



Evolving from a University Mechanician
to a Global Player
Sartorius Chronicle from 1870 to 2005

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Sartorius Chronicle from 1870 to 2005

Researched and compiled
by Karin Sartorius-Herbst and Karl Bracht
in collaboration with Jörg Barankewitz



Dear Friends of Sartorius,

Nowadays, paradigms by which companies would have to "reinvent themselves" are very topical. Today is already yesterday and only tomorrow counts. It is true that orientation towards the future and speed are more crucial than ever for the successful development of a company. In fact, constantly being willing and able to change is required in all sectors and at all levels. No one can thus allow himself or herself to do things alone because that is "what they have always done." However, all those who wish to master these challenges with a clear focus instead of arbitrariness need visions and goals – and their own identity. The history of a company is an important part of its identity.

Sartorius College in Göttingen, an international center for customers, employees and friends of the company, opened in December 2001.



I am therefore delighted and grateful that we now have a comprehensive new chronicle of our company. It gives many interesting, some admirable and quite a few amusing details of the history of Sartorius. It becomes clear what outstanding entrepreneurial achievements the Sartorius family has made over several generations, despite extraordinary difficulties, and their significance for the opportunities that we have today. It also elaborates in detail the most important directions and cornerstones of our development. I would like to highlight two of them.

The first of these is innovation through cooperation. Sartorius has its roots in the Göttingen University; today this would be classed as a – triple – university spin-off. We have been working in close cooperation with research institutes for more than one hundred years.

Our history shows that we have always been particularly successful and made great progress when we worked with scientists and, especially, with customers or other technological companies to develop new products and procedures.

The second cornerstone is cosmopolitanism and internationality: Florenz Sartorius was already focusing on Britain and America at the time the company was founded and in its initial stages. Later, Horst Sartorius was a pioneer in opening up the Russian and Eastern European markets. Today, we are among the first German medium-sized companies to have successfully entered the Chinese and Indian markets.

I firmly believe that this internationality, an imprint of the company's DNA, is one of our most important success factors. This is largely why we are in a position to grow further, also in German locations, across the entire job spectrum from research to production.



I would like to thank Karin Sartorius-Herbst and Karl Bracht. This chronicle would not have been possible without their great dedication. Both of them sacrificed a considerable amount of their free time and worked through numerous documents and literature together, spoke to contemporary witnesses, and viewed and prepared photographic material.

On a regular basis, I followed with increasing anticipation how the individual elements were compiled with great perseverance and dedication and incorporated into the final draft. Jörg Barankewitz rendered outstanding services in presenting the exciting evolution of weighing technology.

I would also like to thank all present and former Sartorius employees. Without your successful work, over decades in many instances, the history written here would not exist.

Friends, I hope that you enjoy and benefit from reading the Sartorius Chronicle.

Göttingen, December 2005

Yours,

Dr. Joachim Kreuzburg



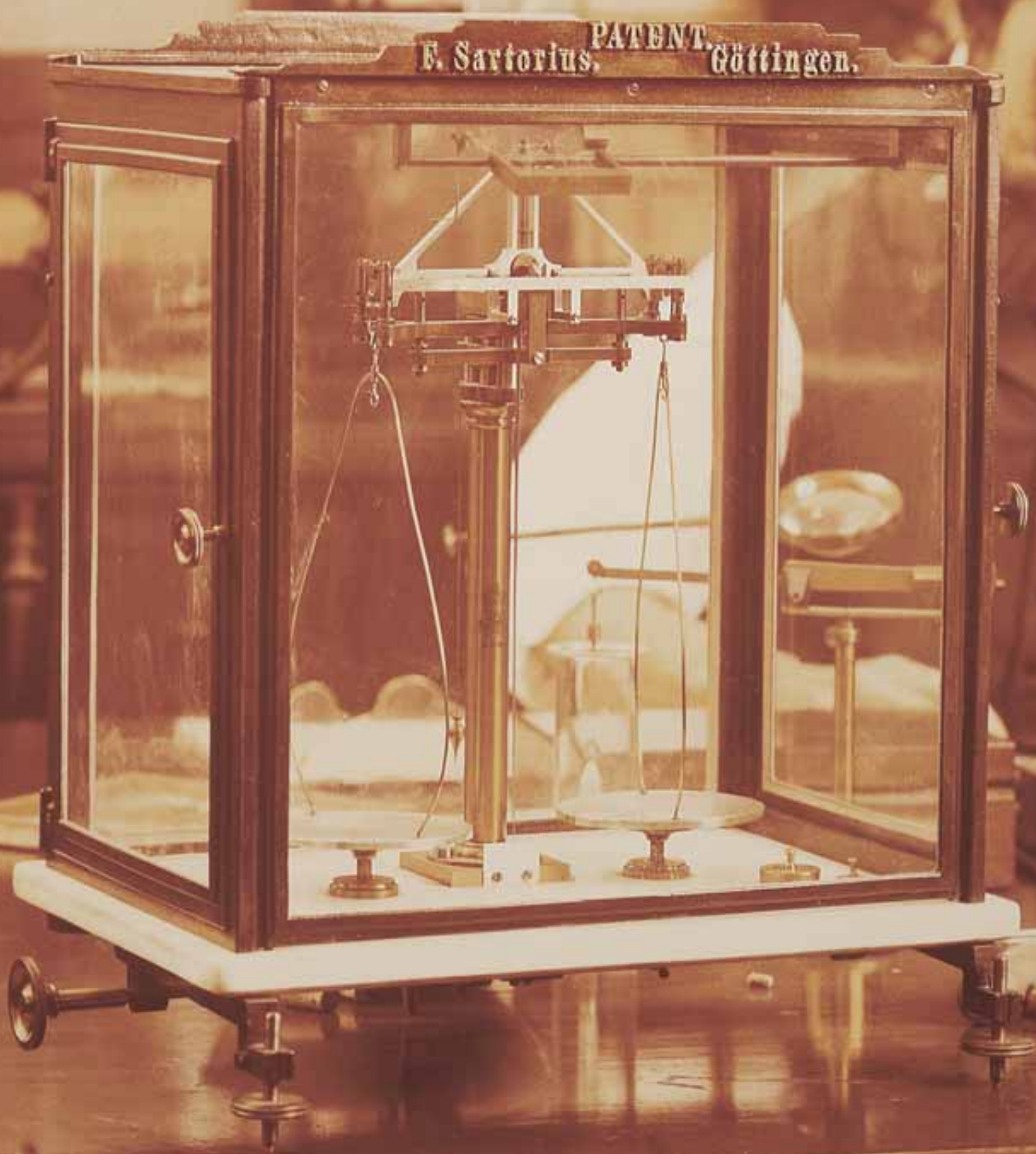


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F. Sartorius, PATENT, Göttingen.



Tradition as a Commitment

History and stories from more than 135 years of work and technical progress at Sartorius for "Sartorians" and friends of the company

Sartorius analytical balance built in 1888;
photographed at the Science Museum, London, UK

We often talk enthusiastically about the past at company parties, anniversaries, reunions and farewells to employees. Thus, it becomes clear time and again how much knowledge and experience is available in the company.

We talk about not just valuable expertise, but also historic knowledge of the development of the company through good and bad times during more than 135 years of its existence. It is about the tradition at Sartorius AG that links employees to the company.

Karin Sartorius-Herbst has always been committed to the documentation of company history. She rummaged deep in old family documents for this text. She also talked to many veteran employees to research the history and stories of Sartorius.

Filter specialist Karl Bracht, a passionate historian on Göttingen and Sartorius in his spare time, contributed his part. Jörg Barankewitz, Head of Mechatronics Training and Curator of the Sartorius collection of balances at Sartorius College, put in his "two cents" on the history of mechatronics.

And so this text was compiled, permanently at risk of never being completed as new material was constantly turning up. We have not kept to the chronological order of events in structuring this text, but have instead presented the individual topics in context. We intentionally refrained from mentioning individual "Sartorians."

While studying the documents, we got to know and appreciate our company anew. We were impressed that many methods that are presented as new achievements today had often been used at Sartorius for a long time beforehand – albeit under a different name. We were filled with admiration for the many achievements at Sartorius, some of which were made under the most difficult of circumstances.



We were eager to find a format that would be easy for "Sartorians" and friends of the company to read, and that also meets professional, technical and business standards.

Above all, this text is intended to contribute to identification with our company by presenting how technical excellence, intensive cooperation with our business partners, entrepreneurial skills, international focus and, last but not least, innovativeness, teamwork and loyalty of all employees make economic and personal success possible.

We hope that Sartorius, its partners and friends enjoy reading this chronicle and wish them all the best for the future.

