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978-1-107-03312-2 - Building on Air: The International Industrial Gases Industry, 1886–2006

Raymond G. Stokes and Ralf Banken

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## 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.

Ralf Banken is a Privatdozent at Johann Wolfgang Goethe University, Frankfurt, and a researcher in the Department of History at the University of Cologne.

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# Building on Air

*The International Industrial Gases Industry,  
1886–2006*

**RAYMOND G. STOKES**

*University of Glasgow*

**RALF BANKEN**

*Johann Wolfgang Goethe-University, Frankfurt*



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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

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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.<sup>1</sup> 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

<sup>1</sup> 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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information. We would like to thank in particular Aldo Fumagalli (SOL), Walter Brant (Indiana Oxygen), Diana Buss (Messer), Betsy Klebe (Air Products), Nigel Muir (Praxair), Yuujirou Ichihara and Hiro Kobayashi (Taiyo Nippon Sanso Corporation), Christine Scully (Matheson Trigas), and Xavier Drago and Adam Cutforth (Air Liquide).

Others, too, were generous in the provision of critical documents and information that were either not available at all in archives or only accessible with great difficulty. These included Hans-Liudger Dienel, who kindly gave us copies of some important material he had collected in the process of preparing his history of Linde; Alison Weir, the wife of the late Dr. Ron Weir, who gave us access to the draft chapter on carbon dioxide from November 2008 in his unpublished manuscript of “The History of the Distillers Company, vol. 2”; Walter Ernst Ruckdeschl, who provided us with copies of materials from his family archive; Inga Weiss, whose unpublished manuscript on Linde and the steel industry was very helpful; and Andrea Reiß, whose University of Münster master’s thesis on Westfalen AG from 1923 to 1970 was also very helpful. Professor Ulrich Pfister made this last work available to us, for which we are grateful.

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

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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.

We have also been fortunate to gain access to a number of prominent executives in the industrial gases business who very generously gave us considerable amounts of their time for interviews. These included Dexter Baker, Dr. Bernd Rüdiger Conrad, Dr. Gunnar Eggendorfer, Aldo Fumagalli, Joseph Kaminski, Dr. Hans Kistenmacher, Dr. Walter Linde, Stefan Messer, Maris Sedlenieks, Lennart Selander, and Mike Wickham. Dr. John Royal and H. C. (Clem) Demmin of Praxair also arranged for Ray Stokes to engage in a roundtable discussion with current and former managers of the company's R&D operations at its Tonawanda R&D facility near Niagara Falls in 2008. In addition, Linde's Aldo Belloni, a member of the firm's managing board, was an important source of information and advice. We benefitted, too, from informal discussions with a large number of people at the IOMA and EIGA meetings, as well as during visits to various company headquarters and production facilities in the course of the project.

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.

We would also like to thank a number of people who have helped us in other ways in the course of the project. Martin Rexroth and Frederik Steinfeld served as Ralf Banken's student helpers in the course of the project, with Steinfeld engaged in particular to do some translations of AGA documents from Swedish into German. Dr. Ann Cameron stepped in at short notice when we had very brief access to the entire run of board minutes from BOC from 1886 to 1990, as well as a number of other key BOC documents, to photograph them.

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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](http://www.tandf.co.uk/journals)).

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## 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 <sub>2</sub>              | 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 <sub>2</sub> H <sub>2</sub> | 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 <sub>2</sub>   | 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 <sub>3</sub> | 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  |



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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 <sub>2</sub> O | nitrous oxide   |
| NH <sub>3</sub>  | 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)    |