Professional Identity and Organisation in a Technical Occupation: The Emergence of Chemical Engineering in Britain, *c.* 1915–30

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The emergence in Britain of chemical engineering, by mid-century the fourth largest engineering specialism, was a hesitant and drawn out process. This article analyses the organisational politics behind the recognition of the technical occupation and profession from the First World War through to the end of the 1920s. The collective sense of professional identity among nascent 'chemical engineers' developed rapidly during this time owing to associations which promoted their cause among potential patrons.

The evolution of those technical occupations that lay claim to professional status remains a comparatively neglected area of the historiography of modern Britain.[1] This is surprising. Many of the other professions that have shaped British society since the eighteenth century continue to attract interest.[2] Political historians remain concerned more generally with the workings of organised interest groups within the British state and society throughout the twentieth century.[3] And although there are still those who wish to emphasise relative economic decline, other writers increasingly acknowledge the success with which, since the late nineteenth century, scientists and technologists have been harnessed to the task of modernising the British economy.[4]

Chemical engineers make up one of the most important groups of these technical workers. They became economically significant in Britain only after the Second World War, but collective efforts to define chemical engineering as a profession date back to at least the 1880s. By the early 1910s a handful of consultants and higher grade workers in the chemical manufacturing and allied industries, such as plant construction, had made some very modest progress towards developing educational courses in

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universities and technical colleges.[5] They lacked, however, an organisational focus, a formal institution such as those enjoyed by the established professions of chemistry, and civil, mechanical and electrical engineering. Such a body would have allowed 'chemical engineers' to pursue their collective claims for professional recognition with employers and other potential patrons, like the state.[6] This article analyses the organisational politics informing both the establishment of the Institution of Chemical Engineers, in 1922, and the hesitant emergence of a collective sense of professional identity among 'chemical engineers' from the First World War through to the end of the 1920s. The IChemE was set up partly as a consequence of far-reaching changes in the political and industrial landscape wrought by the war. Many of these changes can be traced back to the founding of the Ministry of Munitions in 1915. But by the late 1920s, however, the fortunes of the would-be profession and its Institution had fallen to a low ebb from a high tide of post-war optimism. Their subsequent rise is best understood as part of the long preparations for the Second World War and is not treated here.[7]

Our understanding of the dynamics of chemical engineering as a profession is informed by the work of the historical sociologist Andrew Abbott. He argues that the emergence and development of professions cannot be understood by taking them in isolation one from another; instead they must be analysed as parts of evolving systems of interdependent yet competing occupational specialisms. Abbott's key argument is that this competition focuses on 'jurisdictional disputes' – competing claims over who should control the definition and practice of tasks in the workplace.[8] Survival in this competitive system is dependent on the collective strategies and tactics used by practitioners, which are tailored to specific historical circumstances. These strategies and tactics typically involve a range of formal and informal social structures, practices and discourses. Collective organisation in the shape of professional associations can be very important here. These help to define and codify the novel bodies of specialist, expert knowledge that inform a profession's sense of identity, often, but not only or always, codified in the form of academic courses, curricula and research. Equally important, professional associations have an important role to play in trying to persuade potential patrons such as the state, clients or employers of the relevance of this knowledge and the practice that it supposedly underpins. Thus jurisdictional claims over 'professional' tasks in the workplace motivate and shape organisational developments which in turn can – if the professional associations are successful – impact back on workplace practice.[9]

In this article we focus chiefly on the role played by associations in promoting the cause of 'chemical engineers' among potential patrons. The

history of these bodies supports the view that the achievement of jurisdiction usually requires the endorsement of several social groups. The state was one of the most important of these, employers another. Chemical engineering is a particularly interesting case because, during the period under review, collective efforts to define the would-be profession's identity were often couched in terms of political discourses that envisaged bringing these various groups – profession, state and employers – together to promote industrial production, harmony and efficiency: in this it differed quite markedly from certain of the older and more established scientific and technical professions that were its principal competitors. Chemical engineering thus bears some comparison with those other technical specialisms (such as optics) that emerged or were radically transformed around about the time of the First World War.[10] But, as we also show in this article, once the wider enthusiasm for corporatist ideas had dampened by the mid-1920s, the Institution of Chemical Engineers was unable to carve out a stable niche for the inchoate profession in the world of industry. Although 'chemical engineers' had developed the organisational infrastructure necessary to claim jurisdiction, they still had a long way to go in persuading others that they were a distinct profession with anything useful to offer.

Chemistry: the natural jurisdiction?

Originally the term 'chemical engineering' (and its cognates, such as 'chemical engineer') was an *ad hoc* neologism with a confused relationship to both of its supposed parent fields, chemistry and mechanical engineering. The term emerged into regular, if not common, use in the 1880s. The existence of some sense of collective identity is perhaps reflected in the effort particularly associated with the Manchester consultant George Davis to name what became the Society of Chemical Industry (SCI), the 'Society of Chemical Engineers'.[11] However the anodyne title eventually chosen, and indeed the SCI's activities, embodied a narrow technical understanding of the organisation's concerns and reflected its inability to act as the focus of any collective identity.[12]

In the four decades roughly separating the founding of the SCI and that of the Institution of Chemical Engineers in 1922, 'chemical engineering' started to emerge from a highly diverse range of workplace environments and occupations that would be claimed as the basis of a new profession. From the beginning, jurisdiction over the work which came to characterise chemical engineering – the design and management of industrial chemical operations and their associated plant – was contested from several directions. Among those occupations that had some interest in the matter

were works managers, mechanical engineers, civil engineers and chemists – not to mention plumbers. Others, such as academics and employers, had a more distant (though no less enthusiastic) concern with influencing the work and any representative bodies that might grow up. By contrast the state's interest in the technical workforce of the chemical industries was more or less non-existent, except during the First World War and its immediate aftermath.

The competition was rendered the more obscure and complex by the range of labour processes involved. In some sectors of the chemical industries manufacturing processes involved the latest chemical technologies (such as with Solvay soda and synthetic dyestuffs); in others, very traditional activities prevailed. Hierarchies of power and authority were also complicated, while the physically unpleasant and somewhat disreputable character of much of the industry rendered problematic the aspirations of its more senior workers to professional status.[13] Functional responsibilities could cut across industrial hierarchies in ways that were not always easy to discern. Thus the term 'chemical workers' included manual workmen, the plant foremen who supervised them, the most routine of laboratory-bound analytical chemists, research chemists (responsible for the laboratory development of new chemicals and their techniques of manufacture), through works chemists and plant managers with some responsibility for process control and perhaps plant design, to works managers, owners and directors. But the situation differed markedly from firm to firm and from industrial sub-sector to sub-sector, as well as being constantly changeable. Even terminologically the field was problematic – chemical engineering was by no means the only title in play. 'Chemical technology', 'applied chemistry' and 'technical chemistry' were all terms in common use. Despite an heroic attempt by George Davis to delineate them in his *Handbook of Chemical Engineering* (1901–04), their usage remained indeterminate – although around the turn of the century 'chemical engineering' did enjoy strong associations with plant machinery.[14]

Under these confused circumstances it is not surprising that no significant attempts were made during the late-nineteenth century to challenge the existing institutional jurisdiction over work involving plant design and the control of chemical manufacturing. The Institute of Chemistry, established in 1877, was the dominant body, although it catered primarily for the independent consultants and their academic colleagues. In 1906 it attempted to bring all technical activity within the chemical industry under its jurisdiction by setting up examinations in Technological Chemistry; the term 'chemical engineering' was briefly considered as an opportunistic alternative. However the institute would only examine existing members and partly for this reason the examinations failed,

although the institute would eventually gain a strong, if limited, influence over industrial chemistry through its authority within the National Certificate scheme from 1921.[15]

During the early-twentieth century this exclusivity combined with the growing stabilisation of occupational structure and career trajectories within the larger chemical works to catalyse the establishment of a sequence of occupational institutions. Each of these sought to challenge the Institute of Chemistry's dominance by attempting to recruit beyond the elite.[16] The first was the Association of Chemical Technologists (ACT, established in 1911 and known from 1914 as the Institution of Chemical Technologists), followed by the National Association of Industrial Chemists (NAIC, 1917). The British Association of Chemists (BAC), also founded in 1917, mounted a much more limited and hence effective attack on the institute, forcing it in 1918 to accept the claims of graduate chemists working in industry. Finally, in 1918 the Chemical Engineering Group was formed within the SCI. But although it is clear that at this time the Institute of Chemistry held some sway over occupational tasks, such work continued to be spread among a disaggregated array of employees, consultants and manufacturers of chemical plant, so that no single organisation – or named occupation – could claim undisputed jurisdiction, least of all the still very exclusive institute.