Göttingen, December 2005

Karin Sartorius-Herbst
Karin Sartorius-Herbst

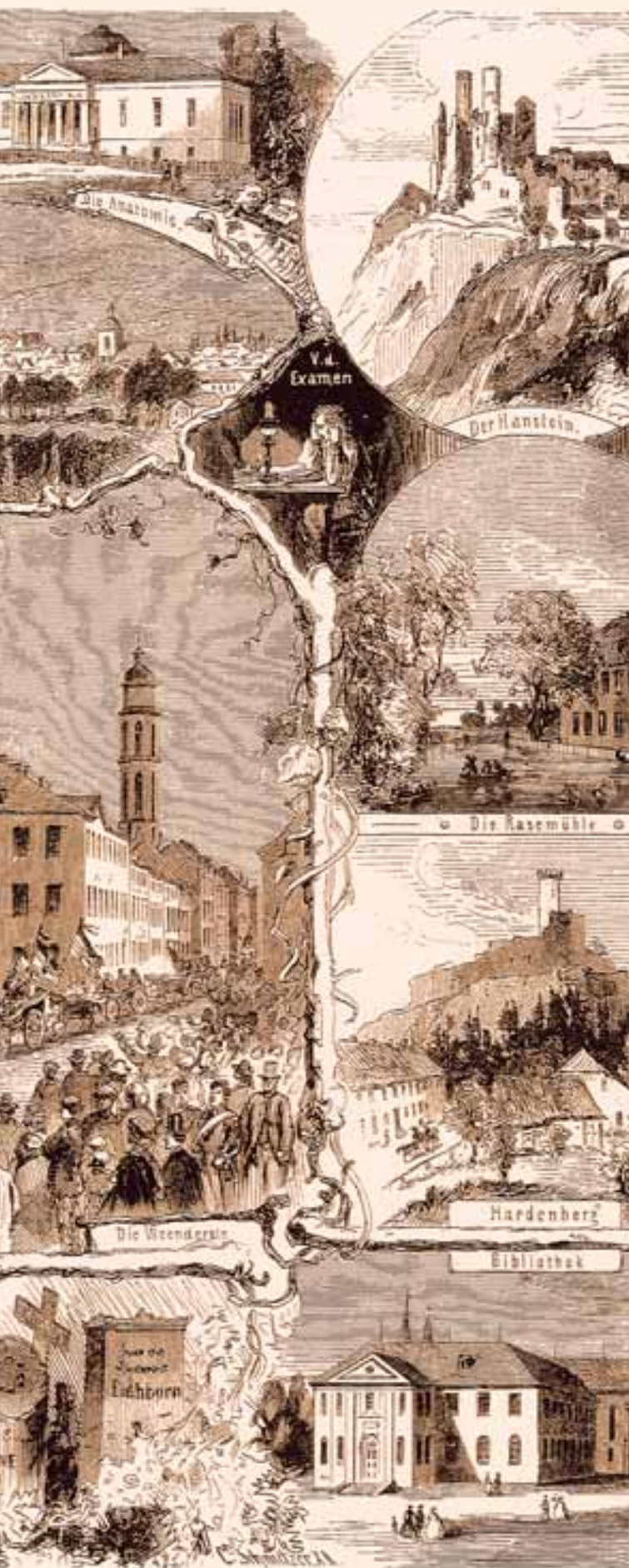
Karl Bracht
Karl Bracht



Göttingen.

neue Collegienhaus

Die Universität Göttingen. Nach einer Originalzeichnung von Robert Geijer. (S. 325.)



Göttingen in the Second Half of the 19th Century

- Göttingen University begins to blossom
- Gauss, Weber, Wöhler and others make Göttingen a center for natural sciences
- University institutes as customers for innovative instruments
- The role of the university mechanician
- The development of the precision mechanical and optical industries in Göttingen

The "new college house" built in 1862–1865, at the street called Weender Landstrasse, and views of the city of Göttingen, important university institutes and popular destinations of excursion for students



Carl Friedrich Gauss



Wilhelm Weber

The history of Sartorius is inseparably linked to Göttingen University, the Georgia Augusta, founded in the old Hanseatic city of the Electorate of Hanover by King George II, King of Great Britain and Elector of Hanover, in 1734.

In 1870, the year in which the precision mechanical workshop "F. Sartorius" was founded, Göttingen had been a provincial town in the Kingdom of Prussia for four years, with a population that grew from 10,000 to 30,000 between 1800 and 1900. The Georgia Augusta already had a high international standing, leading the field of the new, emerging natural sciences in particular. An extremely tight-knit social network dominated the university environment, going far beyond a mere professional level.

The university had only four faculties at the time – Theology, Philosophy, Law and Medicine. There was no specialization in individual subjects as there is today.



Friedrich Wöhler

Georgia Augusta's reputation in the natural sciences was above all due to contributions by the mathematician and astronomer Carl Friedrich Gauss, Professor in Göttingen (1807–1855), the chemist Friedrich Wöhler, Professor in Göttingen (1836–1882), and the physicist Wilhelm Weber, Professor in Göttingen (1831–1837 and 1848–1891).

They were representatives of the successor generation of scientists at the still young and liberal university of the Enlightenment, following esteemed scientists, such as Tobias Mayer (*1723 – †1762) – Head of the Observatory; Abraham Gotthelf Kästner (*1719 – †1800) – Professor of Mathematics and Physics and Gauss's teacher; Johann Christian Polikarp Erxleben (*1744 – †1777) – the first Professor of Animal Pharmacology; and Georg Christoph Lichtenberg (*1742 – †1799) – Professor of Physics and Mathematics.



Plate commemorating the 100th anniversary of the invention of the electromagnetic telegraph in 1833 by Gauss and Weber.



Ten German mark bank note showing a portrait of C. F. Gauss; in the background is a view of Göttingen with the university observatory and Gaussian distribution (bell curve).



The university observatory in Göttingen; opened in 1816. Carl Friedrich Gauss worked and lived here until his death in 1855.

Gauss, who became the world-famous "prince of mathematics" during his lifetime, also dealt with subjects as varied as astronomy, land surveying and magnetism in addition to mathematical problems. Together with his friend Wilhelm Weber, he developed and operated the first electromagnetic telegraph. Wöhler, a close friend of Justus Liebig in Giessen, produced aluminum for the first time and achieved groundbreaking results in chemistry. He was also General Inspector of all pharmacies in the Kingdom of Hanover.

The intensive exchanges between the professors themselves and with their partners for laboratory and equipment technology contributed substantially to the scientists' success. The professors needed new instruments and equipment for new methods, discoveries and inventions, not only during research, but also at the development and application stage.

Naturally, the Göttingen professors endeavored to work with the latest technology in equipment and instruments. The best equipment was traditionally imported from Britain. The mechanics at the university, better known as "mechanicians," were responsible for the maintenance and repair of these apparatuses. These "university mechanics" were generally trained clockmakers. As they gained experience, these specialists were then able to build their own apparatuses, frequently according to scientists' specifications, and sell them with the inventors "seal of approval" at universities and other establishments.

Workshops to supply the scientific institutes with instruments and apparatuses were therefore set up in the neighborhood of the institutes. Other universities in Germany and abroad were soon ordering Göttingen equipment, which often became the international standard. Inventions at the university led to the production of a wide range of technical innovations that also quickly found a large market outside the university at the start of the Industrial Age.

Since 1854, the town had been connected to the railway network, and the first telegram was sent to Göttingen. Still largely based on agriculture, Göttingen developed into a center for optics, measurement and control technology in the second half of the 19th century, whereas the textile and fabric industry that had once dominated the town became less significant.



The former chemical laboratory in Göttingen, the place where Friedrich Wöhler carried out his inventive work

When developing the telegraph, Gauss had the idea of using both rails of the railway as electric conductors.



Inauguration of the Göttingen train station in 1854

The "Reichenbach, Utzschneider and Liebherr Institute for Mathematics and Mechanics" (Mathematisch-Mechanische Institut von Reichenbach, Utzschneider und Liebherr) founded in Munich in 1804 was probably the first internationally renowned German precision mechanical company. Gauss had various apparatuses built there, but the demand for high-quality equipment was also increasingly able to be met in Göttingen.

Friedrich Apel (*1786 – †1851) was the first mechanic to gain major acceptance. After his years as a journeyman – a traveling apprentice – which were customary at the time, he was employed as a university mechanic in 1808. In the same year, he opened his own workshop at Prinzenstrasse 20. He brought important technical stimulus to Göttingen from his travel abroad, above all to London. Following his death in 1851, his son Wilhelm continued to manage the specialized scientific and technical apparatus company.

Florenz Sartorius received his initial training at Wilhelm Apel's company and worked for some time as an assistant for Apel.

Apel's most skilled competitor was Johann Philip Rumpf. Following an apprenticeship as a mechanic, Johann Rumpf had spent a few semesters studying mathematics, geodesy, physics and chemistry at the University of Heidelberg. He then worked at Reichenbach's establishment in Munich for over a year. In 1819, he was employed as a mechanic at the observatory in Göttingen and set up his workshop at Weender Tor. He also worked for the equipment model chamber and the chemical laboratory.



