

# Contents

<b>Introduction</b>	<b>11</b>
The Problematic Relationships Between Science, Technology, and Business—Science, Technology, and Capitalism in Max Weber's Developmental History—Science in Refrigeration and Brewing—The Weberian Perspective	
<b>I. Refrigeration Technology Before 1870</b>	<b>23</b>
1. The Economic, Technological, and Scientific Background	24
Industry and Capitalism in Europe and the United States—The Central Position of the Machine Industry—The Foundation of the Mechanical Theory of Heat	
2. The Classificatory Ideal Types of Natural and Mechanical Refrigeration	34
Max Weber's Concept of Classificatory Ideal Type—Refrigeration Without Machines—Mechanical Refrigeration	
3. Archetypes and Types in Mechanical Refrigeration	50
The Concept of Archetype—Gorrie's Air Expansion Apparatus—The Harrison-Siebe Vapor Compression Machine—The Diffusion and Transfer of Carré Absorption	
4. The Social Carriers and Concerned Parties of Refrigeration Technology	69
The Agency Perspective—Success and Failure in Social Carriage of Refrigeration—Technological Knowledge Before Scientification	

<b>II. The Scientification of Refrigeration Technology, 1870-1893</b>	<b>81</b>
<b>5. The Beginning: Carl Linde's Early Papers</b>	<b>83</b>
The Thermodynamic Approach—Practical Conclusions and Recommendations	
<b>6. The Institutional Background: School Culture Education</b>	<b>97</b>
School Versus Shop Training—Linde's Youth—The Swiss Polytechnic—Linde in Zurich—To the Shop and Back to School	
<b>7. The Intellectual Context: Rationality and the School of Technical Thermodynamics</b>	<b>113</b>
The Legacy of Linde's Teachers—Technological Modes of Presentation—Zeuner's Contributions—The Unfolding of Theoretical and Formal Rationality	
<b>8. The Response: The Brewing and Machine Industries Support Invention</b>	<b>129</b>
The Enrollment of the Scientist-Engineer—The Promises of the Second Prototype—Profits, Science, and Weberian Status Groups	
<b>9. The Expansion: The Linde Co. Supports Innovation and Diffusion</b>	<b>143</b>
The Stabilization of the Technical Core—The Inventor Becomes an Entrepreneur—The Development of Complete Machine Systems	
<b>10. The Final Word: The Scientification of the Marketplace</b>	<b>156</b>
Linde Versus Carré Absorption—Linde Versus Pictet Compression—The Refrigeration Testing Station as a Closure Mechanism—The Rational Experiment and Its Limits	
<b>11. Linde Refrigeration: Social Carriers, Translators, and Agency Networks</b>	<b>171</b>

### III. The Rationalization of the Brewing Industry 179

12. The History of the Brewing Industry:  
Craft and Factory 181

Max Weber's Anti-Evolutionism—Brewing: A Technology Based on Temperature Control—Pioneers: The British Porter Factories—Followers: The Bavarian Lager Breweries

13. The Mechanization of Brewing Refrigeration 193

Max Weber's Anti-Determinism—Non-Mechanical Cooling—The Coming of Mechanical Refrigeration and Large-Scale Brewing—The Adoption of Machinery and the Capitalist Factory

14. The Scientification of Brewing 210

From Brewhouse to School—The Academization of Brewing Training in Bavaria—The Coming of Chemistry and Biology—The Institutionalization of Brewing Science—The Adoption of Science and the Development of Practical Rationality

Conclusion 230

Rationality: The Common Denominator of Science, Technology, and Business—Toward a Weberian History and Sociology of Technology

References 242

Abbreviations—Archives—Periodical—Bibliography

Index 271

# Figures

Figure 1.1	Schematic representation of a steam engine cycle	32
Figure 2.1	Harvesting and storing of natural ice	39
Figure 2.2	The classificatory ideal type of air expansion (cold air)	43
Figure 2.3	The classificatory ideal type of vapor compression (cold vapor)	45
Figure 2.4	The classificatory ideal type of absorption	48
Figure 3.1	The main characteristics of Gorrie's air expansion apparatus	59
Figure 3.2	The Harrison-Siebe vapor compression machine	62
Figure 3.3	Respiration apparatus from the König Co. of Altona	63
Figure 3.4	Ferdinand Carré continuously working ammonia absorption machine	65
Figure 3.5	Ammonia absorption machine manufactured by Vaaß & Littmann, Halle	67
Figure 5.1	A schematic representation of an ice-machine cycle	85
Figure 5.2	The cyclic refrigeration process of Windhausen's air expansion machine	88
Figure 5.3	The cyclic refrigeration process of the Siebe vapor compression machine	89

Figure 6.1	Mechanical engineering curriculum, Zurich	105
Figure 8.1	Linde's first refrigeration patent	131
Figure 8.2	Linde's second compressor design	135
Figure 9.1	Linde's third compressor design	145
Figure 9.2	Laboratory of theoretical mechanical engineering, Munich	147
Figure 9.3	Linde machines at <i>Franziskaner-Keller</i> brewery	152
Figure 9.4	Semi-automatic, continuous ice-generator	154
Figure 10.1	Costs comparison of ice-machines	158
Figure 11.1	The social carriers of the Linde refrigeration machinery	172
Figure 11.2	The manufacture of a Linde refrigeration compressor	173
Figure 11.3	Agency network of the Linde refrigeration machine system	177
Figure 13.1	Brewery cooling system	197
Figure 13.2	Beer being poured into kegs	203
Figure 14.1	Brewing curriculum, Weihenstephan	214
Figure 14.2	Brewing laboratory	222