In sum, by 1918 some five generic organisations might have claimed to represent those employed in technical work within the chemical industry. Three in particular – the ACT, NAIC and BAC – reflected a new demand for industrial chemists during the war. But within all five the prototypic knowledge of industrial chemistry – including the design and management of chemical plant – was chemistry itself; these organisations did not draw on chemical engineering as a defining characteristic. Chemistry was the principal competition against which the nascent professionals had to define their identity as a distinct professional group.

Professional identity, the state and the Ministry of Munitions, 1915–21

Despite the efforts to define it more precisely throughout the 1900s and early 1910s, 'chemical engineering' remained a vague and contested category at the outbreak of the First World War. However the war and its immediate aftermath transformed the prospects for the inchoate profession. New organisational structures, erected with great haste by the state to provide the explosives and other chemicals needed to prosecute the war, provided fresh opportunities for 'chemical engineers' and catalysed the emergence, from around 1918, of claims to professional jurisdiction. Chiefly through the requirements of the Ministry of Munitions – itself a product of the hostilities – the war provided a massive increase in demand

for personnel with the kinds of skills claimed by would-be chemical engineers as their own, and a period of intensive training and industrial experience for many individuals drawn from disparate backgrounds who were unlikely otherwise to have received it. Contacts forged between these men, and between them and industrialists sitting on the several new trade chemical associations set up with the encouragement of the state, enhanced the likelihood that after the war 'chemical engineers' would secure a place on the new industrial and professional map of Britain.

The development of new industrial capacity was important for the altered state of affairs. At the beginning of the war the British government was unprepared for the required scale of explosives production. High explosives had never been produced by the national ordnance factories and there was little commercial capacity for TNT.[17] Commandeering commercial plants was clearly an inadequate response and so, following a request from the War Office, the Board of Trade recommended Lord Moulton, a one-time politician and senior lawyer, as organiser of explosives supply.[18] Moulton recruited Kenneth B. Quinan, the American manager of a de Beers explosives factory in South Africa, to oversee the development of new chemical plants.[19] Following his arrival in January 1915 Quinan supervised the construction of a new state TNT plant at Oldbury, and a TNT and gun-cotton plant at Queensferry, near Chester, started that May.[20] The following month Moulton's committee was incorporated (as the Department of Explosives Supply) within Lloyd George's new Ministry of Munitions. By July the ministry had established four more national explosives factories, the largest of which, a cordite production factory at Gretna, covered 9,000 acres and employed over 16,000 workers.[21] Within a year 17 others were founded, and by the end of war there were 32 HM explosives factories.[22]

These developments were undoubtedly important in providing significant numbers of scientifically and technically trained workers with the experience of industrial manufacturing that they would not otherwise have enjoyed. The 'chemists' war' eventually mobilised well over 2000 higher grade technical workers with chemical and engineering backgrounds.[23] While Quinan's staff in the ministry were mostly from South Africa, the chemical factories were populated mainly with indigenous chemists. Few of these had any experience with explosives manufacture.[24] Many worked in the kinds of areas that 'chemical engineers' were to claim as their own. The war-time *curriculum vitae* of many technical workers show rapid advancement from 'trainee' or 'shift chemist' to 'chemist-in-charge', and then to 'plant designer' or ministry assistant, with residency in each post ranging from three to 24 months.[25] Such plant designers and operators were soon identified by Moulton and other senior officials within the ministry as essential to its goals.

Nevertheless the growth in capacity and the influx of trained personnel did not in themselves help the cause of 'chemical engineering' since the pre-war division of labour between chemists and engineers continued largely to prevail. By the end of the war the 'chemical engineer' was still not clearly distinguishable as an occupational, let alone professional, type. Quinan himself, shunning publicity and diffident about professional bodies, never referred to chemical engineers in his factory organisations. Instead he followed the industrial convention of dividing his factory staff into engineers and chemists.[26] Ironically, his residency was brief and his profession-building influence short-lived; while serving as a convenient exemplar for those concerned with organising the profession, he participated only marginally in such activity himself.[27] Equally, it seems unlikely – with one or two important exceptions – that government officials or senior industrialists recognised the existence of the 'chemical engineer' during the war. Moulton recorded that many ministry employees were seconded from academic chemistry posts, 'drafted off to the new factories that were continually coming into being'.[28] The elusive nature of chemical engineering was the subject of an extended meeting in 1917 under the auspices of the Faraday Society, at which several papers and some hostile comments were offered.[29] Nevertheless the very occurrence of such events and the reaction to them suggest that the term 'chemical engineering' was gaining a wider currency. Indeed, representatives of chemists and engineers, mindful perhaps of the threat to their own jurisdictional authority, started in the last months of the war to criticise the work of Quinan and his staff. Delays in constructing new mustard gas plants were at the heart of these complaints, while later inspections of German chemical factories suggested that the British had been less competent and slower in scaling up from experimental plant to commercial production than had their opponents.[30]

Yet the Ministry of Munitions and its key personnel had transformed many aspects of explosives manufacturing and the production of agents of chemical warfare. It had created new career opportunities based upon the expanded production and novel working practices and industrial structures of war-time. Hesitantly from the last year or so of the war but with increasingly confidence once hostilities had ceased, 'chemical engineers' collectively claimed these opportunities as their own, organising first through the Chemical Engineering Group of the SCI and then, from late 1922, the Institution of Chemical Engineers. They exploited the informal networks of contacts and the formal structure of industrial associations that the ministry had also helped to bring about. In short, 'chemical engineers' exploited war-time changes to sharpen their collective identity and ground their claims to professional status.

The novel ways of doing things were both technical and organisational.

Thus the ministry created a new technical problem (the need rapidly to scale-up technical plants and make them more efficient); encouraged development and instruction in these novelties;[31] and provided an occupational environment in which – with due deference to the needs of national security and competitiveness – solutions to these problems could be publicly demonstrated. The last was particularly important because it enabled 'chemical engineers' to show that they were competent at doing the sorts of things that potential employers wanted.[32] Senior members of the ministry also provided more direct assistance in organising 'chemical engineers'. Several look favourably on the formation, in 1918, of the Chemical Engineering Group of the SCI. This provided an initial organisational focus for the collective identity that was emerging as a by-product of the other changes, and helped to quicken its definition and acceptance. In particular the CEG helped to mobilise much-needed support from outside the would-be profession; as we shall discuss in more detail shortly, it existed in symbiosis with two new manufacturers' organisations, the Association of British Chemical Manufacturers and the British Chemical Plant Manufacturers Association, both of which were partly the product of the ministry's initiative.

The key advocates for 'chemical engineering' were a handful of, often quite senior, personnel who had worked in, or closely with, the Ministry of Munitions. Immediately after the war they set out to exploit what they saw as the legacy of Quinan's work (he soon returned to South Africa) to further their jurisdictional claims in the areas of the problem classification, reasoning and solution. Among those later to describe themselves as chemical engineers were, for example, F.L. Nathan (responsible for propellants and alcohol production), W.B. Davidson (a ministry advisor), H. Griffiths (plant designer), S.R. Illingworth (toluol advisor) and E.C.B. Wilbraham (superintendent of HM factory Rainham).[33] Perhaps the most influential of these protagonists was William Macnab, a senior war-time colleague of Quinan in the ministry and an authority on explosives.[34] He portrayed Quinan and his techniques as a symbol of what was missing in the British chemical industry, crediting him with introducing clear methods of analysing the technical problems of plant design and chemical production, crucial for initiating 'staff and workers largely without expert knowledge of the work they had to do'.[35] Statistical techniques of financial and technical managerial control were also singled out for Macnab's praise.[36] Such claims were nicely targeted at a particularly influential audience: not the general public, but potential patrons such as employers and managers in the chemical manufacturing and plant industries, as well as the higher grade technical workers who might join the profession, and educators.