View of a street in Göttingen, Lange-Geismarstrasse, before the turn of the century; the city still had the definite look of a typical German agrarian town with its half-timbered houses and horse-drawn carriages.

According to Gauss, Rumpf was a "skilled artist who thought for himself." For instance, Rumpf built both the large heliotropes¹ that Gauss used in his land surveys; his products ranged from steam engines to analytical balances. In 1911, Florenz Sartorius replicated one of the heliotropes used by Gauss for the Gauss Tower in Dransfeld.

¹ Sun mirrors for observing distant places

Moritz Meyerstein (*1808 – †1882) took over his former teacher's role and workshop after Rumpf's death, where he had been working since the age of 13. After various jobs in Germany, he studied mathematics and physics at the University of Munich for two years. He made outstanding instruments for Gauss and Weber, and mainly focused on the areas of astronomy and geodesy. The Faculty of Philosophy at the Georgia Augusta awarded him with an honorary doctorate for his services in 1863.

There were seven companies for mechanical work in Göttingen at the start of the 19th century, each employing two assistants and one apprentice. At the end of the '60s, there were still seven companies, but they now had 50 employees. By around 1900, there were already twelve companies with 270 assistants and apprentices.

Besides these companies, which also produced analytical balances, the precision mechanics and optics industry in Göttingen quickly developed at an internationally-recognized level: Rudolf Winkel founded his optical institute in 1857, which, fueled by a groundbreaking essay on the necessity of meat inspection by Rudolf Virchow in Berlin, specialized in the supply of microscopes. The company for meteorological instruments founded by Wilhelm Lambrecht in 1859 has been based in Göttingen since 1864. Besides Weber and Wöhler, Gauss's assistant and successor Klinkerfues was an important partner for him.

And there was Florenz Sartorius.



Gauss-Weber memorial located next to the ramparts of the city; inaugurated in 1899





The Workshop “Feinmechanische Werk- statt F. Sartorius”

- Apprenticeship and years as a journeyman
- University mechanic in Göttingen
- “Small master craftsman” with own workshop
- The vision of the short-beam analytical balance
- International recognition
- Diversification of the product range
- Provision of security for his four sons
- Adaptation of the company structure to the growing business volume

Machinery and milling hall at the factory located at Weender Landstrasse in 1898



*F*LORENZ *S*ARTORIUS
GEB AM 10 APRIL 1846 GEST AM 1 AUGUST 1925
GRÜNDER DER FIRMA

Portrait of Florenz Sartorius, company founder



Florenz Sartorius was born in Göttingen in 1846. He was the son of Johann Georg Sartorius, who had held the position of university clockmaker since 1816, and his wife Friederike, née Stuhl.

Florenz Sartorius completed his precision mechanics apprenticeship and assistant period with Wilhelm Apel. He then worked for Staudinger in Giessen, who made analytical balances for Liebig's chemical laboratory.

Back in Göttingen, he attended lectures by Wöhler and Weber. He then went to Berlin to work as an assembler at Siemens & Halske. From there, his journey led him to Schröder in Hamburg and then back to Staudinger. After these important experiences, Sartorius was ready for self-employment. He returned in 1870 to Göttingen and set up his own workshop at Groner Strasse, where he worked as a "small master craftsman," primarily for Apel und Staudinger.



Medal issued for the 150th anniversary of the founding of the university in Göttingen in 1887.

With business growing and after many moves, he took over the shop of the mechanic Lambrecht, who was moving away from Göttingen, at Weender Strasse in 1872. The well-filled order book meant that the workshop constantly needed to be expanded. Revenue from the additional trade in all types of non-laboratory-related articles, such as sets of cutlery, provided the investment funds for this.

In 1887, Florenz Sartorius, together with Paul Koltze, offered different versions of a fine-crafted medal for the 150th anniversary of the founding of the university. The expansion of the Sartorius workshop was also due in no small way to the sharp business sense of his wife Luise, née Rudolph, who was responsible for shop sales.



Table knife with "F. Sartorius Göttingen" engraved on the blade; probably dates back to before the turn of the century.

A work group from the Göttingen chapter of the Association for Electrical, Electronic and Information Technologies, VDE Göttingen, visited us in 2003. When saying goodbye, an elder member of the group pulled out a bag and said, "We have been using this knife in our household for many years. If I'm not mistaken, it's one of your company's products, but I don't know any details. Maybe you would be interested in this."



Sartorius himself was excited about a groundbreaking idea – the short-beam analytical balance. A fast-growing market for accurate analytical balances had arisen in the chemical industry, which was developing at an explosive rate. However, customers had to live with construction-related disadvantages, due to the complicated operation and the tediousness of the weighing procedure.

It was clear to Sartorius that only the introduction of lightweight, short balance beams could lead to a considerable reduction in their stabilization time. He solved the problem of the time-consuming stabilization procedure by developing a short-beam balance with a triangular shape and a high level of stiffness. He reduced the weight by using aluminum, which had been discovered by Wöhler in 1827 and was a highly innovative material at the time.



One of the oldest Sartorius balances that we know of, built in 1888, is displayed in the Science Museum in London. For a long time, people at Sartorius believed that this yellowed photo was a publicity photo from the early days of photography. This error was corrected by chance when an employee at Sartorius UK explained how much trouble had been taken to recreate this scene in the museum in the late '50s. The triangular short balance beam can be clearly recognized.



One building of the factory complex at the street called Weender Landstrasse after the turn of the century; the main headquarters building of present-day Sartorius AG is still located on the same street.

Wöhler not only supported Sartorius by providing aluminum for his development, but also helped in alloying this metal with silver to make the material stronger. Sartorius was awarded the top prize for this first short-beam balance at an exhibition in Bremen already in 1874.

The benefits for customers and his Göttingen reference led to resounding success: Sartorius had his balance patented, and focused the company on innovative developments.

From this period onwards, Sartorius operated a highly aggressive international marketing campaign. He was active on the international market at a very early stage, receiving a top award in Philadelphia in 1876 and another in Chicago in 1893.



In a Sartorius catalogue from 1912, the high-ranking international awards for Sartorius products are highlighted.



He now had twelve employees. In 1898, Sartorius set up his production company at Weender Landstrasse in Göttingen, where the company is still headquartered today – at the time, this was a “greenfield site” outside the town, as is “Plant 2001,” the latest extension of the company in Göttingen today.

He consistently expanded the company with the latest machinery, some of which he had developed himself. During that time, he increased his workforce to 60 persons. The 3,000th analytical balance was produced. The product range was also extended systematically: there were now balances for heavier loads, less expensive balances for private use, precision balances for laboratories and pharmacies, tare or pharmaceutical balances as well as gold and diamond scales and hydrostatic balances for specific gravimetric analysis. References were made to scientific partners in advertising where this was possible. Sartorius did not sell balances primarily, rather, their successful applications – demonstrated by important reference customers.



Assay balance

The short-beam analytical balance is a clear example of the customer-oriented entrepreneur, whose developments were not only driven by experimenting with technology but also by their benefits for the customer, which were systematically researched. It is also noticeable that his efforts were not primarily about pioneering new technical achievements. He often drew on known ideas and combined them with others to achieve business success. A very skillful patent policy also played a part in this.





The employees had a high regard for the entrepreneur Florenz Sartorius. It is reported that his wife Luise often played an influential role when it came to maintaining a good atmosphere inside the company, creating an equal system through her fairness. She is described as "the good soul of the company."

Florenz and Luise Sartorius had four sons:
 Wilhelm (*1872–†1937)
 Erich (*1876–†1947)
 Julius (*1878–†1918)
 Florenz (*1881–†1918)

They set the course for their sons to take on responsibilities in the company at an early stage, e.g. ensuring that the sons received a good education, including spending time abroad.

Luise and Florenz Sartorius,
 around 1910, shown with their four sons:
 From left, seated: Luise, Wilhelm and Florenz Sartorius senior;
 from left, standing: Erich, Julius and Florenz Sartorius junior





In 1906, Florenz Sartorius included his sons Wilhelm, Erich and Julius in his company, which would now be run as a general commercial partnership.

The youngest son, Florenz, "was to have the right to enter the company at a later date if he decided to do so." Until his death in 1925, the senior boss himself then worked almost exclusively in the branch that he had founded in Rauschenwasser, north of Göttingen, in 1892.

As Julius and Florenz had already died in 1918, responsibility for the company since 1925 rested on the shoulders of Wilhelm as business director and Erich as technical director.

