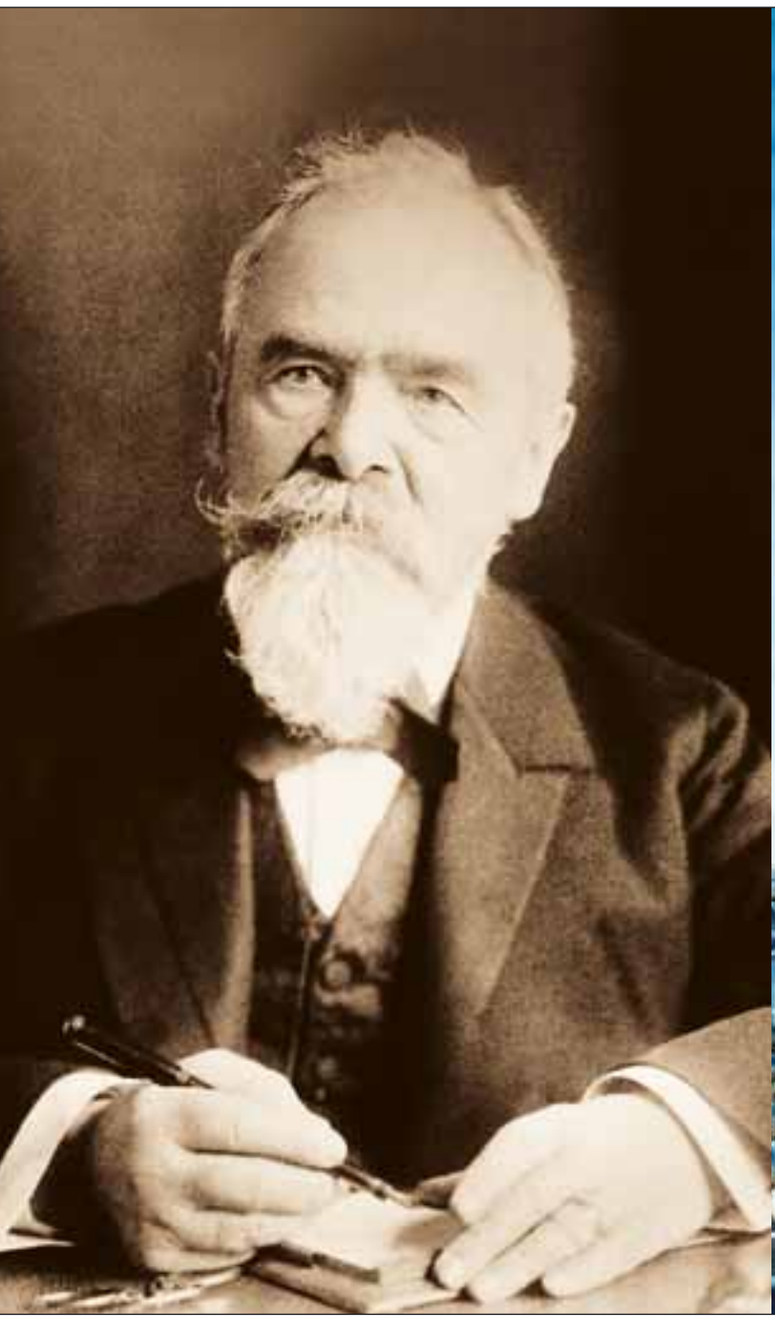
Idea nº 0001 – nº 6385

125 Years of Linde

A Chronicle



Linde

LeadIng.

Idea № 0001 – № 6385

"The only thing I find comparable to the great satisfaction of a scientific endeavor pursued together with ambitious and productive men is production carried out on one's own and in one's own area of expertise."

Carl von Linde in a letter to Göttingen mathematician Felix Klein, 1895

Inventive spirit and innovation are still our mainsprings

A look back at the achievements of engineer/inventor Carl von Linde and at the development of the company he helped found, the "*Gesellschaft für Linde's Eismaschinen*," into today's Linde AG means more to us than fond memories – it is also a commitment to the future.

The abilities and characteristics exemplified by scientist and inventor Carl von Linde during his lifetime are, today more than ever, a model for corporate leaders who want to lead a technology group like Linde into a long-term, successful future. His curiosity as an inventor, his persistence in the implementation of his ideas and theoretical concepts, as well as his ability to recognize the requirements of his customers and fulfill their desire for reliability and quality are all timeless factors for success.

As a pioneer in refrigeration technology, Carl von Linde not only built a dynamic company, which, over the decades, under his leadership developed into a leading plant engineering company, refrigerated building operator and gas producer. His inventions also laid the foundation for a new sector of industry for his day, one without which today's world would be inconceivable.

Refrigeration technology revolutionized the food industry as well as the retail trade. The technology of low temperatures with air liquefaction and separation of air into its component parts oxygen, nitrogen and inert gases was the essential prerequisite for modern metals processing, petrochemistry and even for air and space travel, as well as for the environmentally friendly energy source of the future, hydrogen.

Naturally, much has changed in the last 125 years – both at Linde and in the rest of the world. The company has developed from a small engineering company into an international technology group.

Today, Linde is the world's largest supplier of industrial and medical gases. We stand for cutting-edge technology in international facilities engineering, hold a leading position among the most important manufacturers of forklift trucks and warehouse equipment and are the market leaders in refrigeration technology in Europe. With some 46,500 employees, we achieved sales of approximately 9 billion euro in fiscal year 2003.

This impressive corporate development did not happen on its own, and it is certainly no guarantee of future success. In order to master the challenges in international competition and be able to take advantage of growth opportunities, we must constantly be testing our structures, procedures and our portfolio and continuously optimizing them. This principal was applied by Carl von Linde; it also characterized the successful era of Dr. Hans Meinhardt as head of the company and is still, today, a guide for my colleagues on the Executive Board and myself for our business transactions.

With this in mind, we took a step, in the spring of 2004, which had been discussed time and time again over the years: the sale of the refrigeration division. This decision was not an easy one for us – after all, it was a matter of the very foundation of our company. It is nevertheless the right decision because it brings with it opportunities for the future – for all involved. The American Carrier Corporation and Linde Refrigeration together will form the global market leader for refrigeration and air conditioning. The new company will have good opportunities to realize above-average growth – even in a continuingly difficult economic climate.

At the same time, by concentrating on our two high-income and high-growth divisions of Gas and Engineering and Material Handling, we are freeing up additional driving forces. Our task here is to expand our international business in a targeted manner and further strengthen our current market position in those segments.

Between tradition and present day: Dr.-Ing. Wolfgang Reitzle in the Carl-von-Linde lecture auditorium of the Technical University of Munich.

And here too we can take a page from Carl von Linde's book of engineering principles and, like him, ask: "How can we make it better?" This question and its answers not only relate to technical achievements, but also to our organization, our efficiency and our personal dedication. We need role models in order to constantly improve. And we can find such role models in Linde AG's history, of which all of the employees who have made a decisive contribution to this success story can be proud.

Technology, innovation and inventive spirit have characterized our company from the very beginning. You will be able to experience these in this richly illustrated chronicle. Technology, innovation and inventive spirit also remain Linde's driving forces. For only in this way will we fulfill our mission to be a leading global technology company in a sustainable manner.

Dr.-Ing. Wolfgang Reitzle
President and Chief Executive Officer of Linde AG

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1935–1974 War economy, collapse and economic miracle

1975 – 2004 Becoming a global player

All of the ideas named in this chronicle were the basis for patents. The only exceptions are some of the ideas in chapter 1 – complete documentation of the patents for this time is unfortunately not available. The numbering is chronological and bears no relation to the patent numbers.

Idea № 0001 – 0060

1879 – 1890 From refrigeration pioneer to international technology leader

From the first refrigeration machine to an independent company

At a sometimes staggering pace and with a great love of experimentation, Carl von Linde created a new industry within just a few decades: refrigeration. His engineering company, the "*Gesellschaft für Linde's Eismaschinen,*" was characterized from the very beginning by innovativeness and close customer relations.

Carl von Linde, a professor at the Technical University of Munich (see also page 12), had come upon refrigeration as an area of research by way of a contest for a cooling unit for the crystallization of paraffin. "The thought immediately struck me: here was an area of mechanical thermodynamics that had not yet been fully explored," he said, describing his newly awakened curiosity in his 1916 memoir *"Aus meinem Leben und von meiner Arbeit."*

Von Linde immediately set about laying the theoretical groundwork for an "improved ice and refrigeration machine." In his calculations of caloric efficiency, he had come to the conclusion that the cold vapor machine promised the highest yield of cooling energy as compared to the absorption machine and the cold air machine. The method he conceived would work with the lowest possible temperature differences and use methyl ether as the refrigerant.

Initial contacts with breweries

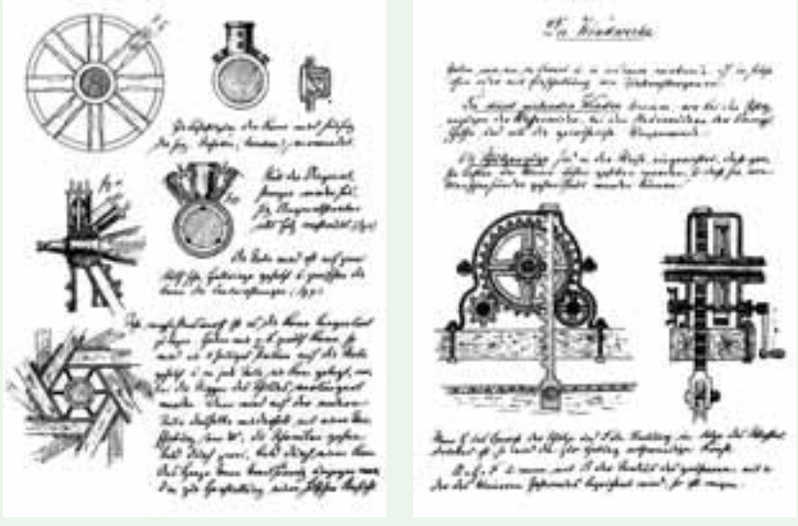
After von Linde had published his ideas in 1870 and 1871 in the Polytechnic Association's "Bavarian Industry and Trade Journal," which he also edited, a development was set in motion that would determine the direction of the entire rest of his life. His articles on refrigeration technology had aroused the interest of brewers who had been looking for a reliable year-round method of refrigeration for the fermentation and storage of their beer.

In the summer of 1871 an agreement was made between von Linde, Austrian brewer August Deiglmayr (Dreher Brewery) and Munich brewer Gabriel Sedlmayr to build a test machine according to Linde's design at the Spaten Brewery. With their help, Linde's ideas would be put into practice, so that a refrigeration unit could then be installed at the Dreher Brewery, the largest brewery in Austria, in the hot, humid city of Trieste (now part of Italy).

Building the first Linde ice machine

The construction plans were finally completed in January 1873 and the patent applied for. The Bavarian patent required, however, that the machine be in operation within one year. Therefore von Linde and Sedlmayr placed an order with *Maschinenfabrik Augsburg* that same month to build it. And with some effort they succeeded in starting operation by the important patent deadline in January 1874. Of course, the first machine did have its difficulties.

The main problem was that von Linde's mercury seal did not work properly so that the methyl ether used as the refrigerant leaked out of the compressor. In Linde's words, "This design was not a suitable solution for the requirements of practical use. So it seemed imperative to build a second machine."



Sketches and notes from Carl von Linde's early lecture drafts when he served as an instructor (1868-1879) at the Polytechnic School in Munich (today TU Munich).

1881

Assassination of Russian Czar Alexander II.

№ 0001 The first refrigeration machine with methyl ether as the refrigerant.

The first Linde refrigeration machine ever sold, an improvement on the original model from 1873, started up in 1877 at the Dreher Brewery in Trieste (now Italy).

№ 0003 Refrigeration machine with horizontal ammonia compressor.

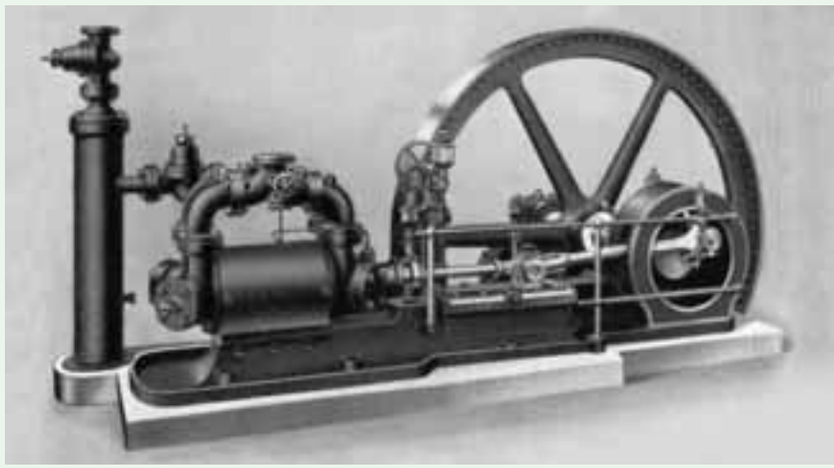
In order to finance it, von Linde assigned part of the patent rights to Sedlmayr, to locomotive builder Georg Krauss and to the director of *Maschinenfabrik Augsburg,* Heinrich von Buz. In return, they provided the funds needed for the development, building and testing of a new refrigeration machine.

Building the second refrigeration machine

With his student and assistant Friedrich Schipper, von Linde designed a new compressor, which had a significantly simpler and more effective seal. The sealing material used in the newly designed gland construction was glycerin and the more efficient ammonia was used as the refrigerant. The new machine weighed and cost only half as much as its predecessor.

In the spring of 1875 Linde ordered the new compressor from *Maschinenfabrik Augsburg* and submitted it for a Bavarian patent, which was awarded on March 25, 1876 for ten years. He received the German *Reichspatent* in August 1877.

"The very first trials with this second compressor yielded fully satisfactory results," said von Linde, not without pride. The machine was sold to the Dreher Brewery in September 1876, erected under Schipper's supervision and started up in spring 1877. It ran until 1908, providing refrigeration and dehumidification.



Horizontal two-stage ammonia compressor by Carl von Linde, the traditional design for major refrigeration units (approx. 1900).

Technical breakthrough

But despite this success, Linde created a third design immediately after the second machine was installed at Dreher, turning his attention to gas pumps, which were already widely used. This third, horizontal design proved to be the best cold vapor machine on the market in terms of its price/performance ratio and became the standard type of Linde compressor for decades to come.

During the more than six-year development and experimentation phase, a reliable solution also had to be found for distributing the generated cold. After long trials, in executing an order for the Heineken Brewery in Rotterdam, von Linde developed a method of circulating cold saltwater brine in a pipe cooling system (natural convection cooling), which was installed on the ceiling of the refrigeration rooms.

Entering the refrigeration market

After Linde and his friends in the breweries had developed a reliable functioning and economic refrigeration system, it was time for him, together with his licensees, *Maschinenfabrik Augsburg* and the Swiss company *Gebrüder Sulzer,* as well as sales representatives Satre & Averly in Lyon, Carels Frères in Ghent and Morton in Great Britain, to pursue a larger customer group.

They found open doors with many European brewers: Because not enough ice was available in warm winters for fermentation and cooling the cellars, Linde's powerful refrigeration machines quickly found strong interest. In addition to the ice machines, von Linde soon also supplied equipment to automate the cooling process and make it more efficient, thus saving strenuous manual labor. Finally, he was able to produce the crystal-clear artificial ice preferred by his customers.

1882
First electric streetlights in Berlin.

№ 0006
Improved gland design.

№ 0010 Circulation of cold saltwater brine in cooling tubes for direct cooling of fermentation and storage cellars, known as natural convection cooling.

First customers and partners: brewers

In 1840, many continental European breweries switched to bottomfermented lager production (in contrast to the "English" top-fermented brown beers or ales) because the beer remained fresh longer and customers preferred the taste. The ice machine described by von Linde seemed ideal for achieving the required lower temperatures and to ensure precise cooling control. So it is no wonder that some major brewers showed great interest in this invention.

Gabriel Sedlmayr of the Munich Spaten Brewerey was willing to let von Linde experiment with an early refrigeration machine in his brewery in the early 1870s. The first unit functioned passably well, but was too large and had numerous flaws. The drawings submitted for the patent showed that Sedlmayr himself had a hand in the second version, which was significantly smaller in size and worked well. This unit was sold to the Trieste Dreher Brewery for air cooling.

With Sedlmayr as an intermediary, the Rotterdam Heineken Brewery under its director Feldmann ordered an ice machine in 1877 for ice production. In his collaboration with the Heineken Brewery, Linde developed "natural convection cooling" with a system of cooling pipes under the ceiling of the cellar. Feldmann in turn put von Linde in contact with J. C. Jacobsen, head of the Carlsberg Brewery in Copenhagen, who ordered a large refrigeration unit in 1878.

Karl Lang, technical adviser and supervisory board member of several Rhineland breweries, also played a significant role during the founding period of the "*Gesellschaft für Linde's Eismaschinen*." He introduced Linde to brewery director Gustav Jung, who not only ordered a refrigeration unit but also became, with Lang and banker Moritz von Hirsch, a shareholder and Supervisory Board member of the Linde Company.

The connection between the Linde Company and brewery directors was maintained to some extent over several generations. After the death of Karl Lang in 1894 his position as chairman of the Supervisory Board was taken over by Gustav Jung, followed by his son Adolf Jung in 1886. Carl Sedlmayr took over for his father Gabriel on the Supervisory Board and in 1915, the third generation of this family followed with Anton Sedlmayr. The Jung and Sedlmayr families held their Supervisory Board seats until after the Second World War.

Fermentation cellar of a brewery with natural convection cooling.

Even before the founding of the "*Gesellschaft für Linde's Eismaschinen Aktiengesellschaft*," von Linde had already delivered 20 refrigeration systems in Europe. In 1878 already, the professor decided to bundle his activities into a company and concentrate on refining and marketing his refrigeration machines. In order to do so, he had to leave his stable job in the civil service.

His negotiations with Karl Lang, the technical adviser and supervisory board member of many Rhineland breweries, were a decisive factor in this decision. In 1878 he advised Carl von Linde to give up teaching and take up a position as head of his own company.

Going into business

After thinking it over for some time, von Linde decided to give up his secure civil service position as a university instructor and jump into the risky world of business. With Lang and banker Moritz von Hirsch, who wanted to help finance the young company, von Linde came to an agreement on pension and disability pay, in exchange for which he granted them patent rights. In addition to Lang and von Hirsch, Linde's previous partners Gabriel and Johann Sedlmayr, locomotive manufacturer Georg Krauss and Heinrich von Buz, Director of *Maschinenfabrik Augsburg* subscribed for shares in the recently-founded "*Gesellschaft für Linde's Eismaschinen*." Finally in May 1879, Gustav Jung, owner of the *Aktienbrauerei* in Mainz, also became a shareholder in the company, which made Wiesbaden its main location.

At first the young company's purse strings were tight. Against von Linde's calls to fund the company with 400,000 marks starting capital, Hirsch and Lang insisted on investing only 200,000 marks – and not even in cash, but by contributing the patents. The original supervisory board at the company's founding on June 21, 1879 included Lang (chairman), Sedlmayr, Krauss, Buz and Jung.

1883

German physician Robert Koch discovers the cholera bacterium.

The company had humble beginnings in terms of personnel as well: Its entire staff consisted of one board member and one designer. And business was extremely slow in the beginning. Linde wrote in his memoirs, "Our quiet beginning was answered during the initial months by an almost oppressive silence in the progress of negotiations and orders for refrigeration systems so as to give the impression that the initially urgent demand had already been satisfied."

But of course that was quick to change. The small engineering office was at the leading edge of a turbulent development, which would soon make it the main supplier of refrigeration equipment even beyond the German border.

A successful start in a difficult environment

The overall economic conditions in Germany in the 1870s and 1880s did not look especially rosy. After the short boom from 1871 to 1873, which in Germany is known as the *Gründerzeit* or founders' era, the German economy crashed dramatically. While the "Great Depression" of the Bismarck era had already reached its lowest point in 1879, the slow economy continued in a less severe form in the course of 1894.

Only the German compressor and refrigeration machine company survived an industry-specific boom and quickly captured a leading international position. The "*Gesellschaft für Linde's Eismaschinen"* benefited especially from this dynamic development because it was represented in all of the important markets early on and could offer the most efficient products.

Weather as an ally

The most important customers of the refrigeration machine builders remained the breweries through the turn of the 20th century. The fast penetration of cooling fermentation cellars and fermentation vats with manufactured ice was assisted by the weather to bring direct cooling into the storage cellar.

The first supervisory board of the *Gesellschaft für Linde's Eismaschinen*
Top: Chairman Karl Lang; below from left: Carl Sedlmayr, Georg Krauss, Heinrich von Buz and Gustav Jung.

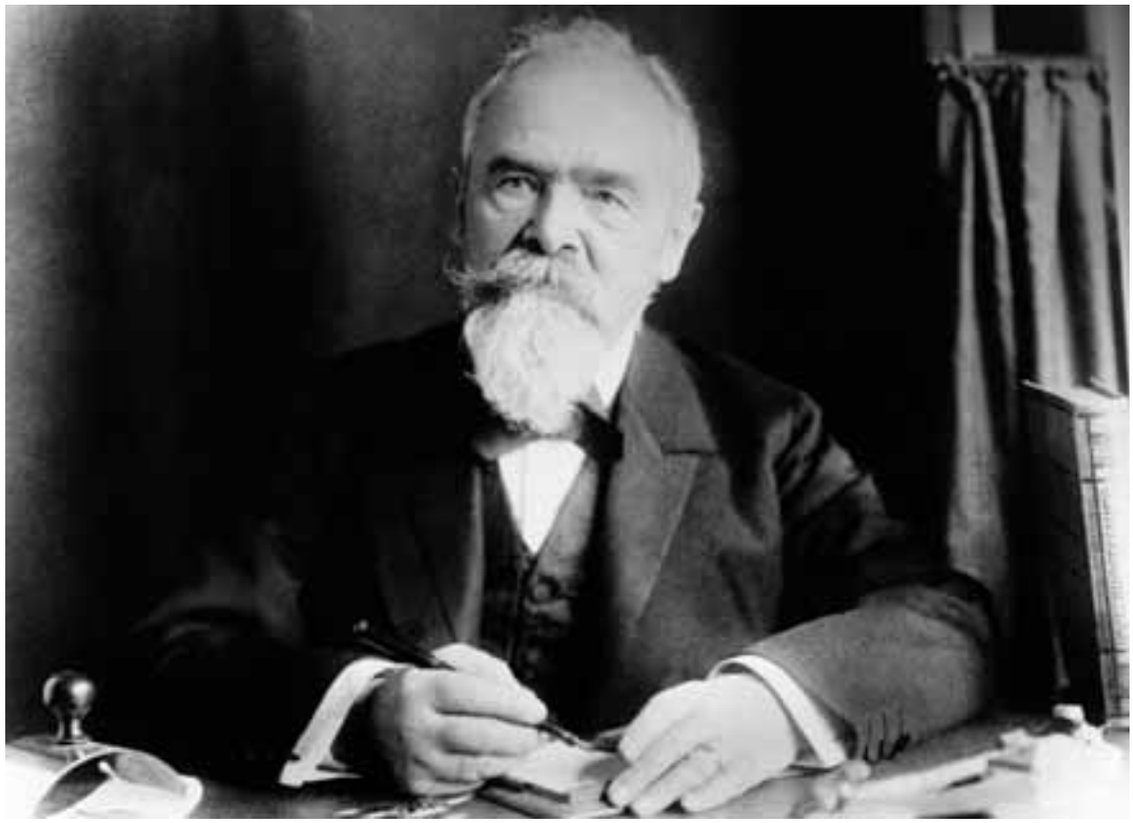
Carl von Linde – gifted engineer and entrepreneur

When Carl von Linde was born on June 11, 1842 in the Lutheran parsonage of Berndorf in the Oberfranken district of Bavaria, he was never expected to forge a career as a distinguished scientist, gifted inventor and successful entrepreneur. His father Friedrich would have liked to have seen the third of his nine children follow in his footsteps as minister.

However, the family's move to Kempten, where his father was assigned a parish, and his later attendance at the local high school put Carl von Linde in close contact with the family of the director of the Kempten cotton spinning mill. His frequent visits to the factory, with its impressive power machines stimulated in the youth an interest in technology and a desire to study engineering.

Despite the tight financial situation in the parson's large household, von Linde was able to convince his father to allow him to study mechanical engineering at the leading technical university of the time, the Polytechnikum in Zurich, Switzerland. There, his most important teachers were Dr. Zeuner (mechanics and theoretical machine studies), Dr. Reuleaux (mechanical engineering) and Dr. Clausius (physics), he reported in his memoir *"Aus meinem Leben und von meiner Arbeit"* (My Life and Work). It was also Zeuner and Reuleaux who wrote personal letters of recommendation for Linde when he had to leave the Polytechnikum without officially graduating as a result of a student protest.

Von Linde received his first practical training as an intern in the mechanical workshop of the Kottern cotton spinning plant near Kempten, then at Borsig in Berlin. He started work as an engineer in the Borsig drawing office in August 1865.



Carl von Linde at the age of 83 (1925).

At the end of 1865, Carl von Linde applied to become the head of the technical office upon the founding of the Krauss & Co. locomotive factory in Munich. On February 20 or the following year he received this position and celebrated by becoming engaged to Helene Grimm on February 26 before leaving Berlin. The wedding was held September 17 in Kempten. During their 53-year marriage, the Lindes had six children: Maria (1867-1954), Franziska (1868-1966), Friedrich (1870-1965), Anna (1873-1949), Richard (1876-1961) and Elisabeth (1880-1959).

Still, the young Linde, not yet 25 years old, had aspirations beyond the drawing office into science and teaching. On the recommendation of the founding rector of the Polytechnic School in Munich (later Technical University) he was hired as an associate professor on August 24, 1868 and on December 24, 1872 was promoted to full professor of mechanical engineering. He included the theory of refrigeration machines in his teaching syllabus.

So that he could also give his students practical instruction, the Bavarian government approved 70,000 florins to set up a machine laboratory – the first of its kind in Germany. It would become the starting point for his groundbreaking developments in refrigeration technology.

During his first teaching period from 1868 to 1879, the restless von Linde was already involved in various technical associations – an activity that would take a

1884

The line of longitude at Greenwich becomes the international Prime Meridian.

№ 0016 Device for the evaporation and direct exchange of heat between a liquid forming drops and a gas.

considerable amount of his time during his term as head of the "*Gesellschaft für Linde's Eismaschinen"* in 1890 after his return to Munich.

Professor von Linde is thus one of the founding fathers of the Bavarian Boiler Review Association and the Munich Thermal Testing Station. In the Polytechnic Association he examined applications for a Bavarian patent and served as part of the Berlin commission that reformed German patent law.

Back in Munich and armed with an honorary professorship (it was converted into a full professorship without teaching duties in 1900), von Linde took the position of Bavarian district chairman of the Association of German Engineers (VDI) in 1892 and was elected chairman of the Bavarian Boiler Association. In 1895 he was appointed to the board of trustees at the German Physical-Technical Institute, one year later to the Bavarian Academy of Science. In 1898 he joined the Göttingen Association for Applied Physics and Mathematics, from which the Kaiser Wilhelm Society and ultimately the Max Planck Society emerged.

In 1904 and 1905 he served as president of the VDI, and in 1903 he immersed himself with Oskar von Miller in the founding of the Deutsches Museum in Munich. Carl von Linde remained on the museum's board until he was 80 years old.

As always, however, his main attention was focused on the Linde Company and its subsidiaries. His practical work in the area of refrigeration and later in air liquefaction and air separation shows the entrepreneur-engineer side of von Linde – and thus his true calling.

His entrepreneurial side was often in demand on many supervisory boards – of a few subsidiaries as well as of the locomotive manufacturer Krauss & Co., the *Mainz Aktienbrauerei,* the Trieberg Electricity Company, The Güldner engine company and *Maschinenfabrik Sürth*.
This multifaceted and diverse range of commitments required an active travel schedule. Since his head engineers were very often also on the road starting up equipment at customer facilities, a unique correspondence culture developed within the Linde Company. A total of 3,010 business letters written personally by Linde alone during the years 1876 to 1929 are preserved in eleven copy books.