Macnab and his colleagues did not make such claims in a political or

ideological vacuum. They were highly sensitive to the concepts of collaborative decision-making across whole industrial sectors that enjoyed wide support among the coalition government, its supporters and even some of its detractors in the immediate post-war era. These corporatist programmes envisaged the joint involvement, in the 'national interest', of the state and bodies representative of capital, the professions and manual labour.[37] Science and technology were to play an important part in the reconstruction of British industry.[38] While the party political beliefs of organisers among 'chemical engineers' spread across a broad spectrum, there was a consensus that the economy should be organised on a similar basis, with new chemical engineering institutions acting as intermediaries between government and other interest groups in the chemical and related industries. Thus, for example, John Hinchley, a lecturer in Chemical Engineering at Imperial College, London since 1912, a consultant and a tireless advocate and organiser, was a Fabian socialist who thought along these lines.[39] By contrast Charles Garland, like Hinchley a campaigner for both the CEG and, later, the Institution of Chemical Engineers, had very different political allegiances: a long-time officer of the National Union of Manufacturers and a founder of the South London branch of the right-wing Junior Imperial League, he was elected a Unionist MP in 1922–23. Yet his commitment to corporatist ideas brought about his involvement with the labour-oriented BAC.[40] Nearer the political median, W.J.U. Woolcock, general manager of the ABCM, was a Coalition Liberal MP from 1918.[41]

While all these individuals demonstrated support for some form of industrial collectivism, it would be misleading to attribute a single philosophy to them as a group.[42] Yet in various ways they took threads of what we might now label Taylorist and technocratic thought and stitched together advocacy for the technical and managerial expertise of chemical engineers with the wider social and political elements of corporatist thinking.[43] An important vehicle for this kind of rhetoric was the several volumes of technical studies of war-time manufacturing that Macnab edited with the assistance of H.W. Cremer.[44] These had been instigated by the Department of Explosives Supply under Quinan's urging to emulate the example of the National Research Council in the USA, which was planning to disseminate previously classified technical documents at war's end.[45] The volumes were therefore not intended – at least officially – to serve the specific interests of chemical engineers. Yet this was one of the effects they had. The first volume, published in 1920, introduced the series by seeking to demonstrate that the ministry's wartime accomplishments had been grounded in the collaborative exploitation of technical expertise; Lloyd George, still then Prime Minister, described the ministry's melding of industry, labour and 'science' as one of the state's most important war-time

accomplishments.[46] Full details were given of the technical aspects of manufacture at which Macnab said chemical engineers were particularly adept. These included flowsheets, blueprints and photographs; actual cost records and the method of determining them; and comparative costs for various raw materials and production processes. But the reports provided much more than illustrations of the value of this 'chemical engineering' expertise. By advocating the reconfiguration of what were characterised as traditionally distant relationships between academia and industry, 'chemical engineers' were offered an opportunity to colonise territory in both sectors and stake out new ground for their embryonic profession.

Equally important was the fact that after the war the government, principally through the Ministry of Munitions but also that of Reconstruction, continued in a limited fashion to intervene in the chemical industries, forcing through the consolidation of many smaller firms into larger businesses. It had formed British Dyes Ltd (later the British Dyestuffs Corporation) in 1915; with the encouragement of Lord Moulton, the explosives companies had similarly merged to form Explosives Trades Ltd in 1918. The process continued through the early-1920s, culminating with the creation of Imperial Chemical Industries (ICI) in 1926.[47] Again, these changes were not intended to serve the claims of 'chemical engineers' to professional status, but they did provide opportunities to colonise new managerial and technical posts in the new, big firms.

Similarly with the trade associations that the Ministry of Reconstruction hoped would promote co-operation across the chemical sector – these gave 'chemical engineers' access to potential patrons and supporters. The new order had been started during the war when the Ministry of Munitions had appointed 'important members of the trade' to official posts, discussed matters with industrial associations, and, where necessary, encouraged the formation of such representative bodies.[48] The Ministry of Munitions had dealt with no fewer than 90 trade associations, many of which were first registered or significantly extended the scope of their activities during the last years of the war and immediately afterwards.[49] As we have already indicated, among the largest and most important of these for 'chemical engineers' was the Association of British Chemical Manufacturers (ABCM), founded in 1917; the British Chemical Plant Manufacturers Association (BCPMA), set up in 1920, was also to prove a significant ally.

In 1921 the Ministry of Munitions was disbanded in the midst of economic retrenchment and chemical engineers lost a powerful ally. But by then the events of the war had provided the opportunity and some of the resources for chemical engineers to organise as a profession. The experiences of the ministry had suggested that industry, technical labour and chemical production could be efficiently coupled: just as for the optical

industry, the war suggested that 'an economic and scientific alliance between government and industry was, whether immediately or in the long term, of vital interest to both'.[50] The ministry had brought together practitioners from disparate backgrounds; allowed them to share knowledge which previously had often been narrowly specialised, secretive or incomplete; dramatically and rapidly increased the scale of British chemical plant and manufacturing; and identified the need for more chemical engineers (even if they were not explicitly identified as such) trained along academic lines. Perhaps most importantly, it released these practitioners at the end of the war to fend for themselves.

Organising as occupational specialists: the Chemical Engineering Group

The climate engendered by the successes of the Ministry of Munitions infused campaigners for new organisations of 'chemical engineers'. They met from the last months of the war. Initially a group devoted to chemical engineering as an occupational specialism proved easier to negotiate than one concerned with chemical engineers as professionals – that is, aspiring to occupational jurisdiction. The most promising route to such a new body was through the Society of Chemical Industry. In the late summer of 1918, John W. Hinchley and Harold Talbot, general manager of the Welsbach Light Company, organised meetings and petitions to create a distinct subject group in the SCI or, if necessary, 'a separate Institution of Chemical Engineers'.[51] Three weeks before the armistice in November, the Chemical Engineering Group officially formed within the SCI with Hinchley as chairman.

For a body which included only a tiny handful of educators it is significant that the stated purpose of the CEG was to promote chemical engineering research and the education of chemical engineers.[52] By thus articulating and spreading a body of specialist, codified knowledge, the nascent profession would lay claim to jurisdictional authority over the fields of technical expertise traditionally filled by chemists and mechanical engineers. But only a handful of mainly part-time, non-degree courses in chemical engineering were available in the late 1910s, while university facilities for research were minimal. Hence these 'academic' functions were shared by three kinds of organisation. The Ministry of Munitions reports codified and spread the occupational experience of war-time chemical engineering; in the early 1920s they were made available to educators who in turn supplied them to post-war students as among the most up-to-date and exemplary texts available on chemical engineering.[53] The CEG supported research and encouraged a wider awareness of the subject within industry;

and a few, relatively weak academic foci such as Hinchley's at Imperial College and, from 1923, a new initiative at University College London provided formal instruction.[54] Although each was vulnerable to attack in itself, the combination of these activities helped to underpin the jurisdictional claims of chemical engineers over their competitors.

Professional status might also be gained by allying chemical engineers with both the state and industrial capital. The CEG's explicit intention was to improve industrial efficiency while preserving commercial secrecy, objectives, as we have noted, of both the Ministry of Munition's reports and wider government policy: implicit in all of this was co-operation with both industry and government.[55] In particular the CEG aimed to act as a confidential intermediary between chemical manufacturers and suppliers of chemical plant. This offered opportunities for fresh claims to jurisdiction on the part of 'chemical engineers'; their claims here were perhaps more secure than those of chemists, but threatened by those of mechanical engineers, who saw the realm of plant as their preserve.

