Chemistry, Engineering, and Rationalisation in Germany 1919-33

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Introduction: The First World War and the changing face of chemistry in Germany

The First World War initiated a fundamental transformation of the German chemical industry, which was affected in several significant ways:

1) the loss of prewar markets (and with them Germany's global dominance in dyes);

2) a shift from dyes and pharmaceuticals to the production of high explosives and chemical warfare agents, which had begun as an explicitly temporary wartime measure but changed its character in September 1916 with the military's so-called Hindenburg Program, requiring major investments in new "preparedness plants" designed to maintain a permanent productive capacity in war-related chemicals [although most of these plants were dismantled after the war as a result of the terms of the Versailles Treaty, they were an important precedent for future developments of consciously "dual use" technologies];

3) major expansions in productive capacity for strategically valuable inorganic raw materials and reagents (especially nitrates and sulfates), intended to make Germany largely independent of foreign imports after the war; and

4) a corresponding change in patterns of production and innovation, involving the production of fewer products at higher volume, which led to greater interest in solving engineering problems and designing apparatus than in the systematic laboratory synthesis that had previously dominated industrial research in organic chemicals.[1]

In addition to these industrial and technological changes, there was a change in the professional landscape of industrial chemists. During the war, a small but significant number of women chemists replaced men who had gone to war; more

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important, for the first time the leading professional association, the *Verein Deutscher Chemiker* (VDC, Association of German Chemists), actually recognised these women as potentially equal professional colleagues, and began admitting them to membership.[2] In the immediate aftermath of the revolution that ended the war, moreover, the new republic legalised collective bargaining for all German workers, including employed chemists, so that such professional employees could for the first time organise unions that industrial employers had to recognise. All of these changes confronted German chemists at the end of the war with major dilemmas.

The following paper will highlight two key responses by the German chemical profession to these transformations during the years from 1919 up to the advent of National Socialist rule in 1933: first, efforts to expand the chemical profession by opening new opportunities for chemists to find employment in branches of the economy where they had previously been little represented; second, efforts to develop closer ties between chemists and engineers, in order to meet the new technological challenges, to promote the ongoing "rationalisation" movement in industrial production, and eventually to establish something like a profession of chemical engineering. These efforts had rather mixed results.

Too many chemists, too few jobs? The problem of maintaining professional growth

One of the leaders of the German chemical industry who thought deeply about the implications of the war for the chemical profession was Karl Goldschmidt (1857-1926), director of the Th. Goldschmidt AG in Essen. In April 1918, with Russia out of the war in the East and Germany still hoping for success in the West as a major spring offensive began, Goldschmidt wrote a perceptive analysis of the economic situation of chemists after the war. In this article, published in the VDC's journal in August 1918, Goldschmidt focused on two critical developments. First, he expected an initially high postwar demand for chemists, paired with an initial shortage of male chemists, to bring more women into the profession and attract more students, including a backlog of five years of chemistry students returning after military service. Second, a "sudden" crisis would come in a few years with the saturation of overseas markets and the industry's inability to hire more young chemists, just at the moment when the new generation of graduating chemists began looking for jobs.[3]

Hence Goldschmidt argued that it would be crucial to expand the profession, and he proposed the following suggestions:

1) the VDC should actively work to expand opportunities for chemists in related economic branches which used chemistry but employed relatively few chemists, especially in agriculture, but also in branches such as dyeing and tanning, ceramics and glass, metallurgy, and cement;

2) additional research institutes should be established, such as the Kaiser Wilhelm Institutes for Chemistry and Physical Chemistry created shortly before the war; and

3) the VDC should coordinate these efforts with an improved job placement service (*Stellenvermittlung*), which would assist young chemists by proposing the most suitable candidates to work in the new branches being opened to the profession.