Although von Linde withdrew more and more from his active working life starting in 1910, he held on to some of his supervisory and advisory activities until the end of his life. His two sons Friedrich and Richard and his son-in-law Rudolf Wucherer (who was married to Linde's youngest daughter Elisabeth) carried on his life's work. Two of his four daughters married pastors and the eldest married psychiatrist Dr. Karl Ranke, who also sometimes served on the company's Supervisory Board.

Carl von Linde died in 1934 at the age of 92. Over the course of his life he was awarded three honorary Doctorates, the Bavarian crown achievement medal, and was honored with elevation to personal nobility status among many other distinguishing honors.

Carl von Linde (front left) appraises the building site for the *Deutsches Museum* in Munich together with the architects and the members of the building committee (ca. 1910).

Carl von Linde (seated, 2nd from right) with his sons and daughters and their spouses.

1885

Pastor Friedrich von Bodelschwingh founds the first building and loan association in Germany.

№ 0023

Device for the production of block ice.

In 1892 the *Gesellschaft für Linde's Eismaschinen* opened a large plant for chilling food and producing ice in Hamburg.

When the warm winter of 1883/84 failed to yield a sufficient supply of natural ice, the last reservations as far as the reliability of artificial refrigeration were removed. And so a "veritable torrent" (Linde) of orders broke over the Linde Company and the machinery builders working with it. Happily, Carl von Linde had had sufficient ice machines in standard sizes produced for stock so that the demand could be met quickly with reliable quality.

By the end of the 1880s, the "*Gesellschaft für Linde's Eismaschinen"* had equipped 445 breweries with 747 refrigeration machines. With year-round refrigeration ensured, the breweries could now brew bottom-fermented beer in summer as well as winter and thus considerably increase their profitability.

Ice factories under own control

During the first several months after the official founding of the company when no refrigeration machine orders were coming in, von Linde felt forced to build ice factories at his own expense. The purpose of these sample plants was to demonstrate their efficiency and cost effectiveness. His first own ice factory was built in Elberfeld-Barmen between two breweries that had agreed to take on greater quantities of the manmade ice. At the same time, financier von Hirsch, who had acquired Linde's patent rights for France, built an ice factory in Paris. And finally, parallel to this, von Linde designed a smaller ice factory for an exhibition taking place in Düsseldorf in 1880.

In addition to Elberfeld-Barmen, the Linde Company had opened other ice factories in Stuttgart, Munich and Strasbourg by 1881. Each one produced up to 50,000 kilograms of ice per day – and at the very competitive price of 70 pfennigs per 100 kilograms. Once the ice plants had proven their profitability, they were sold by 1890 "with considerable surpluses over their book value" (von Linde). It was not until after 1896 that the "*Gesellschaft für Linde's Eismaschinen"* – certainly due to the decline in machine sales and as capital investments – again decided to build its own ice factories and cold storage facilities in Nuremberg (1896), Leipzig (1910), Königsberg (1914) and Magdeburg (1937).

Cold storage facilities market

With the building of city slaughterhouses initiated by new legislation during the last third of the 19th century, the demand for cold storage houses for meat and other food products rose – another driving force for sales of refrigeration machines. The first cold storage facility for meat was built in Bremen in 1882 with von Linde called in as an adviser.

One year later von Linde supplied the equipment for the city slaughterhouse in Wiesbaden, solving the complex problem not only of generating refrigeration but at the same time dehumidifying and purifying the air.

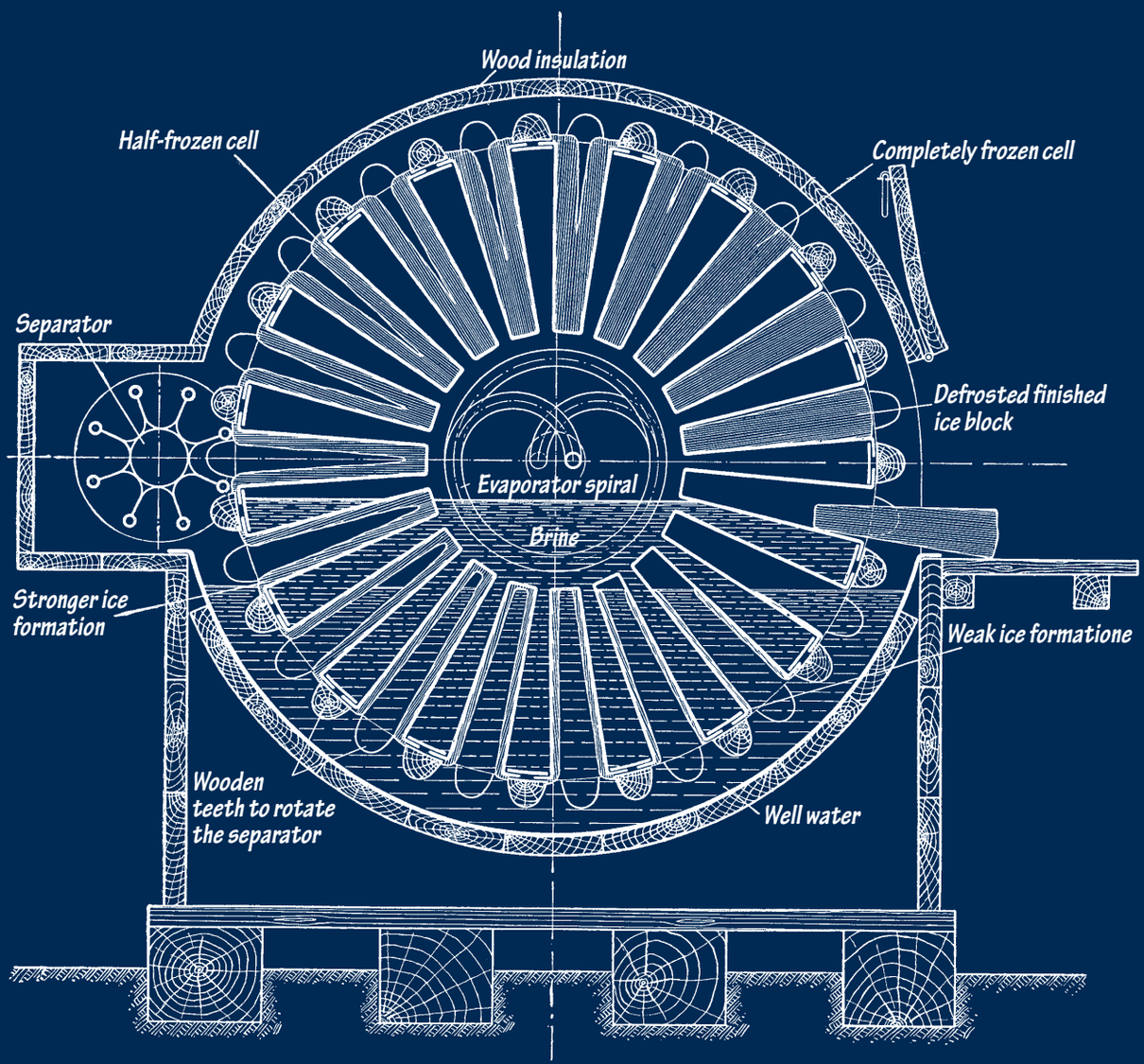
When, at the beginning of the 1890s, nearly all larger communities in Germany built their slaughterhouses with cold rooms and cold storage houses as a result of changed legislation, this industry quickly became the second largest market for refrigeration systems.

1886

First gas-powered vehicle invented by German engineers Gottlieb Daimler and Carl Benz.

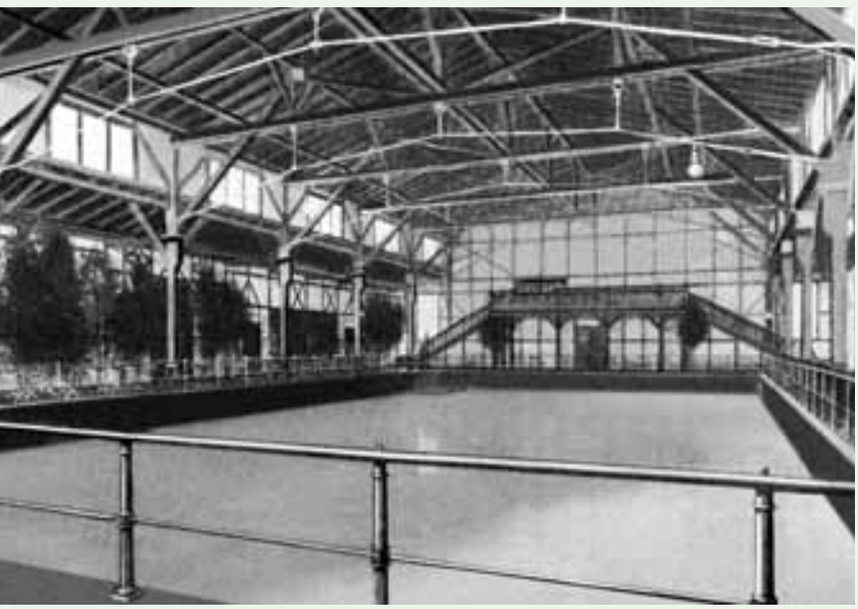
№ 0028

Processes and devices for the preparation of distilled and air-free water for crystal ice production in compression refrigeration machines.

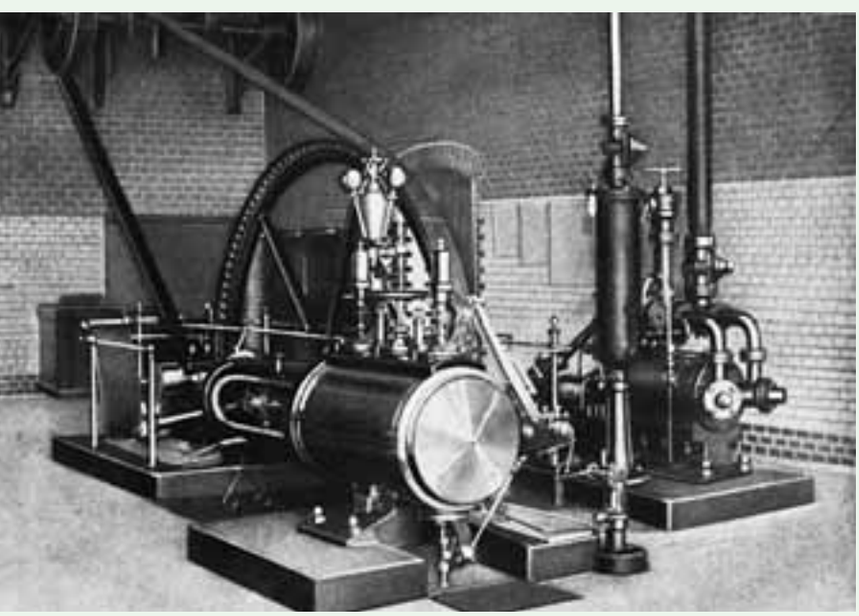


The first device for producing clear ice.

Nº 0032 First man-made ice rink with Linde refrigeration in Nuremberg.



A manmade ice rink with Linde cooling was displayed at the Bavarian Industry and Trade Exhibition in Nuremberg in 1896.



In 1883 the *"Gesellschaft für Linde's Eismaschinen"* equipped the Wiesbaden slaughterhouse with a refrigeration machine.

Additional sales markets

In order to further reduce dependency on business with breweries, von Linde and his top engineers sought other application areas for the new refrigeration technology: ice skating rinks, refrigerator and freezer units for ships and railroad cars and even cooling systems for living spaces. For example, Carl von Linde prepared the complete building plans, including "installations for the dehumidification and temperature control of the air in the living and sleeping areas" of a planned hotel in Calcutta, India. Nothing ever came of this, however, because the financing for the project fell through.

Far greater economic importance came to methods of extracting sugar from sugar beets, refrigerating milk in dairies and refrigeration in chocolate factories. There was also a cooling process for aniline production, refrigeration systems for crystallization from brines and for benzene extraction and refrigeration machines for the liquefaction of carbon dioxide and chlorine – even a method of freezing asparagus.The many new markets for refrigeration technology ensured increasing order receipts when the sales boom in the brewery industry flattened out after 1890 due to market saturation.

By its 50-year anniversary, the company had thus struck a balance: By the end of 1929, the "*Gesellschaft für Linde's Eismaschinen*" had sold 6,599 large refrigeration machines, with 2,057 to breweries, 1,865 for food refrigeration, 727 to ice factories, as well as 14 to mines for sinking shafts in the frozen subsoil and three for cooling furs, to name just a few. All in all, the 50-year anniversary chronicle lists 17 countries and regions where refrigeration machines were sold – ranging from Argentina and Central America to China, Japan and Russia.

1887

Emil Berliner of Germany invents the gramophone.

PATENT-URKUNDE

№ 1250.

AUF GRUND DER ANGEHEFTETEN BESCHREIBUNG UND ZEICHNUNG IST DURCH BESCHLUSS DES KAISERLICHEN PATENTAMTES

Professor Carl Linde, in München

EIN PATENT ERTHEILT WORDEN.

GEGENSTAND DES PATENTES IST:

Kälteerzeugungsmaschine.

GESETZ v. 25. MAI 1877

ANFANG DES PATENTES: 9. August 1877.

LÄNGSTE DAUER DES PATENTES: 24. März 1891.

DIE RECHTE UND PFLICHTEN DES PATENT-INHABERS SIND DURCH DAS PATENT-GESETZ VOM 25. MAI 1877 (REICHSGESETZBLATT FÜR 1877 SEITE 501) BESTIMMT.

ZU URKUND DER ERTHEILUNG DES PATENTES IST DIESE AUSFERTIGUNG ERFOLGT.

Berlin, den 29. Mai 1878.

KAISERLICHES PATENTAMT.

Beglaubigt durch Schmidt

Sekretär des Kaiserlichen Patentamtes.

Imperial patent for Carl von Linde for his first refrigeration machine (1877).

1888
Wilhelm II becomes Kaiser of the German Empire.

№ 0043 Refrigeration systems for crystallization from brine.

№ 0037 Process and device for defrosting air cooling tubes.

Business model and early internationalization: factors for success

A number of factors underlie Carl von Linde's success in developing his young business into Germany's leading international supplier of refrigeration machines within just ten years:

The business model. As an entrepreneur, Carl von Linde relied from the very start on close cooperation with potential users of his technology, above all beer brewers. In production he relied in turn on a few machinery manufacturing companies. But von Linde insisted that only his engineers, assemblers and installers would install and start up the machines at the customers' facilities, thus ensuring direct and exclusive contact with the customers.

Loyalty. One of von Linde's closest confidants was Heinrich von Buz, the director of *Maschinenfabrik Augsburg* (later MAN). Over their entire business relationship of 50 years or so, von Buz sat on the Linde Supervisory Board for 39 years. In the Sulzer brothers von Linde found highly competent people to turn to for technical problem-solving. Von Linde also had the Sulzer connection to thank for the fact that his company became the largest supplier of refrigeration machines for the meat industry in Argentina.

Personnel policies. Over the years, von Linde preferred to hire graduates of the Technical University of Munich whom he knew personally or who were recommended to him by his teaching successor at the university, Moritz Schröter. Friedrich Schipper, Robert Banfield, Rudolf Diesel (see also page 38), Karl Heimpel, Hermann Reuther, August Krebs and Alexius Negele, among others were all alumni of TC Munich. Von Linde also relied on family members. During the early years, two of his brothers and a brother-in-law worked for Linde's company. They were followed by two nephews, two sons-in-law and two of his own sons, physicist Friedrich and engineer Richard Linde, who, together with their brother-in-law Rudolf Wucherer largely determined the fortunes of the company through the middle of the 20th Century (see also page 45).

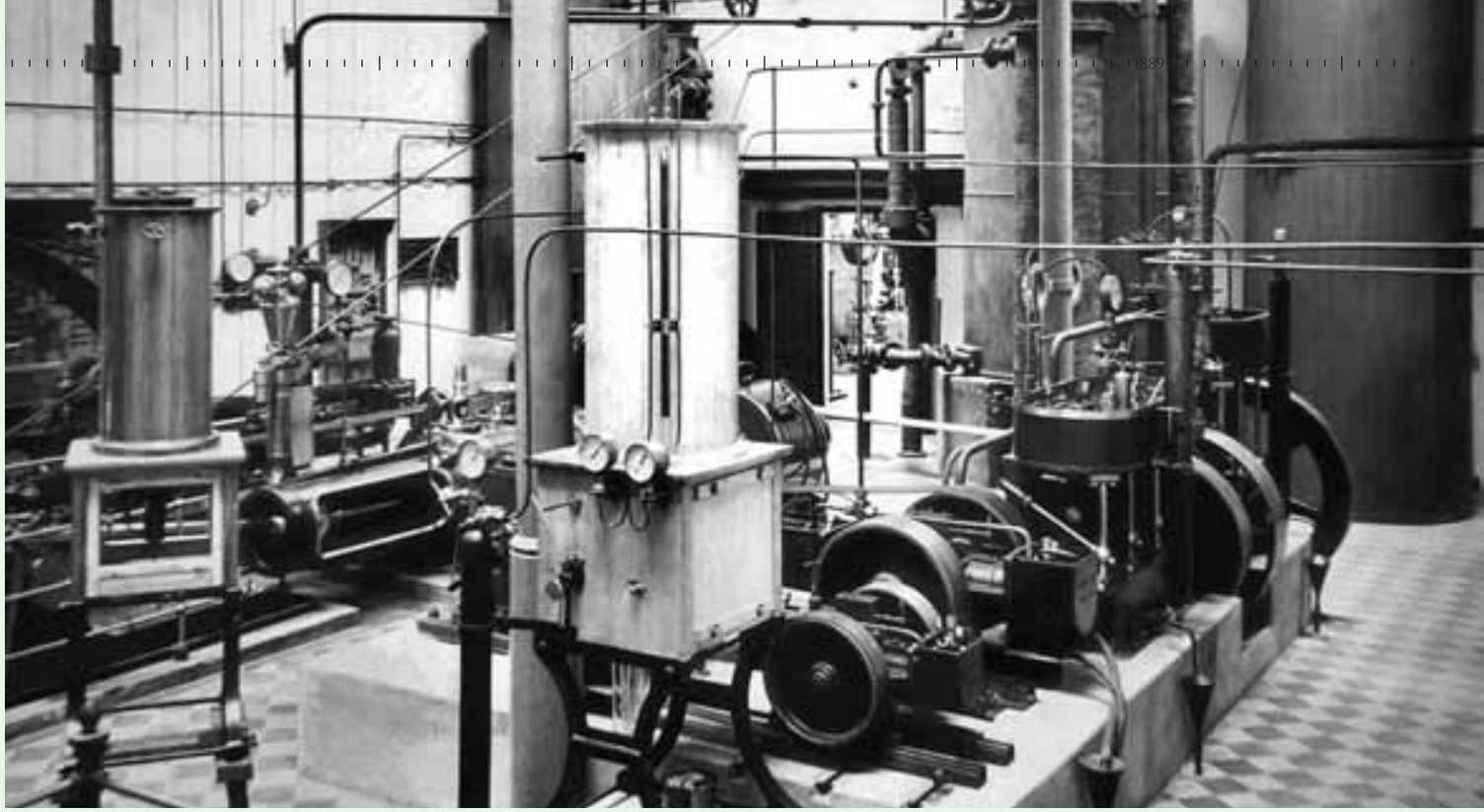
Compensation. In order to create the strongest possible ties between his key people and the company, von Linde paid above-average salaries. Head engineers could earn between 15,000 and 20,000 marks per year including profit sharing during the 1890s. Unlike the engineers, for a long time the commercial employees in the company did not play an especially major role. It is a telling fact that prior to the Second World War no commercial employee was ever appointed to the company's Executive Board.

Early internationalization

For decades Linde's first production partners remained his most important ones, such as *Maschinenfabrik Augsburg* and *Gebrüder Sulzer* in Winterthur, Switzerland. However, because of differing patent regulations in each country, the size of the markets and for reasons of caution, the number of license partners within and outside Germany quickly rose, which didn't always appeal to the company's most important business colleagues.

France

In France, after a few detours and false starts, von Linde established a relationship with Satre & Averly of Lyon in 1877. This company also built the first machine in order to secure the French patent. But after the founding of the Linde Company, shareholder Moritz von Hirsch took over Linde's patents in France and founded the *"Société pour la production de glace et d'air froid d'après le système Linde."* Business, however, was unsatisfactory, so von Linde bought the license rights back from this major shareholder in 1890 and awarded them to the CAIL company.



The testing station for refrigeration machines built in Munich in 1888.
It was also the site of the first trials in air liquefaction. In the foreground:
Two small air liquefiers.

Great Britain
In England von Linde began a cooperation with brewery equipment manufacturer Robert Morton in 1876, but the latter soon switched to a rival product. After fruitless agreements with other partners, a joint venture was finally established in London, the "Linde British Refrigeration Corp." in London, whose shareholders included the Austro-Bavarian Lagerbeer Brewery, the Atlas Engine Works and the "*Gesellschaft für Linde's Eismaschinen.*" The company, which began building Linde machines in England in 1892, was headed by English refrigeration pioneer T. B. Lightfoot.

Belgium/the Netherlands
The entry into the Belgian/Dutch market was not without its problems. Finally in 1886 the Linde Company founded the cold storage company "Société Anonyme des Frigorifères d'Anvers" in Antwerp with some Dutch and Belgian business associates, which at the same time served as the "base for the increasingly important supplier business to Belgium and Holland" (Linde).

Austria-Hungary
The licensing process in Austria-Hungary looked like a relay race until in 1881 Linde's employee Karl Heimpel established himself as an independent representative in Vienna. After 1890, four machinery factories in Austria-Hungary began production of Linde machines within a short time of one another. (In 1913 the competition among the Austrian machine builders was ended by a cartel-like division of the market.)

United States
Carl von Linde started out well in the United States: His collaboration with the German-speaking brewery equipment manufacturer Fred Wolf from Chicago, which began in 1879, developed smoothly. Wolf first imported refrigeration and vapor machines from Sulzer and in the mid-1880s began his own production of refrigeration machines (see also page 35).

Competition in refrigeration

Carl von Linde's quick success naturally attracted competitors to the field who wanted a piece of the booming refrigeration market. Traditional machine builders rose to become the most serious competition. They were able to benefit from their know-how in building vapor machines, pumps and gas engines as well as from their sales networks.

№ 0048 Process for the liquefaction of carbon dioxide and chlorine.

Dr.-Ing. E.h. Friedrich Schipper (1849–1929)

Dr.-Ing. E.h. Friedrich Schipper, Chairman of the Executive Board from 1890 to 1924.

The son of a pharmacist, Schipper was already one of Carl von Linde's closest associates and confidants even before the founding of the "*Gesellschaft für Linde's Eismaschinen*." As early as 1873 he was involved in his teacher von Linde's development and testing work in refrigeration. He succeeded him in 1890 as head of the company and worked for Carl von Linde and/or the Linde Company for 56 years until 1929.

After his university studies at TC Munich from 1870 to 1874, Friedrich Schipper first worked as Carl von Linde's assistant and helped build the first three versions of the refrigeration machines. For example, in 1877 he was in charge of the installation of the refrigeration unit for one of the Anton Dreher breweries in Trieste.

Between 1878 and 1880 Schipper gained practical experience in the workshops of *Maschinenfabrik Augsburg* and in 1879 helped von Linde in the start-up of an ice machine in the Munich Spaten Brewery.

In 1880 he joined the Linde Company as its first engineer and moved to Wiesbaden. Here he became manager of the design office and assisted von Linde in the responsibilities of running the company. In 1888 he became Carl von Linde's deputy and in 1890 his successor as chief executive.

Schipper served in this office until 1924, after which he moved to the Supervisory Board. For the company's 50th anniversary, the 80-year-old man left the firm, ending more than 50 years working for Carl von Linde and the Linde Company. He died on November 13, 1929 in Wiesbaden.

In the intensifying battle for customers and market share, some competitors resorted to means which clearly angered Carl von Linde as he recalled them. The arguments – mainly between the Swiss-French Dr. Raoul Pictet and German licensee Rudolf Grübs & Co. – became a contentious "battle of systems" over which refrigeration method was best thermodynamically.

At Linde's urging, the Polytechnic Association in Munich set up a testing station (financed by the Linde Company) in 1887 and invited the competing refrigeration equipment manufacturers to perform comparison tests.

This step proved to be doubly successful: The Linde concept came out the winner of this battle of systems and the testing station, after the Linde Company took it over, became the seed from which new groundbreaking inventions grew.

Linde's move to the Supervisory Board

Spring of 1889 marked the end of the ten years to which Carl von Linde had committed himself as head of the company. In that time the company had established itself as the market leader in refrigeration and attracted first-class employees. Linde, the wanderer between theory and practice, was drawn back to science and research. Although he was not yet 50 years old, the demands of his position had taken their toll on his health, and so he decided to return to Munich and the Technical University.

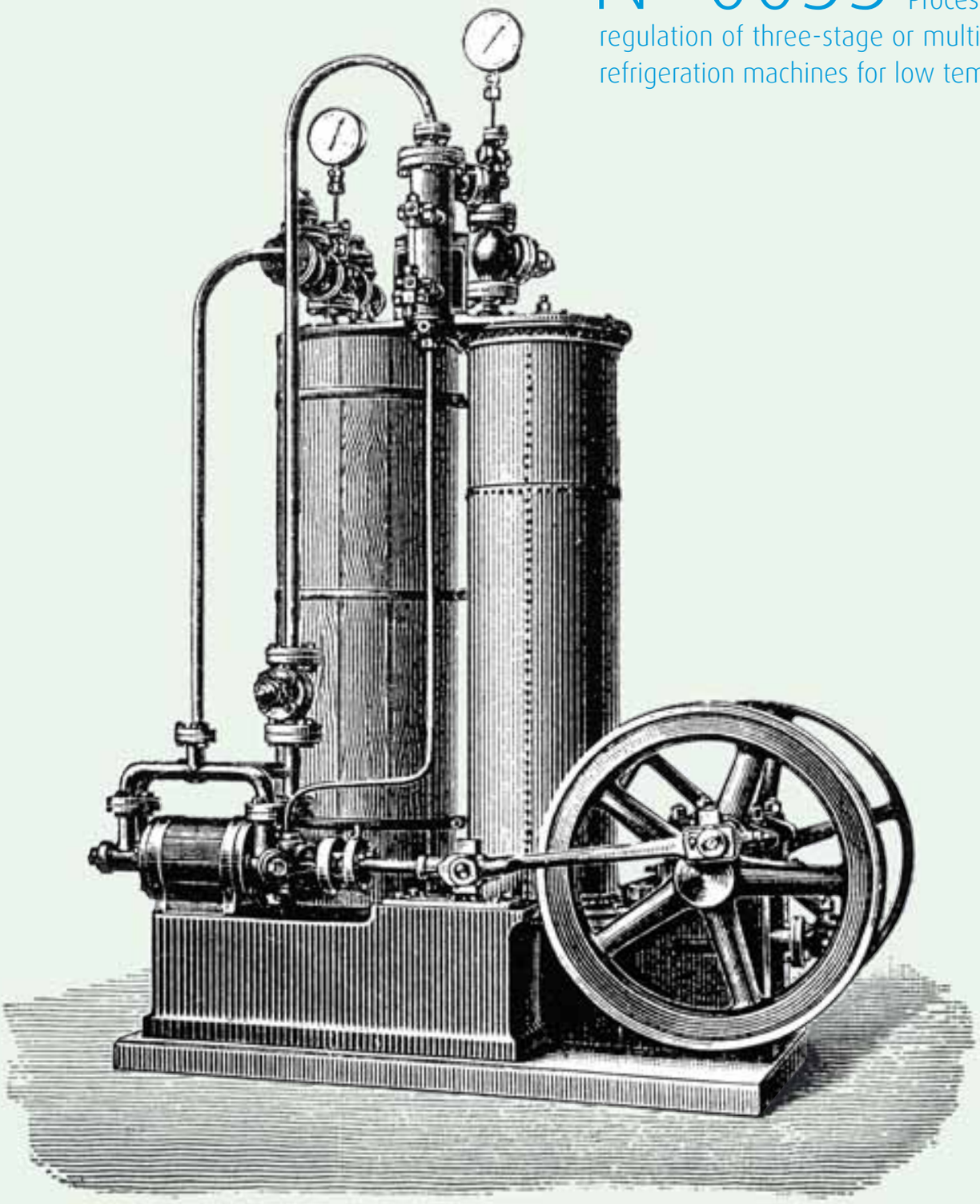
However, in order to set newly undertaken enterprises, such as the founding of the *"Gesellschaft für Markt- und Kühlhallen"* in 1890 in Hamburg, on a secure path and to help break in his successor Friedrich Schipper, von Linde put off his return to Munich. The family finally moved in May 1891 first to their summer home on the Obersalzberg near Berchtesgaden and ultimately to Munich.