The CEG did not, however, enjoy a mandate to pursue explicitly professional aims. While it was successful in focusing interest and promoting the technical aspects of chemical engineering through its activities as a learned society, the organisation was prevented by the SCI's constitution from accrediting engineers. The group was thus unable to anchor the occupational tasks it studied to a project of professional organisation and, after a promising start, membership numbers declined sharply. By the end of 1919 the CEG claimed 510 members. But the accreditation offered by the IChemE from the mid 1920s offered individual chemical engineers considerably more than did the CEG; it certified their competence as members of a profession – albeit one whose foundations were still highly insecure – and their collective claims to authority over the academic discipline and occupation of chemical engineering, rather than signalling a mere interest or passing occupational involvement with the subject. The CEG's membership, initially higher even than that of the American Institute of Chemical Engineers (founded in 1908), was overtaken by the IChemE in 1926, and rose by scarcely 200 members over the following 57 years of its life.[56]

Organising as professionals: the Institution of Chemical Engineers

Those who favoured an accrediting organisation clearly had little faith in the CEG almost from the start, for throughout 1920 a number of members, enthusiastically encouraged by Lord Moulton, agitated for a separate institution specifically to recognise chemical engineers as professionals. Moulton tended to talk in terms of national industrial efficiency, but by the

following year others were placing the call for professional qualifications at the focus of their appeals for the new body.[57] Suggestions were made to form a society for the north of England, separate from the CEG.[58] In response Hinchley, still a CEG council member, called a meeting in November 1921 at which the approximately 100 persons attending unanimously carried motions to form a new Institution of Chemical Engineers.[59]

The new professional organisation was an alliance across traditional occupational categories. Six persons stand out for the range and enthusiasm of their organisational activities: John Hinchley, William Macnab, W.J.U. Woolcock, C.S. Garland, J. Arthur Reavell and Harold Talbot. Each was prominent in at least three organisations linking government, industry and would-be professional chemical engineers. Organisers with direct wartime experience were particularly prominent among those who eventually became officers of the IChemE: ten of the first 16 presidents had ministry experience. Not surprisingly the link with the CEG was also very marked: of the six most active organisers, only Macnab and Woolcock were not CEG council members. Indeed, nearly half the members of the IChemE's provisional committee were also council officers of the CEG.[60] Among the members of the IChemE provisional committee were H. Talbot, the honorary secretary of the CEG, and J. Arthur Reavell, who had taken over from Hinchley as chairman in 1920. Reavell (1872–1942) was a manufacturer of plant equipment, a chairman of the BCPMA, a council member of the SCI and IChemE President for 1929–30. Thus the relationship between the new institution and the CEG was largely amicable, with the two soon sharing office accommodation.[61]

Other participants in war-related engineering formed a very influential minority of early members of the IChemE. For example, the first president, Sir Arthur Duckham, closely associated with the gas industry and industrial management, had been director-general of Aircraft Production and deputy-comptroller of the Munitions Inventions Department, and was one of those industrialists Lloyd George sought in state administration as 'men of push and go'. Prominent individuals with other kinds of background were also important. The third President, Sir Alexander Gibb, was a consultant with strong connections in the field of civil engineering.[62] Indeed owners or managers of chemical plants and related businesses made up over a third of the first members of the IChemE. The remainder divided equally between self-described 'engineers' and 'chemists' employed by others; independent chemical engineering consultants comprised only six per cent.[63]

This diversity of occupations and status was matched by that of professional aims, both in terms of scale and execution. Echoing Moulton, many of the leaders of the IChemE advanced the theme of 'organisation to boost national fortunes'. They represented the professional development of

chemical engineers as a crucial step in making British industry efficient and internationally competitive. Of 206 registered 'supporters of formation' several, particularly those involved in campaigning before 1922, stood out as having a proselytising aim, indicated by remarks added to their registration forms. Among the most fervent were comments by H.J. Pooley, F.H. Rogers, W.J.U. Woolcock and – from a distance – K.B. Quinan.[64] By contrast, most of the IChemE's early members had more limited aspirations. When prompted to supply a reason for their support, they typically listed the importance of a professional qualification as a recognition of experience, or the need to improve standards of training.[65] The first group was thus sympathetic to the post-war government's aims and sensitive to external economic threats; the second, to the more local problems of professional rivalry over jurisdiction. The leaders said they wanted a strong national industry; the majority simply wanted jobs within it.

From the outset Hinchley argued that the IChemE would 'quicken the efforts' of the CEG, while others stressed the 'quite different functions' of the sister organisation.[66] In practice, the two bodies gravitated towards complementary roles. As something akin to a learned society, the CEG throughout the 1920s encouraged the development, distillation and dissemination by and among practitioners of the codified knowledge necessary to stake a claim for chemical engineering as a specialist technical occupation. The IChemE strove to build recognition among employers and others for formal professional qualifications based partly upon this body of practitioners' knowledge and partly on the work of academics. These qualifications, and the schemes of education and training that underpinned them, were the most obvious manifestations of chemical engineers' claims to be treated as professionals. Chemical engineers, argued Hinchley and other educators, designed and operated chemical plants using a set of intellectual tools – known as 'unit operations' – that neither chemists nor engineers knew anything about.[67] But there was no clear consensus over the identity and desirability of the 'professional chemical engineer', even among those who were ostensibly in favour of the project. This was particularly evident in the rapid loss of enthusiasm among the CEG and the trade associations for too close a formal co-operation with and 'active support' of the IChemE.[68]

The strength of the established professional jurisdictions undoubtedly had much to do with this lack of consensus. At the first meeting of the IChemE's provisional committee, Hinchley, the honorary secretary, claimed that inter-professional rivalries were absent. But even Reavell and Macnab, two of the would-be profession's principal advocates, wondered whether existing institutions might not meet the needs of chemical engineering: could not chemical engineers be seen as a variant of some existing type of

professional?[69] After considerable discussion, the committee decided to proceed with its plans, but the immediate task was identified as fitting into the existing complex system of professional bodies. Hinchley initially contacted those representing civil, mechanical, gas and electrical engineers regarding the IChemE's proposed constitution, and eventually he tried to consult with 11 other scientific and engineering societies, including the Institute of Chemistry and the American Institute of Chemical Engineers (AIChE). The Institute of Chemistry alone requested a meeting, and the AIChE merely cabled its suggestion for reciprocal privileges for members of the two organisations. Despite Hinchley's attempt to legitimise the British profession by characterising its American counterpart as a model of success, and Garland's attempts to found a British Division of an 'internationalised' AIChE, contact between the two bodies remained limited, if amicable.[70]

This lack of concern among most of the other professional bodies is not surprising. Two of the most senior of the engineering institutions, the Institution of Civil Engineers and the Institution of Mechanical Engineers, were at this time also trying more generally to reverse the fissiparous tendencies of professional organisation; this almost certainly increased their determination to resist the IChemE's claims.[71] Although in retrospect we can seen how chemical engineers threatened to perturb existing institutional arrangements, British technical societies were adept at neutralising the threat posed by newcomers by permitting the foundation of a specialist body which then had to take a lowly place in the professional hierarchy. Strong objections to the founding of a new association were likely only if the newcomer's claims to jurisdictional authority trespassed too far onto the central domain of an established institution, or if they involved a marginal field acknowledged to be of strategic interest.[72] These cases largely cover the few objections to the founding of the IChemE, which centred on the undesirability of adding yet another institution to the proliferating bodies. The Institute of Chemistry was concerned about its weak jurisdiction over the chemical industry.[73] The Institutions of Civil and of Mechanical Engineers were in little doubt that insofar as 'chemical engineers' claimed a competence in the design and construction of chemical plant they should be resisted; this field was regarded unequivocally as their responsibility.

As we have noted, in the early days the IChemE's hopes of claiming a new jurisdiction rested partly on the explicit accommodation it, like the CEG, sought with both manufacturers and government: the older scientific and engineering bodies were far less clearly wedded to this kind of policy. The relationship was cemented into the very foundations of the IChemE, ABCM and BCPMA by their constitutions and overlapping administrations. For example the general manager of the ABCM throughout this period,

W.J.U. Woolcock, had been a parliamentary private secretary to the Minister of Munitions. By now a coalition Liberal MP, he was well positioned to translate the experience of the Prime Minister, Lloyd George, as a former Minister of Munitions into explicit support for 'chemical engineering' through the embryonic IChemE. The ABCM was in other respects a close ally of the IChemE through personal connections either forged or strengthened at the Ministry of Munitions. The association's first president was Lord Moulton, while Charles Carpenter was a senior organiser at the ministry who later became vice-president of both the ABCM and IChemE.[74] Another organisation with a corporatist outlook was the BCPMA.[75] Woolcock, as general manager of the ABCM, had initiated its organisation and served as its secretary. Four other officers and members of the IChemE comprised nearly half of the officers of the BCPMA.[76]

The many personal connections between Woolcock and other IChemE Council members associated with the manufacturers' organisations helps to explain why apparently no attempts were made to create formal alignments between these bodies. Each fulfilled its role in a system of complementary associations satisfying the related needs of professional chemical engineers, chemical manufacturers and plant manufacturers; in practice their separate spheres of activity rapidly became well defined and distinct, even as they largely shared their officers.

