

Building on Air

The International Industrial Gases Industry, 1886–2006

The industrial gases industry originated in 1886, when a London-based company began producing high-purity oxygen. Initially, purified oxygen was a solution in search of a problem, but demand for it soared early in the twentieth century with the emergence of welding technology. By then, dramatic technological improvements in air separation and purification emerged, as did most key firms dominating the industry today.

Building on air in the decades that followed, the firms expanded their product range and geographical reach to create applications essential to every manufacturing process in the modern world, from semiconductor production to oil refining, waste water treatment, and steelmaking. This is the first scholarly history of this vital but invisible industry from its origins to the present. Based on unparalleled access to company and public archives, the book explores business and technological development, industrial evolution, and the industry's persistent local roots even while becoming international and global.

Raymond G. Stokes has held the Chair of Business History at the University of Glasgow since 2005, where he also serves as Director of the Centre for Business History in Scotland. His book *The Business of Waste: Great Britain and Germany, 1945 to the Present* (with co-authors Roman Köster and Stephen Sambrook) was published by Cambridge University Press in 2013.

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*The International Industrial Gases Industry,
1886–2006*

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*To our parents: Brenda and George,
and Elfriede and Bernd*

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Acknowledgments

The project that resulted in this book had its origins in 2007, not long after Linde AG's 2006 takeover of British-based British Oxygen Company (BOC), an acquisition that made the German-headquartered firm one of the two largest industrial gases companies in the world. Linde's then Head of Corporate Heritage, Klaus Schönfeld, approached one of the co-authors, Ray Stokes, with the idea of commissioning a history of BOC. I was reluctant, though, to write a history of a single firm for a number of reasons and made the counter-suggestion of engaging in a much more ambitious project involving a business history of the international industrial gases industry from its origins when BOC's predecessor firm, Brin's Oxygen was founded in 1886, through to the twenty-first century. Klaus Schönfeld gained agreement from Linde to fund research costs associated with the project; to hire a full-time researcher, Ralf Banken, who is the co-author of the book; to provide archival access not only to its own collections, but also to those of BOC and of AGA, a Swedish-based international industrial gases company that Linde had taken over in 2000; and to arrange for introductions to officials in industrial gases trade associations to enable contact with representatives of other firms. Crucially, too, Linde agreed not to interfere in any way in the process of research and writing that has culminated in this book. We are extremely grateful to Linde for its generosity in funding the project and to company staff for their support as we carried it out, including adhering strictly to their promise to allow us complete independence to pursue it in the years since 2007.

Indeed, the research and writing process has taken considerably longer than we anticipated at the outset, not least because of the extraordinary

richness of primary source material that was made available to us and because of the time needed to unravel some of the complexities of the evolution of the international industrial gases industry between the late nineteenth century and the present. Co-authoring in two languages was also more time-consuming than expected. Each of us wrote the first drafts of a number of chapters in our native language, with Ray Stokes taking responsibility for the introduction, the conclusion, and Chapters 1–5 and 7 and Ralf Banken writing the remaining chapters. The drafts of Chapters 6 and 8–10 were then translated into English by Anne Stokes, and, subsequently, the authors worked together closely on correcting and refining them – often assisted by insightful comments or advice on style from a number of readers of all or parts of the manuscript (thanked below) – until the chapters reached their final form. The final English version of the manuscript then served as the basis for the German publication of this book.¹ We have since made a few additional amendments in preparing the final manuscript for this book.

We have been fortunate throughout this endeavor to be accompanied by an Advisory Board that included Professors Walter Kaiser (University of Aachen) and Ulrich Wengenroth (TU Munich) as academic advisors, as well as Dr. Andrea Schneider of the German Society for Business History as project manager. Klaus Schönfeld, who was extraordinarily helpful in many ways in accompanying and supporting our work during most of the project, was also on the Board for the first several years, while Stefan Metz from Linde was our official contact with the company during the final phase of the project. We are grateful to all of them for their patience, which was sometimes taxed very heavily indeed, and for their insightful advice and comments.

In carrying out the project, we have also been aided by a number of other individuals and organizations in a range of ways. One critical area involved gaining access to primary materials and interview partners at companies, and invitations to Ray Stokes to present the project to meetings of the International Oxygen Manufacturers' Association (IOMA) in Ireland in 2008 and to the European Industrial Gases Association (EIGA) in Brussels in 2010 were especially helpful in this regard. Thanks in particular go to David Saunders for arranging the former and to Frank Finger for the latter. A number of companies who heard (or heard about) the presentations provided us with sources and

¹ Raymond G. Stokes and Ralf Banken, *Aus der Luft gewonnen. Die Entwicklung der globalen Gaseindustrie 1880 bis 2010* (Munich: Piper, 2014).