He did not, however, launch himself with all his energies into his teaching duties, but rather created the completely new low temperature technology – required for the liquefaction of air and to produce pure oxygen and other gases.

1890

German physician Emil von Behring develops serums against diphtheria and tetanus.

Nº 0055 Process for the regulation of three-stage or multi-stage refrigeration machines for low temperatures.



Ongoing technical improvement of the Linde refrigeration machines.
The photo shows a model from approx. 1900.

1891

1892

The General Electric Company is founded in the USA.

Idea № 0061 – 0769

1891 – 1934 From air liquefaction
to air separation

1893
Swedish physicist Anders Ångström measures the total intensity of solar radiation.

1894
German engineer Rudolph Diesel introduces the engine which will bear his name.

Air liquefaction, "Linde Air," rectification: into new markets with new research findings

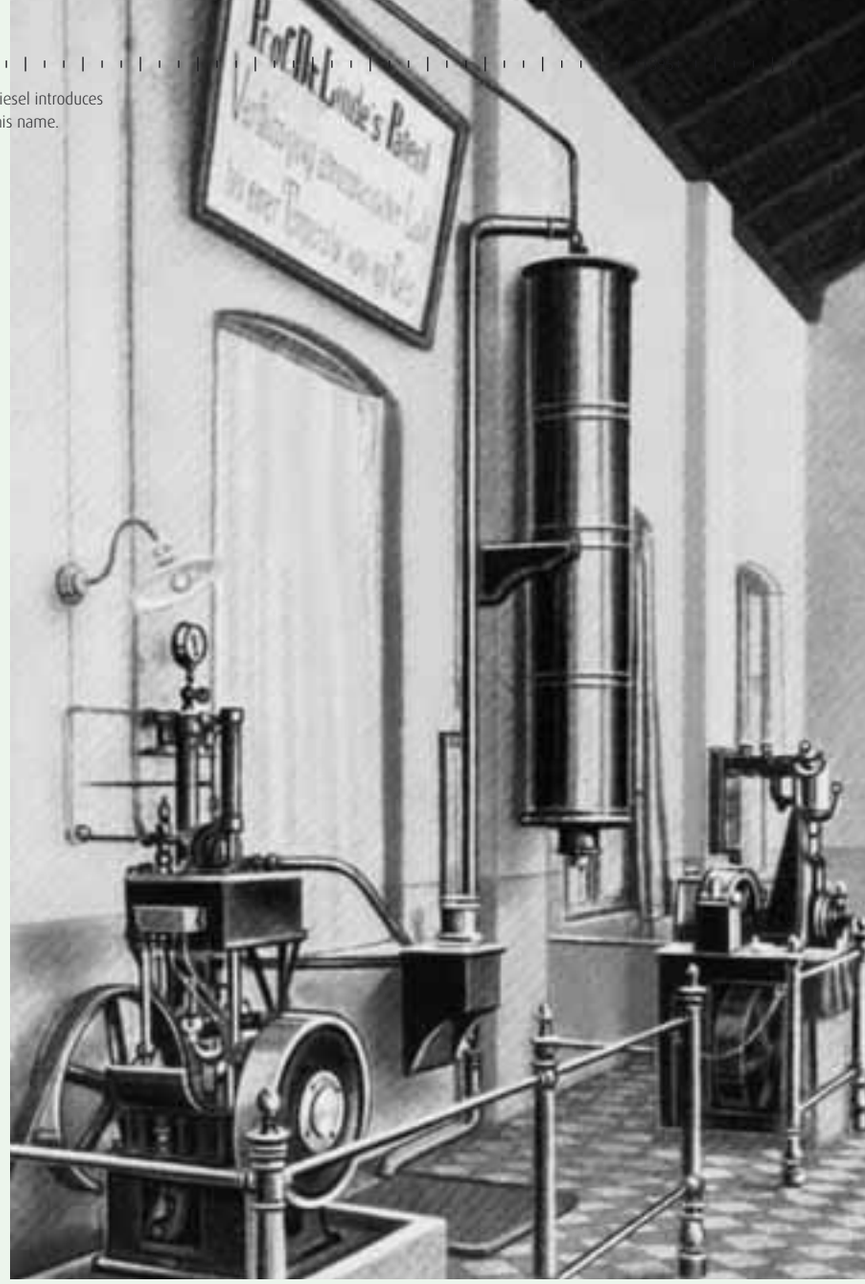
With air liquefaction, Carl von Linde created the conditions needed to produce pure gases using low-temperature processes. These gases include not only oxygen and nitrogen, but also hydrogen and inert gases – a technology whose future has only just begun.

An order from the Guinness Brewery in Dublin in 1892 to develop and install a carbon dioxide liquefaction plant gave von Linde the concrete impulse that started his work with low temperatures. Carl von Linde accepted the project although his company had never yet built any such plant. In 1894, von Linde began developing an early air liquefaction machine based on the knowledge gained from carbon dioxide liquefaction. He started from the idea of using the air itself as a refrigerant – using the cold generated when air moves from a higher pressure to a lower one for the additional cooling. This effect had already been described in 1862 by researchers Thomson and Joule.

The process

The more air is compressed, the more cold is generated when it expands. This cooling effect increases exponentially when the air is pre-cooled. However, von Linde could not achieve the temperature Celsius needed to liquefy the air (about minus 190 degrees) from expansion from high to low pressure and pre-cooling alone. That required a cooling cycle in which the cold generated by the expansion is transferred to the compressed, pre-cooled air in the countercurrent. In a continuous process, the cold given off from each cycle was multiplied until the air was liquefied and could be collected in a container.

While proven technology was available for compression and pre-cooling, the challenge for von Linde and his son Friedrich, who worked in the refrigeration testing station after receiving his Doctorate in physics, was to develop a suitable countercurrent apparatus. They decided on a 100-meter long double steel tube, which was wound into a spiral and well insulated, encased in wood.

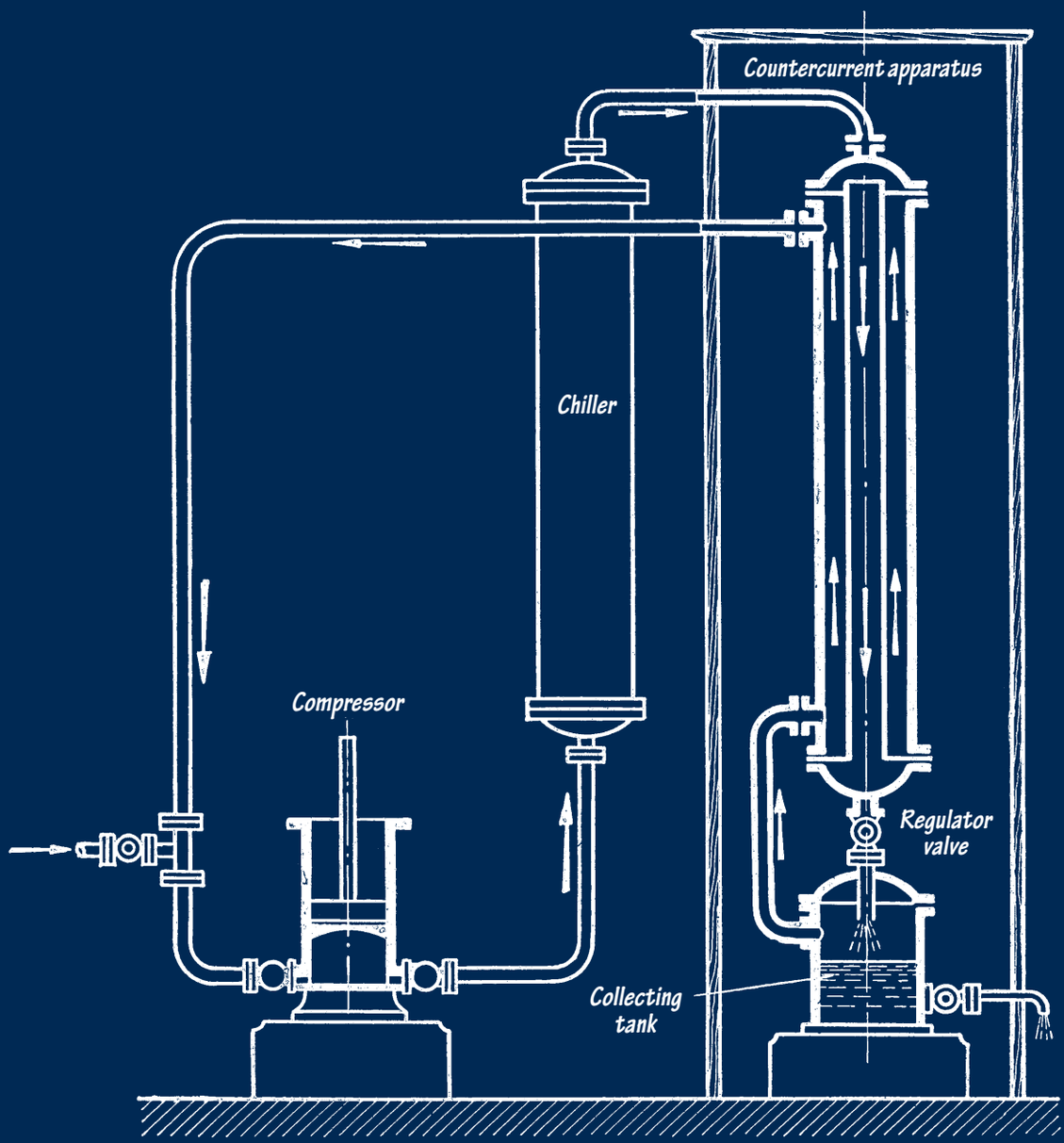


A small air liquefaction plant by Linde could be seen at the Bavarian Industrial and Commercial Exhibition in Nuremberg as early as 1896.

If at first you succeed ...

The first trial then began in May. In his memoir *"Aus meinem Leben und von meiner Arbeit,"* Carl von Linde wrote: "Happy and excited, we watched the temperature drop according to the effect described by Thomson and Joule, even after we had far surpassed the limits within which those researchers had worked."

№ 0082 Process for the liquefaction of atmospheric air or other gases.



Sketch of the first air liquefaction plant from 1895.

1898
First cathode ray luminescent screen tube by Karl Ferdinand Braun.

1899
Chemical company Bayer puts aspirin on the market.

№ 0087 Device for the recovery of refrigerant lost from the suction line of a refrigeration machine.

Of course the cooling in the 1,300 kilogram apparatus did not happen in one day. And during the night, some of the cold they had obtained was lost again. But on the third day, May 29, 1895: "With clouds rising all around it, the pretty bluish liquid was poured into a large metal bucket. The hourly yield was about three liters. For the first time on such a scale air had been liquefied, and using tools of amazing simplicity compared to what had been used before," said von Linde, still highly enthusiastic even 20 years after that day.

Air liquefaction: just the beginning

Air liquefaction was only the first step for von Linde towards a commercial viable use for his invention. His goal was to separate the liquid air, while re-evaporating it, into its constituents, since only these, primarily oxygen and nitrogen, held promising industrial potential.

First, however, he set about speeding up the long, drawn-out process of cooling and liquefaction. To do this, he condensed the air to 200 atmospheres in the compressor and built the countercurrent apparatus out of light, thin copper tubes.

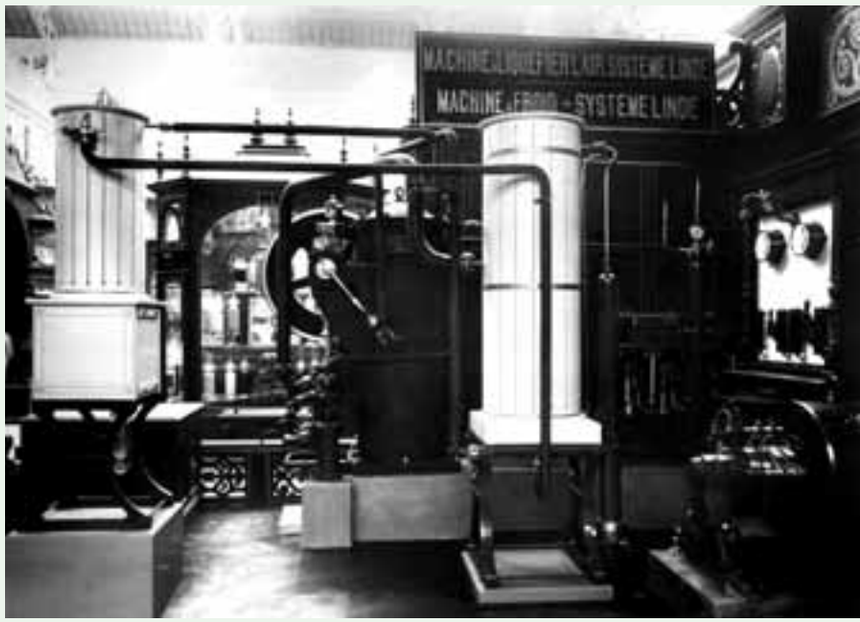
Air liquefiers for research

The company soon delivered 72 small liquefaction plants to scientific institutions and used them for public demonstrations. In Munich in 1898 at the "Second Engine and Industrial Machine Exhibition," von Linde presented a small plant in the Diesel Pavilion driven by a 10 hp diesel engine – an impressive demonstration of the two greatest achievements of that time in the area of thermal engineering. And at the 1900 Paris World's Fair, Linde's air liquefaction plant received the Grand Prix, the most coveted prize of the exhibition. These public demonstrations – even Kaiser Wilhelm II came to see it in Berlin – were possible because, with the new design, he had reduced the chilling time until liquefaction from 15 hours originally to just one hour. Further improvements later reduced the process to just 15 minutes.

Years of patience

A commercially viable method of separating oxygen out of liquid air would, however, take some time. Von Linde made his first attempts with "fractionation": Since oxygen boils at minus 183 degrees Celsius, and nitrogen at minus 196 degrees Celsius, when liquid air is heated, nitrogen evaporates 13 degrees Celsius sooner than oxygen and can be separated – "fractionated" – from the rest of the gas mixture.

However, because the temperature difference was so slight, not all of the nitrogen was released using the fractionation method. In fact a considerable portion remained in the subsequently evaporating oxygen. Only a 50-50 mixture could be economically produced in this way – the "Linde Air."



Linde air liquefaction plant at the Paris World's Fair in 1900.

1900
First dirigible flight by Ferdinand Graf von Zeppelin.

1901
Germany's Wilhelm Conrad Röntgen receives the first Nobel Prize in physics for the discovery of x-rays.

1902
The Nobel Prize in physics is awarded to Henri A. Becquerel and Marie and Pierre Curie for the discovery of radioactivity.

1903

Oskar von Miller and Carl von Linde, among others, found the Deutsche Museum (of Technology) in Munich.

In 1900, inventor Paulus Heylandt (page 38) built the first tank car for liquid oxygen, called the "Laubfrosch" or "Tree Frog."

1905

The Simplon Tunnel, the world's longest mountain tunnel at 19.6 kilometers, is completed.

1906

San Francisco is almost completely destroyed by fire and earthquakes.

1907

№ 0112 Process for the production of so-called Linde Air – oxygen and nitrogen in a ratio of 50:50.

A look inside the engineering office in Höllriegelskreuth (1910), where additional uses for the air liquefaction process (rectification) were being tested at the time.

1908
Hans Köppen of Germany wins the international "Around the World" auto race from New York to Paris in 165 days.

1909
German chemist Fritz Hofmann successfully produces synthetic rubber.

The Linde plant facilities in Höllriegelskreuth in 1909 (top) and 1929 (bottom).

At first it looked as if "Linde Air" would have a market with a strong future, mainly in the chemical industry. "Linde Air" also appeared to promise sales opportunities for use as an explosive. Test blasts during the construction of the Swiss Simplon Tunnel strengthened this hope. But this activity was ceased after the First World War.

Increasing demand for pure oxygen

The industry's demand for oxygen-rich gas mixtures quickly fell. The demand for pure oxygen on the other hand grew by leaps and bounds because autogenous (gas) welding and cutting processes began to take hold in metal working. In order not to lose his connection to this very promising market, von Linde intensified his search for a new method of separating out pure oxygen.

He finally convinced his son Friedrich and chemistry professor Hempel to try "rectification." This was a method of separating alcohol and water that had been long practiced in the field of chemistry: The fermented mash was heated until the alcohol evaporated. Heat was removed from the alcohol vapor by water cooling so that it could be condensed (rectification process) and captured as a liquid.

Technological breakthrough

Carl von Linde and his employees set in motion a comparable process, letting liquid air trickle down into to rectification column, while the oxygen vapor provided a countercurrent. This continuous process of liquefaction and evaporation produced nearly pure oxygen.

At the suggestion of Prof. Hempel, the first rectification column consisted of a steel tube filled with glass beads. This heavy apparatus with a long cool-down period was soon replaced with a lighter version with holes in the bottom instead of glass beads. Von Linde and his employees combined the liquefaction and separation units into one unit. "This opened up the road by which low-temperature technology finally found success in industry," wrote von Linde on this sensational breakthrough.

One of the first production plants, which was used to generate gas for many years, went into operation in Höllriegelskreuth, near Munich, in 1903.

Nitrogen production

The publication of this new process in 1902 not only attracted a number of imitators to the scene, but also aroused the interest of the chemical industry in pure nitrogen. Nitrogen compounds (calcium cyanamide, ammonia) were gaining increasing importance as fertilizers.

In a modified rectification process, the team in Höllriegelskreuth achieved nitrogen purification as well in 1903. Linde sold the first such plant to an Italian customer in 1905. And by 1910 the team, under the direction of Friedrich Linde and Rudolf Wucherer, had developed a "two-column apparatus," which delivered pure oxygen and pure nitrogen at the same time at a low cost.

1910
Electric washing machines come into use.

1911
Norwegian Roald Amundsen is the first man to reach the South Pole.

№ 0123 Process and device for the use of liquid air in combustion engine machines.

Dr. phil. Friedrich Linde (1870–1965)

Dr. phil. Friedrich Linde, Chairman of the Executive Board from 1924 to 1946.

The elder of Carl von Linde's two sons built Department B (gas liquefaction and separation) into a major pillar of the company and, from 1924, as Chairman of the Executive Board, determinedly led the entire company through the turbulent times of the 1920s, the Nazi era, the Second World War and the reconstruction after 1945.

Friedrich Linde studied physics in Strasbourg and Berlin and received his Doctorate in 1895. That same year he went to Munich and began the groundbreaking trials on air liquefaction with his father in the Linde testing station.

Together with his father, Friedrich Linde headed Department B starting in 1897 in Höllriegelskreuth and first developed equipment for the production of small air liquefaction machines for scientific laboratories. At the same Friedrich Linde worked on separating liquid air. He was the first scientist to succeed in producing pure oxygen by means of rectification.

In 1903 he was given power of attorney for the *"Gesellschaft für Linde's Eismaschinen"* and in 1908 he took over the management of Department B as a member of the Executive Board of the Linde Company. In 1924 he became chairman and in 1929 received the title of general director.

Friedrich Linde achieved decisive commercial successes. He brought about a cartel with the powerful IG Farben in the field of technical gases (1932), in which the Linde Company functioned as an equal partner. Above all, however, he steered the company through the economic and financial crises of the time between the wars, through the war and through the years of reconstruction after the Second World War. In 1952, at the age of 81, he gave up the Executive Board chairmanship to his brother-in-law Rudolf Wucherer, remaining on the Supervisory Board until 1961. Friedrich Linde died in 1965.

Further uses for rectification

Another interesting field of research came about with the emerging demand by the incandescent light industry for inert gases to fill electric light bulbs. Argon in particular was successfully extracted using a modified separation process starting in 1912.

In 1906, the rectification experts also started working in a study cooperative with Prof. Adolf Frank and Heinrich Caro on separating water gas into its constituent parts hydrogen, carbon monoxide, carbon dioxide, nitrogen and methane.

After extensive research trials in 1909 and 1910 the Höllriegelskreuth team succeeded in producing pure hydrogen. The members of the study cooperative joined together to form a company to take advantage of the "Linde-Frank-Caro process," with exclusive sales rights going to Linde. One early plant with an hourly yield of 2,000 cubic meters of hydrogen and 700 cubic meters of nitrogen was sold to the *Badische Anilin- und Sodafabrik (BASF)* for the synthetic production of ammonia. Other plants were ordered by margarine factories for hydrogenation.

Experience with water gas separation led in the 1920s to coke gas separation at low temperatures into its valuable components of hydrogen, nitrogen, methane and ethylene, in which rectification played a major role.

The knowledge needed for the complex coke gas separation process finally came from the principle for producing from natural gas and oil – a major prerequisite for the production of plastics after the Second World War.

The oxygen business

First, however, they had to service the flourishing oxygen market almost exclusively. To that end, the Linde Company joined together in 1904 with its two potential German competitors in the chemical production of oxygen to form *Vereinigte Sauerstoffwerke GmbH (VSW).* This company received the exclusive right to sell the oxygen produced by its member companies at an agreed-upon price. By 1910, the Linde Company had gradually acquired all of the shares in VSW and brought them into *Sauerstoffwerke GmbH* in Berlin.

1912
The "Titanic" passenger ship sinks after colliding with an iceberg.

1913
Henry Ford introduces the first assembly line in industrial production.

1914
World War I begins.

№ 0247 Process and device for the production of oxygen of any purity.

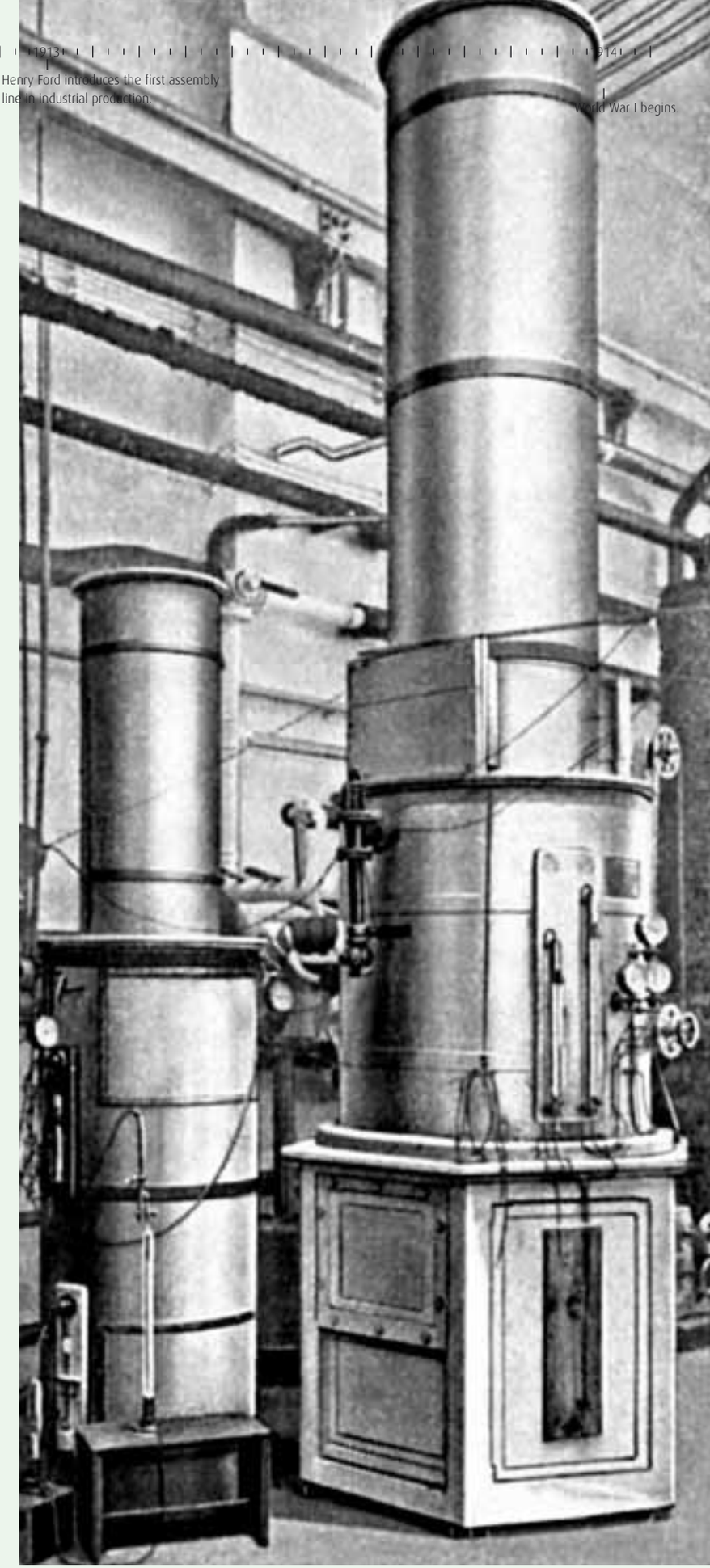
Since transportation costs had to be kept low, Linde built its own oxygen plants in major regional centers of the iron industry starting in 1904 – often directly on the grounds of major customers' facilities or adjacent to the companies' own refrigerated buildings. By the start of the First World War, Linde had built 20 of its own oxygen plants in Germany alone. These were in addition to plants ordered by major customers. These customers had to agree to sell any oxygen produced beyond their own requirements exclusively to the monopolistic trading company.

Patent disputes

The sensational method of air separation naturally attracted competitors and hangers-on to the scene, which in some cases led to drawn-out legal disputes. The first court encounter took place in England in 1907 between the Linde patent-holder British Oxygen Co. and the French company Air Liquide. British Oxygen won in all three instances. Soon thereafter Linde and Air Liquide came to an agreement on joint market exploitation.

In 1908 the Linde Company also made an agreement with the German user of the Air Liquide patents, the chemical company *Griesheim-Elektron,* on dividing up the German industrial gas market.

Von Linde also pursued patent infringement complaints against Prof. Raoul Pictet and his German patent user *Sauerstoff-Industrie AG* In a settlement, *Sauerstoff-Industrie AG* agreed to discontinue the sale of oxygen machines and oxygen in Germany. Three years later, all of that company's activities were merged with Linde and *Griesheim-Elektron.*



The world's first apparatus for the production of inert gases (oxygen-argon unit, 1913).

1915
Nobel Prize in chemistry goes to Richard Willstätter for work on chlorophyll and other plant pigments.

1916
Construction of the Trans-Siberian Railroad from Moscow to Vladivostok, which began in 1902, is completed.

№ 0325 Process for the recovery of hydrogen from gas mixtures containing hydrogen.

Untermaubach oxygen plant (west of Cologne, approx. 1920).

Starting in 1908, von Linde was involved in a dispute for many years against *Nürnberglicht,* which had far-reaching effects on the later development of the Linde Company. This company had copied an oxygen machine built by Linde and was doing a booming business with the stolen design.