Attaining the social and economic authority commensurate with professional status required, at the very least, acknowledgement of a distinctive identity for 'chemical engineers' among potential employers. Recognition seemed assured in the immediate post-war years. The leaders of the CEG and the IChemE placed chemical engineers at the centre of the new industrial landscape that they thought would follow from what appeared to be a political consensus in favour of greater co-operation between the state, industry, science and technology. But the support of government and of industry proved difficult to sustain. Much later, in 1950 when the profession's fortunes were on the upturn, Herbert Cremer recalled that the early IChemE was received with 'suspicious glances of other members of the engineering fraternity' and 'feeble jokes of some industrialists'.[77] As we shall now argue, the IChemE's problem stemmed in part from changes in the wider political context within which it had to operate.

The struggle for professional recognition, 1922– *c.* 1930

The IChemE was founded in a volatile economic and political climate, with no fewer than four prime ministers and three governing parties during its first three years. It was, in a sense, born just too late. The leaders of the

young institution pitched their collective bid for professional status partly in terms of what chemical engineers could offer a chemical industry reorganised by the state, on the lines of big, oligarchical firms, 'scientifically' managed. But widespread support in mainstream political and industrial circles for this kind of thinking was already in sharp decline in the early 1920s. By the mid-1920s, just as the institution was finding its feet, broader political currents favoured instead the 'rationalisation' of industry. This involved the creation of large, but still privately owned and managed firms, rather than the more radical reshaping of the political and industrial landscape implied by earlier thinking.

The most explicit confrontation of visions was the so-called Underwood-Garland scheme. In its earliest days the IChemE looked directly to the state as a possible source of support and legitimation. An ambitious plan promoted in 1925 aimed to link government policy with industrial development and the employment of chemical engineers through a co-operative advisory body, the Industrial Development Council. This would have been effectively under the control of chemical engineers. The proposal was, however, short-lived. Its ultimate rejection later that year by the IChemE's council illustrated the rapid depreciation of collectivist rhetoric within the organisation in the face of wider political and industrial realities and the opposition of existing interests in government, industry, and trades unions.[78]

Shifts in governmental policy still amounted to a degree of intervention in industry unprecedented outside the war years, and the IChemE's leadership was, as we have seen, quick to claim for chemical engineers places high in resulting new managerial bureaucracies. But in practice the biggest firms were controlled by individuals who were not sympathetic to chemical engineers. The IChemE's failure to gain industrial employment for its members in the 1920s was one demonstration of how uncertain was the identity of the 'chemical engineer', how weak the would-be profession's claims were to jurisdictional authority.

A key exemplar is ICI. The firm had been formed in 1926 with the encouragement of the government, keen to promote the consolidation and rationalisation of chemical manufacturing in the face of difficult trading conditions since the slump of 1921. The new company controlled a third of chemical production in Britain. The claims made for the managerial expertise of 'chemical engineers' suggest that hopes were entertained that they would find senior places in the hierarchies of this, and other, big companies. But any such expectations were quickly dashed. Although some such firms were pleased to employ chemical engineers – Glaxo was a good example – in ICI the rejection was almost total, and quite deliberate. Chemists and mechanical engineers continued to monopolise positions of

any seniority in the company. The company's first research manager, William Rintoul, appointed at its formation, reversed the support that his former superior at Nobel's Explosives, Sir Frederic Nathan, had given chemical engineering.[79] Those chemical engineers who found jobs within ICI tended to do so without using their credentials to their advantage, and they were in any case usually restricted to technical posts at a fairly junior level.[80]

On the whole, the failure of chemical engineers to make significant inroads into the management and even the more lowly of technical posts in big chemical manufacturers meant that they were restricted to small businesses. Here their talents were commonly perceived more in terms of being cheap jack-of-all-trades than the industrial leaders envisaged by some among the IChemE's promoters. By the late 1920s the difficulties of finding employment even in smaller firms was an endemic problem, at least if the evidence of the Appointments Bureau with which the IChemE experimented between 1925 and 1936 was representative of wider trends. The profile of available candidates was a chronically poor match for employers' expectations. The more senior positions commonly demanded a higher degree of expertise in the industrial chemistry of specific industries than that possessed by the average chemical engineer, while the most junior posts on offer were well below what might have been expected by those with qualifications from a university or similar institution. Most employers were unwilling to pay what the IChemE saw as a reasonable salary.[81]

Despite these failings, widespread sentiments of 'corporate bias' (as Keith Middlemas describes the persistent tendency of British industrial politics to favour co-operative solutions to structural and economic weaknesses) continued to be voiced by leading members of the IChemE through the late 1920s and into the 1930s. J. Arthur Reavell, for example, in his 1930 presidential address described the need for a trusting combination of industry, finance and science. With wartime events behind them and economic difficulties at the forefront, however, the role of government was noticeably absent from his scheme.[82] A network of representatives of chemical bodies in the state and industry had gradually developed, through which initiatives for the development of the chemical industries were discussed.[83] The institution represented one focus within it.

None of this amounted to very much, however. The chemical trade was, as a whole, less affected by the slump after 1929 than it had been during the brief, but deeper, 1921 recession, and so economic circumstances did not provoke major changes of industrial policy.[84] Further consolidation of the chemical industry was much discussed during the early years of the slump, and some mergers came about; Unilever, for instance, was founded in 1929 out of British and Dutch interests.[85] Several influential individuals in the

chemical industries continued to favour a co-operative, business-led economy which included elements of a corporatist state; these figures included the second Lord Melchett, head of ICI. But they and others argued that a series of healthy industries added up to a healthy economy, without co-ordinating machinery or widespread intervention at the level of the state; industries would be made healthy by mergers, cartels and rationalisation.[86] If chemical engineers were to secure a place of authority in this industrial order, it looked as though they would have to find a fresh way of characterising what it was that they particularly had to offer. The circumstances needed to command professional jurisdiction had yet to be created and would necessitate cognitive, institutional and political work by members of the incipient profession.[87]

Concluding remarks: state, employers and professional organisation

What then does this study tell us about the institutional politics of those technical occupations that have claimed professional status in Britain during the twentieth century? Obviously the analysis of just a single would-be profession – and one, moreover, that achieved only the most modest of its goals during the period under review – is, in general terms, merely suggestive rather than conclusive. Nevertheless, our findings support the view that those British engineers for whom professionalisation was a significant project, saw the project in terms of creating 'professions of capital'. From the last months of the First World War the leaders of this inchoate profession clearly thought that the path to social and economic authority lay in claiming a place for chemical engineers high in the hierarchy of some kind of corporate industrial order. The basis for this claim lay in the particular managerial and technical expertise in the economic manufacture of chemical products and their associated plants that 'chemical engineers' said were not to be found among chemists and other kinds of engineers.

Our study also confirms the relevance for the professionalisation of technical occupations of the phenomenon of 'corporate bias' that Keith Middlemas has skilfully diagnosed as operating more generally in the industrial politics of Britain throughout this century. Technical occupations that see themselves as developing in a symbiotic relationship with industrial employers have to deal with the continuing problem that these employers do not always share common views with the occupation. Employers are, moreover, unlikely as a group to welcome the disruption to the existing industrial order implied by the jurisdictional claims of a would-be profession. Hence the rudimentary profession has to construct a consensus, although by definition it does not itself yet possess the necessary social and

cultural resources with which to do so. The state can act as an important surrogate agent in this process. Like a seed crystal, the First World War triggered crystallisation in an industrial pool already super-saturated with attempts to organise chemical practitioners; the British state (or at least, important parts of it) carried through a reorganisation of the relationships between chemical firms and their technical staffs that was sufficiently radical to permit 'chemical engineers' a realistic chance of occupying a key place in the new industrial landscape.