Goldschmidt's suggestions initially had little impact, as the German military collapse and the November Revolution of 1918 raised many more pressing political and economic questions. But events soon proved Goldschmidt right. The data in Tables 1a/b reflect the postwar influx of chemists that he had predicted, together with the subsequent collapse in the job market. Thus while the number of chemistry students peaked in 1922/23, and the number of graduates peaked in 1923/24 (approaching triple the prewar level from 1913), the number of chemists hired by industry had already peaked in 1922 and by 1924 was little higher than the prewar level. At the same time, the number of new women graduates being hired fell from a relatively small but still promising figure of 16 to the discouragingly small number of 3.

Table 1a

Chemistry students and graduates, 1913/14 vs. 1923/24[4]

Winter-Semester:	*1913/14*	*1921/22*	*1922/23*	*1923/24*
Chemistry students (German)	2,729	7,005	7,325	6,851
Index (1913/14=100)	100	256	268	251
Chemistry graduates (with Dr. or Diplom)	362	544	776	941
Index (1913/14=100)	100	150	214	260

Table 1b

Hiring of chemists by the chemical industry, 1913 vs. 1922-24[5]

Chemists hired in year	*1913*	*1922*	*1923*	*1924*
by the chemical industry	336	695	534	383
Index (1913=100)	100	207	159	114
[of these, new graduates]	170	411	345	215
Index (1913=100)	100	242	203	126
[number who were women]	n/a	16	10	3
(% who were women)		3.9%	2.9%	1.4%

Up to this point professional organisations like the VDC had been content simply to distribute notices to the schools warning students against studying chemistry, unless they were unusually well qualified. But these warnings seemed not to have had much impact.[6] For every starting position in the industry there were currently as many as 200 applicants. Hence new opportunities for employment must be found, or an entire generation of promising young chemists might be lost to the profession. In 1925 Goldschmidt thus repeated his earlier warning (using long passages taken unchanged from his 1918 article), and now he especially stressed the need to promote chemistry in related economic branches that hitherto had employed few chemists.[7] This time the VDC recognised the need to respond decisively.

Chemists and the industrial rationalization movement in the 1920s

The VDC may have responded more strongly to Goldschmidt's renewed suggestions of 1925, because his arguments now seemed well-suited to the idea of "rationalisation," which had become a widespread trend in German industry in the postwar era. This was a general movement toward greater efficiency in production by more applying more "scientific" approaches, and one way to do this would be to replace vocationally trained masters and foremen by academically trained scientists.[8] The coal-tar dye industry, which began this process decades before the war, could be a model for the success resulting from carrying through this process, which could now be promoted in other industrial branches as well.

The Karl Goldschmidt Office, 1925-34

During 1925-26, the VDC established an agency to promote opportunities for chemists outside the traditional chemical industry. This they named the "Karl Goldschmidt Office for Chemistry and Economics" (*Karl-Goldschmidt-Stelle für Chemie und Wirtschaft*) in Goldschmidt's honor, after his sudden death in 1926. In the following year it was renamed "Karl Goldschmidt Office for Chemistry in Scientific Management" (*chemisch-wissenschaftliche Betriebsführung*). Participa ting with the VDC in this office were the Chemical Industry Employers' Association (*Arbeitgeberverband der chemischen Industrie*), and the League of Employed Academics in Technical and Scientific Professions (*Bund angestellter Akademiker technisch-naturwissenschaftlicher Berufe* (previously [1919-1925] known as Budaci, for *Bund angestellter Chemiker und Ingenieure*, or League of Employed Chemists and Engineers, the professional union of the chemical industry). The Goldschmidt Office was not intended to be a job placement service as such, but acted instead as an information service (one might say propaganda office) to inform other branches of industry and governmental agencies as to the value of using professionally trained chemists to achieve their goals. In this function it would serve to promote "the most complete rationalisation" of German production, by making it "thoroughly scientific."[9] Space in this paper does not permit a detailed analysis of the work of the Goldschmidt Office, which in any case existed in its original form only until 1929, when the crisis of the depression led the VDC to merge it with a job placement service. Then in 1933 the National Socialist regime forced the dissolution of the *Bund*, and in 1934 merged the Goldschmidt Office into a national jobs register controlled by the NS German Labor Front (*Deutsche Arbeitsfront* or DAF).[10]

Did the profession expand?

