1990); Hugh Gusterson, *Nuclear Rites: A Weapons Laboratory at the End of the Cold War* (Berkeley: University of California Press, 1996).

[29] See Spencer R. Weart, *Nuclear Fear: A History of Images* (Cambridge, Mass.: Harvard University Press, 1988). On the relationships between mass media, science and the public, see Dorothy Nelkin, *Selling Science: How the Press Covers Science and Technology* (New York: W. H. Freeman, 1995). For a range of examples, see Christopher Frayling, *Mad, Bad and Dangerous? The Scientist and the Cinema* (London: Reaktion Books, 2005).

[30] Smith, I. Norman. "The Magic and Reality of Nuclear Energy: A Layman Takes a Look." *Ottawa Journal*, 17 Nov 1953.

[31] E.g. Canadian Broadcasting Corporation, *Chalk River's 'Atom Smasher'* (CBC Newsmagazine), 5 Dec 1953, television documentary, http://archives.cbc.ca/science_technology/energy_production/clips/909/; Pathe News, *Peace - and the Atom*, 12 Apr 1954, newsreel, http://www.britishpathe.com/record.php?id=31742, both viewed 19 Feb 2018.

[32] Lang, *From Hiroshima to the Moon: Chronicles of Life in the Atomic Age*; quotation p. 247. See also *Early Tales of the Atomic Age* (New York: Doubleday, 1948) and *The Man in the Thick Lead Suit* (Oxford: Oxford University Press, 1954).

[33] J. B. Conant to C. J. Mackenzie, letter, 24 Aug 1945, LAC RG77 Vol 283. In the same vein, Nelson W. Hope, *Atomic Town* (New York: Comet, 1954) describes the adaptation of locals to the Hanford plutonium production project. Adopting a more critical social perspective were Catherine Caulfield, *Multiple Exposures: Chronicles of the Radiation Age* (London: Secker & Warburg, 1989) and Jeremy Hall, *Real Lives, Half Lives* (London: Penguin, 1996).

[34] William E. Dick, "The Hangars Hide Uranium Piles," *Discovery*, 1948 1948; quotations pp. 281 and 285.

[35] ORINS, *The Peaceful Atom: American Museum of Atomic Energy* (Oak Ridge TN: ORINS, 1954); Arthur Molella, "Exhibiting Atomic Culture: The View from Oak Ridge," *History and Technology* 19, no. 3 (2003). This faceless representation of atomic energy is typical of the genre and has a British equivalent [Duncan Jackson, "Bringing Technology to the Community: Sellafield Visitors' Centre," in *Museums and the Public Understanding of Science*, ed. John Durant (London: Science Museum, 1992)].

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[36] See, e.g., Bernard Newman, *Soviet Atomic Spies* (London: Robert Hale Ltd, 1952).

[37] Paul Boyer, *By the Bomb's Early Light: American Thought and Culture at the Dawn of the Atomic Age* (New York: Pantheon, 1985); Paul Loeb, *Nuclear Culture: Living and Working in the World's Largest Atomic Complex* (New York: New Society, 1986); Jeff Smith, *Unthinking the Unthinkable* (Bloomington: Indiana University Press, 1989).

[38] Lawrence Badash, "From Security Blanket to Security Risk: Scientists in the Decade after Hiroshima," *History and Technology* 19, no. 3 (2003).

[39] The most public case was that of Robert Oppenheimer, who lost his security clearance when links were sketched to communist organisations of the 1930s. See Charles Thorpe, *Robert Oppenheimer: The Tragic Intellect* (Chicago: University of Chicago Press, 2006) and Gregg Herken, *Brotherhood of the Bomb: The Tangled Lives and Loyalties of Robert Oppenheimer, Ernest Lawrence, and Edward Teller* (New York: Henry Holt and Company, 2002).

[40] E. M. Friedwald, "Atomic Scientists and Atomic Politics," *Discovery*, 1948 1948; "The Atomic Scientists Association Ltd: Policy and Associated Correspondence 1950-1951, 1954-1959", NA AB 27/6.

[41] With declining memberships, the INucE and BNES eventually merged in 2009.