The competitor was able to draw von Linde's case out by constantly changing its ownership and partnership configurations until Linde's patent rights had expired. Finally, in 1916 Linde and *Griesheim-Elektron* took over the company, which by that time was doing business as a corporation under the name *Deutsche Oxydric (DOAG),* and its assets were divided between the two buyers in 1920. In the process, the Linde Company somewhat accidentally acquired its first production subsidiary: *Maschinenfabrik Sürth* (see also page 33).

Foreign oxygen business

In order to build up the oxygen infrastructure in other countries, the Linde Company established joint ventures with local partners in the main consumer countries. In addition, the Internationale *Sauerstoffgesellschaft (ISG)* in Berlin would supply all production equipment for the worldwide distribution of oxygen technology.

Although the foreign companies established under their own direction (in such countries as France, Great Britain, Italy, Spain, Austria, Hungary and the United States) quickly found success, ISG never quite made it out of the starting gates. After five years, the Linde Company took over ISG altogether and integrated it into the company.

Its cooperation with French competitor Air Liquide, with which the "*Gesellschaft für Linde's Eismaschinen*" divided the markets in close collusion, contributed to its success in other countries. Linde's partial subsidiary British Oxygen Works, which supplied England and Scotland as well as the British Empire, functioned as the third member of the confederacy.

After also selling its patent rights for oxygen and nitrogen production in China and Japan, the Linde process had conquered 19 countries, and the Linde Company had holdings in 13 companies.

An especially exciting chapter to this story took place in the United States of America, which at that time represented a potential oxygen market of unlimited possibilities (see also page 35). Linde Air Products, founded in January 1907, developed so dynamically under American dominance that by the First World War it had surpassed its German parent company in size.

First World War and The Great Depression: return to old strength through innovation

With the outbreak of the First World War in August 1914, the business of Division B (gas liquefaction and separation) collapsed almost completely. In addition, most of its staff was drafted into military service. Friedrich Linde volunteered for his artillery regiment and served first in France, then in Galicia and Russia. In the fall of 1915, he was discharged from the military because he was urgently needed in Höllriegelskreuth.

There, after a short break, the work continued almost unabated for the engineers and technicians. After the deliveries of Chilean saltpeter had stopped, there was an urgent need for

№ 0384 Process for the separation of air or other gas mixtures (oxygen-argon apparatus).

nitrogen compounds for the production of explosives and artificial fertilizers. Large nitrogen plants were needed to produce nitric acid from calcium cyanamide – and quickly: In late 1914/early 1915, Department B received an order for four large nitrogen plants with a total output of 14,000 cubic meters per hour, to be delivered within eight to ten months. These output requirements pushed the Linde Company into a completely different scale. Since the four plants were identical, a kind of mass production could be organized in the Höllriegelskreuth facilities, which had been significantly expanded in 1913.

More orders for nitrogen plants followed soon thereafter, the last ones coming out of BASF as late as 1918 for its plant in Leuna. Inquiries for the construction of large and medium-sized oxygen plants, which were needed for direct saltpeter production and metal processing – mainly in airplane manufacture – also came in. Furthermore, liquid oxygen was gaining new importance in mining as the explosive "Oxyliquid." The overall demand for liquid oxygen grew so dramatically that the Linde Company had to give licenses to former competitors, while the Höllriegelskreuth plant was operating up to twelve hours a day, seven days a week.

But both Department A (refrigeration machines) in Wiesbaden and the cold storage facilities business were under extreme pressure after the war. The refrigerating capacity of refrigerator and freezer equipment had to be increased and additional cold storage facilities built so that food reserves could be preserved. Orders for ice machines for field hospitals began to come in starting in spring 1915 as well.

Maschinenfabrik Sürth and G. H. Walb & Co.: Problem child in household refrigeration appliances

Maschinenfabrik Sürth in 1920, when it was acquired by the Linde Company.

The first production subsidiary – as far as manufacturing for plant construction in Höllriegelskreuth – came to the Linde Company in 1920: Maschinenfabrik Sürth near Cologne. The company was founded in 1871 as a manufacturer of carbon dioxide and air liquefaction plants and after a bankruptcy in 1908 was operated by the management under Ernst Volland (later on the Executive Board at Linde) together with *Mannesmann Röhrenwerken.* After many changes in the company's structure, *Maschinenfabrik Sürth* was taken over by *Deutsche Oxydric AG (DOAG)* in 1916 and built rectification plants for its new parent company in competition with Linde, as well as compressors. That same year, DOAG was taken over by Linde and *Griesheim-Elektron.* In 1920 Linde integrated *Maschinenfabrik Sürth* with its Wiesbaden Department A (refrigeration machines).

Immediately after the First World War, the new subsidiary had to keep itself afloat primarily by repairing locomotives damaged in the war. For this and other reasons, the Wiesbaden central office decided to invest in the growing market for small commercial refrigeration equipment (for butchers, bakeries, etc.) and refrigerators. It shifted its small commercial refrigeration projects to Sürth, where a true top seller had been developed in the "Rhineland" small refrigeration machine.

Since *Maschinenfabrik Sürth* had only moderate sales in the refrigerator sector, in 1926 Linde bought additional expertise, taking over the G. H. Walb & Co. icebox factory in Mainz-Kostheim. One of the main factors in favor of G. H. Walb & Co. was its comprehensive icebox sales network throughout Germany.

But after great success in the 1950s, the company slipped back into the red with refrigerators in the 1960s. Linde therefore spun off this division into *Linde Hausgeräte GmbH* in 1965 and sold it to AEG.

1919
Treaty of Versailles between the Allies and the German Reich.

1920
Nobel Prize in Chemistry goes to Walther H. Nernst for third law of thermodynamics.

1921
Nobel Prize in physics is awarded to Albert Einstein for his theory of the photoelectric effect (quantum theory of light).

№ 0507 Apparatus and method for separating the constituents of air or other gaseous mixtures (US Patent).

№ 0546 Process for the storage of unsaturated gaseous hydrocarbons such as acetylene.

Passing the torch

Carl von Linde had already begun to transfer responsibility in stages for project planning, production and management of Department B to his sons Friedrich and Richard and to his son-in-law Rudolf Wucherer before the First World War, after the company founder and chairman of the Supervisory Board started to withdraw from operations in 1910 and handed over the reins in Höllriegelskreuth to Friedrich Linde.

While Friedrich Linde increasingly concentrated on the organization of the company and took over from Friedrich Schipper as chairman of the Executive Board in 1924, Wucherer primarily took care of building and expanding their own oxygen and acetylene plants. Between 1914 and 1929 he built 13 new oxygen factories with 25 new plants. This allowed oxygen production to quadruple between 1914 and 1929 and acetylene production to triple. At the same time he established regional monopolies in the cylinder business.

Rudolf Wucherer can rightly be called the founder of the Linde Gas Business Segment. He was appointed to Linde's Executive Board in 1928 and became chairman in 1952.

Richard Linde organized the installation and startup of the many new plants during the war as head engineer. In the 1920s he began increasingly to make a name for himself as the leading technical mind in the Munich business segment.

Post-war development

After the First World War, which had led to the loss of most of the foreign companies, the German economy suffered from hyperinflation, the occupation of the Rhineland and the oppressive reparations payments. But it was not long before the Linde Company's strong innovativeness brought it back to its old strength.

The Supervisory Board of the "*Gesellschaft für Linde's Eismaschinen*" in 1932, with Carl von Linde (center) at the age of 90.

1922
Englishman Howard Carter discovers the tomb of Pharaoh Tutankhamen in the "Valley of Kings."

1923
Adolf Hitler attempts the "Beer Hall Putsch" in Munich.

Nº 0562

Production of ethylene (US Patent).

Rise to US market leader: Carl von Linde founds Linde Air Products

Cecil Lightfood, head of Linde Air Products (USA).

Carl von Linde had systematically promoted the internationalization of his business even before the founding of the "*Gesellschaft für Linde's Eismaschinen*" with the sale of patent rights and the founding of subsidiary and partner companies. In the giant market of the faraway United States of America, he had sold the patent rights to his refrigeration and ice machines to German-American Friedrich (Fred) Wolf in Chicago in 1879.

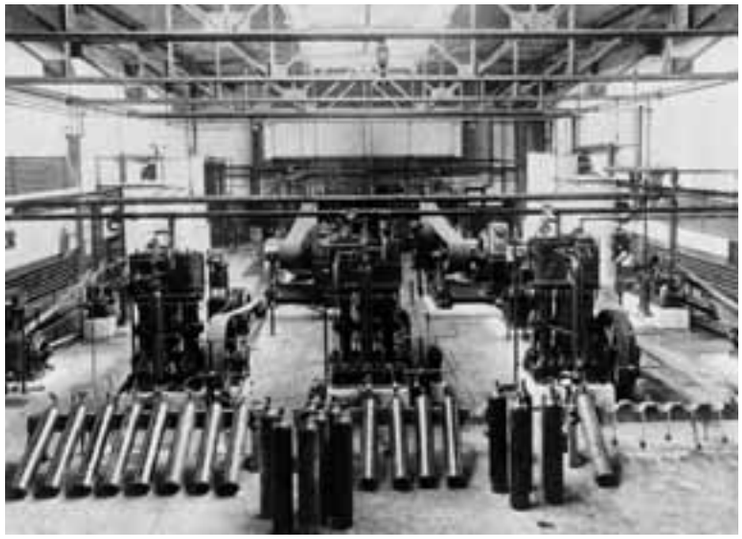
But before he could market his air liquefaction plants in the United States, von Linde needed to have the American patents. This became a lengthy hurdle race, since American engineer Charles Tripler already held a patent for an air liquefaction plant and for years prevented the granting of a patent to von Linde.

In 1900, electrical engineer Charles Brush joined in the dispute and offered to fight for the patent rights for Carl von Linde in exchange for a 33 percent share in the rights. He was finally successful in this fight in 1903. When the rectification patents were also disputed in the US in 1906, Carl von Linde decided to found his own company in the States. To do this, he needed American partners and immediately thought of the familiar Fred Wolf, Charles Brush and Adolphus Bush, the country's biggest brewer (Budweiser Beer).

He asked Cecil Lightfoot, the son of T. B. Lightfoot, who had headed Linde British Refrigeration Corp. in England for over 20 years, to make the preparations for founding the company. Although the younger Lightfoot found a suitable site for building an air separation plant in Buffalo, he was unable to reach an agreement with the potential investors.

And so on December 15, 1906, Carl von Linde himself traveled to the US and went to Buffalo with Lightfoot to purchase the land and to sign the order for building the oxygen factory.

However, von Linde had to do without his first choices of partners Bush and Wolf. In his negotiations, Charles Brush in Cleveland managed to found an American-dominated company. Still, Carl von Linde insisted upon bringing on Hugo Reisinger (son-in-law of Adolphus Bush and German Consul General in New York) as a partner and Cecil Lightfoot as a member of management. All of this finally ended in the founding of Linde Air Products.



A look inside the Linde Air Products plant in Buffalo (1910) – the first oxygen plant in the US.

Lightfoot successfully handled the building of the factory, which opened on Thanksgiving Day, November 1907 with 16 employees – it was the first oxygen production plant in the United States. Linde Air Products sold not only oxygen but also acetylene and welding equipment. By the outbreak of World War One, the US company had built a dozen factories and supplied the most important industrial regions in the US.

Since the founding of the American company, the Linde Company's share of Linde Air Products continued to fall as a result of several capital increases. When it became apparent in 1916 that the US would enter World War One, the German company presumably divested itself of its shares.

After the war, the comparative sizes of the parent company and subsidiary had finally switched: While the US company had a share capital of 15 million dollars, it would have needed only about 200,000 dollars to purchase the German parent company.

In 1917 Union Carbide and Carbon Corp. took over Linde Air Products, but continued to operate under the old company name. The German Linde AG thus lost its rights to the name Linde in the United States. It was not until effective January 1, 1999 that the North American group companies were once again permitted to use the name "Linde." The Linde Group now once again owns the global rights to the "Linde" name and trademark.

1924

German chemists discover polyvinyl alcohol, the basis for the manufacture of artificial fibers and films.

1925

Werner Karl Heisenberg presents his theory of quantum mechanics.

№ 0658 Process for the separation of coke oven gas by means of intense cooling.

№ 0667 Process and device for the condensation of vapors contained in air and other gases by means of cooling.

Güldner Motoren-Gesellschaft mbH: from diesel engines to tractors and forklifts

Hugo Güldner, co-founder and namesake of Güldner Motoren-Gesellschaft mbH

The gradual takeover of *Güldner Motoren-Gesellschaft mbH* in Aschaffenburg by 1929 caused a major change in the Linde Company: It helped the engineering company to grow into a major machine builder, which started out in the 1960s to garner the world market for industrial trucks, especially forklifts.

The Linde – Güldner connection goes back to 1904, when Carl von Linde founded *Güldner Motoren-Gesellschaft mbH* along with Hugo Güldner and other partners, and took a seat on the Supervisory Board. In 1908 the Linde Company took on partial ownership of this company for the first time. When Güldner began to have financial problems in 1925, the Linde Company purchased additional shares. Then, during the Great Depression of 1929, Güldner came under complete ownership of Linde.

Starting in the late 1930s, tractors became the company's main product group aside from engines. But in 1952 its tractor business was in the red, a situation that was not changed by the introduction of air-cooled diesel engines in 1954 either. Güldner made a technological leap into the future in 1955 with the continuous hydrostatic drive, which was first installed in the "Güldner Hydrocar" transport vehicle.

In 1969, Linde ceased production of tractors and diesel engines in order to concentrate on the high-growth sectors of industrial trucks and hydraulics. Over the ensuing years, this division developed into one of the Linde Group's main support pillars with strong sales and income.

The entry into machinery building at first had an hindering effect. In order to improve the situation of *Maschinenfabrik Sürth,* which was taken over in 1920, the Linde Company acquired the G.H. Walb & Co. refrigerated appliance factory in Mainz-Kostheim, which initially handled the sale of the small refrigeration machines made by Sürth.

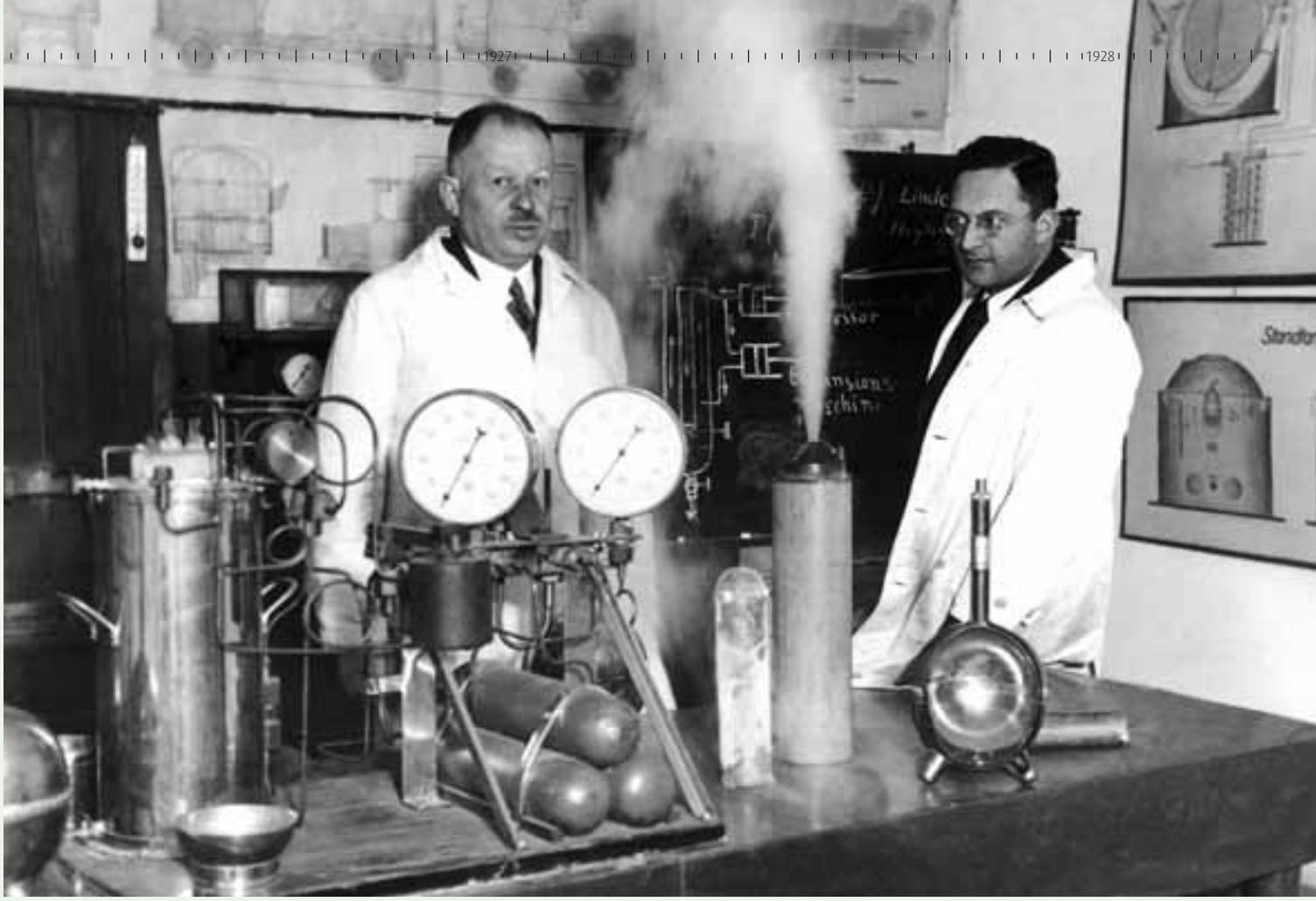
In 1922, Linde purchased shares in *Heylandt Gesellschaft für Apparatebau* of Berlin, simultaneously acquiring the company's patents for low-temperature engineering and process technology (see also page 38).

Finally, in 1929, the Linde Company also purchased all of the shares in *Güldner Motoren-Gesellschaft mbH,* which Carl von Linde had co-founded in 1904. This company was later moved to Aschaffenburg (see also page 52). That move, which was actually motivated with social welfare in mind, would in hindsight be seen as a major milestone, as it made possible the later entry in tractor manufacturing – and even more importantly, *Güldner* became the seed from which today's Material Handling Business Segment grew.

Modernization and innovation

Friedrich Linde and particularly his brother-in-law Rudolf Wucherer made use of the difficult years of the post-war period to modernize their gas operations and streamline their organization. At the same time, Richard Linde in Department B (gas liquefaction and separation) worked on the technological optimization of the Linde process. Engineers increased the purity of the oxygen from Linde plants from 98 to 99 percent and that of nitrogen to 99.999 percent. At the same time they reduced the plants' energy consumption.

They also developed a process for separating coke oven gas to produce a mixture of hydrogen and nitrogen for the synthesis of ammonia. Linde sold one of the first plants of this type to a Belgian customer in 1924. In the years to follow up until 1928, the company had sold or booked orders for 47 such plants of various sizes.



Paulus Heylandt (left) in his Berlin laboratory, approx. 1935. In front on the right is a cutaway model of the transport tank for liquid air, which he developed.

The Great Depression

The crisis after the collapse of the financial markets in October 1929 hit the Linde Company with full force in 1931: In Department A (refrigeration machines), sales collapsed to less than 60 percent of the previous year's. Sales fell again the following year to around one third. Layoffs and reduced hours were unavoidable.

Orders also failed to materialize in Department B in the second half of 1931. In order to avoid job cuts on a larger scale, the workshops in Höllriegelskreuth were only staffed in two shifts of 26 hours per week – with corresponding wage cuts. The "celebration that would normally be held" on Richard Linde's 25-year company anniversary "was called off in view of the dark times," he wrote to his sisters. The order situation in gas liquefaction and separation was quite weak in 1932 as well.

The technical gases branch likewise suffered from the general economic crisis. Sales of oxygen and acetylene dropped so far that staff had to be cut and the oxygen plant in Mülheim an der Ruhr had to be temporarily shut down altogether. Thanks to such restrictions and with "the greatest possible frugality" (Annual Report 1932) facilities engineering as well as the oxygen and acetylene plants were able to achieve a "somewhat satisfactory profit."

At *Maschinenfabrik Sürth* and *Güldner Motoren-Gesellschaft,* however, losses could not be prevented. In the 1932 Annual Report, the Executive Board reported that of all the plants in the company, Department C *(Maschinenfabrik Sürth)* was "worst affected by the crisis." "Despite all efforts to economize" the ongoing costs could not be earned back.

When Carl von Linde died in 1934 at the age of 92, the worst of the post-war Great Depression was already over. Thanks to the economic boom of 1933 both in Germany and abroad, as well as the support of the employment-creation schemes of the National Socialist Party in power at that time, the company entered a new period of growth - albeit under the conditions of the increasing war economy.

1929

Stock market crash in New York on October 29 launches The Great Depression.

1930

Max Schmeling becomes the first German world boxing champion in all classes.

№ 0743 Recovery of krypton and xenon from oxygen.

№ 0756

Transport of liquefied gases.

Rudolf Diesel, Paulus Heylandt and Mathias Fränkl: independent inventor-engineers

Test run of the "Heylandt" rocket car at Tempelhof Field in Berlin, 1920s. Standing at the cockpit is Paulus Heylandt.

From left to right: Rudolf Diesel, Moritz Schröter and Heinrich von Buz at the presentation of the diesel engine in Kassel (1897).

Mathias Fränkl, founder of MAPAG.

The Linde Company was surrounded from its very inception by so-called inventor-engineers – as both employees and outside advisers. These included, for instance, Rudolf Diesel, who worked for Linde for 13 years, Mathias Fränkl and Paulus Heylandt.

Rudolf Diesel (1858-1913) was born in Paris and studied engineering at the Technical University of Munich under Carl von Linde. After receiving an honors-level examination score and completing a practical placement at Sulzer in Switzerland, he went to Paris at the request of Carl von Linde to manage the sales office there starting in 1881. In 1890 Diesel became director of the *Linde-Gesellschaft für Kühlhallen* in Berlin.

In addition to his work for Linde, Diesel designed an engine that was driven by an inexpensive fuel instead of steam. When Linde declined to collaborate on the further development of this oil engine, Diesel handed in his notice and after 1893 they went their separate ways. In 1897 Diesel had his first engine built by the Krupp Company in Essen.

The new engine soon became widely used, first as a stationary unit and soon after as a ship's engine as well. It was only later used in standard production in the automobile. Diesel himself survived to witness only a small part of its success. Protracted patent disputes and business failures led to his suspected suicide in the English Channel during the crossing to England.

Mathias Fränkl (1877-1947) was head of a pipe and tube factory in Bochum. After the end of the war, he founded several small machinery plants, including *Maschinenfabrik Augsburg-Plattling Aktiengesellschaft (MAPAG)* in 1923.

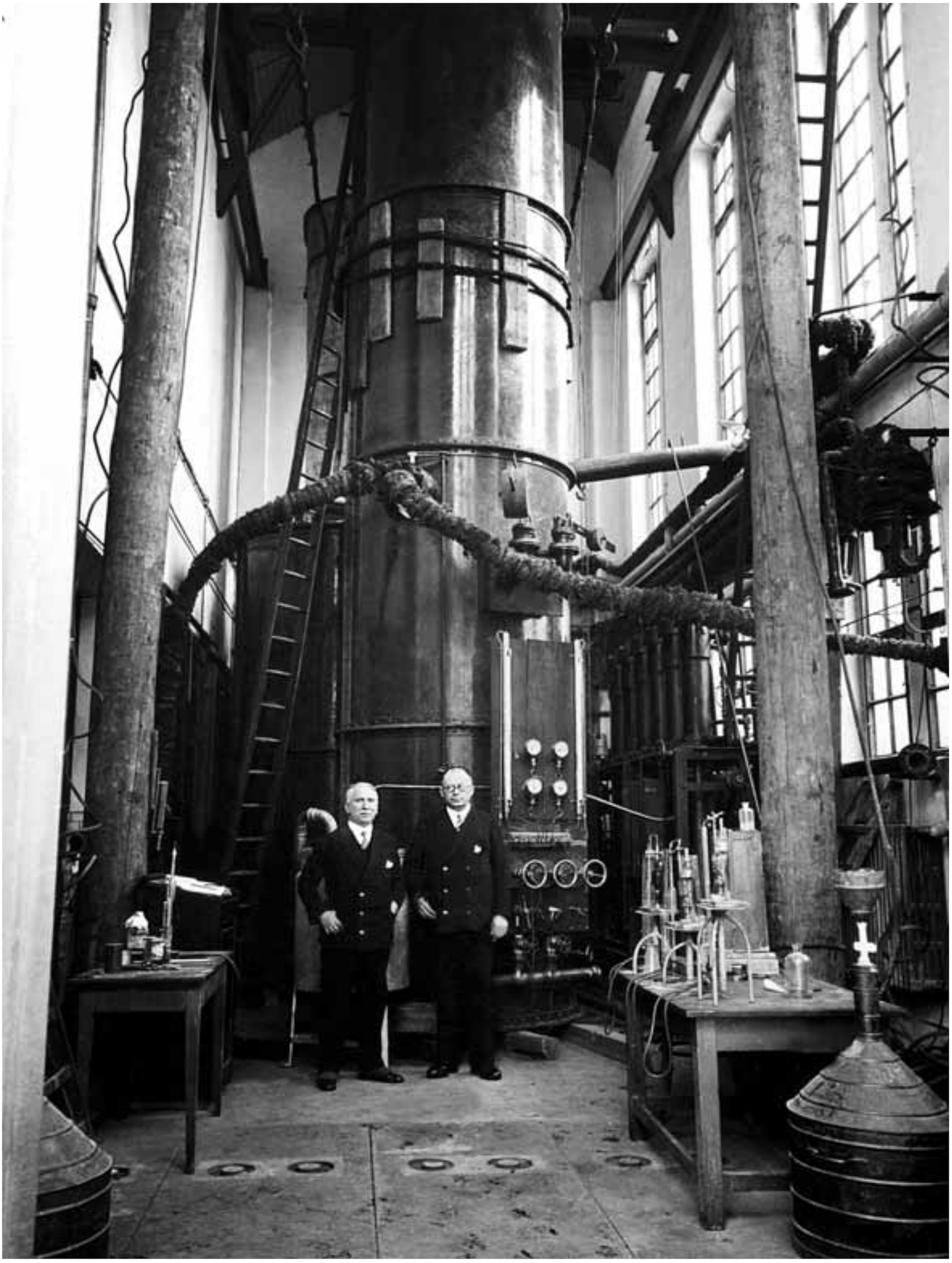
In 1925 he applied for a patent on the alternating switch-over operation of heat exchangers (regenerators). His idea was first to cool the heat exchangers and then in the second step to remove the cold (alternating operation). The Linde-Fränkl process, developed together with Linde's Department B, led to a breakthrough in oxygen top-blowing for steel production after the Second World War by allowing low-cost oxygen production. Fränkl died in 1947. MAPAG, located in the Bavarian city of Horgau, has been fully integrated in the Linde Group since 1990.

Paulus Heylandt (1884-1947) was, like Fränkl, an autodidact. At the age of 18 he applied for patents for liquid air transport cylinders, and one year later built the first air liquefier. His most important invention was the gasifier tank from 1917, in which boiling liquid oxygen could be transported. In 1923 the Linde Company signed a cooperative agreement with *Heylandt AG* for industrial gas recycling and invested in the company.

In the late 1920s, Heylandt began experimenting with rocket propulsion vehicles. After 1945 he was abducted to the Soviet Union, where he passed away in 1947.

Right: In the oxygen machinery assembly hall in Berlin-Britz; Paulus Heylandt (right) and his employee Michael Laschin.

1931 1932 1933



1934

1935

Ferdinand Porsche presents the prototype of the Volkswagen VW Bug.

Idea № 0770 – 2289

1935 – 1974 War economy, collapse and economic miracle

№ 0838

Device for the quick freezing of foods.

Growth in the times of war

Although not a direct arms supplier, the Linde Company experienced vigorous growth during the Nazi period. Its entire product line – from gas separators and industrial gases to motors and mobile repair facilities – was considered important to the war effort. Despite great destruction, the company was able to return quickly to its original markets after the war – with a few changes.