The Sartorius family house and part of the Rauschenwasser factory at the turn of the century



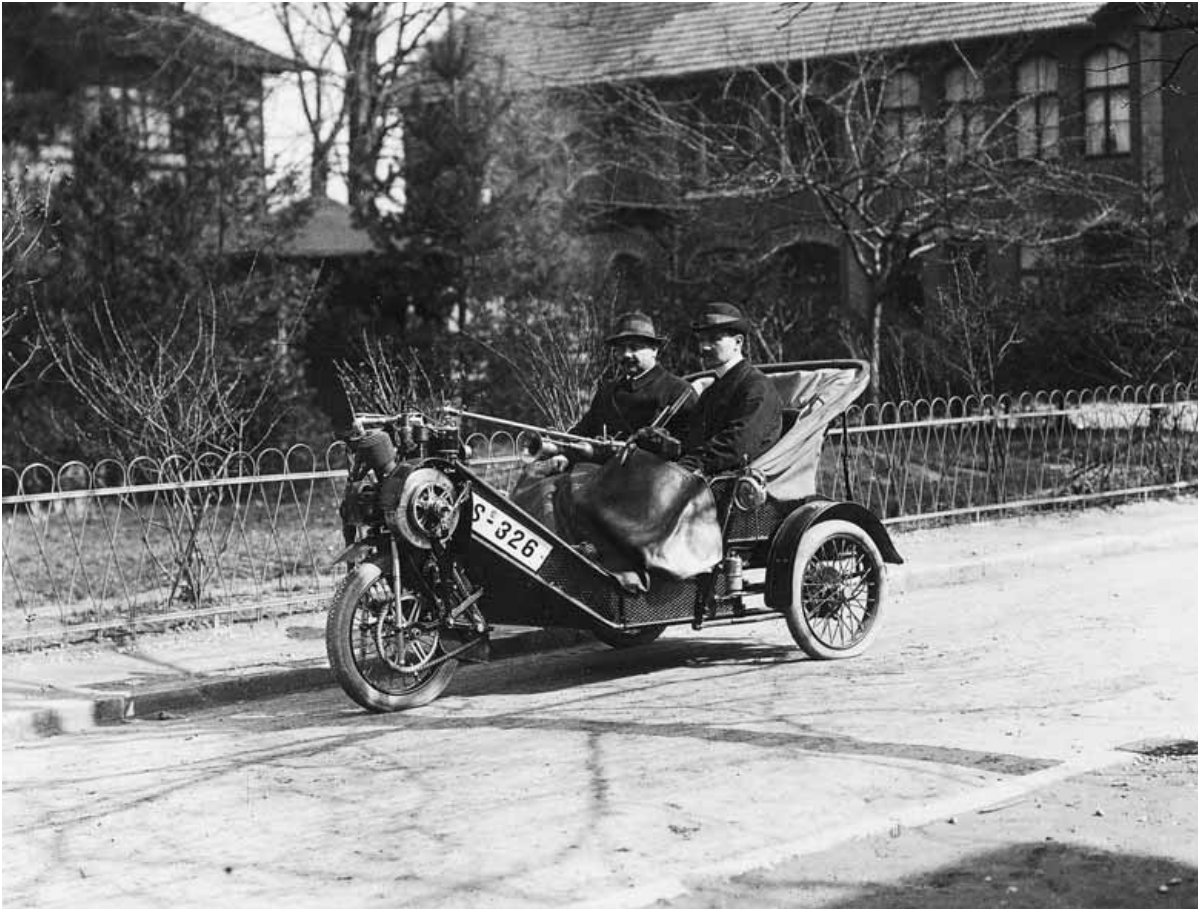


New Applications and Technologies

- New lines of business
- Incubators for poultry breeding and bacteriology
- Takeover of the August Becker company and the Ludwig Tesdorpf factory for geodetic instruments
- Consolidation and division structuring of the company organization
- Expansion of the international structure in procurement and sales
- Use of modern production technologies at the Göttingen factories
- Foundation of Sartorius-Werke A.G.
- Second natural science boom in Göttingen after the First World War
- Smooth transfer of company management through a generation change

Inside the Rauschenwasser factory where egg incubators for raising poultry were manufactured





Julius and Florenz Sartorius with their first automobile, probably one of the first in Göttingen



The Sartorius family has always been very open-minded about technical innovations: this is also shown in their means of transportation.

However, Sartorius did not only adopt new technologies for use. He also utilized established methods to find new applications for these. Incubator units were produced at the new Rauschenwasser factory for use in poultry breeding. This did not diverge so far from the core business of the company as one might expect, as Sartorius obviously knew about American and French incubators that were used to breed poultry. He had also become aware of the emerging area of bacteriology (Robert Koch studied in Göttingen from 1862–1866).

In both areas, precise temperature control played a crucial role in breeding organisms in confined spaces. Interested in technology and with a feel for future areas of application, the entrepreneur opened up a promising new area of activity in which technical innovation was expected to quickly bring market success.



"A completely desperate neighbor told Florenz Sartorius that her hen had abandoned the nest and now there were no chicks and therefore she could not continue raising poultry. She said that this was an economic catastrophe for the household. Florenz Sartorius reacted completely unexpectedly by taking a great interest in this calamity and promised her his help, but which could not be expected immediately. Sartorius set out feverishly to develop an egg incubator with controlled heating, and carried out the first tests 'in cooperation' with his neighbor."

◀ Sales brochure from 1920



Advertisement for Sartorius egg incubators printed in the German publication "Woche" on January 8, 1910



Advertisement from "Woche" dated November 26, 1910, for world-famous Sartorius egg incubators



Advertisement from "Woche" dated May 3, 1913, listing Sartorius fishing equipment

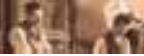


Original label of a Sartorius egg incubator built before 1900

The innovation primarily consisted of cutting-edge temperature control for his apparatuses, which could be used with the most diverse energy sources. This was an automatic membrane control of outstanding precision that was given the brand name "Germania Regelung." For his poultry incubators, Sartorius also introduced an egg-turning device that imitated the breeding behavior of poultry.

Sartorius focused on intensive marketing once again, particularly by attending German and international trade fairs, and success followed: his incubators were sold successfully all over Europe.

In 2004, a 16-sequel series on "Adventure in 1900 – Living in a Manor House" was aired on German television. In four of the sequels, an original Sartorius Germania egg incubator was to play a central role. The TV set producer turned to Sartorius, who found persons there willing to help and capable of making this museum piece operable again. In an acceptance test using modern measuring equipment, it was determined that the temperature control of this apparatus that was more than 100 years old operated accurately to within a tolerance of $\pm 0.5^{\circ}\text{C}$



Business for the agricultural sector was later expanded, particularly to meet the demand from fishermen. Some items were simply sold in partnership, but Florenz Sartorius developed fishing rods together with his son Florenz. Japanese partners supplied the high-quality bamboo. Thus, there were even joint ventures in those days.

This was not the only forward-looking development in Göttingen: at the same time, the "Vereinigte Mechaniker Göttingens" (Göttingen Association of Workshops and Mechanics) was founded. This interesting organization formed a shared platform for sales, procurement and customer service for the reputable Göttingen companies in the fields of optics and mechanical components.

However, the participating companies remained independent in both legal and economic terms. Sartorius profited highly from this union. For the World Exhibition in Paris in 1900, Otto Berendsen, Professor at the Königliches Gymnasium in Göttingen, published a compendium entitled "Die mechanischen Werkstätten der Stadt Göttingen"² (The Mechanical Workshops of Göttingen), which presented the companies of Göttingen in detail. This organization was not dissimilar to Measurement Valley, the regional trade association established in Göttingen in June 1998, which aims to create close cooperation in the areas of technology, purchasing and training.



Company sign of the Göttingen Association of Workshops at Hospitalstrasse in Göttingen

² Otto Berendsen, "Die mechanischen Werkstätten der Stadt Göttingen. Ihre Geschichte und ihre gegenwärtige Einrichtung."
Publisher: Verlag F.E. Haag, Melle in Hanover, Germany, 1900.

A development in 1906 is another example of fundamental company strategies at Sartorius: Florenz Sartorius took over two companies that had got into difficulties by growing too quickly and encountered the related liquidity problems and unresolved matters with regard to succession in ownership. The companies of August Becker and Ludwig Tesdorpf manufactured products that were a prudent, complimentary supplement to Sartorius's product range.

Sartorius expanded his product range by taking over microtomes and auxiliary apparatuses for microscopy from the Becker company in Göttingen; the Tesdorpf company in Stuttgart contributed astronomical and geodetic instruments and telescopes, thus creating the new company "F. Sartorius, Vereinigte Werkstätten für wissenschaftliche Instrumente von F. Sartorius, A. Becker und Ludwig Tesdorpf" (F. Sartorius, Consolidated Workshops for Scientific Instruments by F. Sartorius, A. Becker and Ludwig Tesdorpf). As mentioned previously, Florenz Sartorius took this opportunity to pass responsibility for important management tasks to his sons Wilhelm, Erich and Julius, who were also responsible for integrating the acquired companies into the Sartorius group.