Unfortunately, as 1933 was the worst point of the economic depression, it is difficult to use data from that period to measure the effectiveness of the efforts of the Goldschmidt Office to expand professional opportunities for chemists. Even so, although the onset of the Great Depression after 1928 increased the unemployment rate of chemists, the success of efforts to promote the expansion of chemistry into new areas was reflected in the fact that chemists lost relatively fewer jobs in the branches of industry outside the traditional chemical industry. By 1933 the VDC estimated that there were nearly as many German industrial chemists working outside the chemical industry (4,000, down only 500 since 1928) as within it (4,400, down 1,100 since 1928).[11] In the longer term, with economic recovery,

this trend of successful expansion into other industrial branches continued. One can compare employment statistics from the Reich Occupational Censuses for 1925 and 1939, which are shown in Table 2. These figures clearly show that the profession as a whole expanded by nearly 50% during this period, but more important, that two-thirds of the new opportunities were to be found outside the chemical industry as traditionally defined.

Table 2

Reich Occupational Census data for numbers of employed German chemists[12]

Occupational branch/year	*1925*	*(%)*	*1939*	*(%)*
Chemical industry	6 019	57	7 581	50
Education (all levels)	684	6	1 071	7
Government (except army)	204	2	883	6
iron, other metals industry	522	5	760	5
sugar industry	244	2	251	2
Electro-technical industry	236	2	424	3
Machine construction	178	2	300	2
Other branches	2 487	24	3 989	26
Total of employed chemists	10 574	100	15 259	100

The problem of establishing chemical engineering as a German profession before 1945

Closely related to the postwar problems of rationalisation and expanding the chemical profession was the idea of developing closer ties between chemistry and engineering, which would be essential to ensuring the most efficient methods of large-scale production. As is well known, however, the situation in Germany was very different from that in the Anglo-American context, where during the first three decades of the twentieth century a profession of "chemical engineering" developed in close connection to the profession of chemistry and complete with professional organisations, teaching institutions and journals, as well as a fundamental methodology based on the concept of "unit operations."[13] Although the larger German chemical plants all had many engineers, many leading German chemists and businessmen strongly opposed the idea of a "chemical engineer" or "chemist engineer" as such. For the typical attitude of leaders of the VDC, consider the views of Alfred Stock (1876-1946, chair of the VDC in the 1920s and director of the Kaiser Wilhelm Institute for Chemistry): "*German* higher education

knows no 'chemist engineers.' …The education of men who are simultaneously chemists and engineers, given the high skills demanded from both types, would produce a half-breed, from which the chemical industry at least could hardly benefit." Here Stock was almost directly quoting Carl Duisberg, technical director of the Bayer Dye Works and from 1907 to 1912 chair of the VDC, who in 1896 had similarly denounced the "chemist engineer" as an unworkable combination, because no one could simultaneously master both chemistry and engineering. [14] The German opposition to developing an interdisciplinary field of this type may seem a bit odd, as the German colleges of technology (*technische Hochschulen* or THs) all had departments of chemistry (often combined with metallurgy), and since 1899 chemists trained there could receive a degree of "Dr.Ing.," i.e. doctorate of engineering. Despite this nominal expertise in engineering, however, before the war the actual content of a chemical education in the THs was not significantly different from that at the university, except for a greater emphasis upon physical and inorganic chemistry as well as the addition of a variety of mainly descriptive, survey courses on various aspects of "technical" or "applied" chemistry (or "chemical technology"). If chemists studied engineering, they generally did so in supplementary courses rather than as a major field. Before the Second World War there were only a few weak efforts in Germany to develop chemical engineering (or chemical process technology) as an academic discipline.

Chemical engineering without "chemical engineers"?