Even after the death of Carl von Linde, the company still reflected his values. Despite having its own manufacturing operations, engineering and development still took the same high priority as before. But, Carl von Linde's professional versatility had been divided among three people in the company since 1900: Friedrich Linde took on the role of entrepreneur, Rudolf Wucherer became general manager, and Richard Linde remained, all his life, the gifted developer and engineer.

The Linde cold storage building in Munich (approx. 1938).

"Assumption of power" and economic upswing

Within just a few years after the "assumption of power" by the National Socialists in January 1933, the economic atmosphere changed: Public spending on weapons as a percentage of total spending rose from four percent in 1933 to 50 percent in 1938, export conditions became increasingly worse and self-sufficiency efforts and a shortage of foreign currency made raw materials more difficult to acquire and shifted the focus of investments.

Products and know-how from all divisions of the Linde Company were in demand during the "Third Reich." For example, Department B sold a total of 37 air separation plants between 1935 and 1941 just for the new facilities being built for the production of synthetic fuels from coal and the production of synthetic rubber. Some of the biggest customers were subsidiaries of IG Farben.

The Linde Company's gas plants also profited from the economic upswing after 1933. In 1934, the 24 Linde-owned plants in Germany were supplying nearly as much oxygen as in the peak years of 1928 and 1929, and acetylene sales rose even more.

In order to be able to satisfy the strong demand for compressed gases, Linde first stocked up its cylinder fleet, and then the company relocated and expanded its oxygen plants in Nuremberg and Dresden. In 1938 the factories in Hamburg-Wilhelmsburg and Mülheim-an-der-Ruhr, which had long been shut down, were put back in operation. Linde also expanded its plants in Untermaubach near Cologne, Düsseldorf-Reisholz and Braunschweig.

1938
Konrad Zuse creates the first computer with his Z1 calculating machine.

1939
World War II begins.

№ 0875 Process for the melting of metals onto electrically conductive bodies, in particular for electric welding.

№ 0895 Process for the evaporation of liquid oxygen.

Cold storage facilities and ice production

The cold storage houses built by the "*Gesellschaft für Linde's Eismaschinen"* also went through a boom period as a result of the National Socialists' self-sufficiency policies. While the company posted a loss in this division in 1933, the economic situation for refrigerated buildings and ice factories was much improved in 1934. Of "considerable influence" here were the "measures by the Reich to support the products of the national economy and to regulate the market in these products," wrote the Executive Board in the annual report from 1934.

Deep-freeze food storage meant a new field of business for the refrigeration sector. Prof. Rudolf Plank, Germany's greatest refrigeration engineer after Carl von Linde, thus founded the *Reichsinstitut für Lebensmittelfrischhaltung* in Karlsruhe, and the *"Institut für Lebensmittelforschung"* was established in Munich. Linde supplied the testing equipment for both institutes. Numerous quick-freeze devices soon followed for long-term food supply storage.

Due to the strong demand for refrigerated storage, Linde even built a few new refrigerated storage buildings after a long interval, starting in the mid-1930s: One project which Linde had been planning for several years was opened in 1935, while a second facility was built in 1937 in cooperation with the city of Magdeburg.

Skating rink business

And yet another application of ice technology flourished in the mid-1930s: ice skating rinks. Carl von Linde had had his eye on this market since the company's early days and in 1882 presented the world's first manmade ice rink at the German Patent and Utility Model Exhibition in Frankfurt am Main. Another ice rink followed shortly after in Nuremberg. But the breakthrough was still some time away.

In anticipation of the upcoming 1936 Olympic Games in Berlin, and promoted by state propaganda, Germany was enjoying a widespread interest in sports, which prompted Linde to build the Linde Stadium in Nuremberg in 1935. This Linde operated sports center, with an outdoor ice skating rink and swimming pool, served as advertising for Linde – and with much success: By the end of 1936 Linde had already received orders for ice skating rinks in Hamburg, Munich, Krefeld, Dortmund and Cologne. Of the twelve ice skating rinks erected in Germany in the 1930s – ten outdoor and two indoor rinks – seven were built by Linde.

After World War II, ice revues stimulated demand once again. First Linde built a small ice rink for variety shows for American soldiers, to be followed soon after by transportable skating rinks – such as one in 1950 for the famous German skating pair Maxi and Ernst Baier.

Güldner Motoren-Gesellschaft mbH

The economic situation at the Aschaffenburg plant, which made various sizes and types of diesel engines, as well as compressor parts for refrigeration machines, remained precarious despite increasing sales figures and quantities. Sales of large engines in particular fell sharply in the early 1930s.

In response, *Güldner* added small diesel engines to its production line and in 1935 built an additional factory building to meet the increasing demand. This product line, with engine outputs of between 20 and 120 hp, was met with strong interest, particularly in agricultural machinery. In 1938 *Güldner* began building tractors itself. In the 1950s this line of business became the Güldner group's strongest sales performer.

Photo right: Tractor production at *Güldner Motoren-Gesellschaft mbH*


Studebaker

1941
Japanese attack on Pearl Harbor, Hawaii, USA.

1942
Italian Enrico Fermi succeeds in producing the first nuclear chain reaction.

№ 0915 Process for the separation of air by liquefaction and rectification (US Patent).

Portrait of Erich Marx on a product brochure for the Marx & Traube company (1932-1935).

Marx & Traube GmbH (MATRA-Werke GmbH)

Güldner in Aschaffenburg and the plant in Mainz-Kostheim also worked for Marx & Traube GmbH. This automobile industry supplier specialized in machine tools and toolsets for vehicle maintenance, some of which it produced itself, but it also imported from the US.

The Linde Company owned 50 percent of this company in 1931, with the other half owned by Erich Marx. When Marx, as a Jewish businessman, had to leave the country in 1935, Linde purchased the rest of the shares in the company. When the law was changed in 1937 to require the names of (former) Jewish business owners to be erased from company names, Linde renamed the firm from Marx & Traube to *MATRA-Werke* as of January 20, 1938, thus retaining the founders' names in the form of an acronym. After the war, Erich Marx pursued a lengthy legal battle with the Linde Company over the return of his shares in the business.

Starting in the mid-1930s, MATRA primarily sold mobile auto repair facilities to the German army and air force. MATRA built an additional production plant before in Kahl am Main World War II to handle the extensive orders.

Linde and National Socialism

Although the Linde Company benefited considerably from the self-sufficiency policies and the arms buildup, the relationship between the Executive Board – particularly the members of the Linde family – and the regime remained distant.

As General Director, Friedrich Linde was least able to avoid contact with state institutions, and naturally wanted to take advantage of the business opportunities for the company. This also explains his willingness to be appointed as a *"Wehrwirtschaftsführer"* or "defense economics leader." This title, however, also gave Friedrich Linde the authority to protect the company from state interference.

After the war ended, both Linde brothers were arrested by the Americans. Friedrich Linde was held in solitary confinement in Stadelheim Prison from July to November 1945. Moreover, the occupation authorities temporarily barred him from managing the company.

One of Friedrich Linde's closest employees, the plant manager at Höllriegelskreuth, was an openly avowed supporter of the party and regime: Dr. Alfred Hess, uncle of Rudolf Hess, Adolf Hitler's "deputy." Alfred Hess also managed the Linde Company's internal newsletter beginning in 1936, which, in addition to information about the company and its operations, also published National Socialist propaganda – mainly regarding the German labor front. The elder Hess left the company in 1942 after his nephew Rudolf stole a small airplane and attempted to defect to England.

Richard Linde had recognized the danger of the Nazis even before their "seizure of power" and took no public offices while they ruled. For this reason as well he refused the chairmanship of the German Association of Refrigeration Engineers. Nevertheless, he was not able to avoid the function of "Special Director for Welding and Cutting Technology" in the *"Organisation Speer."*

Richard Linde's two eldest sons, Helmut and Werner, died in the war. His third son committed suicide during the Nazi period. Fourth son Hermann was seriously wounded in France in 1940, but nevertheless survived the war, as did his younger brother Gerhard.

Rudolf Wucherer managed to avoid any political activity and questioning during the "Third Reich." His only "office" was that of an air defense guard.

Jewish employees at Linde

Starting in 1933, the political pressure on Jewish citizens grew unrelentingly. At Linde there were several Jewish employees in management positions surrounding Richard Linde, including the manager of the assembly department, Philipp Borchardt, the manager of the chemical laboratory, Dr. Franz Pollitzer, and his close associates Dr. Paul Schuftan and Dr. Lothar Meyer. Schuftan and Meyer had already emigrated by the middle of the 1930s; Borchardt and Pollitzer were arrested on *"Kristallnacht,"* taken away to the Dachau concentration camp and abused there.

However, after massive intervention by Richard Linde they were released, although they did not return to their same jobs. To ensure their safety, Richard Linde found work for them abroad: Pollitzer went to Air Liquide in Paris and Borchardt to British Oxygen in London.

In a letter to his sisters on December 7, 1938, Richard Linde writes: "I have had plenty to do in the last few weeks because my closest employees were apprehended as non-Aryans. One has already been out for 10 days, but has had to recover some at first and also is not allowed back in the office; he can only work for us at home. The other will hopefully be out tomorrow. It is impossible for one to write or speak about this matter without one's blood beginning to boil."

Rudolf Wucherer (1875–1966)

Rudolf Wucherer, chairman of the Executive Board from 1952 to 1954.

A mechanical engineer, and married to Carl von Linde's youngest daughter Elisabeth, Wucherer first worked as a designer in the Krauss & Co. locomotive factory in Munich after completing his studies at the Technical University in Munich.

On June 1, 1905 he moved to Department B at Linde where he was responsible for the commissioning of major plants. In 1914 he received power of attorney and managed the company's oxygen and acetylene plants. This laid the foundation for the highest-earning division at Linde AG today. Between the outbreak of the First World War and 1928, Linde, under Wucherer's leadership, quadrupled its oxygen production compared to 1914 and secured regional monopolies for the company in the cylinder business. In 1928 Rudolf Wucherer was appointed to Linde's Executive Board.

The founding of the Ellira *(Elektro-Linde-Rapidschweißung)* department in Höllriegelskreuth can also be traced to Wucherer's initiative. Linde acquired the license for the submerged arc welding and gas-shielded welding processes from its former subsidiary Linde Air Products in New York.

In 1952 Rudolf Wucherer became chairman of the Executive Board and changed to the Supervisory Board in 1955. He stepped down from this post in 1965 and died one year later in Munich.

Dr.-Ing. Richard Linde (1876–1961)

Dr.-Ing. Richard Linde at the age of 53 (1929).

Carl von Linde's second son studied mechanical engineering at the Technical University in Munich until 1900 and received a Doctorate in technical sciences at the Laboratory for Technical Physics at TU Munich. After working at *Maschinenfabrik Augsburg Nürnberg* (MAN) for about two years, he took a position in Department B at Linde in Höllriegelskreuth. There he worked at first with his father on the development of equipment for air liquefaction and gas separation. In the beginning still with his brother-in-law Rudolf Wucherer and later with various different employees, he was successful in developing many new separating processes and rectification columns.

In 1914 he received power of attorney and responsibility for facilities engineering as well as all business to do with supplying gas liquefaction and separation plants, which required the highest level of commitment, especially during the war period. In 1928 Richard Linde was appointed to the Executive Board and remained the top developer and engineer in Department B until 1949.

Richard Linde lost three of his five sons during the Nazi period. The oldest, Helmut, and the second oldest, Werner, had both worked for the Linde Company after receiving their Doctoral degrees. The third son Gustav committed suicide in 1935 at the family's summer home in Berchtesgaden. Dr. Hermann Linde, who began working for the company in 1948, was appointed to the Executive Board in 1961 and acted as its speaker from 1972-76. The youngest son Gerhard worked as sales manager for Linde in Höllriegelskreuth.

Richard Linde changed to the company's Supervisory Board in 1949 and stepped down in 1955. He died on January 16, 1961 in Munich.

Borchardt returned to Höllriegelskreuth in 1946 and resumed his position from before 1938 as technical director with power of attorney for negotiations and contracts abroad. Pollitzer, however, was taken into custody by the Gestapo in Paris in 1940 and in 1942 was murdered in the Auschwitz concentration camp.

Otto Hippenmeyer, a Member of the Executive Board of the Linde Company since 1929, was assisted by both the Linde family and the Linde Company and as a "half-Jew" managed to survive in Germany.

War and collapse

Although Linde did not supply arms products in the narrower sense, all of its departments were nevertheless connected with arms production. The oxygen plants supplied the Luftwaffe, and Linde was also involved in the rocket program (V1/V2) by way of the *"Heylandt-Gesellschaft für Apparatebau"* in Berlin. The refrigerated case plant in Mainz-Kostheim built mobile repair shops and complete repair trains for MATRA during the war.

The Güldner plant group also manufactured such products as cylinder boring machines and hydraulic presses for MATRA. Later Güldner also sold engines with wood carburetors for tractors, etc.

During the war, Ellira *(Elektro-Linde-Rapidschweißung),* the electric welding systems department established in Höllriegelskreuth in 1937, worked almost exclusively on supplying welding equipment for the arms industry.

One of the darkest chapters in Linde's history was certainly the company's involvement in the construction of production facilities for IG Farben surrounding the Auschwitz concentration camp. The Merseburg GmbH ammonia plant, owned by IG Farben, built a synthetic rubber factory there using prisoners at the Auschwitz II satellite concentration camp in spring 1941 for which Linde built and installed four oxygen and two helium plants. Two more plants ordered for Auschwitz could not be produced due to the war.

Nº 0930 Arrangement for the enrichment of radioactive decay products in solid materials containing fats.

Foreign workers and forced labor at Linde

In order to maintain operations, which were essential to the war economy, plants operated by the Linde Company also employed so-called "foreign workers," forced laborers and prisoners of war. The numbers varied widely depending on the year. In Höllriegelskreuth the highest number was 232 foreign workers out of a total of 1,054 workers in 1943.

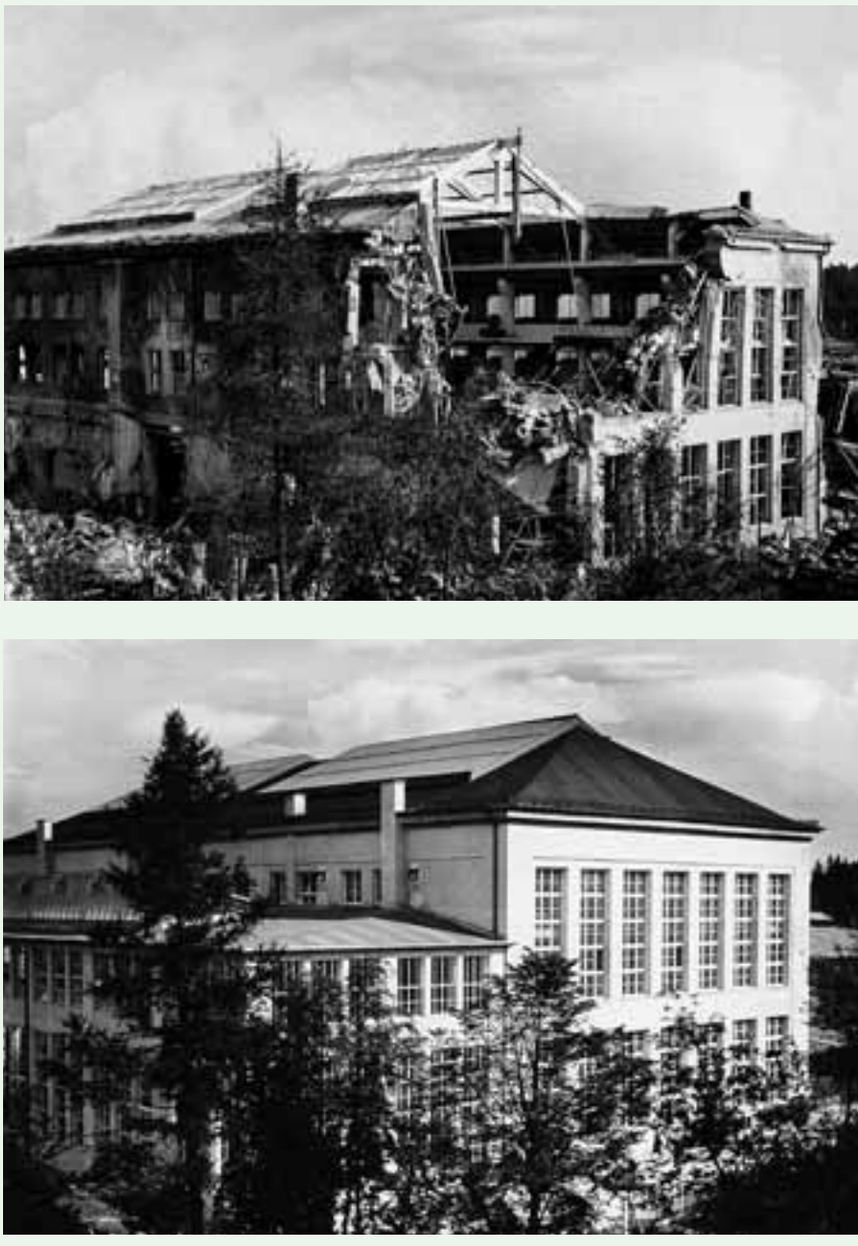
For the German government's charitable foundation for the compensation of former slave laborers which was founded in 2000, the Executive Board of Linde AG calculated – based on surveys, since most records were destroyed in the war – between 400 and 500 forced laborers and prisoners of war for mid-1944.

Destruction

The allied bombings hit most Linde plants. Already in 1942 the refrigerated display case plant in Mainz-Kostheim and individual cold storage houses, such as in Munich, were heavily damaged. The Berlin-Britz plant of Linde subsidiary Heylandt was largely destroyed in 1943.

On June 19, 1944 the plant in Höllriegelskreuth suffered severe damage. Soon, however, production in the partly destroyed assembly hall was able to be resumed at 40 percent capacity. Some production was relocated to rented facilities in Schalchen, near Trostberg. After the war, most production followed to the old relocation site.

The *Güldner Motoren-Gesellschaft* in Aschaffenburg also suffered severe damage in an air attack in 1944. Then on January 21, 1945 the plant was completely destroyed. Production of tractor motors with wood carburetors, which were classified as important to the war effort, moved to the grounds of agricultural machinery manufacturer Fahr in Baden.



Destroyed plant facilities in Höllriegelskreuth before (top) and after the reconstruction (bottom approx. 1950).

№ 1149 Combustion engine with thrust cam mechanism for tractors, etc.

Building refrigerated display cases in the factory in Mainz-Kostheim (approx. 1950).

In 1944 the bombs struck *Maschinenfabrik Sürth*. The MATRA plants were also heavily damaged. The plant in Kahl am Main, to which some of the production had been shifted, remained unharmed, and so production was able to resume quickly here after the war.

The oxygen plants in Magdeburg, Bielefeld and Dresden also fell victim to the bombing war. In February 1945 the administration building in Wiesbaden went up in flames, destroying the valuable drawing archives.

War's end: a new beginning

Despite all of the destruction, Linde suffered less from the war than many other German companies. For one thing, the company was little involved in occupied areas. For another, its main production facilities were located in the western parts of Germany and were largely spared from expropriation and dismantling after the war. And finally, the Linde Company did not manufacture any actual weapons and so could continue and expand its existing production program unchanged both during and after the war.

Although reconstruction work was delayed due to a shortage of building materials and specialists until 1949, the Linde Company nevertheless managed to turn a profit once more in 1946 of about 1.7 million Reichsmarks. This was offset, however, by a loss of almost 3.7 million Reichsmarks carried forward from the previous year and charged against 1946 and 1947.

Expropriation after the war

Linde companies and subsidiaries in Hungary and Austria were expropriated after the war. The feared loss of all foreign subsidiaries in the west was largely prevented, however. Only two plants in Alsace and Lorraine built after the start of the war were lost.

1951
First color television transmissions sent by CBS in the USA.

1952
American Edward Teller invents the hydrogen bomb.

Currency reform and economic upturn

At the time of the currency reform of 1948, when the course was set for the post-war economic upturn and the new prosperity, the Linde Company was already back on solid ground. In its opening balance sheet dated June 21, 1948 the "*Gesellschaft für Linde's Eismaschinen*" converted its equity capital 1:1 to DM 34,266,000. DM 34,000,000 were bearer shares and DM 266,000 nominal shares with 20x voting rights, which were held for the most part by the family to prevent hostile takeovers. Reserves of nearly DM 22 million were also built.

The home office in Wiesbaden, which had served primarily as the head design office for Department A (refrigeration machines) since Carl von Linde's return to Munich and the establishment of Department B (gas liquefaction and separation), received a new administration building and the status of main administration.

Economic miracle: not all industries benefited

Fortunes at the different departments of the company did not all rise at the same rate after the war. The Höllriegelskreuth facilities engineering department received many orders even before the currency reform, primarily from abroad, in particular for "pure nitrogen plants as well as for the same in connection with coke oven gas separation plants (especially for Belgium, Spain and Italy)," according to a report to the Supervisory Board.

The oxygen and acetylene works, which had been operated together with IG Farben until 1945, had a more difficult time of it, because, of course, IG Farben was dissolved by the Allies. It took some time before the Linde Company was able to take over its old gas works under its own control once again. At first it produced "primarily for the foreign troops." After the currency reform, sales of oxygen and acetylene "rose remarkably" (report in the opening balance sheet of 1949), and so from 1948

Dr.-Ing. Hugo Ombeck (1886–1963)

Dr.-Ing. Hugo Ombeck, chairman of the Executive Board from 1954 to 1961.

Hugo Ombeck joined the "*Gesellschaft für Linde's Eismaschinen*" in January 1913 as a young engineer in Department A (refrigeration machines). After World War I he became the manager of the sales department (July 1, 1919) and received power of attorney in 1924. In 1928 he became a deputy member and in 1929 a regular member of the Executive Board. He became chairman of the Executive Board on October 1, 1954.
Ombeck was an old-style "general director" – self-confident and quick to make decisions. At the same time, during his period in office he supported the reorganization of the Sürth and Güldner plant groups according to the American model.

Ombeck left the existing structures at the top of the company, with the two main locations of Höllriegelskreuth and Wiesbaden, untouched and made possible a harmonious transition from the second generation of the Linde family to the third in the management of the companies.

In 1961, at the age of 75, Hugo Ombeck retired from the position of chairman of the executive board, which was taken over by Dr. Johannes Wucherer, a grandson of Carl von Linde. Ombeck died on December 27, 1963 in Wiesbaden.

№ 1312 Process for the purification of gases by means of intense cooling and washing.

to 1951, Linde rebuilt the oxygen factories in Nuremberg, Düsseldorf-Reisholz and Hamburg-Wilhelmsburg. In 1950 the company built a new oxygen factory in the Britz area of Berlin (American sector).

After extensive reconstruction efforts, Department C *(Maschinenfabrik Sürth)* was hardly able to "meet the strong demand for small refrigeration machines and refrigerators" (annual report of June 20, 1948). The economic miracle was thus slowly beginning on the consumer side as well.

Unprofitable large refrigeration equipment production

The large refrigeration equipment sector, by contrast, never really got going in the 1950s. While the foreign market was booming – in 1954 foreign sales were nearly 75 percent of the total – domestic sales were already below the expectations of Linde's Executive Board in 1951.

In view of this unsatisfactory situation, the Executive Board decided to move large refrigeration equipment from Wiesbaden to Sürth near Cologne and merge it with small industrial refrigeration. Among other things, this would reduce the outside production of refrigeration compressors and units in favor of in-house production. In 1960 the large refrigeration equipment department finally moved to Sürth, and after the merger took on the designation "industrial refrigeration equipment."

Small refrigeration equipment and household refrigerators

The small commercial refrigeration equipment and refrigerator sector also faced organizational and technical production problems. The Mainz-Kostheim plant produced and sold household refrigerators and commercial refrigerators and freezers for which the Sürth plant supplied refrigeration machines and equipment. This uneconomical division of labor first led to the

Milk bar outfitted with Linde refrigeration equipment in the Bundeshaus Restaurant in Bonn (approx. 1950).

1955

The Warsaw Pact is founded under the leadership of the Soviet Union.

Linde household refrigerator of the 1950s.

1956
First telephone cable between Europe and the US goes into operation.

1957
Sputnik I, the first artificial satellite, orbits the Earth.

№ 1461

Vehicle whose movement is controlled by pedals (Hydrocar).

Hydrostatics – it started with the Hydrocar

Seeking new products to offset the stagnating demand for tractors, the *Güldner Motoren-Gesellschaft* took over the hydrostatics operations of the Saalmann company in the mid-1950s, including all employees working in that area.

In a hydrostatic drive, a rotating cylinder drum driven by a combustion motor pumps oil into a driving gear at high pressure (420 bar) by means of pistons. This driving gear in turn is rotated by means of its pistons. The flow and, thus, the rate of rotation is controlled by a swash plate whose tilt angle determines the piston stroke (see also page 56). Transmission gears in the driving gear reduce the rate of rotation from 2000 to 200 rpm and transmit this to the wheels of a vehicle such as a forklift.

The change in the rotation speed is smooth. A significant advantage of the hydrostatic drive is that both acceleration and braking are effectively achieved by depressing the pedal to adjust the swash plate of the vehicle – and without any wear. Another point in favor of the hydrostatic drive is that the vehicle runs smoothly at the same speed once it has been set – no matter the resistance, such as when it goes over a threshold.

Finally, the hydrostatically driven vehicle can be operated away from its energy source; it can be connected over a distance using cables and hoses.

Linde tested this hydrostatic drive in the "Hydrocar" starting in 1958, which was primarily used for internal transport. After extensive testing, the Hydrocar made up the core around which today's Linde Material Handling Division was built. From the beginning, the first hydrostatically driven forklift had a smooth ride, simple, precise handling, low wear and high safety.

In the course of ongoing development, Linde integrated the hydrostatic drive, hydraulic pump, hydraulic motor and gearbox into one compact axle. The latest generation offers a higher power density (greater pivoting angle) and can do without the mechanical gear transmission stage since the wheels are driven directly by the "slow running" hydraulic motor.

The "intelligent" electronics provide excellent driving behavior and make optimal use of the power of the diesel engine, thus minimizing fuel consumption.

Linde hydrostatics supplies not only the forklift customers in its own plant but also a number of outside customers, such as manufacturers of construction machinery, harvesters, street-cleaning and refuse vehicles. One of its specialties is the drive for baggers: One hydraulic pump can control several "consumers" (such as a drive motor and shovel) at the same time without affecting their performance. Here too electronics developed at Linde ensure sensitive control and optimal use of the power.

The hydrostatics shop at the Aschaffenburg plant now makes some 120,000 units per year, about half of which are for external customers.

A Güldner Hydrocar tows an air force plane. These vehicles were built from 1958 to 1965 in Aschaffenburg.

The "Hubtrac" was the first Linde forklift truck; it was built from 1959 to 1969.

Linde Series 313 forklifts were produced from 1967 to 1977.

Nº 1503

Shovel loader with telescoping mast (Hubtrac).

construction of a new factory for household refrigerators in Mainz-Kostheim. In 1964, after lengthy discussions, the Executive Board finally decided to merge the subsidiaries in Sürth and Mainz-Kostheim with the Sürth Group (Linde Refrigeration).