But once the military crisis had passed, chemical engineers were faced with the huge task of retaining even the limited ground they had gained during the war. For a brief period, the emergence of a political consensus concerning the desirability of industrial structures involving – by British standards – a fairly high degree of state intervention and centralisation ('state corporatism') seemed to suggest that the chemical engineers could continue to employ ideologies forged during the war to lay siege to the industrial fortresses occupied by chemists and engineers. But the mood for collective action by the state and industrial bodies was short-lived. Starting with the 1921 slump, the various representative bodies in the chemical manufacturing and plant industries adopted roles rather distant from the close co-operation originally envisaged. The IChemE was founded just as the train of political thinking to which it was coupled took off in a new direction: co-operation in industry now involved, at most, the establishment of relatively autonomous, representative bodies coming together in voluntary association ('societal corporatism'). Cut off from the resources of the state and having to operate in an industrial and professional terrain of established interests that could see no good reason why they should have to accommodate the new institution and would-be profession, the IChemE found itself in difficulties. The existing professions largely ignored it; employers were, on the whole, unreceptive to the skills of the chemical engineers it represented; and government backed away from collaboration with industry and professionals even in the name of promoting economic efficiency and employment. There would be no easy options or shortcuts in the creation of a new 'profession of capital'.

NOTES

1. A recent exception is C. Smith and P. Whalley, 'Engineers in Britain: a study in persistence', in Peter Meiksins and Chris Smith (eds), *Engineering Labour: Technical Workers in Comparative Perspective* (London: Verso, 1996), pp.27–60.
2. Penelope J. Corfield, *Power and the Professions in Britain 1700–1850* (London: Routledge, 1995), passim; Harold Perkin, *The Rise of Professional Society: England Since 1880* (London: Routledge, 1989), passim.

3. See, for example, the otherwise excellent studies by Keith Middlemas, *Power, Competition and the State*, 3 vols (London: Macmillan, 1986, 1990, 1991), passim, and *Politics in Industrial Society: The Experience of Britain Since 1911* (London: Andre Deutsch, 1979), passim.
4. For a summary of this literature see, David E.H. Edgerton, *Science, Technology and British 'Decline'* (Cambridge: Cambridge University Press, 1996), passim.
5. J. Donnelly, 'Chemical engineering in England, 1880–1922', *Annals of Science,* Vol.45 (1988), pp.555–90; C. Cohen, 'The Early History of Chemical Engineering: A Reassessment', *British Journal History of Science,* Vol.29 (1996), pp.171–94; C. Divall and S.F. Johnston, 'Scaling Up: The Evolution of Intellectual Apparatus Associated With the Manufacture of Heavy Chemicals in Britain, 1900–1939', A.S. Travis, H.G. Schröter and E. Homburg (eds), *Determinants in the Evolution of the European Chemical Industry, 1900–1939: New Technologies, Political Frameworks, Markets and Companies* (Dordrecht: Kluwer Academic Publishers, 1998), pp.199–214.
6. Hamish B. Watson, 'Organizational Bases of Professional Status: A Comparative Study of the Engineering Profession' (unpublished University of London PhD thesis, 1976), passim; R. Angus Buchanan, *The Engineers: A History of the Engineering Profession in Britain, 1750–1914* (London: Jessica Kingsley, 1988), passim; Colin Russell, Noel Coley and Gerrylynn K. Roberts, *Chemists by Profession: The Origins and Rise of the Royal Institute of Chemistry* (Milton Keynes: Open University Press/Royal Institute of Chemistry, 1977), passim.
7. For an initial analysis see C. Divall, 'Professional Autonomy, the State and Employers: The Politics of Chemical Engineering "Manpower" in Britain, 1939–1990', *Journal of Contemporary History* Vol.31 (1996), pp.675–97.
8. See for example, Andrew Abbott, *The System of the Professions: An Essay of the Division of Expert Labour* (Chicago: University of Chicago, 1988), pp.59–85.
9. Abbott, *Professions*, pp.66–8, 128.
10. R. and K. MacLeod, 'Government and the Optical Industry in Britain, 1914–1918', in J.M. Winter (ed.), *War and Economic Development* (Cambridge: Cambridge University Press, 1975), pp.165–204.
11. Society of the Chemical Industry archive, London [henceforward MS SCI]: Minute Book of the Preliminary Meetings; *Journal Society of Chemical Industry*, Vol.34 (1915), p.750. George Edward Davis (1850–1907) was a works chemist and manager, alkali inspector, consultant and Editor of the *Chemical Trade Journal. Journal of the Society of Chemical Industry*, Vol.26 (1907), p.588.
12. J.F. Donnelly, 'Defining the Industrial Chemist in the United Kingdom, 1850–1921', *Journal of Social History,* Vol.29 (1996), pp.779–96.
13. A.E. Dingle, ' "The Monster Nuisance of It All": Landowners, Alkali Manufacturers and Air Pollution, 1828–64', *Economic History Review,* Vol.35 (1982), pp.529–48.
14. G.E. Davis, *A Handbook of Chemical Engineering* (Manchester: Davis, 1901–4).
15. Russell, Coley and Roberts, *Chemists*, pp.265–6.
16. See Donnelly, 'Defining the Industrial Chemist'.
17. David Lloyd George, *War Memoirs* (London: Ivor Nicholson & Watson, 1933), p.575. For the pantheon of available explosives, their constituents and manufacturing processes, see H.F. Moulton, *The Life of Lord Moulton* (London: Nisbet, 1922), chap. 7, and R.P. Ayerst, M. McLaren and D. Liddell, 'The role of chemical engineering in providing propellants and explosives for the U.K. armed forces',W.F. Furter (ed.), *History of Chemical Engineering* (Washington: American Chemical Society, 1980), pp.367–92.
18. Three-times Liberal MP, Lord Chief Justice and Lord of Appeal before WWI, John Fletcher Moulton (1845–1921) had acted in explosives patent-cases following an education in mathematics and law. See *Journal of the Society of Chemical Industry*, Vol.40 (1921), pp.137R–138R; *Transactions of the Institution of Chemical Engineers*, Vol.17 (1939), pp.184–5.
19. Chief Advisor and Controller in the Explosives Supply Department and later responsible for poison gas production, Quinan (1878–1948) had developed his practical experience in explosives manufacture at his uncle's factory in California. See IChemE archive, George E.

Davis Building, Rugby [henceforward MS IChemE]: Application Form [henceforward AF] no. 109; obituary, *The Times*, 28 Jan. 1948, p.4; C.S. Robinson, 'Kenneth Bingham Quinan'; *The Chemical Engineer*, Nov. 1966, pp.CE290–CE322; and A. P. Cartwright, *The Dynamite Company: The Story of African Explosives and Chemical Industries Ltd* (London: MacDonald, 1964); L.F. Haber, *The Poisonous Cloud: Chemical Warfare in the First World War* (Oxford: Clarendon Press, 1986), pp.148–9.