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Much of the material we gathered, though, came from more mainstream company and public archives. We visited a large number of them over the course of the project, and the full list of archival repositories consulted is found at the end of this book. We, of course, very much appreciate the access and support given in each case, but would like to thank in particular Werner Jakobsmeier (Corporate Archives of Linde), Vladimir Marek (Evonik Archives, Marl), and the staff at the Merseburger Stadtarchiv and Staatsarchiv. All of them deserve a special vote of thanks because they were especially helpful. Mechthild Wolf and Wilfried Forstmann have also helped in the archival work through specialist organizational and/or language knowledge.

Not all of the sources we have used have been documents or printed materials. We also benefitted from a number of oral sources. In two briefings during 2008 to meetings of the Project Advisory Board on aspects of the structure of the contemporary industrial gases industry, Linde’s Dr. Peter Vocke provided a valuable overview that helped orient us at the start of the project. In November 2010, Klaus Schönfeld organized briefings for Ray Stokes at the Linde Applications Center near Munich. Here, Henning Tomforde, Michael Graf, Wilfried-Henning Reese, and Dr. Dirk Hupperich provided information in particular on the promise and potential of the emerging hydrogen business, whereas Dr. Jörg-Michael

Willke's more general presentation on the evolving role of applications in the industrial gases industry during the twentieth century was extremely helpful in providing insight and context, as was a tour of the facilities after the briefings. In addition, we benefitted from a very long, informal discussion of the project with Andrew Butrica, the author of a 1990 monograph on Air Products, in the context of a scholarly conference held at the University of Glasgow in Summer 2011. We are grateful to them all.

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Information is essential to a project like this, but so is engagement in critical dialog with other scholars as the analysis develops. Here, we benefitted from incisive feedback and extensive discussion in seminars and presentations at the Universities of Bochum, Cologne, Frankfurt, Göttingen, Newcastle, and Strathclyde; at the Fuji Conference in Kyoto in September 2013; and at various meetings of the Association of Business Historians, the European Business History Association, and the Gesellschaft für Unternehmensgeschichte. We also got some very useful advice, in particular for the discussion of Britain's industrial system in the 1970s, in the course of conversations with Jim Phillips, Duncan Ross, and Neil Rollings in 2009 and 2011.

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We are particularly grateful to several people for their outstanding work in helping us bring this multiyear project to a successful conclusion. First, thanks go to a number of critical readers of the manuscript. In addition to translating four chapters written by Ralf Banken into English, Dr. Anne Stokes read, commented on, and corrected the entire English-language manuscript that formed the basis for the German version of the book, which appeared in June 2014 and has been revised to some extent for this version. She also suggested the final version of the title of the book to us. Dr. Gunnar Eggendorfer and Professors Walter Kaiser and Ulrich Wengenroth also read the entire manuscript, providing excellent feedback in spite of short notice, as did Stephen Sambrook. These critical readings have helped make the book as factually correct, clear, coherent, and well-written as possible, although we, of course, are responsible for any errors or stylistic infelicities that remain. Second, we are extremely grateful to Tanja Roos, who did all sorts of work, often at short notice, to ensure consistency and accuracy in citations and formatting. She also read the manuscript critically to ensure clarity and helped in the selection of, and gaining permissions for, photographs and illustrations. Third, we are grateful to Frank Smith, Deborah Gershenowitz, Dana Bricken, and Paul Smolenski at Cambridge University Press for shepherding the book from contract through review, acceptance, and production, as well as to Philip Alexander at Integra Software Services, and to Joann Woy, the copyeditor of the manuscript at Blue Moon Editorial Services. Last, but not least, our thanks to Dr. Andrea Schneider, who has been a remarkably cheerful and calm manager of a project, the completion of which depended fundamentally on two authors who are difficult to manage, particularly in relation to deadlines. That we got there in the end is in no small measure owing to the direction and organizational support that Dr. Schneider provided, as well as the support, assistance, and advice of all of those already acknowledged.

A final note: Part of Chapter 6 and the brief note on BOC archives in the list of archives appeared in Ralf Banken and Ray Stokes, “The trauma of competition’: The entry of Air Products Inc. into the industrial gases business in Britain and continental Europe, 1947–70,” *Business History* 52 (December 2010): 1047–1064. The excerpt is used by kind permission of the publisher (Taylor & Francis Ltd., www.tandf.co.uk/journals).