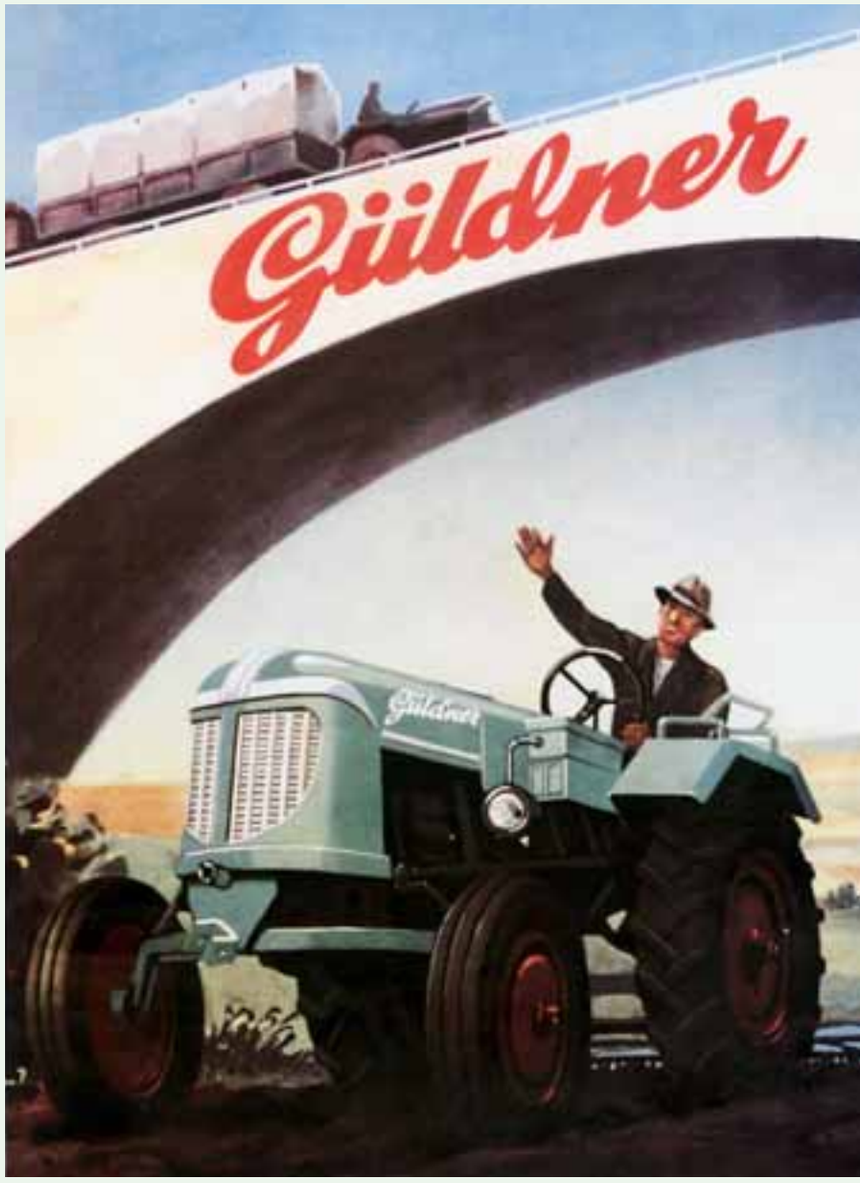
The "white goods" division, meaning refrigerators and chest freezers for home use, could not be rehabilitated. In 1965 Linde finally spun off the refrigerator business into an independent company, which then underwent a majority takeover by AEG in 1967.

Tractor and engine manufacturing

After a very promising start in the post-war period with strong demand for tractors, Department D *(Werksgruppe Güldner,* formerly *Güldner Motoren-Gesellschaft)* also encountered turbulence. Although it had to increase capacity in 1951 due to a growing market share, tractor sales already stagnated the following year. In 1953 Department D reported its first drop in sales. From this point on until production was ended in the late 1960s, tractor manufacturing was plagued with problems.

Neither the new air-cooled diesel engines, which were introduced in 1954, nor the modern production plant opened in Nilkheim, near Aschaffenburg, in 1956 produced a turnaround. Even during the economic miracle, agriculture was never a booming sector and there were too many manufacturers in a very small market.

In order to reduce dependence on agricultural machinery, the management sought "new products," according to the 1957 annual report. The next year, *Werksgruppe Güldner* took over the hydraulics division of *"Gusswerk Paul Saalmann & Söhne OHG"* in Velbert. Together with the hydrostatic drive, a Linde development,



Advertisement for the *Güldner Motoren-Gesellschaft* in Aschaffenburg.


Fuldner · HYDROCAR

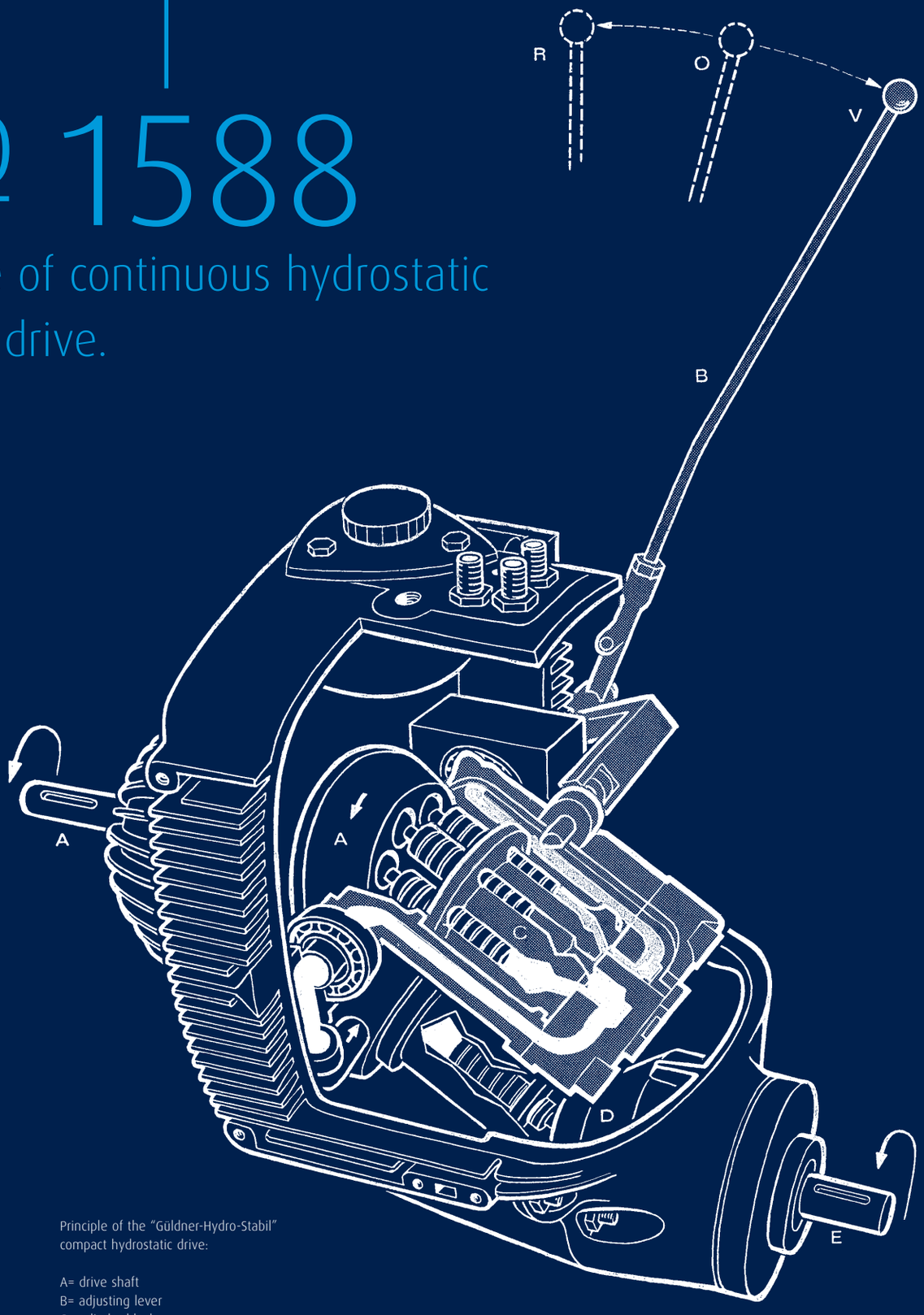
The Güldner Hydrocar was the precursor to the forklift truck.

1964
Nikita Khrushchev is removed from power in the USSR.

1965
The Vietnam Conflict expands into war.

№ 1588

The use of continuous hydrostatic vehicle drive.



Principle of the "Güldner-Hydro-Stabil" compact hydrostatic drive:

A= drive shaft
B= adjusting lever
C= cylinder block
D= hydraulic motor
E= drive shaft
V, O, R= possible adjusting lever positions

1966 Mao Tse-tung ignites the "Cultural Revolution" in China.

1967 "Six-Day War" between Israel and Arab neighbors Egypt, Jordan and Syria.

№ 1593 Process and device for the residual purification of gas mixtures during low-temperature rectification at the temperature of liquid hydrogen (–252.8 °C) (cryotechnology).

№ 1712 Plate condenser evaporator, especially for gas and air separators.

which Güldner used as a test in 1955 in its "Hydrocar" transport vehicle (see also page 52), the group now had two new seeds for growth. It is one of Dr. Hans Meinhardt's great entrepreneurial achievements to have recognized the significance of these innovations and to have systematically built on them (see also page 65).

Prior to the stunning decision by the Executive Board of March 21, 1969 to immediately cease tractor construction and massively expand forklift production, however, there had been many attempts during the 1960s to streamline tractor and diesel engine manufacture and set them on more stable footing. The *Werksgruppe Güldner* in 1958 had announced a close collaboration with *Maschinenfabrik Fahr* in Baden. Beginning in 1959, both companies produced tractors in the "Europa series" that were nearly identical in construction. This collaboration broke up after Fahr was taken over in 1961 by its competitor Deutz.

When a sale of the motor and tractor business fell through, the Executive Board finally put an end to tractor and diesel engine production due to dramatically increasing losses. Güldner had produced some 300,000 diesel engines and 100,000 tractors in Aschaffenburg by that point.

Entry into large plant engineering

Plant engineering on the other hand was growing by completely new dimensions in Höllriegelskreuth during the 1950s. While international customers were ordering primarily oxygen and nitrogen plants in the early 1950s, Linde was soon involved in new applications for gas separation in the petrochemical industry, which soon became the most important customers.

For Linde these orders meant entering the field of large plant engineering, with completely new technical and financial challenges: the trend towards complete "turnkey" solutions. Despite a lack of experience in this field, Linde made the daring leap, becoming a supplier of complete large plants. This was a very risky field, but one which could be just as rewarding.

Dr.-Ing. Johannes Wucherer (born in 1906)

Dr.-Ing. Johannes Wucherer, chairman of the Executive Board from 1961 to 1972.

The son of Linde Executive Board Chairman Rudolf Wucherer and grandson of Carl von Linde studied mechanical engineering at the Technical University in Munich and receiving his Doctorate in engineering (Dr.-Ing.) in 1931 from the Technical University in Dresden. He remained in Dresden as assistant to the famous thermodynamics expert Prof. Richard Mollier until 1934.

That year he started his career at the Linde Company in Wiesbaden in the inspection office for refrigeration systems. In 1937 he transferred to Höllriegelskreuth and was soon the closest employee to his uncle Richard Linde, who at that time managed facilities engineering. During this period, Johannes Wucherer played a leading role in the continuing development of low-temperature technology, the Linde-Fränkl process and ethylene production.

On October 1, 1954 he became a deputy member and in 1957 a regular member of the Executive Board. While he was in office, the Executive Board and Supervisory Board of Linde AG restructured the responsibilities of the central administration in Wiesbaden and the division of labor in the Executive Board so that the central administration in Wiesbaden played a stronger role.

In 1972, Johannes Wucherer retired from his position in favor of Hermann Linde and was appointed to the Supervisory Board. Johannes Wucherer lives in Diessen am Ammersee.

1968

Warsaw Pact troops end the "Prague Spring" under Alexander Dubcek.

1969

American Neil Armstrong is the first man to walk on the moon on July 21.

№ 2064 Special fixation of the spiral-wound tube coil of a heat exchanger.

№ 2082 Process and device for the recovery of ammonia synthesis gas.

The development of gas companies outside Europe began in 1968. Pictured here: transporting liquefied gases in Brazil.

Gas application in the construction industry: Flame descaling with autogenous flame for finishing concrete surfaces.

It would be fully developed, beginning in the mid-1960s, under the leadership of Hermann Linde, Georg Plötz, Joachim Müller, Hannes Kneissl and Karl Heinz Jungmann. Linde received its first contract to build a petrochemical ethylene plant in Scholven, near Gelsenkirchen (Veba) in 1965.

Business in technical gases also contributed to the economic strength of the company. After the chemical industry, the steel industry developed into the most significant customer sector. The production of acetylene and inert gases also took on increasing importance.

Refrigerated buildings benefited almost exclusively from political developments in the mid-1950s: first from the Korean war, later from the agricultural policies of the EEC, which led to considerable agricultural surpluses – to lakes of milk and mountains of butter and meat that had to be stored and refrigerated.

In the 1950s, the engineers in Höllriegelskreuth also worked on the peaceful use of nuclear energy, and in 1955 built a facility for the production of heavy hydrogen (deuterium). But after light water reactors became established internationally, Linde dropped out of this field. One useful thing came out of this venture, however: in the production of heavy hydrogen, the Linde engineers made progress for the first time in an industrial process at minus 252 degrees Celsius. Since that time Linde is now among the world's technological leaders in the field of ultra-low temperatures (cryotechnology).

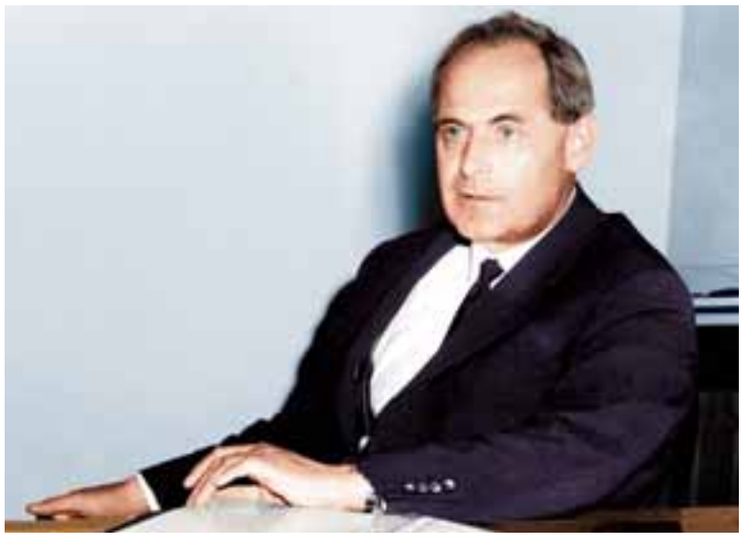
Partial view of a petrochemical plant constructed by Linde in South Africa.

1971
German Chancellor Willy Brandt receives the Nobel Peace Prize.

1972
USA and USSR sign SALT treaty to limit strategic arms.

№ 2123 Process for the separation of nitrogen-containing natural gas.

Prof. Dr. Hermann Linde (born in 1917)



The third generation of the Linde AG Executive Board: Dr. Hermann Linde as speaker of the Executive Board (1972-1976).

The fourth son of Richard Linde was born on November 12, 1917 in Munich, studied physics at the Technical University in Munich, receiving his Dr. rer. nat. degree in 1948. He began his professional career in January 1949 in the chemical department in Höllriegelskreuth. One year later he transferred to the process technology office.

In 1957 he became manager of the technical office, assembly office, calculation office and manufacturing areas in Höllriegelskreuth and in Schalchen with power of attorney.

In 1961 he was appointed as a deputy member and in 1965 as a regular member of the Executive Board of Linde AG with responsibility for the low temperature engineering and process technology section of the Munich plant group. Under his leadership the former equipment manufacturer went into large plant engineering, in which Linde acted as general contractor for the customer with overall responsibility for the individual projects.

In 1970 Hermann Linde also took on the supervision of the Sürth division and a year later of refrigerated buildings as well. In 1972 he was appointed speaker of the Executive Board, a position which he held until 1976.

The ongoing restructuring of the Executive Board's responsibilities and the centralization of the company management in Wiesbaden were left to his successor at the top of the company, Dr. Hans Meinhardt.

On September 30, 1976 Hermann Linde stepped down from the Executive Board of Linde AG and went to TU Munich as an honorary professor. He lives in Pullach, near Munich.

A new generation: beginning of the strategy debate

The second generation change in the Executive Board of the Linde Company since the company's founding in 1879 took place in the early 1950s, this time from Carl von Linde's sons (-in-law) to his grandsons. In 1952, at the age of 81, Friedrich Linde gave up the Executive Board chairmanship to his brother-in-law Rudolf Wucherer (p. 45), serving instead on the Supervisory Board until 1961. Wucherer held the post of chairman of the Executive Board until 1954, when he handed it over to Hugo Ombeck (see also page 49). Rudolf Wucherer joined the Supervisory Board in the middle of 1955, where he remained until 1965. Ombeck served in the post of chairman of the Executive Board until just 1961 and handed it over to Rudolf's son Johannes Wucherer (see also page 57), a grandson of Carl von Linde. Johannes Wucherer came to the Linde Company after receiving his Doctorate in engineering. He first became a deputy member in 1955 and then in 1957 a regular member of the Executive Board.

Richard Linde had stepped down from the leadership of the equipment and plant engineering division and his chairmanship in 1950 and served thereafter in the Supervisory Board until 1955. He died in 1961. Richard Linde's successor in Höllriegelskreuth and in the Executive Board was his longtime employee Walter Ruckdeschel.

In 1961, Hermann Linde, the fourth son of Richard Linde, became the last member of the family thus far to serve in the Executive Board and served as head of facilities engineering. In 1972 the Supervisory Board named him spokesman of the Executive Board.

1973
OPEC restricts supply and triggers international oil crisis.

1974
The Watergate scandal leads to the resignation of US President Richard Nixon.

№ 2251 Process and device for the cooling of objects or materials.

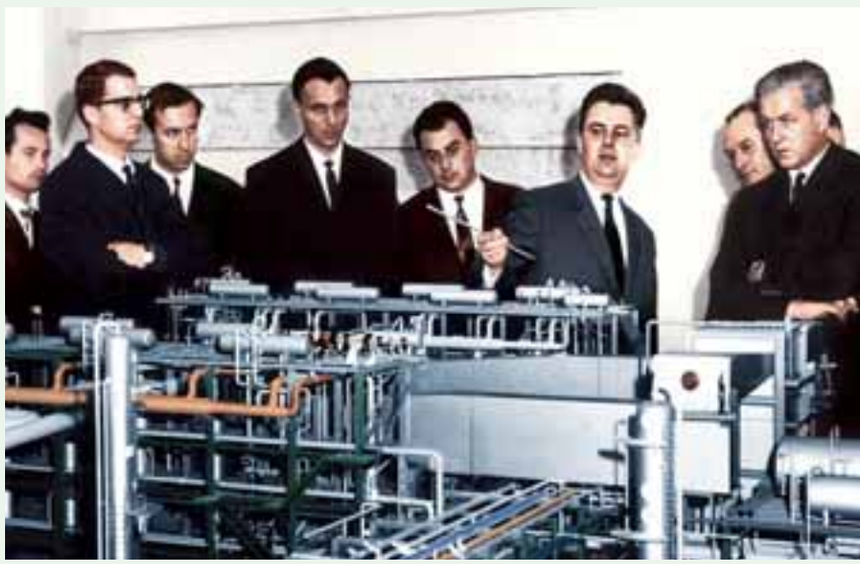
Discussion of future direction

Starting in the mid-1960s the Executive Board of the Linde Company engaged in a highly controversial strategy debate whose outcome was unknown. Indications of economic problems, above all in the refrigeration division and at Güldner, and the general sense of an increasing "technological gap" compared with the United States led to uncertainty and strategic considerations in the company which would soon change both the leadership structure and the corporate culture.

First the Executive Board decided on a few somewhat cosmetic changes: The now old-fashioned sounding name "*Gesellschaft für Linde's Eismaschinen*" was changed to the short, concise Linde AG in 1965. The plant groups were named after their geographical location – Munich, Sürth, Aschaffenburg and – breaking from the pattern – refrigerated buildings; the production lines were now called divisions: low temperature engineering and process technology; technical gases; welding technology; refrigerated buildings; compressors, expansion turbines, compressed air tools; refrigeration and air conditioning; refrigeration and freezer units; hydraulics; diesel engines; tractors and industrial trucks.

With the weak economy and the early globalization starting in the second half of the 1960s, the strategic discussions in the Linde AG Executive Board intensified. Dr. Hans Meinhardt primarily set the tone. He joined the company in 1955, was promoted to the top management of Güldner in Aschaffenburg in 1963 and beginning in May 1965 also acted as assistant to the deputy chairman of the Executive Board and head of central administration, Dr. Johannes Simon.

From this position, Meinhardt introduced the structural changes which he purposefully completed as speaker of the Executive Board beginning in 1976.



Höllriegelskreuth in the ethylene plant boom: Armin Dorner (center) explains a model of the Scholven, Germany ethylene plant to a delegation.

The finished Scholven ethylene plant in the late 1960s.

Idea № 2290 – 6385

1975 – 2004 Becoming a global player

1976
World boxing champion Muhammad Ali retires undefeated.

1977
First democratic elections in Spain since the beginning of the civil war in 1936.

Nº 2361

Storage vessel for liquefied gas (US Patent).

On an expansion course through acquisitions

From the mid-1970s to the start of the new millennium, all signs at Linde pointed to expansion. With a series of acquisitions during the "Meinhardt era" from 1976 to 2003 – especially in the areas of industrial trucks, technical gases and commercial refrigeration – the company tripled its staff, while sales rose fourfold in the same period, after allowing for inflation.

The Linde Corporate Center, which was acquired in 1974 on the outskirts of Wiesbaden.

The structural changes to Linde AG that were begun in the 1960s were concentrated in the 1970s on centralizing corporate leadership and on developing management control instruments. The driving force behind these changes was Dr. Hans Meinhardt, until 1970 still as a member of management in Aschaffenburg and assistant to the deputy speaker of the Executive Board, Dr. Johannes Simon, thereafter as an Executive Board member, later as its President and CEO (until 1997) and then as chairman of the Supervisory Board (until 2003).

From 1959 to 1962 Meinhardt first set up management organization departments in the Güldner plant group, at the Wiesbaden headquarters and finally in the plants in Mainz-Kostheim, Sürth and Höllriegelskreuth. Meinhardt modeled these after American corporate structures.

Simon and Meinhardt also established a central market research department. It was based on the studies carried out in this department that the company decided to spin off its home refrigerator segment and to switch from diesel engines and tractors to industrial trucks and hydraulics.

Strengthening the corporate center

Meinhardt was convinced that in order to secure its future, a diversified, international company needed not only cutting edge technology but also the same level of organizational and planning expertise. He developed a model of a diversified company with approximately equal-sized business segments which would advance to the top of their respective industries.

The questions regarding the distribution of responsibility both within the Executive Board and between the Executive Board and the plant groups and the extent to which the company management should be centralized were points of disagreement in the 1960s and 70s. Meinhardt, who was appointed as a deputy member of the Executive Board in 1970 and as a regular member in 1971, argued for the centralization of the strategic leadership with operational responsibility in the business segments. Hermann Linde, speaker of the Executive Board as of 1972, was for even farther-reaching decentralization and believed in technological leadership as a decisive factor for competitive success.

Corporate mission statements

Hans Meinhardt articulated corporate principals which would apply for decades to come under his aegis. They included:

- "The company will only operate in areas with demanding technology in which it has a strong market presence or can achieve such with reasonable effort and expense.

№ 2514 Process for the biological purification of wastewater.

- The business segments should balance one another out in size or in achievable business volume, should have different economic cycles and different levels of capital and personnel intensity.
- The Executive Board manages the company. The individual members of the Executive Board are responsible for business segments and perform functional tasks for the company.
- The staff of the Executive Board and the administration department of the company are combined in the central administration. They are led by the President and Chief Executive Officer of the Executive Board."

As a visible sign of the new era with a strong central administration, Linde AG acquired new administration buildings on the outskirts of Wiesbaden. The company headquarters are still located here on Abraham-Lincoln-Straße.

The corporate structure of 1973.

New plant groups

The Executive Board decided, based on the new corporate principals, to divide the Munich plant group into the Low-Temperature and Process Technology (TVT), i.e., plant engineering, and Technical Gases (TG) plant groups.

Linde AG split the Sürth plant group into the Industrial Refrigeration and the Refrigeration and Installation Systems segments. The Güldner Aschaffenburg plant group remained unaffected by the reorganization. Industrial Refrigeration sold refrigeration and air conditioning units for industrial use, while the Refrigeration and Installation Systems segment supplied refrigerated display cases and refrigeration and air conditioning units for wholesale distribution.

By 1971, Linde had already purchased Variant GmbH in Bad Hersfeld as a manufacturing operation for non-refrigerated shop equipment. In 1976 the Commercial Refrigeration division increased its production capacity once more by taking over Tyler Refrigeration International GmbH in Schwelm, Germany.

A few years later (1979) Linde combined the Industrial Refrigeration and the Refrigeration and Installation Systems segments together once more. Two years later, the Executive Board decided on a further restructuring in the Refrigeration plant group, as a result of which Industrial Refrigeration was nearly completely dismantled by the late 1990s, while Commercial Refrigeration rose to no. 1 in Europe.

Strengthening the market position in refrigeration

Commercial Refrigeration sought to combat the increasing competition in Europe and the rising demand power of the grocery and discount chains by modernizing production and by using volume effects. In 1987, Linde built a new plant in Bad Hersfeld for the production of refrigerated and frozen display cases and in 1988 acquired the factory in Mainz-Kostheim back from the AEG subsidiary *Duofrost Kühl- und Gefriergeräte GmbH.* After the modernization, Linde gradually concentrated the production of commercial refrigerated and frozen display cases here until 1990. The new plant in Bad Hersfeld began to produce non-refrigerated shop equipment in 1989.

1979

European rocket "Ariane" begins its maiden voyage on December 24.

Dr. rer. pol. Hans Meinhardt (born in 1931)

Dr. rer. pol. Hans Meinhardt, President and CEO of the Executive Board from 1976 to 1997; chairman of the Supervisory Board from 1997 to 2003.

For more than 48 years – that is more than a third of the company's entire history – Hans Meinhardt has been in the service of Linde AG. He not only helped shape the corporate culture, under his leadership as President and CEO the company also grew to completely new dimensions: Between 1980, the year he was appointed President and CEO, and 1997, the year he transferred to the Supervisory Board, sales more than tripled from 2.742 billion marks to 9.545 billion marks, and profits (net income before taxes) increased by nearly a factor of six.

Actually, Hans Meinhardt originally wanted to study history. But then he decided to pursue his degree in business management at the University of Frankfurt am Main and began his professional career in 1955 at Linde AG. He first completed a cycle through each of the individual plant groups as part of an internal training program and then worked in the auditing department in central administration in 1956. In 1957 Meinhardt received his Dr. rer. pol. degree.

In 1959 Hans Meinhardt transferred to the Güldner plant group in Aschaffenburg to set up an organization department. Two years later he joined commercial administration and in 1963 advanced into management.

One of Meinhardt's great business successes is the development of this ailing plant group into a world market leader in industrial trucks.

In 1965 Meinhardt also became the assistant to the Deputy Chairman of the Executive Board and head of central administration, Dr. Johannes Simon, and built up the market research, marketing and planning departments, becoming manager of those departments as well.

In 1970 Hans Meinhardt became first a deputy member and as of June 1, 1971 a regular member of the Executive Board. He was responsible for the central administration and soon also for the Güldner and Köln-Sürth plant groups.

In 1976 Meinhardt replaced Hermann Linde as speaker of the Executive Board and became President and CEO in 1980.

Under his more than 20 years as Chief Executive, Linde AG rose to become a world market leader in industrial trucks, solidified its outstanding position as a facilities engineering company for the chemical and petrochemical industry, established itself as the European market leader in commercial refrigerated display cases, developed cryotechnology into a profitable field of business and established itself as one of the leading European manufacturers of technical gases.

In 1997, Hans Meinhardt transferred to the Supervisory Board and became its chairman. At the shareholder meeting of 2003, Dr. Hans Meinhardt brought his service on the Linde AG Supervisory Board to a close and entered retirement.

Linde Refrigeration supplied all refrigerated display cases for the Pinguin Supermarket in Siegen, Germany in 1973.