20. For more on the wartime changes in the industry, see D.W.F. Hardie and J. Davidson Pratt, *A History of the Modern British Chemical Industry* (Oxford: Pergamon Press, 1966), pp.98–115.
21. See Moulton, *Lord Moulton*. For accounts emphasising the administrative history of the ministry, see R.J.Q. Adams, *Arms and the Wizard: Lloyd George and the Ministry of Munitions, 1915–1916* (London: Cassell, 1978), and C. Wrigley, 'The Ministry of Munitions: an innovatory department', in Kathleen Burk (ed.), *War and the State: The Transformation of the British Government* (London: George Allen & Unwin,1982), pp.32–56. *The History of the Ministry of Munitions* Vol.8 (London: HMSO, 1922), Part II.
22. Twenty-one were constructed by the state; the remainder were nationalised commercial factories. See *History of the Ministry of Munitions*, and R. MacLeod, 'The Chemists Go To War: The Mobilisation of Civilian Chemists and the British War Effort, 1914–1918', *Annals of Science*, Vol.50 (1993), pp.455–81.
23. See Haber, *Poisonous Cloud*, and R. MacLeod, 'Chemistry for King and Kaiser: revisiting chemical enterprise and the European war', in Travis, Schröter and Homburg, *European Chemical Industry*. Haber estimates the figure at about 1,500; MacLeod adds another 800 to 1,000 workers in the explosives factories and other war-related chemical occupations.
24. *History of the Ministry of Munitions*, p.74; Robinson, 'Quinan', pp.CE290–CE322; Moulton, *Lord Moulton*, p.216.
25. See MS IChemE: AF, e.g. W.B. Davidson, H.F. Hill, W.S. Milne, A. Cottrell and H.W. Cremer, Nos. 23, 43, 60, 135 and 203, respectively.
26. Public Record Office, Kew [henceforward PRO]: SUPP10/286, K.B. Quinan, 'Memo on organisation of staffs at Queensferry'.
27. Made a 'corresponding Vice President' of the IChemE, Quinan did not communicate regularly with the Institution or attend Council meetings.
28. Moulton, *Lord Moulton*, p.216.
29. 'The training and work of the chemical engineer', *Transactions of the Faraday Society*,Vol.13 (1917–18), pp.61–118.
30. Haber, *Poisonous Cloud*, pp.165, 171. The missions are detailed in: *Report of the British Chemical Mission on Chemical Factories in the Occupied Areas of Germany* (London: ABCM, 1919), and Ministry of Munitions, *Report of the British Mission Appointed to Visit Enemy Chemical Factories in the Occupied Zone Engaged in the Production of Munitions of War* (London: HMSO, 1919).
31. The most notable example of process development during the war was that of high-pressure nitrogen manufacture begun at Billingham by Quinan and others, and publicly praised by Churchill, then Minister of Munitions.
32. See Abbott, *Professions*, p.39.
33. See PRO: SUPP 10/278, 10/286, Quinan correspondence; and MS IChemE: AF Nos 90, 23, 43, 46 and 243 respectively. Quinan's limited public exposure appears to have been restricted largely to the efforts of Macnab, to a few brief mentions in parliament by ministers, and to being granted a Companion of Honour in Aug. 1917. He received scarcely a mention in the reminiscences of the first Minister of Munitions or in several historical accounts of the ministry.
34. Macnab (1858–1941) spent his early career in sugar chemistry, and developed chemical engineering connections later through associations with a water softening company and the management of explosives works. See W. Macnab, 'Chemical Engineering in Explosives Manufacture', *Transactions of the Institution of Chemical Engineers*, Vol.13 (1935), pp.9–13.
35. [W. Macnab], Ministry of Munitions, Dept. of Explosives Supply, *Preliminary Studies for H.M. Factory, Gretna and Study for an Installation of Phosgene Manufacture* (London:

HMSO, 1920), p.ix.

36. [W. Macnab], Ministry of Munitions, *Report on the Statistical Work of the Factories Branch* (London: HMSO, April 1919). By 1917 such methods had led to significant manufacturing efficiencies: the cost of TNT production, for example, had fallen from the pre-war commercial cost of 1s 9d per pound to 8½ d per pound at Queensferry, a 60% saving even neglecting inflation. *The Times,* 28 June 1917, p.8. J.C. Burnham, *HM Factory, Gretna: Description of Plant and Process* (London: HMSO, 1918), p.v.
37. Middlemas, *Power*, chap. 13, esp. pp.382–4.
38. See for example, R. MacLeod and E.K. Andrews, 'The Origins of the D.S.I.R.: Reflections on Ideas and Men, 1915–1916', *Public Administration* Vol.48 (1970), pp.23–48; I. Varcoe, *Organising for Science in Britain: A Case Study* (London: Oxford University Press, 1974) and 'Co-operative Research Associations in British industry, 1918–34', *Minerva* Vol.19 (1981), pp.433–63.
39. E.M. Hinchley, *John William Hinchley: Chemical Engineer: A Memoir* (London: Lamley, 1935); M. Cole, *The Story of Fabian Socialism* (London: Heinemann, 1961), pp.187–8. C.A.F. Hastilow and L.P. Wilson, *Chemical Trade Journal* Vol.63 (1918), pp.248 and 273. See also B. Russell, *Principles of Social Reconstruction* (London: George Allen & Unwin, 1916), pp.141–2.
40. Garland (1887–1960), after an apprenticeship at an iron works, was afterwards manager and director of several companies. From 1925, he was president of the BAC and vice-president of the National Union of Manufacturers; he was president of the IChemE for 1941–2. MS IChemE: AF No.153; *The Chemical Engineer* Feb. 1961; *Chemistry & Industry*, 7 Jan. 1961, p.25.
41. During the war, while acting secretary and registrar to the Pharmaceutical society, William James Uglow Woolcock (1878–1947) was appointed assistant director of Army Contracts and acted as chairman of the Committee responsible for medical supplies to the Army. He was president of the SCI 1924–6 and later a vice-president of the Federation of British Industry. Not himself a chemical engineer, Woolcock was made the first honorary member of the IChemE. See 'Nominations', *The Times*, 5 Dec.1918, p.14; MS IChemE: Gayfere box VII/1, 'Founders' biographies'; and *Chemistry & Industry* Jubilee Number (1931), p.89.
42. Peter Williamson, *Varieties of Corporatism: A Conceptual Discussion* (Cambridge: Cambridge University Press, 1985) and *Corporatism in Perspective: An Introductory Guide to Corporatist Theory* (London: Sage Publications, 1989), in attempting to clarify the definition, distinguishes at least three varieties of corporatism, ranging from authoritarian regimes to liberal democracies. See also O. Newman, *The Challenge of Corporatism* (London: Macmillan, 1981), chap. 1.
43. C.S. Maier, 'Between Taylorism and Technocracy: European Ideologies and the Vision of Industrial Productivity in the 1920s', *Journal of Contemporary History* Vol.5 (1970), pp.27–61. See also J. Meynaud, *Technocracy* (London: Faber & Faber, 1968), passim.
44. Herbert William Cremer (1893–1970) had been in charge of the TNT plant at Queensferry and later an assistant to Quinan in London, being appointed Director of Chemical Warfare Supply in 1918. Regarding Quinan's 'truly immediate influence', see H.W. Cremer, 'Chemical Engineering: Fact or Fiction?', *Chemistry & Industry*, 14 Jan. 1950, pp.31–3.
45. PRO: SUPP 10/279, 9 Dec. 1918. Quinan urged the rapid printing of as many as 20,000 copies to be issued 'without restrictions, to all of the Teaching Institutions throughout Great Britain and the colonies, to all of the various manufacturers, and also to the Technical Societies both at home and in the Colonies'.
46. Macnab, *Preliminary Studies*, pp.ix–xii.
47. W.J. Reader, *Imperial Chemical Industries: A History*, 2 vols (Oxford: Oxford University Press, 1970–1975).
48. See Ministry of Munitions, 'Mr Lloyd George's farewell address to the staff of the Ministry' (London: HMSO, 1916), p.6, and Lloyd George, *War Memories*, pp.566–7. K.B. Quinan's factory liaison officer, on the other hand, complained that ministry organisation was complex and inefficient: 'Gretna is the greatest Socialist experiment of our time, it is State Socialism gone mad'. PRO: SUPP 10/278, W. Corbett to Quinan, 19 Aug. 1916.
49. *Industrial Trade Associations: Activities and Organisation* (London: PEP, 1957), pp.3–19.