As Krug and Meinicke have pointed out, the German chemical industry nevertheless found various ways to substitute for the lack of "chemical engineers," principally by promoting the cooperation of chemists and mechanical engineers in the design of plant and apparatus.[15] For example, perhaps the leading chemical firm making extensive use of engineering was the Badische Anilin & Sodafabrik in Ludwigshafen and Oppau, with a subsidiary in Leuna-Merseburg (BASF, from 1925 the Upper Rhine division of IG Farbenindustrie AG), which had developed the Haber-Bosch ammonia synthesis before the war, followed by other hydrogenation processes). In July 1928 this division had 345 engineers in its "machine-technical" departments, most holding the Dipl.-Ing. or Dr. Ing. title, but it is unlikely that any of these was designated a "chemical engineer." At the same time they had more than 500 chemists, nearly all with doctorates, as well as physicists, botanists, and agricultural scientists.[16] Smaller chemical firms, however, found themselves at a disadvantage, because they could not so easily afford to employ such large teams of specialists, nor could they easily obtain the information they

needed to enhance their production processes, as the bigger firms naturally sought to keep proprietary control over the innovative plant and apparatus designed by their teams.

Apparatus design as a substitute for "chemical engineering"

As a result, even before the end of the First World War there were efforts to approach the problem of marrying chemistry and engineering within the VDC by focusing on apparatus design. One of the leaders in this effort was the chemist Max Buchner (1866-1934), who in 1918 helped to organize the *Fachgruppe für Chemisches Apparatewesen* (Fachema, Specialty Group for Chemical Apparatus) within the VDC, in order to promote collaboration among chemists, engineers, machinists, and industry in the development of new chemical process equipment. The group, initially divided into a section for "scientific and laboratory apparatus" as well as one for "large-scale technical apparatus" (the latter chaired by Buchner), shared the common goal of simplifying and standardising materials and forms, which was a central focus of the emerging rationalisation movement. Similarly central to the rationalisation movement was Buchner's emphasis on replacing human labour by machines, which would make chemical production increasingly dependent upon engineering. But machine engineers could not successfully design chemical apparatus without the cooperation of chemists.[17] Thus he hoped to use the Fachema to bring chemists and engineers together for exchanges of ideas on large-scale plant apparatus — thus bypassing, one may say, the German reluctance to promote an interdisciplinary profession such as chemical engineering. Moreover, he soon found an ideal means to foster such interchanges, as well as to promote the development of an industry for chemical manufacturing apparatus (as well as laboratory apparatus). In 1920 Buchner organized the first "Exhibition of Machines, Apparatus, Equipment and Materials of all Types for Chemical Industry and Laboratories," which was held on a rather modest scale at the VDC's annual meeting in his home town of Hanover.[18]

The clumsy title of the first exhibition was subsequently simplified *to Ausstellung für chemisches Apparatewesen* (Exhibition of Chemical Apparatus), universally known by its acronym, Achema. Initially each Achema was held in conjunction with the VDC's annual meetings (Achema II [Stuttgart 1921], III [Hamburg 1922], IV [Nuremberg 1925]), but by the latter year it was beginning to outgrow the framework of the VDC, having grown from an exhibition space of 560 m^2 (with 75 exhibitors and 876 participants) in 1920 to 2650 m^2 (with 112 exhibitors and 8,173 participants) in 1925.[19] Buchner also scored what he must have seen as a

major achievement by persuading none other than Carl Duisberg, a longtime opponent of chemical engineering in the VDC, to write the introduction to the first Achema yearbook (1925). In Duisberg's words, "the more the boundaries between physics and chemistry overlap in science and in practice, the more significant becomes the question of apparatus."[20]