Glasgow and Frankfurt,
28 January 2015

Abbreviations

AG	Aktiengesellschaft (joint-stock corporation)
AGA	AG Gasaccumulator
AGAD	AGA Depository (held in Centrum för Näringslivshistoria, Bromma/Stockholm)
Airco	Air Reduction Corporation
AL	Air Liquide
ANMT	Archives Nationales du Monde du Travail, Roubaix
AP	Air Products
APCI	Air Products and Chemicals, Incorporated
APL	Air Products Limited
ASU	air separation unit
AVDEh	Archiv des Vereins Deutscher Eisenhüttenleute, Düsseldorf
BaO	barium oxide
BaO ₂	barium dioxide
BLA	British Liquid Air
BOC	British Oxygen Company
BOCI	British Oxygen Company International
BOCM	Archives of BOC held in Corporate Archives of Linde AG, Munich
BOCW	Archives of BOC held in storage facility in Wales (electronic versions of some of the holdings in possession of authors)
BOL	British Oxygen Linde Limited
BRABAG	Braunkohlen-Benzin AG
BSA	Berlin State Archives (Staatsarchiv)
Burdox	Burdett Oxygen of Cleveland
C ₂ H ₂	acetylene

CAB	Corporate Archives of BASF AG
CABY	Corporate Archives of Bayer AG, Leverkusen
CAEI	Corporate Archives of Evonik Industries AG, Marl
CAL	Corporate Archives of Linde, AG, Munich
CAS	Corporate Archives of Sanofi Group, Frankfurt-Hoechst
CATK	Corporate Archives of Thyssen-Krupp AG, Duisburg
CEO	chief executive officer
CME	coordinated market economy
CO ₂	carbon dioxide
Corgon	carbon dioxide and argon gas
Coxogen	carbon dioxide, argon, and oxygen gas
DCM	Deutsches Chemiemuseum Merseburg
DHZ	Deutsche Handelszentrale Chemie (German Trade Central for Chemicals)
DM	Deutsche mark
ECSC	European Coal and Steel Community
EEC	European Economic Community
EIGA	European Industrial Gases Association
EOR	enhanced oil recovery processes
ETH	Eidgenössische Technische Hochschule
FAB	Federal Archives (Bundesarchiv), Berlin
FAZ	<i>Frankfurter Allgemeine Zeitung</i>
FTC	Federal Trade Commission (USA)
Galco	Gesellschaft für Industrielle Fertigungen der Chemie und Physik
GDR	East German Democratic Republic
Hüsa	Hüttensauerstoff GmbH
IGA	Industriegas GmbH & Co KG
IOMA	International Oxygen Manufacturers Association
ISG	Internationale Sauerstoffgesellschaft AG
JV	joint venture
KClO ₃	potassium chlorate
KZO	Koninklijke Zout Organon
LAL	L'Air Liquide
LANA	Liquid Air of North America
LAP	Linde Air Products Company
LAS	Linde AG Aufsichtsratssekretariat (Bureau of Supervisory Board) [no public access to archival material]
LD	Linz-Donau process
LFC	Linde-Frank-Caro

List of abbreviations

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LME	liberal market economy
LNG	liquefied natural gas
Lotepro	Low Temperature Processes Corporation
LOC	Library of Congress
LOX	liquid oxygen
LPG	liquefied petroleum gases
MAD	Municipal Archives, Dresden
MAL	Municipal Archives, Leuna
MAPAG	Maschinenfabrik Augsburg-Plattling AG
MG	Messer Griesheim
MITI	Ministry of International Trade and Industry (Japan)
MRI	magnetic resonance imaging
N ₂ O	nitrous oxide
NH ₃	anhydrous ammonia (industrially produced ammonia)
PSA	pressure-swing adsorption
QEK	oxygen-enriched blast process
RFA	Ruckdeschel Family Archive, Munich [no public access]
RM	Reichsmark
RWWA	Rheinisch-Westfälisches Wirtschaftsarchiv, Cologne
SAG	Soviet joint-stock company
SAS	State Archives of Saxony, Leipzig
SASA	State Archives of Saxony-Anhalt, Merseburg
SIAC	Société Industrielle de l'Anhydride Carbonique
SIO	Italian Oxygen Company
SOL	Società Lombarda Ossigeno
SSPC	Société savoisienne des produits cryogéniques
Tega	Technische Gase (East German gases producer and distributor)
TIG	tungsten inert gas
UCC	Union Carbide Corporation (with Linde Air Products subsidiary/division)
USAAF	US Army Air Force
VEB	Volkseigener Betrieb (State-owned enterprise)
VPSA	vacuum pressure swing adsorption
VSW	Vereinigte Sauerstoff-Werke
VVB	Vereinigung Volkseigener Betriebe (Union of State-owned Enterprises)