50. MacLeod, 'Optical Industry'. For an economic history of the business side of this post-war rationalisation movement, see L. Hannah, *The Rise of the Corporate Economy* (London: Methuen, 1976), chap. 3. On the State corporatism enforced during and following the First World War, see Perkin, *Professional Society*, pp.174–86.
51. 'History of the formation of the group', *Proceedings of the Society of Chemical Industry*, Vol.1 (1919), pp.3–6. MS SCI: Minutes of Council, 19 April 1919, pp.90–1. Talbot (b1885) had previously held posts as Chief Chemist and Manager at lighting, dye and other companies. MS IChemE: AF no.159 and *Chemistry & Industry*, Vol.51(1932), p.860.
52. *Chemical Age*, Vol.1 (1919), p.442.
53. See, for example, W.C. Peck, 'Early Chemical Engineering', *Chemistry & Industry*, 2 June 1973, pp.512–7.
54. The support for research by the CEG did not live up to the rhetoric, the most notable early accomplishment being the publication of data sheets. On educational provision, see C. Divall, 'Education for Design and Production: Professional Organization, Employers, and the Study of Chemical Engineering in British Universities, 1922–1976', *Technology & Culture*, Vol.34 (1994), pp.258–88.
55. *Chemical Age*, Vol.1 (1919), p.537.
56. The Chemical Engineering Group ceased publication of separate *Proceedings* in 1972 and was re-named the Process Engineering Group in 1976.
57. See Moulton's speech at University College London, reprinted in *Transactions of the Institution of Chemical Engineers*, Vol.17 (1939), pp.186–91; see also *Chemical Age*, Vol. 10, July 1920, pp.32–3. Sir Alexander Gibb observed in 1929 that Moulton would have been the institution's first president had he not died in 1921.
58. Some 100 persons were distributed between the industrial centres of the north-west, north-east and Yorkshire. An early compilation by the CEG listed 32% Northern, 36% London, 18% Midlands, 9% Scottish and 4% foreign locations for its first 395 members. *Journal of the Society of Chemical Industry*, Vol.38 (1919), p.100R. The corporate membership of the early IChemE to 1929 (598 members) was similarly 29% Northern, 32% London and home counties, but 8% Midlands, 5% Scottish and 20% foreign. MS IChemE: AF, 1923–1929. More senior members commonly lived near London.
59. Speakers included H.M. Ridge (b.1873), the managing director of a furnace and engineering company; consulting chemical engineers F.H. Rogers, F.A. Greene and J.A. Reavell (who also were members of the Institution of Mechanical Engineers); chemical engineers C.J. Goodwin, D. Brownlie and J. MacGregor; and W.J.U. Woolcock. Camillo J. Goodwin (b.1884) took over his father's chemical engineering practice in 1910 (which had for a time employed Hinchley) and consulted for Nobel's Explosives and the Ministry of Munitions during the war. David Brownlie (1880–1951), after part-time technical school training, served an apprenticeship as a technical chemist and then became a company Director. James MacGregor (b.1878), also with part-time chemistry training and wide industrial chemistry experience, became a company manager and owner. MS IChemE: AF nos1a, 33, 36, 53, 71, 74, 120, 271; and Minutes of Council (henceforward CM), 9 November 1921.
60. The 16 IChemE Provisional Committee Members (1922–3) and 21 CEG (1923) council members included seven in common.
61. MS IChemE: CM 7 Mar 1923; *Proceedings of the Chemical Engineering Group*, Vols. 5 and 6A, 1923, 1924, p.1.
62. Duckham (1879–1932) had held supervisory and engineering appointments since 1899 in gas and water companies. His invention of an improved retort for coal carbonisation led to formation of the 'Woodall Duckham' group of companies, of which he was chairman. Duckham was also President of the Society of British Gas Industries and Vice President of the British Commercial Gas Association. See *Chemistry & Industry*, Vol.51 (1932), p.167. Gibb (1872–1958) was owner of a civil engineering consultancy from 1921 and a member of several post-war transport committees. See G. Harrison, *Alexander Gibb: The Story of an Engineer* (London, 1950); MS IChemE: Gayfere box VII/1, 'Founders' biographies'.
63. MS IChemE: AF,1923–26.
64. MS IChemE: Gayfere box VII/1, 'Supporters of formation of the Institution'.
65. Ibid.

66. Editor, and J.W. Hinchley, *Chemical Trade Journal & Chemical Engineer*, 9 July, 1921.
67. Divall, 'Education for Design'; Divall and Johnston, 'Scaling Up'.
68. IChemE MS: CM 1922–26.
69. MS IChemE: CM 7 Dec 1921.
70. MS IChemE: Gayfere box VII/1, Hinchley, 'Re Proposed Institution of Chemical Engineers', October 1921; open letter, Hinchley to Managing Directors, March 1922; 'Founders' biographies', June 1938. C.S. Garland, 'The chemical engineer in reconstruction', *Transactions of the Institution of Chemical Engineers*,Vol.21 (1943), p.xvi.
71. Watson, 'Organizational Bases', chp 3.
72. Buchanan, *The Engineers*, passim. The Institution of Mining and Metallurgy, for example, had obtained a Royal Charter in 1915, and the Institutions of Gas Engineers and of Mechanical Engineers were seeking one.
73. Russell, Coley and Roberts, *Chemists*, pp.221–63.
74. Also a member of Moulton's committee for Explosives Supply in 1914 and a council member of the SCI, Carpenter (1859–1938) had studied science at Birkbeck College, University of London, and from the early 1880s worked for the South Metropolitan Gas Company. He was President of the SCI 1915–1917, and a founder of the ABCM in 1916. See *Chemistry & Industry*, Vol.57 (1938), pp.878–9.
75. *Journal of the Society of Chemical Industry*, Vol.39 (1920), p.229R.
76. H.J. Bush, E.A. Alliott, L.M.G. Fraser and R. Seligman.
77. Cremer, 'Chemical Engineering'.
78. Sources for the scheme are found in MS IChemE: Gayfere box III/5, file 'Industrial development sub-committee'.
79. Rintoul (1870–1936) had worked under Nathan at both the Royal Gunpowder Factory at Waltham Abbey from 1894 as a chemist, and at Nobel's Explosives, Ardeer, from 1909. Nathan's first draft plan as IChemE president for the training of chemical engineers was criticised by Rintoul, who became the most vocal opponent of chemical engineering education in the inter-war years. Rintoul denigrated the categorisation of the specialism and the feasibility of inculcating the required training in any academic programme. MS IChemE: 'Extracts from replies received to the memorandum on "The training of the chemical engineer", circa late 1924; 'The education and training of the chemical engineer' (discussion), *Transactions of the Institution of Chemical Engineers* ,Vol. 9 (1931), pp.14–20; W. Rintoul, 'Technical education as applied to the training of industrial chemists', *Chemistry & Industry*, Vol. 53 (1934), pp.868–70.
80. P.W. Reynolds, 'Chemical Engineering with ICI at Billingham', *The Chemical Engineer*, March 1965, pp.CE55–59; interviews and questionnaires, R.S. Tailby, June 1992 and Nov. 1997; P.H. Sykes, Dec. 1996; G. Sachs, Jan. 1997; C.S.H. Munro, Jan. 1997; C.A. Noble, Feb. 1997.
81. Sources regarding the Appointments Bureau are IChemE annual reports, 1926–1938, in *Transations of the Institution of Chemical Engineers*, and MS IChemE: CM 1926–36.
82. MS IChemE: J.A. Reavell, 'The role of science in industry', presidential address 4 April 1930.
83. The 1934 annual dinner, for example, brought together senior members of the Ministry of Health, National Physical Laboratory, Patent Office, Institute of Fuel, Institution of Petroleum Technologists, Institute of Marine Engineers, Institution of Engineers-in-Charge, SCI, Institute of Chemistry, Society of Public Analysts, British Association of Chemists, Coke Oven Managers' Association, Diesel Engine Users' Association, ABCM, BCPMA, Association of Constructional Engineers, Unilever Ltd, the Dyers' Company, and King's, Imperial and University Colleges, University of London. *Morning Post*, 17 Feb 1934.
84. During the 1929–31 depression, industrial production fell by only 11%. Overall, the rate of growth of the chemical industry was only slightly behind the average for all industry in the inter-war period. Derek H. Aldcroft, *The Inter-War Economy: Britain, 1919–1939* (London: Batsford, 1970), pp.30, 199–200 and 249; C. L. Mowat, *Britain Between the Wars, 1918–1940* (London: Methuen, 1955), pp.125–6. See also S. Pollard, *The Development of the British Economy, 1914–1990* (London: Edward Arnold, 1992), p.45.

85. E.g. items in *The Times*: J.D. Pratt, 12 Oct. 1929, p.12; 'In Parliament', 4 Feb. 1930, p.8; Sir H. Hartley, 'Chemical Industry Rationalisation', 9 Mar. 1931, p.14. C. Wilson, *The History of Unilever: A Study of Economic Growth and Social Change* (London: Cassell, 1954).
86. L.P. Carpenter, 'Corporatism in Britain, 1930–1945', *Journal Contemporary History* Vol.11 (1976), pp.3–25.
87. Colin Divall and Sean F. Johnston, *Scaling Up: The Institution of Chemical Engineers and the Rise of a New Profession* (forthcoming).