The founding of the German Society for Chemical Apparatus (Dechema), 1926

In 1926, following Buchner's proposal in connection with the 1925 Achema, the Fachema was reorganized as the *Dechema - Deutsche Gesellschaft für Chemisches Apparatewesen* (German Society for Chemical Apparatus), an independent group that remained affiliated with the VDC, but was now open to a wider membership beyond professional chemists. The purposes of the new organisation included the recruitment of both chemists and non-chemists as members, including engineers and technicians as well as firms engaged in the manufacture of apparatus for chemical plants, while promoting cooperative work between the VDC and other organizations including the *Verein Deutscher Ingenieure* (VDI, Association of German Engineers). Accordingly Waldemar Hellmich, an engineer who was particularly interested in the design of apparatus for chemical processes, joined the Dechema board as VDI representative. Of course the Dechema would continue to sponsor expanded Achema exhibitions, and its other goals included the supervision of standardisation work and "rationalisation" for chemical laboratories and industry (in cooperation with the *Deutscher Normenausschuss* (German Standards Committee, or DNA, founded in 1917; this had already issued 1500 standardisation leaflets by 1926), as well as the promotion of research and publications on chemical apparatus.[21]

The Association of German Chemists, Dechema, and Die chemische Fabrik

The VDC first began to systematically examine questions of engineering (as opposed to its previous focus on "applied chemistry") with the serial publication *Die chemische Fabrik* (*The Chemical Factory*), which began in October 1927 as a joint VDC-Dechema enterprise under Max Buchner's editorship as a supplement to the VDC's *Zeitschrift für angewandte Chemie*. The preface emphasised the VDC's work in the "border areas between chemistry and other disciplines," partic-

ularly that "which joins the work of the chemist to that of the engineer and the builder of apparatus." Just as in recent years it had become increasingly necessary to acquaint engineers and specialists in other disciplines with the creative processes of chemistry, so the students of chemistry needed to be introduced to the technical aspects of factory production. The new publication would thus cover the "nature of the chemical factory as a whole."[22] By the end of the year the "supplement" had grown to nearly 400 pages, making it obvious that an independent publication would be needed; hence in 1928 *Die chemische Fabrik* began to appear as a separate journal (which continued under this title until 1941). Its substantial volumes contained articles and news on chemical manufacturing technology and apparatus, Achema news, specifications for new standards from the DNA (in cooperation with Dechema), and initially (in cooperation with the VDC's Karl Goldschmidt Office) suggestions for new employment opportunities for chemists in other industries.

Conclusions

The problems of the German chemical profession and the chemical industry in the aftermath of war, as discussed above, led to innovative responses on two related fronts during the years up to 1933. On the front of professional employment, the VDC established an organisation (the Goldschmidt Office) to promote new opportunities for chemists in areas outside the traditional chemical industry, in part with the justification that this would help to further rationalise the German economy by making production more scientific. On the front of German chemical manufacturing technology, the VDC also initiated efforts to promote closer cooperation between chemists and engineers, without promoting a nominal discipline or profession of "chemical engineering" (a notion then unacceptable to many leading academic and industrial chemists). On this front, German chemists and engineers also promoted the rationalisation of chemical laboratory work and industrial production, and the institutionalisation of a new focus on chemical apparatus, through the creation of professional groups (Fachema and Dechema), the holding of regular exhibitions (Achema), and the creation of a professional journal (*Die chemische Fabrik*). These various efforts together provided some, if not all, of the functions of the professional organisations for chemical engineering found in other nations. The most significant missing elements were in education and licensing; these were to some extent compensated for by the development of the academic discipline "process technology (*Verfahrenstechnik*)," which however did not become fully established until well after the period under discussion.

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Notes

[1] These generalisations are based on current research on the German chemistry during the First World War, as part of a comparative analysis of munitions production, in collaboration with Roy MacLeod of the University of Sydney, and supported by a research grant from the U.S. National Science Foundation. For initial results see Roy MacLeod and Jeffrey Allan Johnson (eds.), *Frontline and Factory: Comparative Perspectives on the Chemical Industry at War, 1914-1924* (Dordrecht, NL: Springer, 2006).