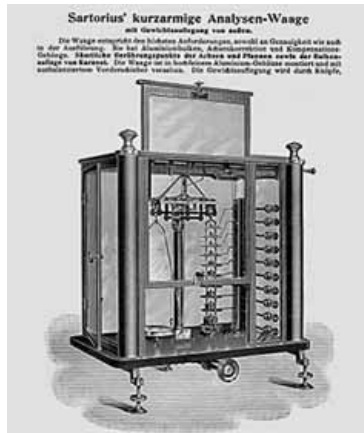
The consolidated companies were divided into four "departments" according to the different product groups. Today, we would now refer to these as "business segments."³

³ The presentation of the company structure is taken from a Sartorius advertisement in the "Chronik der Stadt Göttingen" by town archivist Dr. Wagner from 1930. At that time, the company had already been operating under the name of Sartorius-Werke A.G. since 1914 with an equity of around 900,000 reichsmarks⁴. However, this name was still valid five years after the death of the founder of the company (in 1925) (Wagner [1930]).

⁴ In 1914, one American dollar bought 4.2 reichsmarks acc. to Kihlstrom.



Sartorius-Werke A.G., Göttingen – The Four Departments of the Company



Department 1

Analytical, micro- and air-damped balances, fast industrial scales, and technical-analytical, specific tare and precision balances for technical purposes



Department 2

Microtomes of all kinds, such as sledge and freezing microtomes, ultramicrotomes, saw microtomes and those for cutting ultra-thin sections, immersion and for cutting brain tissue



Department 3

"Incubator" for bacteriological purposes and paraffin wax embedded material, thermostats in any size and for any type of heat source, egg incubators and poultry raising apparatuses for breeding

Repetitions-Theodolit mit Höhenkreis und zentrischem, durchschlagbarem Fernrohr.



Größtenfeld des Mikroskops.
Die Intervalle und Zahlen erscheinen größer.
 $\frac{1}{2}$ " Teilung durch Schätzung
12" ablesbar.

Theodolit No. 82.

Department 4

Geodetic, astronomic and terrestrial magnetic instruments of the highest precision



Die Entwicklung der Sartorius-Werke A. G. von der Gründung bis zum 60jährigen Bestehen

Am 1. Juli d. Js. konnte die Firma Sartorius-Werke A. G. auf ihr 60jähr. Bestehen zurückblicken. Wie so manche feinmechanische Werkstätte in kleineren Universitätsstädten, verdankt auch die Firma Sartorius-Werke A. G. ihr schnelles Emporblühen zum Teil dem innigen Zusammenarbeiten mit den Gelehrten der Göttinger Universität. Der Gründer der Firma, Herr Florenz Sartorius, erhielt aus dem Zusammenarbeiten mit den derzeitigen Göttinger Gelehrten, besonders dem Physiker Wilhelm Weber und dem Chemiker Wöhler die Anregung zum Bau von feinmechanischen Apparaten, welche den Anforderungen der Wissenschaft entsprechen. Besonders dem Einfluß Wöhlers, welcher Herrn F. Sartorius besonders auf die Verwendung des von ihm entdeckten Aluminiums für den Waagenbau hinwies, dürfte es zuzuschreiben sein, daß sich Herr F. Sartorius dem Bau von Fein-Analysen-Waagen zuwandte. Im Laufe der Zeit wurden dann die Sartorius-Analysen-Waagen so vervollkommenet, daß sie bald Weltruf erlangten und nicht nur in den wissenschaftlichen Laboratorien der Hochschulen, sondern besonders in der Industrie sowohl im Inlande wie auch im Auslande schnell Aufnahme fanden. Immer größer wurden die Anforderungen, welche die Wissenschaft und Technik an die Waagen stellte; während jene besonders Wert legte auf hohe Empfindlichkeit, verlangte diese neben der hohen Empfindlichkeit auch schnelles Arbeiten mit den Waagen. So entstanden dann die Mikro-Waagen, mit denen man Wägungen auf $1/1000 \text{ mgr} = 1/1000000 \text{ gr}$ genau ausführen kann, andererseits wurden Dämpfungswaagen und Industrie-Schnellwaagen durchkonstruiert, mit deren Hilfe man Wägungen in weniger als einer halben Minute ausführen kann, während man früher für derartige Wägungen 3–5 Minuten benötigte.

Besonders dem tatkräftigen Streben der Söhne des Herrn F. Sartorius, nämlich der Herren Wilhelm, Erich und Julius, ist es zu ver-



danken, daß die Firma sich immer weiter ausdehnte. Im Jahre 1905 wurden die Werkstätten von August Becker den Sartorius-Werken angegliedert. Diese Firma stellte Mikrotome her, welche zur Herstellung von Dünnschnitten aus menschlichen, tierischen und pflanzlichen Geweben verwendet wurden. Auch diese Instrumente wurden im Laufe der Zeit so vervollkommen, daß man heute in der Lage ist, Schnitte von 1/1000 mm und darunter, sowie Dünnschnitte durch das ganze Gehirn herzustellen. Hierdurch ist der medizinischen Forschung ein bedeutendes Hilfsmittel in die Hand gegeben.

Kurze Zeit darauf wurde auch die feinmechanische Werkstätte von Ludwig Tesdorpf in Stuttgart übernommen, so daß nunmehr auch geodätische, astronomische und erdmagnetische Instrumente in den Sartorius-Werken hergestellt werden konnten. Schon vorher hatte die Firma, einer Liebhaberei ihres Seniorchefs folgend, die Fabrikation von Brutapparaten und Geflügelzuchtgeräten übernommen; während zunächst nur Brutapparate zum Ausbrüten von Geflügel hergestellt wurden, wurden die Apparate im Laufe der Zeit auf Grund der gesammelten Erfahrungen so umgebaut, daß sie auch als Wärmekästen für bakteriologische Zwecke, Paraffin-Einbettungsapparate, Thermostaten usw. vielseitige Verwendung finden konnten.

So ist die Firma heute in 4 Abteilungen eingeteilt: in der 1. werden Analysen-, Mikro-, Dämpfungs-, Industrie-Schnell-Waagen, technisch-analytische, spezifische, Apotheker- u. Präzisions-Waagen für technische Zwecke hergestellt.

In Abteilung 2 werden Mikrotome aller Art fabriziert, wie Schlitten-, Gefrier-, Bandschnitt, Tauch- u. Gehirnmikrotome nebst Zubehör. Abteilung 3 ist in 2 Unterabteilungen gegliedert. In der einen werden Wärmekästen für bakteriologische Zwecke und Paraffin-Einbettungen, Thermostate in jeder Größe und für jede beliebige Heizquelle hergestellt, die andere Unterabteilung befaßt sich mit dem Bau von Brutapparaten und Aufzuchtgeräten zur Geflügelzucht. – Abteilung 4 liefert geodätische, astronomische und erdmagnetische Instrumente höchster Präzision.

Die Firma hat nun im Laufe der 6 Dezennien auf den verschiedensten Gebieten des wissenschaftlichen und technischen Instrumentenbaues Weltruf erlangt, so daß heute ungefähr 60 % der Produktion ins Ausland geht. Die kaufmännische Leitung ruht heute in den Händen des Herrn Senators Wilhelm Sartorius, während Herr Erich Sartorius die technische Leitung hat. Zur Zeit ist die Belegschaft ca. 250 Mann stark, welche im besten Einvernehmen mit der Geschäftsleitung an der Weiterentwicklung des Werkes mitwirkt.



Herrn Direktor Erich Sartorius zum 60. Geburtstage
gewidmet von der Belegschaft der Sartorius-Werke Aktiengesellschaft.
Göttingen, 29. August 1936.

Photo presented by the workforce to Director Erich Sartorius on his 60th birthday

Concerning the status of the company, the following was further reported:

"Within the course of six decades, the company has now earned a global reputation in the most diverse fields of scientific and technical instrument-making so that today, about 60% of the instruments produced is delivered to countries outside Germany. Presently, responsibility for the company's commercial operations rests in the hands of Senator Wilhelm Sartorius, whereas Mr. Erich Sartorius is responsible for running technical operations. Currently, the company's workforce is approx. 250 strong, who enjoy the best rapport with the company management in supporting and propelling the further development of the factory" (Wagner [1930]).



Because of the First World War and the untimely death of Florenz Sartorius's two youngest sons, the company developed differently than had been originally planned.

Geodetic devices were abandoned during the Second World War; incubators continued to be built into the '50s and microtomes into the '70s before they were also discontinued. The end of these segments was primarily due to the increased complexity in terms of technology and sales at the company, while little use could be made of synergy effects.