[42] E.g. Atomic Research Workers' Union, Ottawa Atomic Energy Workers Union and Association of Atomic Energy Technicians and Draftsmen. See LAC categories RG145, MG27, MG30.

[43] Early examples include Wayne State University, Michigan, Queens University, Ontario and Imperial College, London, all in 1958. Sean F. Johnston, "Implanting a Discipline: The Academic Trajectory of Nuclear Engineering in the USA and UK," *Minerva* 47, no. 1 (2009).

[44] See, for example, Kenneth Jay, *Calder Hall: The Story of Britain's First Atomic Power Station* (London: Methuen, 1956): its photographs depict nuclear workers rather than identifiable scientists. Leonard Bertin, *Atom Harvest: A British View of Atomic Energy* (San Francisco: W. H. Freeman, 1957) again favoured engineers.

[45] *Nuclear Power* 1 (1956), 275. The title evokes the virtues of perseverance and nationalism in the stirring Welsh military march *Men of Harlech.*

[46] Of the catastrophic overheating and radioactive breaching of the Canadian NRX reactor in 1952, the Director privately observed, 'such accidents... provide experience for future designs which could not be obtained in any other way' [C. J. Mackenzie to R. Newton, letter, 19 Dec 1952, LAC MG30-B122 vol 3].

[47] Loudon S. Wainwright, "The Heroic Disarming of Diablo - Atomic Engineers Make a Suspense-Laden Climb," *Life*, 16 Sep 1957.

[48] C. P. Snow, *The New Men* (London: MacMillan, 1954); William E. Akin, *Technocracy and the American Dream: The Technocrat Movement 1900-1941* (Berkeley: University of California Press, 1977); Sean F. Johnston, *Techno-Fixers: Origins and Implications of Technological Faith* (McGill-Queen's University Press, 2020), Chapter 2.

[49] Heinz Haber, *The Walt Disney Story of Our Friend the Atom* (New York: Simon & Schuster, 1957).

[50] Julian May, *There's Adventure in Atomic Energy* (New York: Popular Mechanics Press and Hawthorne Press, 1957), republished for British audiences by Bailey Bros & Swinfen, London, in 1963), p. 156.

[51] Leo A. Meyer, *Atomic Energy in Industry: A Guide for Tradesmen and Technicians* (Chicago: American Technological Society, 1963).

[52] S. Makepeace-Lott, *Alan Works with Atoms* (London: Chatton & Windus, 1962), p. 19. Would-be university applicants were targeted by pamphlets such as "Harwell: Careers in Nuclear Engineering 1959 Feb.", NA AB 17/231.

[53] There appears to have been no Canadian analogue. The only children's book relating to atomic energy of the period was probably Joe Holliday, *Dale of the Mounted: Atomic Plot* (Toronto: Thomas Allen, 1959), in which the Royal Canadian Mounted Police foil espionage at Chalk River.

[54] Howard M. Vollmer and Donald L. Mills, "Nuclear Technology and the Professionalization of Labor," *American Journal of Sociology* 67, no. 6 (1962), quotation p. 696.

[55] Alvin Weinberg, note [3], p. 229.

[56] On the rise of American concerns about nuclear technologies, see Brian Balogh, *Chain Reaction: Expert Debate and Public Participation in American Commercial Nuclear Power, 1945-1975* (Cambridge: Cambridge University Press, 1991).

[57] Ron Von Burg, "The Cinematic Turn in Public Discussions of Science" (PhD University of Pittsburgh, 2005).

[58] See J. H. Callow, "What Is a Nuclear Engineer? Whither INucE?," *Nuclear Engineer* 23, no. 4 (1982).

[59] Grigori Medvedev and Evelyn Rossiter (translator), *The Truth About Chernobyl*, American ed. ([New York]: Basic Books, 1991). While generating strongly negative reactions from most quarters, the accidents also rehearsed narratives of heroic workers. See, for example, Tania Branigan and Justin McCurry, "Fukushima 50 Battle Radiation Risks as Japan Nuclear Crisis Deepens," *Guardian*, 15 Mar 2011.