[2] Jeffrey A. Johnson, "Frauen in der deutschen Chemieindustrie, von den Anfängen bis 1945," in *"Aller Männerkultur zum Trotz": Frauen in Mathematik und Naturwissenschaften*, ed. Renate Tobies, 2nd ed. (Frankfurt/M., New York: Campus-Verlag, 2008), 283-305, on 287-291; Christine Roloff, *Von der Schmiegsamkeit zur Einmischung. Professionalisierung der Chemikerinnen und Informatikerinnen* (Pfaffenweiler: Centaurus, 1989), 99-100.

[3] Karl Goldschmidt, "Die wirtschaftliche Lage der Chemiker nach dem Kriege," *Zeitschrift für angewandte Chemie*, 31 (1918), 157-160, on 159.

[4] Sources for Table 1a/b: "Statistik der Chemiker und Chemiestudierenden," *Zeitschrift für angewandte Chemie*, 26 (1913), *Aufsatzteil*, 756-757; "Statistik der Chemiker", "Statistik der Chemiestudierenden," *Zeitschrift für angewandte Chemie*, 38 (1925), *Aufsatzteil*, 1211-1214. The data are based on VDC annual surveys of approximately 480 firms and all but six university-level teaching laboratories.

[5] Sources for Table 1b: see previous note (Sources for Table 1a/b).

[6] "Warnung vor dem Chemiestudium," *Zeitschrift für angewandte Chemie,* 38 (1925), 219-220.

[7] Karl Goldschmidt, "Die Not der jungen Chemiker," *Zeitschrift für angewandte Chemie,* 38 (1925), 357-359.

[8] The classic analysis is Robert A. Brady, *The Rationalization Movement in German Industry: A Study in the Evolution of Economic Planning* (Berkeley, Calif.: University of California Press, 1933; repr. New York: H. Fertig, 1974); Hans Wupper-Tewes, *Rationalisierung als Normalisierung: Betriebswissenschaft und betriebliche Leistungspolitik in der Weimarer Republik* (Münster: Westfälisches Dampfboot, 1995).

[9] Alfred Stock, "Die Karl Goldschmidt-Stelle für Chemie und Wirtschaft," *Zeitschrift für angewandte Chemie,* 39 (1926), 441-443, on 441; on Budaci see Heiner Ramstetter, "Der deutsche Chemiker im Krieg und Frieden (1914-1945)," in Eberhard Schmauderer (ed.), *Der Chemiker im Wandel der Zeiten: Skizzen zur geschichtlichen Entwicklung des Berufsbildes* (Weinheim: Verlag Chemie, 1973), 311-323, on 321-322.

[10] See documents in "Karl Goldschmidt Stelle 1926" (file), Gesellschaft Deutscher Chemiker, Frankfurt am Main; and annual reports in *Zeitschrift für angewandte Chemie*. On the Labor Front there is no general history, but see Karl Heinz Roth, *Intelligenz und Sozialpolitik im*

"Dritten Reich": eine methodische-historische Studie am Beispiel des Arbeitswissenschaftlichen Instituts der Deutschen Arbeitsfront (München: K.G. Saur, 1993).

[11] "Statistik der Chemiker," *Zeitschrift für angewandte Chemie*, 49 (1936), 522.

[12] Sources for Table 2: Germany, Statistisches Reichsamt, *Volks-, Berufs- und Betriebszählung vom 16. Juni 1925 (Statistik des Deutschen Reichs,* Band 402, I and II: *Berufszählung: Die berufliche und soziale Gliederung der Bevölkerung des Deutschen Reichs*), passim; and *Volks-, Berufs- und Betriebszählung vom 16. Juni 1933 (Statistik des Deutschen Reichs,* Band 556: *Die Berufstätigkeit der Bevölkerung des Deutschen Reichs*, Heft 1), passim. The table excludes directors and self-employed individuals.