This was even more the case when new technology and sales channels had to be developed for the Membranfiltergesellschaft m.b.H. and for bearing technology after the Second World War.



The Gauss Tower at the top of the Hohen Hagen mountain in Dransfeld, Germany; cornerstone ceremony on July 29, 1909; opened on July 31, 1911; collapsed on November 14, 1963, as a result of basalt mining



Plate on the replica of the Gauss heliotrope donated by Florenz Sartorius

In 1910 at Dransfeld near Göttingen, a tower named after Gauss was built at one of the points of reference that he used in land surveying. A small exhibit was also set up to showcase the instruments that Gauss still used himself. Because the university refused to provide an original heliotrope for this exhibit, Florenz Sartorius had one replicated and provided it for the Gauss Tower exhibit.⁵

⁵ We thank Dr. Axel Wittmann of the Gauss Society in Göttingen, "Gauß-Gesellschaft," for providing this information.



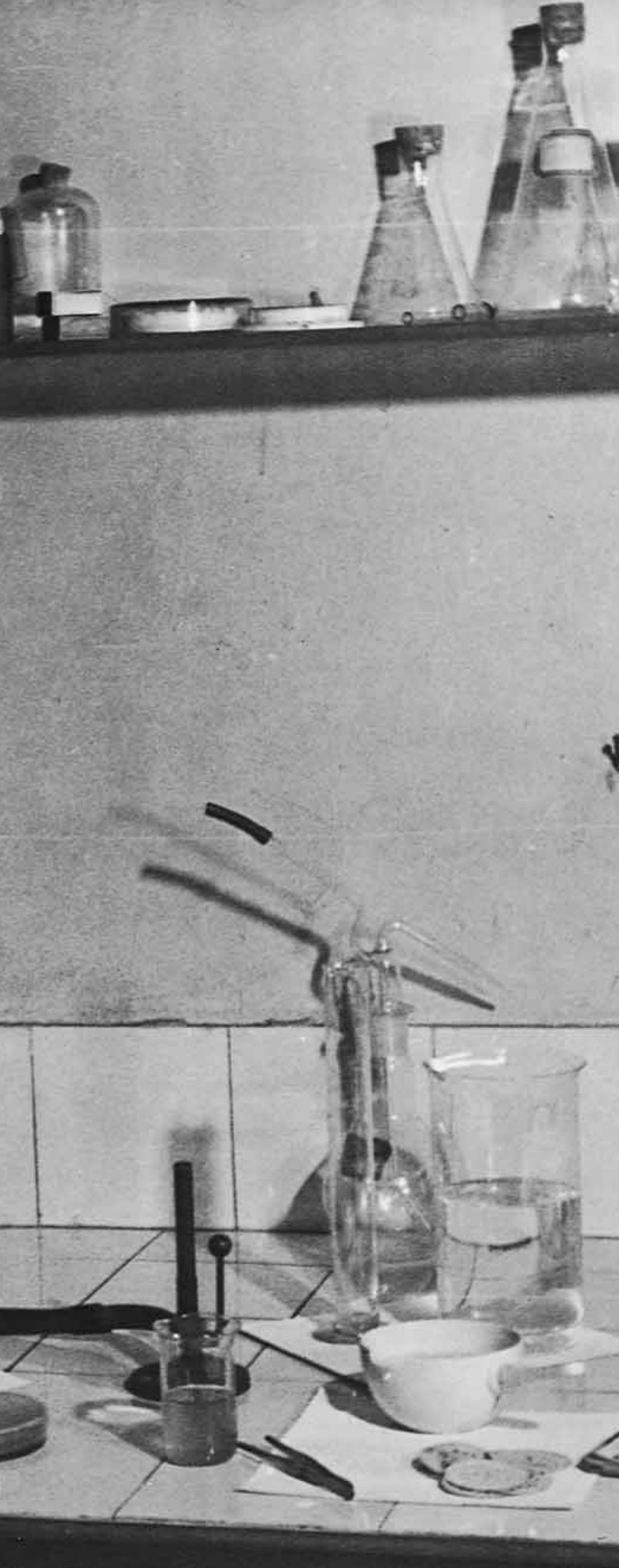
Karl Gauss from Velbert, Germany, a direct descendent of Carl Friedrich Gauss and a member of the Gauss Society in Göttingen, views the Sartorius heliotrope at Sartorius College.



The Membrane Filter Company “Membranfiltergesellschaft m.b.H.”

- Membrane filters invented by Nobel Prize winner Richard Zsigmondy
- Attempts at commercialization of membrane filters initially unsuccessful
- Production started at the university institute
- Membranfiltergesellschaft m.b.H. founded for the manufacture of membrane filters
- Strictly scientific focus
- Legal form of the company changed to a limited partnership and company acquired by Sartorius
- New methods developed
- Drinking water testing, an essential requirement following the Second World War, has relevance up to the present
- Build-up of process filtration

Production and testing of membrane filters were lab-scale operations up until the '60s.





Prof. Richard Zsigmondy in front of an experimental setup for visualization of colloids under scattered light



The Republic of Austria dedicated a special postage stamp to Nobel Prize laureate Prof. Richard Zsigmondy in 1979 commemorating the 50th year of his death.

The chemist Richard Adolf Zsigmondy worked from 1908 until his death in 1929 as a professor for inorganic and colloid chemistry at the Georgia Augusta University. In particular, he dealt with the practical and technical applications of chemistry. Thanks to Zsigmondy, Göttingen became a center of the emerging new science of colloid chemistry. In 1925, he received the Nobel Prize in chemistry for his studies on the heterogeneous nature of colloidal (gel-like) solutions.

In addition to various other technical inventions, Zsigmondy and his employee Bachmann during the First World War further developed "small collodion bags," originally manufactured by Bechhold, into the first generation of membrane filters with a sufficiently tight pore size differentiation.

These new filters were immediately used in applications for determining the weight of molecules and ions, and the filters proved indispensable as tools for isolation and identification of microorganisms in bacteriology that was still in its infancy.



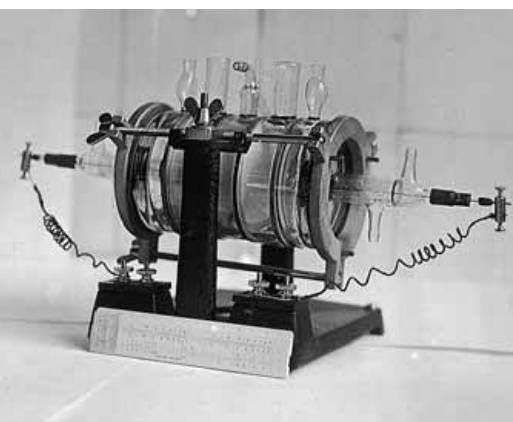
Zsigmondy transferred the rights to use his patents initially to the company called de Haen that was based in Seelze, Germany, as this firm had the raw material basis for manufacturing the required cellites. However, de Haen lacked the scientific prerequisites for development of production, with the consequence that these patent usage rights were returned to Zsigmondy. With the approval and the financial support of the German Ministry of Education and Cultural Affairs and the Göttingen University, Zsigmondy was now able to set up and improve production of membrane filters at his own institute, particularly as the demand for these filters from the fields of chemistry, bacteriology, hygiene and medicine continued at the same brisk pace at which this new technology and initial publications on its applications gained publicity.

When Zsigmondy was awarded the Nobel Prize in chemistry in 1925, his institute for inorganic chemistry became too small to accommodate the burgeoning number of students, and new facilities had to be found for membrane filter production. At the same time, Zsigmondy had kindled the interest of the industry, which was willing to invest in the commercialization of membrane filters.

On May 30, 1927, the Membranfiltergesellschaft m.b.H. for production of membrane filters was founded in Göttingen. The share owners were Zsigmondy, Wilhelm Sartorius, Sartorius-Werke A.G., the wood carbonization company Holzverkohlungs AG from Konstanz, factory owner Karl Schwab from Mannheim, factory owner Rudolf Winkel from Göttingen and Dr. Kratz, Dr. Thiessen and Dr. Demuth. Zsigmondy provided his patents as capital in the company, and was entrusted with "senior scientific management."

Under his leadership, further scientific research of ultrafiltration was pursued. At that time, sales and distribution were not understood as the major objective of the company. Its "business objective" was primarily concerned with "research, development and manufacture"; the objectives "sale and distribution of membrane filters and the associated apparatuses"⁶ were considered secondary.

⁶ English translation of excerpted German-language bylaws of Membranfiltergesellschaft m.b.H.