The upheaval in Eastern Europe opened up new future opportunities for Commercial Refrigeration: Beginning in 1992, Linde used the cost advantages of the Czech Republic and, with a partner, founded Linde Frigera spol. s.r.o. for the production of plug-in refrigerated and frozen display cases.

In Warsaw, Poland in 1996, Linde set up a sales company in order to gain a share of the demand from Western retailers by building up their presence in Poland.

Focus on Europe

Starting in 1997, Linde concentrated more strongly again on the Western European countries. In England, the Wiesbaden corporation rose to become the market leader in commercial refrigeration with the purchase of Radford Retail Systems Ltd. Linde AG also strengthened its market position through a majority takeover of the Chief Group, a leading sales company for commercial refrigerated display cases in France, Great Britain, Belgium and the Netherlands in 1998.

In Southern Europe, Linde consolidated its position in commercial refrigerated display cases with the purchase of the remaining shares of Frigel Apostolou S. A. (1997) and the remaining 20 percent of the Italian Criosbanc S. p. A.

Linde secured the Swiss commercial refrigeration market for itself in 1996 by taking over Frigorex AG in Lucerne from *Gebrüder Sulzer AG;* Linde also acquired the remaining shares in *ZEHAG Kälte + Klima AG* as well as EQUIPE FROID S. A., La Conversion, which the company had been invested in since 1991.

A further competitive edge was obtained when Linde quickly converted to CFC-free – and thus environmentally friendly – refrigeration units.

Overseas, Linde set up joint ventures in Thailand and the Philippines; in Brazil, the Commercial Refrigeration division acquired 75 percent of Seral do Brasil S. A., a leading supplier of refrigerated display cases, non-refrigerated equipment and checkout systems.

1981

Egyptian President and Nobel Peace Prizewinner Anwar al-Sadat is assassinated.

№ 2837 Process for operating a pressure swing adsorption plant operating cyclically (European Patent).

1982

The refrigerated display case plant in Mainz-Kostheim in the 1960s.

But despite all efforts, the commercial refrigerated display case business has to this day earned significantly lower margins than the other business segments.

Pulling back from peripheral activities

In order to streamline its corporate structures, Linde, under the leadership of Hans Meinhardt, spun off the Refrigerated Buildings plant group into its own legally independent company in 1984 and sold it to *Markt- und Kühlhallen AG* in Hamburg in exchange for additional shares in this company. This portfolio clear-out also saw the sale of *Kolben- und Turboverdichterbau* of Cologne, with 760 employees, to the Swedish machinery builder Atlas Copco.

Technical gases: expansion and internationalization

In 1972, Linde AG strengthened its Low-Temperature Engineering and Process Technology segment with the takeover of the low- and ultra-low-temperature technology business of Messer Griesheim GmbH. In exchange, Linde transferred its welding technology division (Ellira) to Messer Griesheim. In addition, both companies combined part of their international gases business into the Zürich company Likos AG for some years.

In the years that followed, this joint venture set up production and sales companies in Belgium, France, the Netherlands and South Africa. Linde AG also built up its gas activities in Australia and Brazil in 1974 through cooperation with major customers for gas separation plants.

Expansion in Germany

In Germany the Linde Technical Gases segment already owned 50 percent of *Industriegas GmbH & Co. KG (IGA)* in Cologne in 1972. In 1985 Linde took over the rest of the shares in the IGA companies *(Industriegas GmbH, Industriegas GmbH & Co. KG, Azetylenfabrik Hagen GmbH and Industriegas GmbH & Co. Nord KG).*

In the early 1980s, 50 percent of the investments of the domestic group went to the gas sector. A new gas center was built in Herne and another one in late 1983 in Gablingen, near Augsburg. Linde also acquired companies for the gas division in Austria, the Netherlands, Portugal and France starting in the mid-1980s. Linde entered the market for the first time in Great Britain and Italy.

The crisis in the steel industry in the late 1970s and early 1980s also left its mark on sales in industrial gases. On-site business with large clients suffered in particular, due to the structural problems in the metals industry.

1982
Falkland War between Argentina and Great Britain.

1983
The new disease AIDS is discovered.

№ 3157 Method and apparatus for liquefying a low-boiling gas (helium liquefaction, etc.).

№ 3024 Development of an inert gas welding torch.

Strengthened position in Europe

At the European level in 1989, the Commission of the European Community demanded that the gas activities of Linde and Messer Griesheim be disentangled. In the separation, all shares in the Dutch gas companies nv W.A. Hoek's Maschine- en Zuurstoffabriek and Linde Industriegassen B.V. (formerly Airgas Nederland B.V.), which had previously been jointly held, went to Linde. In France, Linde received the gas separation plant in Salaise, near Lyon, and merged it with the newly founded Linde Gaz Industriels S.A.R.L., headquartered in Lyon.

In the 1990s, Linde further expanded its gas activities in order to finally rise to become one of the world's leading suppliers of industrial and medical gases by the turn of the millennium. In 1992, Linde AG increased its participation in Hoek's Maschine- en Zuurstoffabriek (now Hoek Loos) first to over 60 percent in order to completely take over the Dutch market leader in technical gases in 2000. Linde also acquired gas producers in such countries as Portugal, England, Italy, Austria and, together with the Swedish company AGA.

Linde Gas Center in Herne, Germany (1982).

New markets for technical gases

In addition, new markets and customer segments for the Technical Gases segment began to develop in the 1980s: Gas-shielded welding quickly became established in automobile manufacturing by the mid-1980s, significantly increasing the demand for liquid argon. The increasing demand in the mid-1980s for high-purity gases in the semiconductor and fiber optic cable industry, the most important suppliers to the soon to be booming computer and communications technology industries, proved to be even more economically important.

After German reunification, the new German states soon became a focus for the technical gases segment. In 1990, the newly founded Leuna Werke AG and Linde AG signed a long-term cooperative agreement in the area of technical gases. On March 1, 1991, Linde took over this division completely from Leuna and built one of the largest gas centers in Europe, which has served the eastern German market since 1994 and supplied hydrogen and nitrogen to the Dow Chemical Buna rubber plant in Schkopau and the chemical plants in Bitterfeld. Linde built another large hydrogen plant for the nearby refinery of the TOTAL oil group. By 1998, Linde had invested some 310 million euro in Leuna.

Linde also became active in the Czech Republic, Hungary and Poland after the fall of the Iron Curtain: In the Czech Republic in early 1991, Linde took over a majority of the Technoplyn a. s. gas company in Prague and in 1995 all shares; in Hungary, Linde took majority control of Linde Repcegas RT in 1992, thus securing exclusive usage rights over the largest sources of carbon dioxide in Hungary; in Poland, Linde took over two plants in 1993 as part of the privatization of the state-owned Polgaz, merging it into the new Linde Gaz Polska z. o. o. In 1999, Linde also bought the Polish gas activities of the American Airgas Inc., thus advancing to the position of the largest technical gases supplier in Poland.

Welding with the protective gas "Corgon" from Linde.

1985

Mikhail Gorbachev becomes General Secretary of the Soviet Communist Party.

Linde Series 351 forklifts were the bestselling forklifts in Europe from 1985 to mid-2003.

The R50 electric truck was the STILL successor model in the 1980s.

№ 3580 Coupling of the lifting equipment on the driver protection roof.

Calculated expansion of industrial truck business

Since the late 1960s, Hans Meinhardt gave special attention to the new business in industrial trucks. In order to grow as quickly as possible into a leading market position, this sector had to strengthen itself through company acquisitions.

The first good opportunity came in 1973, when the Quandt Group wanted to sell STILL GmbH in Hamburg, which was especially strong in the area of forklifts with electric motors. The takeover was finalized in November 1973. Since that time, Linde has had two company groups manufacturing within the Forklift plant group: Güldner and STILL.

Multi-brand strategy

In order that no market share would be lost due to the merger, the two brands continued to operate separately from and in competition with one another. This strategy would continue even after the later acquisition of two foreign competitors: In 1977, Linde purchased a majority share in the American industrial truck manufacturer Baker Material Handling Corporation; in 1984 Linde succeeded in advancing to the world's top group in this industry with the purchase of France's largest manufacturer of forklifts, Fenwick Manutention S.A.

From 1985 until the takeover of AGA in 1999 this segment, which was split into two groups, "Linde FH" (which in German stands for industrial trucks and hydraulics) and "STILL," was the largest division of Linde AG.

Linde took further steps in its expansion to become the world's leading industrial truck supplier:

- The gradual takeover of Wagner Fördertechnik GmbH & Co. KG in Reutlingen (between 1986 and 1991)
- Cooperation with Asea Truck AB in Sweden, which added heavy electric trucks to the STILL product line
- The takeover of British forklift manufacturer Lansing Bagnall Ltd. in 1989
- Majority participation in FIAT OM Carrelli Elevatori S.p.A. in Milan (1992)
- The founding of the Linde-Xiamen joint venture in China
- The cooperation with Komatsu Forklift Ltd., Tokyo

1986
Chernobyl nuclear disaster in the Ukraine.

1987
Apple introduces the world's most powerful personal computer, the Macintosh.

№ 4167
Process and device for air separation.

After German reunification, the Linde FH and STILL groups benefited from the need of the new federal states to modernize, securing considerable market share. Sales of industrial trucks in the reunified Germany in 1990 were 40 percent above the previous year's sales.

Linde AG established sales companies in the Czech Republic and Hungary in 1992 to market industrial trucks. Linde and its German competitor Jungheinrich AG also started up JULI-Motorenwerk k.s. in Brno, Czech Republic, for the production of electric motors for industrial trucks. In addition, Linde produced gearbox components for forklift trucks since its takeover of JIPO Domoradice spol. s.r.o. in Ceský Krumlov, Czech Republic.

Strengthening facilities engineering

After the Facilities Engineering division had established itself as a reliable partner to act as general contractor for turnkey facilities – to which the involvement in chemical furnace builder Selas-Kirchner GmbH in 1975 contributed – the TVT segment could benefit from new business opportunities without restriction: The eastern policy of 1969 made by the Social-Liberal coalition opened up the markets of the Soviet Union and Eastern European countries in the 1970s; two oil crises (1973/74 and 1979/80) and the burgeoning environmental consciousness – the first report by the Club of Rome "The Limits to Growth" appeared in 1972 – led to a sharply rising demand for environmentally friendly technologies. And Linde AG took advantage of these opportunities.

After the initial pilot installation of an ethylene plant for Veba Oil in Scholven, Germany, incoming orders concentrated on ethylene and nitrogen plants for plastics production until far into the 1970s. Beginning in the mid-1970s, however, energy-saving technologies and facilities for cleaning bodies of water, wastewater and exhaust gases became increasingly important. Several major German cities – Bremerhaven, Karlsruhe, Nuremberg, Munich, Peine – received "Lindox" and "Lindpor" plants for biological wastewater treatment using oxygen. In 1982, Linde AG handed over what was, at that time, the world's largest PSA hydrogen cleaning plant to *Union Rheinische Braunkohlen Kraftstoff AG* in Wesseling, near Cologne.

Between 1977 and 1992, Linde took over the Baker (USA), Fenwick (France), Lansing (Great Britain) and OM PIMESPO (Italy) brands of forklifts.

1988
The USSR and the USA agree on the complete dismantling of all medium-range nuclear missiles.

1989
Soviet Union ends the war in Afghanistan.

In 1994, Linde opened one of Europe's largest gas centers in Leuna (near Leipzig).

Business in the former Eastern Block

State agreements with the countries behind the Iron Curtain with respect to the eastern policy also opened up new business opportunities for Linde AG. The Soviet Union, East Germany, Poland, Romania and Czechoslovakia purchased primarily turnkey oxygen plants for the steel industry and ethylene plants for the chemical industry from Linde. Ethylene plants were also sold to China – although under a different political program.

But in contrast to the trade with China, orders from the states of the former USSR fell through after the beginning of 1990. Business relations with EU neighbor-states Poland, the Czech Republic and Hungary showed more positive development.

In China, Linde benefited mainly from the build-up of the petrochemical industry and metallurgy. For example, Linde supplied variable-pressure adsorption units for the production of pure hydrogen, a new inert gas production plant, large plants for the production of gaseous and liquid oxygen and nitrogen as well as of all inert gases found in the air in the highest purity. In addition, Linde sold turnkey plants for the preparation of petroleum gases.

Major projects in facilities engineering

The fact that the Linde Facilities Engineering segment was able to do well, even despite rather weak demand in the 1980s, can be attributed to Linde's traditional strengths in the planning and reliable execution of large facilities, good political connections, which led among other things to orders from East Germany and South Africa, and new products and processes.

One example is the boom – surprising even to the engineers themselves – in the construction of vacuum-brazed aluminum heat exchangers: Thanks to a Linde-developed manufacturing process, it was possible to build plate heat exchangers with working pressures of up to 96 bar. These plate heat exchangers proved to be so successful that Linde advanced to become the top supplier of these units and the Höllriegelskreuth plant was able to install two additional vacuum brazing furnaces in 1986 and 1987.

Also in the 1980s, Linde expanded the Schalchen plant for the production of spiral-wound heat exchangers, tank systems and cold boxes for air and gas separation plants.

Major large-scale projects during the 1980s included the construction of the first methanol plant in the US for Georgia Pacific, for which Linde accepted the order in 1983 as an object of reference. The most important major project during this decade was the natural gas terminal for Statoil in Kårstø, Norway, through which natural gas meeting certain specifications from the Ekofisk oil field is delivered by pipeline to Western Europe. More than 100 Linde specialists and some 1800 construction and assembly

№ 4712 Spiral-wound heat exchanger with tube coils wound in a helical line in several positions on a core tube.

workers installed 26 process modules and ten prefabricated columns in record time. The terminal went into operation in 1985 – three months ahead of the agreed deadline.

In 1990, the TVT plant group, now renamed Process and Facilities Engineering (VA), received its largest order up to that time in the amount of 1.3 billion marks in the face of stiff international competition from BASF. As general contractor, Linde handled the planning, construction and installation of a turnkey ethylene plant.

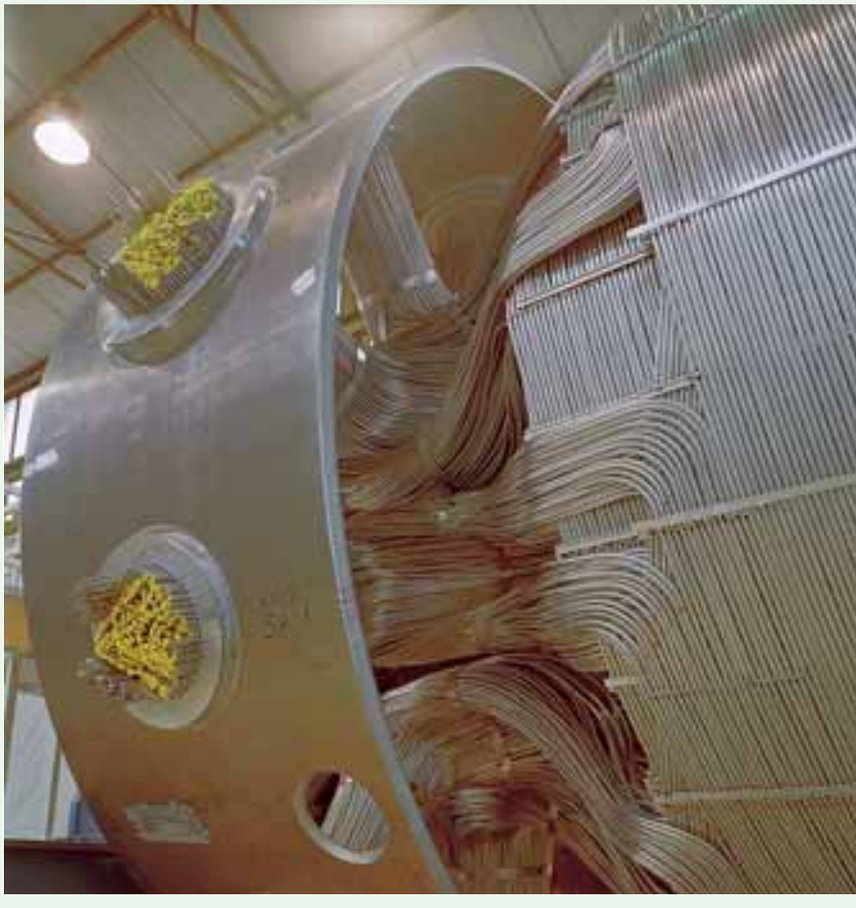
Linde's plant constructors moved forward in new dimensions in 1997: They received an order from the Mexican oil company Pemex to construct the fourth largest air separation plants in the world, with a total value of 150 million US dollars. These plants went into operation in the year 2000.

In the context of the world's shrinking oil reserves, natural gas is gaining increasing importance – for Linde Engineering as well. The company possesses all of the technologies needed for natural gas liquefaction and separation. One of its current projects is the construction of Europe's largest natural gas liquefaction (LNG) plant for the international Snohvit Consortium near Hammerfest, Norway, north of the Arctic Circle. It will make it possible to transport this environmentally friendly energy carrier. The plant should begin operation no later than 2006. The Hammerfest project has an order value of more than 500 million euro and, because of its geographical location alone, poses extreme challenges for the company's performance and efficiency. In Tuha, China and Kollsnes, Norway, Linde Engineering is currently building other plants of this type as well.

Acquisitions in facilities engineering

After the fall of the German internal border, Linde Engineering was quick to become involved in the new states. As early as April 1990, Linde acquired a majority stake in the second-largest facilities engineering company in the former East Germany, the previous *"Komplette Chemieanlagen Dresden."* This company was renamed *"Linde-KCA-Dresden GmbH"* and first took over the environmental technology activities of Höllriegelskreuth and then the construction of polyethylene plants. Other acquisitions and takeovers also contributed to the growth of Linde Engineering. In 1990, for example, Linde incorporated *Maschinenfabrik Augsburg-Plattling Aktiengesellschaft* (MAPAG GmbH) into the VA plant group and opened a new plant in Horgau, Bavaria, in 1996.

In 1994, a joint venture was formed in China for the planning and installation of air separation plants, and in 1996 Linde acquired the cryotechnology segment of *Gebr. Sulzer AG.*



A key component of natural gas plants: spiral-wound heat exchangers.

1991
Persian Gulf War I to free occupied Kuwait.

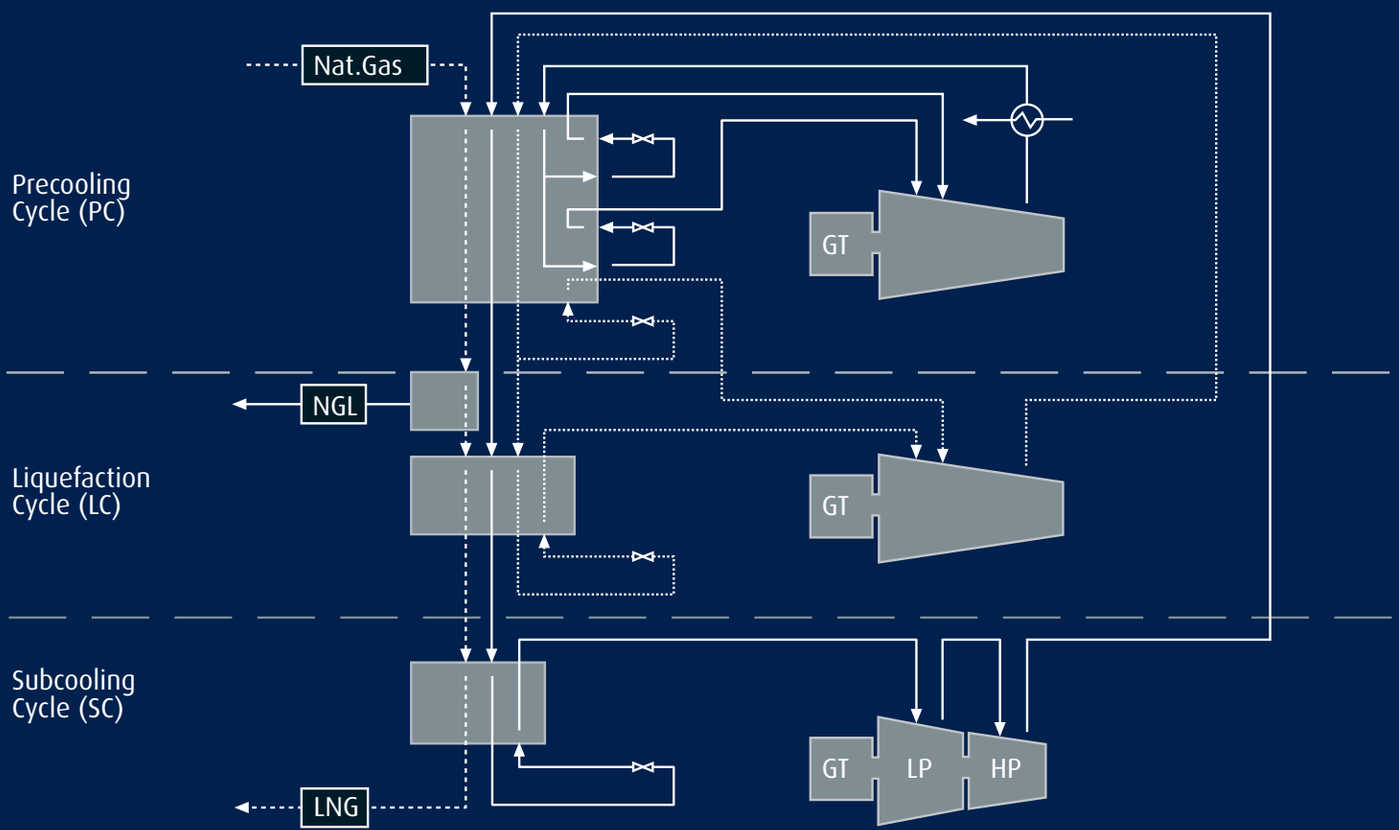
№ 4793 Process for the liquefaction of a hydrocarbon-containing flow. (Liquefied petroleum gas).

Innovative Linde plant technology on the west coast of Norway: The environmentally friendly fuel LPG (liquefied petroleum gas) is produced in the natural gas plant in Kollsnes.

1992

End of Apartheid in South Africa.

№ 4851 Linde process of natural gas liquefaction (MFC®s3)



Functional schematic of the Linde process of natural gas liquefaction (MFC® s3).

Precooling Cycle (PC)
Liquefaction Cycle (LC)
Subcooling Cycle (SC)
Nat. Gas = Natural Gas
NGL = Natural Gas Liquids = liquid gases such as propane and butane
LNG = Liquefied Natural Gas

GT = Gas turbine
LP = Low pressure
HP = High pressure

1995
End of the civil war which has raged since 1991 in the former Yugoslavia.

№ 4946 Device for the recovery of pure xenon.

№ 4969 Cold compressor with integrated double seal system (cryotechnology).

The successful history of cryotechnology

As early as 1932, Linde installed the world's first industrial helium liquefaction plant at the University of Kharkov in the Ukraine – now over 500 such plants are in operation worldwide. Cryotechnology plants are used for a wide variety of applications: for basic research, in industry, for cooling superconductors, for fusion and fission research and for the liquefaction of helium and hydrogen.

In the area of resistance-free superconduction, for example, which is possible only at ultra-low temperatures, Linde has been involved in every major project of the last several decades, such as the Hadron Electron Ring Accelerator (HERA) at DESY in Hamburg to research microstructures, or the LHC (Large Hadron Collider), the latest particle accelerator at the European Center for Particle Physics (CERN) in Geneva, which has been in progress since 1999.

Linde is also supplying a helium cooling system for a high-energy physics project by the Technical University of Munich. In medical technology, for example, liquid helium is used to cool the superconducting magnetic coils in nuclear spin tomography. Linde also built a cryolaboratory in Höllriegelskreuth in 1987 for the development of cryogenic applications for space technology, in which experiments were carried out at a temperature of minus 271 degrees Celsius (1.5 K). By 1994 Linde had equipped the ISO research satellite of the European Space Agency (ESA) with a cryogenic helium tank, for example.

In 1992, Linde took over the cryotechnology department of the Swiss machinery builder *Gebrüder Sulzer AG,* thus acquiring, among other things, the technology to build expansion turbines, a key component of helium and hydrogen cooling systems or liquefiers.

Cryogenics is already a significant technology today for the use of hydrogen in a number of industrial processes. If hydrogen becomes widespread as an alternative fuel for automobiles, this will give cryotechnology another decisive push forward.

Liquid helium from Linde is also used in medical procedures such as nuclear spin tomography.

Strategic directions within the Group

In order to repel the threat of a takeover – or better yet not to let one come up at all – Hans Meinhardt had already effected a voting rights limit of ten percent at the shareholders' meeting of 1973. After intense discussions, 80 percent of the shareholders voted for this proposal. The attitude of major shareholder Allianz AG, which supported the proposal by the Executive Board, was one factor that contributed to its success.

After 1976, Meinhardt worked successfully to engage institutional investors such as Commerzbank and Deutsche Bank in longterm involvement with Linde AG and thus create a stable ownership structure.

The total number of people infected with the AIDS virus is estimated to be 22.6 million.

Nº 5124 Storage receptacle for cryogenic media (tank for liquid hydrogen).

Linde Gas LLC is mainly represented in the eastern United States and Puerto Rico. Approx 160 tanker trucks are on the highway.

In 1980, at Meinhardt's request, the then CEO of Allianz, Wolfgang Schieren, joined Linde's Supervisory Board and soon thereafter became its chairman, acting as a guarantor of stability and continuity.

Linde in the United States

In 1990s, Linde stepped up its involvement in North America. Although the company had already been represented there during the early years, it had not only lost its subsidiaries after the two world wars but even the rights to the Linde name in the US. The reference plants built after WWII did not immediately lead to the hoped-for breakthrough on the US market. In the industrial truck market, however, the entry in to the US market through a subsidiary was finally successful with the takeover of the Baker Material Handling Corporation in 1977.

Linde was successful in 1996 with the strategically important purchase of the Pro-Quip Corporation (TPQ) in Tulsa, Oklahoma, which is, among other things, the world market leader in small hydrogen plants. After this acquisition, Tulsa was built up to become a new "Linde center" in the US. In 1999, Linde moved the subsidiary Lotepro Inc. from New York to Oklahoma and, at the end of 2001, merged Lotepro Inc. and the Pro-Quip Corp. into Linde Process Plants Inc. In 2002, the British gas company BOC acquired a 30 percent investment in this company, after which it was known as Linde BOC Process Plants LLC.

In the US, Linde also expanded in the area of technical gases with the takeover of the Sunox Inc. gas company in Charlotte through subsidiary Holox Inc. And Linde successfully entered the American hydrogen and carbon monoxide business through a cooperative agreement with Millenium Petrochemicals Inc.

But symbolically the most important date for Linde in the US was certainly January 1, 1999: As of this date, the North American group companies were once again permitted to use the name "Linde." Forty-four years after the end of the war, Linde once again owns the rights to the "Linde" name and trademark in the United States.

From Dr. Hans Meinhardt to Gerhard Full to Dr. Wolfgang Reitzle

During the shareholders' meeting in May 1997, Hans Meinhardt stepped down from his post as President and CEO of Linde AG after 21 years, taking instead the office of chairman of the Supervisory Board, which he held until spring 2003.