[13] On the early development of chemical engineering (in the peculiarly German form of *Verfahrenstechnik* , "process technology"), with some comparisons to other countries, see the works of Klaus Krug, particularly "Zur Herausbildung der Verfahrenstechnik," in *Der Ursprung der modernen Wissenschaften. Studien zur Entstehung wissenschaftlicher Disziplinen*, ed. Martin Guntau and Hubert Laitko (Berlin: Akademie-Verlag, 1987), 257-271, and "Zur Entwicklungsgeschichte der Verfahrenstechnik von den Quellen bis zu ihrer Emanzipation," Diss. B (Dresden: Technische Universität, 1983), summarised in "Zur Entwicklungsgeschichte der Verfahrenstechnik von den Quellen bis zu ihrer Emanzipation (Thesen)," *NTM-Schriftenreihe zur Geschichte der Naturwissenschaft, Technik und Medizin*, 22 (1985), 51-59. See also Wolfgang Fratzscher and Klaus Krug, "70 Jahre Verfahrenstechnik: ein Rückblick," *Chemie-Ingenieur-Technik,* 70 (1998), 634-646. A brief general survey with emphasis on the United States is Wayne M. Pafko, *The History of Chemical Engineering* (updated 9/25/2000), at *http://www.pafko.com/history/h_chem20.pdf* (accessed 6/9/2008).

[14] *Zeitschrift für angewandte Chemie,* 32/1 (1919), 93; *Z. angew. Chem.,* 9 (1896), 97.

[15] Klaus Klug and Klaus-Peter Meinicke, "Verfahrenstechnik: Auseinandersetzungen um ihre Emanzipation," Wissenschaftliche Zeitschrift TH Leuna-Merseburg, 30 (1988), 331-338, on 332.

[16] Ingenieur-Liste (1. Juli 1928), in BASF Unternehmensarchiv, Ludwigshafen/Rh., C 623 Ingenieureinheiten Betriebsgemeinschaft Oberrhein 1928-1940; Chemiker-Liste (April 1926), BASF/UA, C 623. On BASF and its role in IG Farbenindustrie AG see Parts II and III (by Jeffrey Allan Johnson and Raymond G. Stokes, respectively) in Werner Abelshauser et al., *German Industry and Global Enterprise. BASF: The History of a Company* (New York: Cambridge University Press, 2004).

[17] Max Buchner, *Denkschrift über die Ziele und Aufgaben der Fachgruppe für chemisches Apparatewesen, Abteilung für chemische Großapparate* (Hanover, Ger.: Wilh. Riemschneider, [no date, 1919?]).

[18] "Chemisch-wirtschaftliche Nachrichten," *Zeitschrift für angewandte Chemie,* 33 (1920), Wirtschaftlicher Teil, 288, 350-351.

[19] Utz-Hellmuth Felcht, Wolfgang Habig, and Gerhard Kreysa (Hrsg.), *Signale und Spuren: Festschrift anläßlich des 25. ACHEMA-Jubiläums 1997* (Frankfurt/M.: DECHEMA e.V., 1997), 34; see also Utz-Hellmuth Felcht, "Die DECHEMA – Geschichte im Spiegel der Gegenwart," in Felcht and Kreysa (Hrsg.), *75 Jahre DECHEMA 1926-2001: Festschrift anläßlich des 75. DECHEMA-Jubiläums* (Frankfurt/M.: DECHEMA e.V., 2001), 6-15.

[20] *Achema-Jahrbuch, Jahrgang 1925,* Hrsg. Max Buchner (Leipzig: Verlag Chemie, 1925).

[21] "Fachgruppe für chemisches Apparatewesen," *Zeitschrift für angewandte Chemie,* 38 (1925), 840; "Deutsche Gesellschaft für chemisches Apparatewesen," *Zeitschrift für angewandte Chemie,* 39 (1926), 709-714, on 709-710. See also Bruno Holm, *Fünfzig Jahre Deutscher Normenausschuss* (Berlin : Beuth-Vertrieb, 1967).

[22] "Die chemische Fabrik," *Zeitschrift für angewandte Chemie,* 40 (1927), 1203.