Test apparatus for determining the separation of molecules by ultrafilters

At "Factory Street No. 2" (Fabrikweg 2) in Göttingen, the membrane filter company moved into its new premises shared with the firm known as Boie, and began production using improved methods. Dr. Kratz, one of Professor Zsigmondy's students, took over management of the private limited Membranfiltergesellschaft m.b.H. Its line of membrane filters and ultrafilters was expanded by a new family of cellafilters for organic solutions and stabilized filters with a batiste insert. In the early '30s, the first "protein-tight" ultrafine and ultracell filters were developed.

In 1935, production was relocated to the factory called Sartorius Werke at Weender Landstrasse. Wilhelm Sartorius died in 1937. In that same year, the private limited company's legal form changed to a partnership (abbreviated "KG" in German), and the sole managing director of Sartorius AG, Erich Sartorius, took over management of Membranfiltergesellschaft KG.

At first, the partnership still received funds from the Office for Economic Development of the German Reich; however, during the Second World War, it had to cope using its own financial resources. Further new products were introduced, especially filter apparatuses. The company placed particular value on the development of standard methods for the various applications. In close cooperation primarily with Göttingen University, and also with industrial users, the company accomplished pioneering work on a broad basis. This is also reflected in the plethora of scientific publications on the subject of membrane filtration.



After the war, the company's business flourished, above all, with filters for testing drinking water, as most of the water supply piping had been destroyed, and the risk of contamination, mainly by cholera, was considerable. This led to the consequence that in 1947, a member of the U.S. military authorities in Germany confiscated the company's entire know-how, which thus became available to an American competitor. Hence, the major rival of the Biotechnology Division of the present-day Sartorius parent corporation, Sartorius AG, emerged.

When reconstruction after the Second World War began, decisive breakthroughs were made in the pharmaceutical industry, particularly in the fields of sterile filtration and microbiological testing of liquid media and gases. The company's intensive cooperation with research and industry still continued to play a decisive role.

Already in those days, the company set standards in the publication of technical and scientific literature and in the organization of training courses and seminars, not only for its own employees, but also for customers and those interested. As a result, the company's state-of-the-art was documented and new applications were made accessible to broad groups of users.



Bacteria colonies on membrane filters after incubation



Filter holder and barrel made of porcelain

The rumor persists that the famous Meissen bone china manufacturer "Meissener Porzellanmanufaktur" produced certain versions of this filter holder.

JAHRESMITTELANGE ERFAHRUNGEN
in Bau von Analysenwaagen, Präzisionswaagen, Mikroskopen, Zelektrolyseapparaten und anderer in der gesamten Welt, vornehmlich für wissenschaftliche Gebrauchung oder für Fabriken in eigenen Laboratorien, sorgfältige Auswahl der Apparate für die verschiedenen Methoden, so wissenschaftlichen Untersuchungen, seltene Überwachung oder anderen Gebiete u. s. w.

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KOLLOIDE, BAKTERIEN, VIREN
Dann — Membranfilter nach Prof. Zsigmondy
für wässrige und organische Lösungen in allen Fallzahlen.
Für präparative und analytische Arbeiten mit feinsten Membranen.
Für Kolonien und einseitige Lösungen,
für bakteriologische, bakteriologische, serologische Arbeiten und Mikroanalysen.

Membranfilter-Methode

Zum Nachweis von Coli-Bakterien und Colmen der Typhus-Paratyphusgruppe in Trink- und Abwasser.
Zum bakteriologischen Tuberkulose-Nachweis sowie zur Anreicherung für Kultur- und Tierversuche aus sterilisiertem Untersuchungsmaterial.
Zur Zählung von Wärmern in Abwasser und Blut.
Sterile Filtration und Sterilisation mit Membranfilter-Behältergeschichten für die Getränke-Industrie sowie für die Chemie- und Pharmazeutische Industrie.
Special-Filtrier-Apparate aus Porzellan, Glas und Metall.





Unser

**FABRIKATIONS-
sind
LIEFERPROGRAMM**



**SARTORIUS-
WERKE AG
GÖTTINGEN**

Company brochure from 1952

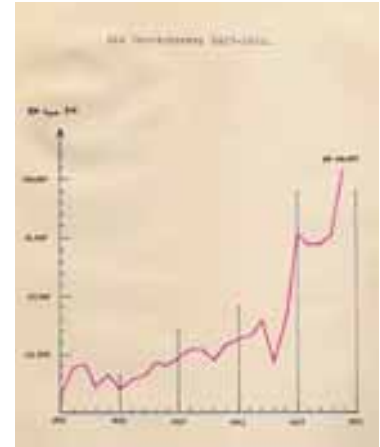
In this context, the fact that the "membrane filter method" is referred to regularly in company brochures and publications seems absolutely programmatic in explaining that the correct use of membrane filters is possible only with precise knowledge of the conditions of application and the properties of the product to be filtered.



We have records from 1951 describing the sales development of the membrane filter company. These show that the company's business volume had been only quite moderate over the decades so that today's development of membrane filters as an interdisciplinary technology was at best difficult to foresee. Here, it must be kept in mind that up until the mid-'40s mainly membranes for analytical purposes were supplied, and the sales volume was accordingly low.

During the post-war era, by contrast, business with filters was increasingly supplemented by the developing business with industrial applications. The company's product array during this time essentially consisted of disc filters of various pore sizes in different formats. These flat filters were used in filter holders made of glass, ceramic or stainless steel, which could be easily disassembled for cleaning or sterilization.

Filter membranes were manufactured by manually spreading a thin liquid layer consisting of polymers and solvents on glass plates. Once the solvents had evaporated and the membrane layer solidified, the resulting product was separated from the glass plate and further processed.



The sales curve reveals that up until the mid-'40s, primarily membranes for analytical purposes were supplied, and their sales volume was correspondingly low.



Visual inspection of
membrane filter discs

It is obvious that with this method of manufacture, one had to take in stride the considerable variations in thickness and consistency of the product. Quality control of the filters was not performed until they had been cut into discs, and this always led to substantial reject rates. Some types of filter had to be packaged in wet condition to prevent them from drying out and becoming brittle. However, this made it necessary to add disinfectants to the packaging to prevent contamination by microbes. That, in turn, limited the use of these filters. Particularly in ultrafiltration, filters in the form of collodion bags manufactured by a casting process were also offered.

Above all, cellulose derivatives in the form of cellulose acetate and cellulose nitrate purchased as granulate were used as the basic polymers for membrane manufacture. To be sure, these raw materials were manufactured in large quantities as the film and photo industry began to develop rapidly. But a major problem with these materials remained for quite some time: the batch-to-batch consistency, as the specifications for use of this material to make other products were insufficient for membrane processing. Consequently, incoming inspection of the granulate was laborious and expensive, and this necessitated frequent intervention in the manufacturing processes to adjust the parameters accordingly.



At that time, the manufacture of membrane material was pretty much empirical, and strongly dependent on the experience of the production workers. To expand the applications for membrane filters, Sartorius experimented with combinations of conventional filter layers and membrane materials in order to enhance the stability of the filters and their throughput in operation.

At the beginning of the '60s, the first membrane with a backing was developed on the basis of cellulose acetate for use in electrophoresis. In this technique, molecules are separated from one another according to their molecular weight in an electrical field.

The low unspecific adsorption and the surface properties of the membrane are primarily responsible for the efficiency and type of separation. Together with leading manufacturers in this field, Sartorius developed its membranes for electrophoresis into an international business.

Although the Membranfiltergesellschaft m.b.H. meanwhile belonged to the Sartorius group of companies, it was still managed as a separate organization with its own company logo until it merged in 1978 with Sartorius Werke GmbH. Afterwards, it became the Sartorius Filter Technology Division, the core of the Sartorius Group's present-day Biotechnology Division.



Testing the hybrid purity of seeds by phenotyping isoenzyme patterns obtained by electrophoresis using Sartorius cellulose acetate membranes





Sartorius During Two World Wars

- Founding of Sartorius-Werke A.G.
- Second boom in natural sciences in Göttingen after the First World War and the effects on Sartorius
- Smooth transfer of company management despite a generation change
- The Third Reich and armament production during the Second World War
- New start after the war at the edge of the Western occupation zone
- Third boom in natural sciences in Göttingen (university and Max Planck Institute)

In the '30s, early daily calisthenics were part of daily work (photo taken in 1938).



The German economy suffered dramatic setbacks and changes during both World Wars in the last century. Many small companies had to give up or were taken over by stronger companies. Florenz Sartorius led his company with great entrepreneurial skill, even through the First World War and the post-war period. His goal was to leave each of his four sons their own area of responsibility in this association of companies, and, for this reason, he expanded his company on a broad base through acquisitions and new branches. This also enabled a relatively high level of independency from the critical economic situation to be achieved. However, his two sons Julius and Florenz died in 1918, leaving the sons Wilhelm and Erich to take over the company management following Florenz Sartorius senior's death in 1925.

The company had become "Sartorius-Werke Aktiengesellschaft" (a stock corporation or public limited company) already in 1914 to expand its capital base. However, control of the company still remained in the Sartorius family.