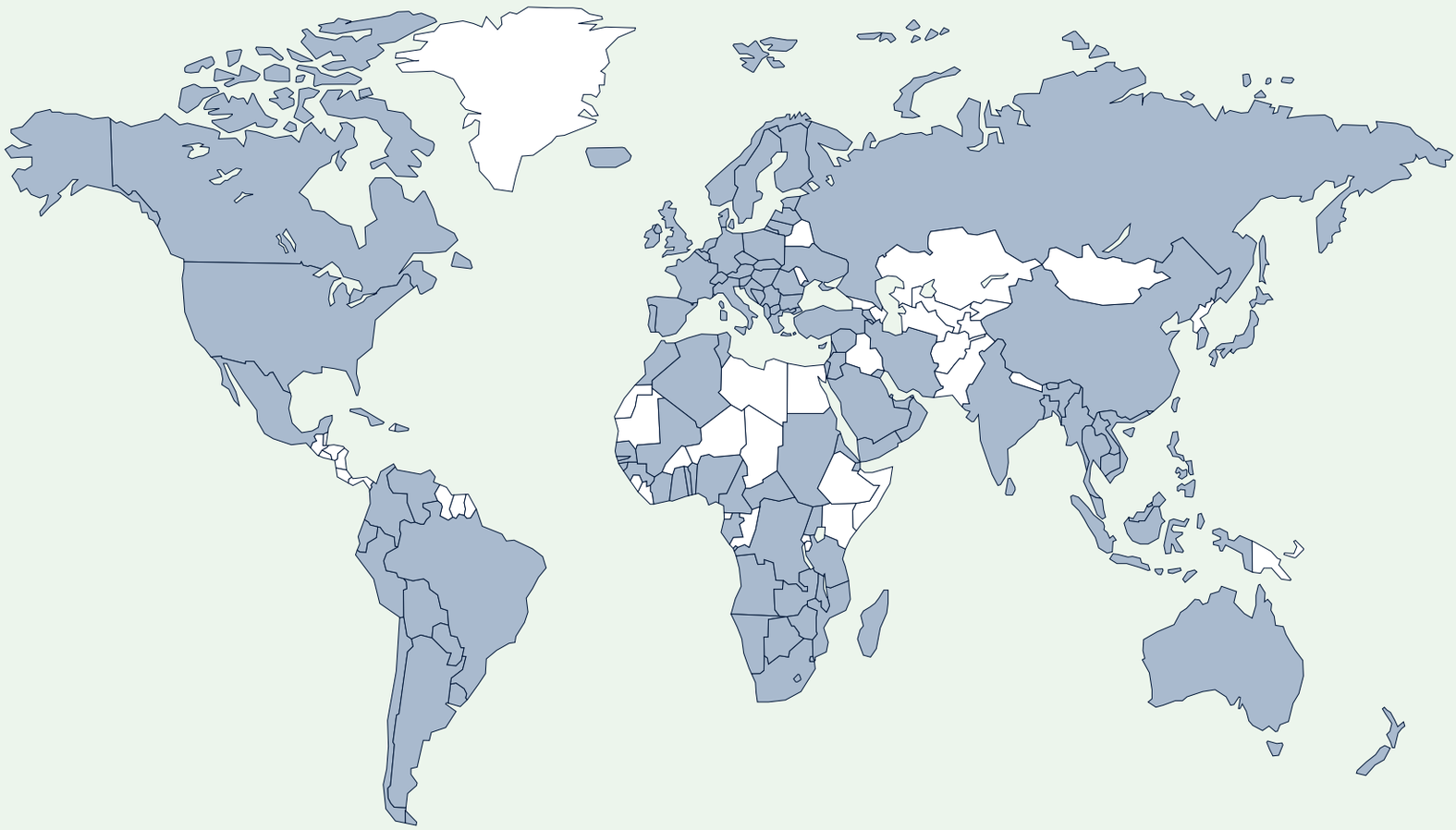
Under Meinhardt's leadership, Linde received new structures and new fields of business and transformed itself from a technology-loving engineering company with strong ties to its founding family to a global, manager-led technology company.

Linde's sales during the "Meinhardt era" rose by a factor of 25. And profits after taxes grew by a factor of 33, from 7.2 million to 240 million euro. Over the same period, the number of employees rose from 13,500 in 1970 to more than 46,500 in 2002.

In 1997, Gerhard Full became President and CEO. He had worked for the company since 1962 and was first in charge of facilities engineering on the Executive Board (see also page 82).

1997

Regime change in Great Britain: Labour Party, led by Tony Blair, wins the Parliamentary elections.



Global Presence

Business Segments:
Gas and Engineering: (GE)
Material Handling: (MH)
Refrigeration: (KT)

America
Argentina (GE, MH, KT)
Bolivia (GE)
Brazil (GE, MH, KT)
Canada (GE, MH)
Chile (GE, MH, KT)
Columbia (GE, MH, KT)
Cuba (MH, KT)
Dominican Republic (GE)
Ecuador (GE, MH)
Mexico (GE, MH, KT)
Paraguay (GE, MH)
Peru (GE, MH)
Puerto Rico (GE, MH)
United States (GE, MH)
Uruguay (GE, MH)
Venezuela (GE, MH, KT)

Europe
Austria (GE, MH, KT)
Belarus (MH)
Belgium (GE, MH, KT)
Bosnia-Herzegovina (GE, MH)
Bulgaria (GE, MH, KT)
Croatia (GE, MH, KT)
Cyprus (GE, MH, KT)
Czech Republic (GE, MH, KT)
Denmark (GE, MH, KT)
Estonia (GE, MH, KT)
Finland (GE, MH, KT)
France (GE, MH, KT)
Germany (GE, MH, KT)
Great Britain (GE, MH, KT)
Greece (GE, MH, KT)
Hungary (GE, MH, KT)
Iceland (GE, MH, KT)
Ireland (MH, KT)
Italy (GE, MH, KT)
Latvia (GE, MH, KT)
Lithuania (GE, MH, KT)
Luxembourg (MH)
Malta (MH)
Macedonia (MH)
Netherlands (GE, MH, KT)
Norway (GE, MH, KT)
Poland (GE, MH, KT)
Portugal (GE, MH, KT)
Romania (GE, MH, KT)
Serbia and
Montenegro (GE, MH)
Slovakia (GE, MH, KT)
Slovenia (GE, MH)
Spain (GE, MH, KT)
Sweden (GE, MH, KT)
Switzerland (GE, MH, KT)
Turkey (MH, KT)
Ukraine (GE, MH, KT)

Africa
Algeria (MH)
Angola (MH)
Benin (MH)
Botswana (MH)
Burkina Faso (MH)
Cameroon (MH)
DR Congo (MH)
Egypt (MH)
Equatorial Guinea (MH)
Gabon (GE)
Ghana (MH)
Guinea (MH)
Ivory Coast (MH)
Kenya (MH)
Lesotho (MH)
Libya (MH)
Madagascar (MH)
Mali (MH)
Mauritius (MH)
Morocco (GE, MH)
Mozambique (MH)
Namibia (MH)
Nigeria (MH)
Senegal (MH)
South Africa (GE, MH)
Sudan (MH)
Swaziland (MH)
Tanzania (MH)
Togo (MH)
Tunisia (MH)
Uganda (MH)
Zambia (MH)
Zimbabwe (MH)

Asia
Bahrain (GE, MH, KT)
Bangladesh (MH)
Brunei (MH)
Cambodia (GE, MH)
China (GE, MH, KT)
India (GE, MH)
Indonesia (GE, MH)
Iran (GE, MH)
Iraq (MH)
Israel (MH)
Japan (GE, MH)
Jordan (MH)
Kazakhstan (MH)
Kuwait (GE, MH, KT)
Laos (GE)
Lebanon (MH)
Malaysia (GE, MH, KT)
Myanmar (Burma) (GE)
Oman (GE)
Philippines (MH, KT)
Qatar (GE, MH)
Russia (GE, MH, KT)
Saudi Arabia (GE, MH, KT)
Singapore (GE, MH, KT)
South Korea (GE, MH, KT)
Sri Lanka (MH)
Syria (MH)
Thailand (GE, MH, KT)
United Arab Emirates
(GE, MH, KT)
Vietnam (GE, MH)
Yemen (GE)

Australia
Australia (GE, MH)
New Zealand (MH)

The highlighted countries have at least one plant location in the indicated business segment.

Takeover of AGA

The most lasting business decision of the recent past was the December 1999 takeover, under the leadership of Gerhard Full, of the Swedish gas company Aktiebolag Gasaccumulator AB (AGA), which was finally approved by the European Commission in February 2000.

This acquisition has brought the company a decisive step closer to the strategic goal of strengthening its gas business outside Europe. Linde thus became the world's fourth-largest gas supplier. It maintains a total of 17,420 employees (as of 2003) in this area in 45 countries.

Linde had been holding purchase negotiations with both Messer Griesheim and AGA since mid-1999. When the EU Commission was unwilling to approve a takeover of Messer Griesheim, Linde concentrated on the Swedish AGA AB, whose gas business – primarily in Scandinavia, the US and Latin America – represented an ideal addition.

The two companies were a good fit with one another, and not only in their regional focal points. They also had a similar history and corporate culture. This helped to make the merger go as smoothly as possible. AGA brought 1.7 billion euro in sales and 9,500 employees to Linde.

After the takeover was approved by the EU Commission – with certain conditions – trading of AGA shares was officially ended. Since July 1, 2000, AGA, has been fully integrated in the Linde Group. This brought about a rise in sales for the Technical Gases division in 2000 of some 134 percent, from 1.6 billion to 3.8 billion euro.

Group sales revenues increased 36.4 percent to 8.45 billion euro during the first fiscal year after the takeover. After the successful integration, the Executive Board of Linde AG merged the two former segments Technical Gases and Facilities Engineering into the Gas and Engineering Business Segment, thus creating the conditions needed to efficiently use the various synergies between these two areas, such as in expanding on-site business. The value of this close connection can be seen in the project surrounding the new helium production plant in Skikda, Algeria, which is being built by Linde Engineering while Linde Gas handles the marketing of the helium produced there.

Growth market: healthcare

With the AGA takeover, Linde also strengthened its position in a market segment that will become more and more important to the company in the years to come: the healthcare sector, or sales of medical gases.

AGA was successful in this area since as early as the 1930s, above all in the institutional segment, which means especially in supplying hospitals with medical gases. Linde too was active early on with a similar program, but this sector had not been a priority within the Gas Division for some time.

Today, Linde is one of the world's leading suppliers of medical gases in this market, which, with annual growth rates of 10 to 15 percent, is among the highest-growth markets in the gas industry. We do business in four areas: Institutional, Respiratory Homecare, INO Therapeutics und GEMI (Gas Enabled Medical Innovations). In the institutional segment, the company supplies clinics, physicians' practices and rescue services with medical gases such as oxygen and nitrous oxide as well as the corresponding services. Respiratory Homecare means supplying patients who have respiratory disorders with medical oxygen at home along with the required technical equipment. In its subsidiary INO Therapeutics, Linde consolidates all activities related to the product INOmax™, a special gas product that is an effective tool for treating newborns with respiratory failure.

At the turn of the millennium, there are more than six billion people living on earth.

Nº 5375 Improved paper-making process. (AGA European Patent).

AGA – a strong partner for Linde

Gustav Dalén, an inventor/engineer like Carl von Linde, was president of AGA from 1909 to 1937.

As a formerly diversified technology company with an exceptionally gifted entrepreneur-engineer at its head, the "Aktiebolag Gasaccumulator" company, or AGA for short, made an ideal partner for Linde AG.

AGA originated in 1904 as "Gasaccumulator AB" from the "Svenska Carbid & Acetylen AB" company, founded in 1901 by Swedish businessman Axel Nordvall. The young company developed and marketed possible applications for acetylene gas. The rise to become a leading Swedish company of international significance was successful even before World War I thanks to the numerous inventions of Gustaf Daléns (1869 to 1937), who had a decisive impact on the company beginning in 1909.

In 1905 Dalén developed a flash device for lighthouses and buoys that reduced gas consumption to one tenth of the original amount. In 1906 there followed a storage body for acetylene in gas tanks, which minimized the risk of explosion. Dalén's "sun valve," introduced in 1907, regulated the intensity of light from lighthouses and buoys depending on the level of daylight. The "Dalén Mixer" of 1909 finally made it possible to produce the mixture of acetylene and air (in a ratio of 1:10), which was necessary for navigation lights, safely and automatically.

This "AGA System" for lighthouses and buoys formed the basis of the company's economic success. In 1912, Gustaf Dalén received the Nobel Prize in physics for the invention of his system. Some of his gas-run lighthouses light the way for ships even today. Although he was blinded in an accident in 1912, Dalén successfully led the company until his death in 1937.

In the period between the two world wars, AGA expanded its product line with signal systems, welding equipment, heating elements, radios, large film projectors and automobiles, which were manufactured in Berlin. From the late 1930s until the 1960s, AGA also sold gyro compasses, gyro-horizons and bomb target sights for the Swedish Air Force.

In 1947 AGA took over the battery manufacturer Tudor. In 1954, AGA introduced the world's first heart-lung machine; other innovative products included the distance meter with a geodimeter in 1953 and in 1965 contact-free temperature measurement with the AGA Thermovision.

But the most important field of this diversified technology company was technical gases. AGA went from acetylene to oxygen and soon produced a number of other gases. As early as the 1930s, AGA became involved in the area of medical gases. For example, the company supplied oxygen, mainly as a mixed gas together with laughing gas and "Carbogen" (oxygen with five percent carbon dioxide) to hospitals for the treatment of respiratory diseases, for anesthesia and for treatment of pain. AGA also built corresponding technical medical equipment.

With its highly diversified product line, AGA was unable to withstand international competition over time. For that reason, the company concentrated exclusively on its gas business starting in the 1980s. In 1981, AGA already held the position of the world's fifth largest gas producer. Political changes made it possible for AGA to return to the markets in Hungary, East Germany, Estonia, Latvia, Lithuania, the Czech Republic, Slovakia, Poland, Russia and Romania after 1989, where the company had been represented before 1945.

In 1999, AGA was an innovative gas company with a strong market position in Europe and North and South America with a sales volume of 1.6 billion euro and 9,500 employees. As far as regional positioning and product and service lines, AGA made the ideal complement to Linde – the main requirements for the takeover were there.

After the integration of AGA, Linde Gas and Linde Engineering were merged in 2001 to form the Linde Gas and Engineering Division.

In the 1980s, AGA concentrated exclusively on the gas business.

On September 11, Islamic terrorists destroy the World Trade Center in New York.

Nº 5766 Filling station for cryogenic media (hydrogen filling station).

Gerhard Full (born in 1936)

Gerhard Full, President and CEO of the Executive Board from 1997 to 2003; since 2003 member of the Supervisory Board.

After receiving his diploma as an industrial engineer at the Technical University of Darmstadt, Gerhard Full entered the organization department of Linde AG in Wiesbaden in 1962 and in 1969 became deputy Production Manager of the MATRA plant in Kahl am Main, his first responsibility for an operative unit.

After returning to the central organization department in 1970, Gerhard Full answered the call of the State Engineering School in Rüsselsheim and lectured there as an instructor. In 1973, the Technical University of Wiesbaden named him Professor for Life in the mechanical engineering department.

In 1975 Gerhard Full was drawn back into business practice. He took on the management of the technology department in Linde's central administration. In 1977 the Executive Board appointed him to be a member of management of the expanding Industrial Trucks and Hydraulics plant group (FH). One year later, the Supervisory Board appointed him a deputy member of the Executive Board of Linde AG. In 1978/79, Gerhard Full also managed the American subsidiary Baker Material Handling Corp. (known today as Linde Lift Truck Corp.). During this period, Baker opened a new production and administration building in Cleveland.

After his appointment to regular member of the Executive Board in 1981, Gerhard Full was first responsible for Refrigeration and the Hydraulics segment; in 1985 he took over the management of the FH plant group from Dr. Hans Meinhardt.

Full managed Facilities Engineering from 1995 until his appointment as President and CEO of the Executive Board in 1997. He also demonstrated his versatility in the position of human resources executive, which he held from 1991 to 1993 in addition to his other duties.

After Gerhard Full took over the office of President and CEO as the successor to Dr. Hans Meinhardt as of the shareholders' meeting in May 1997, he continued to expand Linde AG's international presence in all divisions. The most important milestone of his term in office was the takeover of the Swedish gas producer "Aktiebolag Gasaccumulator" (AGA) in late 1999, which made Linde the fourth-largest supplier of industrial and medical gases in the world.

On January 1, 2003, Gerhard Full handed over the presidency of the Linde AG Executive Board to Dr. Wolfgang Reitzle and in May 2003 became a member of the Supervisory Board.

Change at the top

On April 19, 2002 the Supervisory Board appointed Dr. Wolfgang Reitzle to the Executive Board effective May 10, and President and CEO effective January 1, 2003. Gerhard Full retired on December 31, 2002. In May 2003, the shareholders' meeting elected him to the Supervisory Board.

Fit for the future

Even under the new leadership, Linde still stands for continuity. "We will continue our earnings-oriented growth course and solidify our position as a leading global technology concern," said the new President and CEO Dr. Wolfgang Reitzle when he took office. In order to achieve this goal, the new management has placed structures, procedures and the portfolio on the test stand and taken steps to further increase the efficiency of the Group as a whole.

In the Linde Gas Division, the company has significantly increased efficiency, above all in the areas of distribution and purchasing, and further streamlined administrative processes.

In the Material Handling Business Segment, the management has applied TRIM.100, a program to further improve international competitiveness. The core items of this program are profiling the multi-brand strategy, a more efficient sales structure and bundling purchasing activities.

The sale of refrigeration

In the Refrigeration Division, the Group has made a clean cut. After the business segment was made into a legally independent unit as of January 01, 2004, the management signed an agreement on the sale of the refrigeration segment on March 15, 2004 to the American company the Carrier Corporation, a subsidiary of the United Technologies Corporation (UTC, Hartford, Connecticut).

2002

The euro becomes the sole currency in twelve EU countries on January 1.

№ 6132 Efficiency increase in hydrogen-driven combustion engine.

Japan's first filling station for liquid hydrogen is in Tokyo – with storage and filling systems from Linde.

The US and its allies topple Saddam Hussein in the second Gulf War.

№ 6176 Efficiency increase in hydrogen-driven combustion engine.

Dr.-Ing. Wolfgang Reitzle (born in 1949)

Dr.-Ing. Wolfgang Reitzle became President and CEO of the Executive Board on January 1, 2003.

Before Wolfgang Reitzle joined the Executive Board of Linde AG in 2002, he had already held high-profile positions in the automobile industry. Having received his Diploma in Mechanical Engineering at the Technical University of Munich in 1971 and in 1974 the degree of Dr.-Ing. in metal physics, he completed a second course of university study in 1975 to receive a Diploma in Industrial Engineering as well.

In 1976 he joined BMW AG as a manufacturing specialist and, after a rapid climb in production and development, was appointed a deputy member in 1986 and in 1987 a regular member of the executive board with responsibility for research and development. In 1993 he received additional responsibility for purchasing and in 1997 for global sales and marketing.

In 1999 Reitzle joined the Ford Motor Company, and, as Group Vice President as well as Chairman and Chief Executive Officer, ran the Premier Automotive Group, including the automobile brands Aston Martin, Jaguar, Land Rover, Lincoln and Volvo.

In May 2002, Wolfgang Reitzle joined the Executive Board of Linde AG and on January 1, 2003 took over the presidency of the Linde AG Executive Board.

After in-depth analysis, Reitzle initiated a radical restructuring of the material handling division with the TRIM.100 program, a cost-reduction program in the gas division, an overhaul of the refrigeration division, spinning it off into a legally independent company as well as the Six Sigma fitness program for the entire corporation. In addition, the Executive Board approved Reitzle's initiative for a new personnel development strategy and introduced the Balanced Scorecard to control business processes according to uniform figures and measures.

All of these measures – together with an innovation offensive – are intended to make Linde AG a leading player on the global markets in all divisions.

In making the decision on the future of the Refrigeration Business Segment, the main objective was not a quick solution but one that made sense for all sides. "After all, we weren't just talking about any division of the Group, but of the very foundation of our company," explained Dr. Reitzle. That is why Linde did not simply yield to the pressure from the financial markets to divest itself of its smallest and least profitable division but rather carefully sought the most sustainable alternative. In fact the new alliance is built on a very stable foundation. Carrier is the world's leading provider of air-conditioning equipment and enjoys an outstanding position in the United States; Linde leads the European market for refrigerated and frozen-food display cases and the associated refrigeration equipment. Together, they will form nothing less than the global market leader for refrigeration and air conditioning, with good opportunities to realize above-average growth – even in a difficult economic climate.

In addition to these optimizations within the portfolio, the new President and CEO has started other initiatives for the continuous improvement of the Group's operative performance. At the center is the introduction of the Balanced Scorecard in July 2003 and the beginning of the Six Sigma program in spring 2003.

The Balanced Scorecard is a control instrument, which will expand on and standardize the existing key figure systems within the group. The result is that the individual operative measures by the business segments are now even more closely interlocked with our strategic corporate goals.

The goal of Six Sigma is to minimize possible errors in all procedures and processes and thus increase quality. At the same time, this program is intended to realize considerable cost reductions and raise customer satisfaction further on an ongoing basis.

What is more, Linde has restructured its personnel development department and enacted a comprehensive personnel strategy. Performance-based compensation systems, efficient management of potential and deliberate continuing education and qualification are the most important building blocks of this concept.

Right: LeadIng. stands for Linde's requirement to be a leading company in all segments, while at the same time pointing to the company's tradition in technology.

The EU expands eastward: ten new countries join the European Union on May 1.

Ambitious goals

With these measures and by concentrating on its main pillars of Gas and Engineering and Material Handling, the Linde strengthens its earning power and is well equipped to take on international leading positions in the future as well.

As one of the world's leading providers of industrial and medical gases, the company intends to exploit its growth potential in the international gas business even further. The focus here will be on further developing on-site business as well as the growth markets in healthcare, i.e., medical gases, and hydrogen.

With the clear direction towards high-growth markets such as natural gas, hydrogen and oxygen plants, Linde Engineering will continue to strengthen its international technological leadership in facilities engineering in the future as well.

In the Material Handling Business Segment, the Linde Group is one of the world's largest manufacturers of forklifts and warehouse equipment and is the market leader in Europe. It is the declared aim of Linde's management to solidify this position and at the same time further increase profitability. Linde will achieve this with innovative products and services as well as by developing new markets – which is to say, using the strategy that has run like a red thread throughout the company's 125-year history.

There is no question that the bar is raised – and remains – high at Linde. Or in the words of Dr. Wolfgang Reitzle: "Linde should and must be among the top three competitors – or better – in every market we choose to enter." With this challenge as well the current President and CEO remains firmly within the tradition of the company's founder, Carl von Linde.

125 Years of Linde AG

Milestones

1879 Carl Linde founds a joint-stock company called "*Gesellschaft für Linde's Eismaschinen*" on June 21 in Wiesbaden with financing partners and becomes head of the engineering company.

1880 The first refrigeration machines are primarily used in breweries, slaughterhouses and ice factories.

1885 The Linde Company founds The Linde British Refrigeration Co. in London as its first associated company abroad.

1890 Order for the 1,000th refrigeration machine.

1891 Carl Linde steps down as head of the company, becomes chairman of the Supervisory Board and returns to Munich as a professor; his successor on the Executive Board is Friedrich Schipper.

1895 On May 29, Carl Linde successfully liquefies atmospheric air; that same year he receives a patent for this process.

1897 Carl von Linde receives the Knight's Cross of the Bavarian Crown Order of Merit from Prince Regent Luitpold of Bavaria, an honor that elevated the recipient to personal nobility status.

1902 After many years of research trials, the Höllriegelskreuth team is successful in producing oxygen through air separation using the rectification process.

1907 The Linde Company and partners establish the Linde Air Products Company in Cleveland, Ohio (USA).

1910 Friedrich Linde and Rudolf Wucherer develop the "two-column apparatus," which is capable of producing oxygen and nitrogen at the same time.

1918 At the end of WWI, Linde loses significant industrial property and name rights as well as important subsidiaries and investments.

1920 Acquisition of Maschinenfabrik Sürth near Cologne.

1922 Acquisition of shares in *Heylandt Gesellschaft für Apparatebau* in Berlin.

1924 Friedrich Schipper hands over the reins as chairman of the Executive Board to Friedrich Linde.

1926 Acquisition of *Kühlmöbelfabrik G.H. Walb & Co.* in Mainz-Kostheim.

1929 Takeover of *Güldner Motoren-Gesellschaft mbH* in Aschaffenburg.

1934 Death of Carl von Linde at the age of 92.

1935 Takeover of all shares of Marx & Traube GmbH (as of 1937 *MATRA-Werke GmbH*).

1937 Founding of the Ellira electric welding systems department.

1938 Tractor production is started at Güldner in Aschaffenburg.

1943 Facilities engineering begins in Schalchen (Upper Bavaria).

1945 During WWII plant facilities at Höllriegelskreuth, Sürth, Mainz-Kostheim and Aschaffenburg as well as several oxygen plants and the company headquarters in Wiesbaden are destroyed; renewed loss of significant industrial rights.

1948 Opening balance sheet of the "*Gesellschaft für Linde's Eismaschinen*" as of June 21 with DM 34,266,000 equity capital. The company employs 4,100 people at this time.

1952 Friedrich Linde hands over the reins as chairman of the Executive Board to his brother-in-law Rudolf Wucherer.

1953 Completion of the largest air separator ever built in Europe for delivery to the US; output: 13,000 kg/h oxygen, 22,500 kg/h nitrogen.

1954 Hugo Ombeck takes over from Rudolf Wucherer as chairman of the Executive Board.

1955 Güldner presents the first "Hydrocar," a transport vehicle with hydrostatic drive.

1958 Güldner manufactures the 100,000th diesel engine and begins production of hydraulic units and forklift trucks.

1961 Johannes Wucherer replaces Hugo Ombeck as chairman of the Executive Board.

1965 Company name changes to Linde AG; first contract to build a large petrochemical plant in Scholven (Germany).

1967 Business in domestic appliances relinquished to AEG.

1969 Tractor production is ended at Güldner to concentrate on production of industrial trucks.

1972 Hermann Linde becomes speaker of the Executive Board.

1973 Takeover of *SE Fahrzeugwerke GmbH,* Hamburg, since renamed STILL GmbH. This makes Linde the leading industrial truck supplier in Western Europe.

1974 Development of industrial gases business in Brazil and Australia.

1976 Dr. Hans Meinhardt replaces Hermann Linde as speaker of the Executive Board (and becomes President and CEO in March 1980).

1977 Acquisition of the Baker Material Handling Corporation in Cleveland, Ohio (USA).

1984 Purchase of France's largest forklift manufacturer, Fenwick Manutention S.A.

1986 Acquisition of shares in Wagner Fördertechnik GmbH & Co. KG, Reutlingen.

1989 Takeover of British forklift manufacturer Lansing Bagnall Ltd.

1990 Founding of the engineering and contracting company *Linde-KCA-Dresden GmbH.*

1991 Majority stake in the leading Czech gases company Technoplyn a.s. (complete takeover in 1995).

1992 Acquisition of majority stake in FIAT OM Carrelli Elevatori (complete takeover in 2003); Majority stake in Dutch nv W.A. Hoek's Machine- en Zuurstoffabriek (complete takeover in 2000).

1993 Linde-Xiamen joint venture founded in China.

1994 Inauguration of one of Linde's largest European industrial gas centers in Leuna, Germany.

1996 Takeover of the Frigorex AG refrigeration company, Lucerne, Switzerland; acquisition of the Pro-Quip Corporation facilities engineering company, Tulsa, Oklahoma (USA).

1997 Dr. Hans Meinhardt steps down as President and CEO of the Executive Board in favor of Gerhard Full and becomes chairman of the Supervisory Board; Linde builds the largest air separator in the world to supply nitrogen to the Mexican oil company Pemex.

1999 Starting January 1, the company is again able to use the Linde name and trademark in the United States.

2000 Takeover of the Swedish gas company AGA; as a result, Linde becomes one of the world's largest gas companies. Beginning of cooperation with Komatsu Forklift Ltd., Tokyo.

2001 The two areas of technical gases and plant construction are merged to form the Gas and Engineering Business Unit.

2002 Linde and The BOC Group, Great Britain agree to work together on air separation and synthesis gas plants.

2003 Dr. Wolfgang Reitzle takes over from Gerhard Full on January 1 as President and Chief Executive Officer; Gerhard Full elected on May 27 to the Supervisory Board; gas activities in the US combined with the Cleveland, Ohio (USA) headquarters.

2004 The refrigeration business unit is spun off to form *"Linde Kältetechnik GmbH & Co. KG";* this company is sold in March 15 to the Carrier Corporation, a subsidiary of United Technologies Corporation – subject to authorization by the responsible antitrust authorities.

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