When the membrane filter company "Membranfiltergesellschaft m.b.H." was founded in 1927, Sartorius-Werke was in such a stable economic position that the then head of the company, Senator Wilhelm Sartorius, was able to invest in a company that was expected to do innovative business in the future but that was certain to make only a loss in the short term according to its statutes.



During the First World War, important employees, also from management, were drafted for military service, and general business development weakened. However, business continued in Göttingen and at Sartorius, particularly with the university.

Unfortunately, we do not have any exact data from this period, but it can be assumed that a number of traditional "men's jobs" were carried out by women. After the end of the war, the familiar tough, but friendly, working environment took hold once again, as was typical in an industrial company in the small town of Göttingen with its agricultural surroundings.

Original quotes from retired employees from this period describe the atmosphere:



Department for microtome assembly at the second factory in Rauschenwasser, Göttingen

"Each worker had an employment record book, in which all work was recorded on an ongoing basis. After breakfast, the books were collected and submitted to foreman Fischer. Payment was made in the evening at around 5:00 pm.

A stamp box installed at the factory entrance monitored punctuality. Everyone was given a monitoring stamp that they had to take every morning and return every evening. The box was closed every morning at 7:00 am. Anyone who arrived late had to pay 25 pfennig, the average salary for one hour's work."

"When the weather was nice, the sons used the penny farthing; otherwise, the horses were their main means of transportation."



Young people learning from experienced master craftsmen and journeymen ('20s)



To this very day, we still have not been able to answer the question as to whether these practical workers' smocks were provided by the company (around 1900).



In the '40s, the foreman kept a critical eye on his employees.



Apprentices' workshop at the factory at Weender Landstrasse (in the '40s) – check the length of those trainees' haircuts



The new commercial trainees on their first day cautiously eye their new environment. The upcoming generation of male business employees wore a business suit and a tie (in the '50s). Even commercial trainees had to learn how to file metal for at least four weeks.

In the '70s, vocational trainees started wearing quite casual clothes to work. ▶

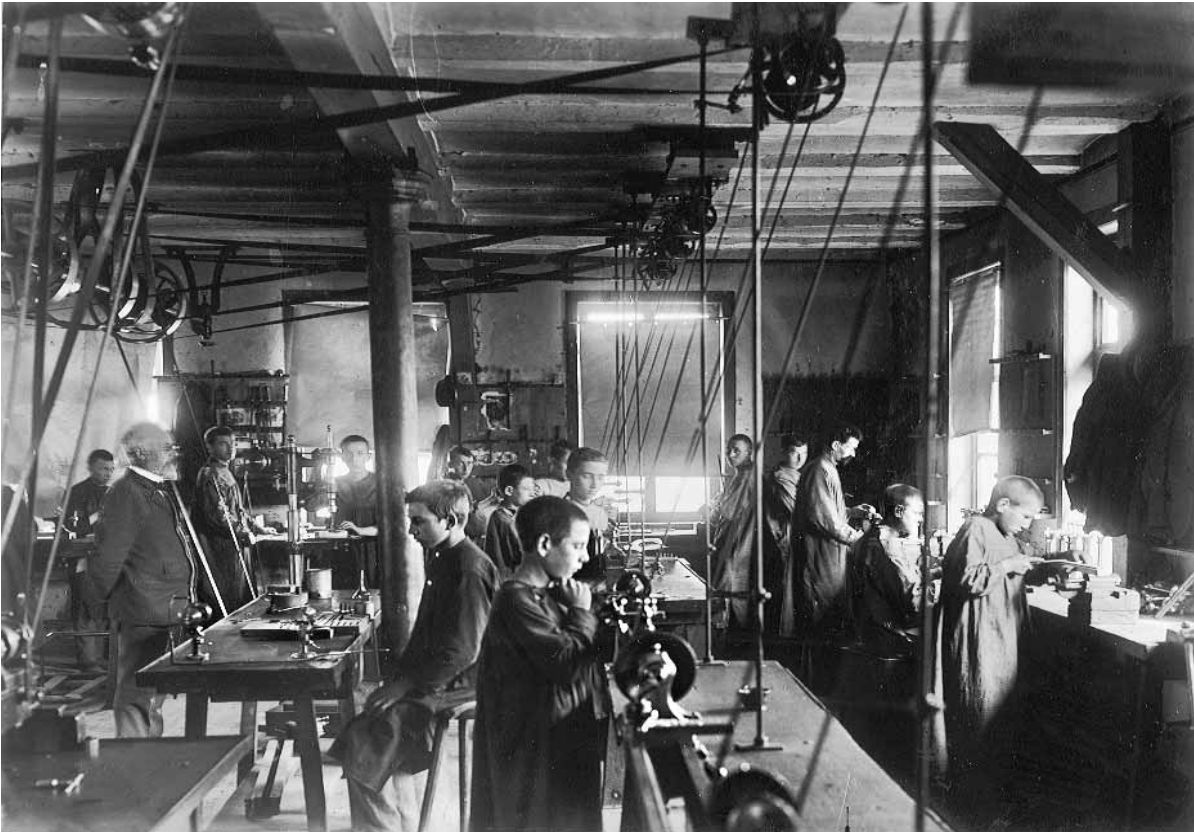
Training the New Generation Is a Sartorius Tradition

The diverse production range, the large vertical range of integration and the international focus of the company have offered a broad spectrum of training opportunities for technical and commercial trainees throughout the company history.



In those days, the trainees' excursion was to Kassel (43 km south of Göttingen) with its multi-faceted sightseeing opportunities (end of the '40s).





The foreman at the apprentices' workshop in Rauschenwasser kept a close watch on his trainees (around 1900).

An original quote from a retired employee from this period describes the atmosphere:

"My training as a technical apprentice lasted four years; first of all, the apprentice had to file a block of iron straight – a much-hated task. Erich Sartorius led the training; he was very meticulous and did not let anybody get away with anything. Eight apprentices and six assistants worked in the mechanician workshop at that time. The top boss arrived by horse every other day. Happy was the man who was allowed to hold the horse, for he was spared from any thunder and lightning in the workshop."



After the First World War, the University of Göttingen was internationally renowned, particularly for the natural sciences (Otto Wallach, Walter Nernst, Richard Zsigmondy, Adolf Windaus, Max von Laue, James Franck, Max Born, Werner Heisenberg – to name only a few Nobel Prize winners working in Göttingen – among many others). This meant that suppliers with links to the university were also able to survive better than others when compared on a worldwide basis. Between 1870 and 1911, ten thousand analytical balances were produced. From 1911 to 1939, forty thousand balances were built and sold.

The University of Göttingen conformed to the system of the Third Reich: globally recognized scientists, such as Max Born, James Franck, Emmy Noether and Richard Courant, left the university and their homeland.

However, the "new spirit" had little influence on the traditionally strong emotional and social relations between the company and the workforce at Sartorius. Starting in 1939, manufacturing operations also included armaments. Fin assemblies were produced for bombs in addition to the range of balances for pharmacies. Looking back, it is reassuring to see that no high-priority weapons were manufactured at Sartorius, so there was little direct state and party influence.

During the Second World War, workers who were from occupied countries and lived under dreadful conditions in collective camps replaced employees who were conscripted.

Senator Erich Sartorius was responsible for running the company during this bad period. He showed remarkable personal courage to protect his company and employees. From talking to former foreign workers, we know that Erich Sartorius also frequently did extraordinary things to relieve the suffering of these members of the workforce. The company was bombed towards the end of the Second World War, but could continue operating.



The factory buildings at Weender Landstrasse following the Second World War

Erich Sartorius led the rebuilding of the company after the war until his death in 1947. His son, Horst Sartorius, supported him, then took over management of the company.

Although the company had suffered, production could still continue, and experienced employees returned to Göttingen. The traditional apprenticeship program run by Sartorius also had positive effects: well-trained junior employees were available to join the workforce.

Göttingen had a special position as a location in Germany after the Second World War as the town had sustained little damage. It was near the zone border, which later became the Iron Curtain.

Georgia Augusta Göttingen was the first university in Germany to begin teaching again in 1945, and Göttingen became a center for natural sciences and for the newly founded Max Planck society. Refugees from the East came to the town and the surrounding area, many of whom became valuable employees at Sartorius.

As previously mentioned, membranes were much sought-after for drinking water testing in post-war Germany, and a wide range of products was also manufactured using materials, labor and machinery that were available. Furniture, everyday items and even toys for the Christmas market were produced. At first, it was a question of survival and reorganization.



Old models continued to be built where materials were available. The breakthrough came with new types: The novel generation of balances, such as the SELECTA with a metal housing and important innovative advantages, became a great success.

Rumor had it that the new balance had been developed during the war, but that Erich Sartorius had craftily arranged it so that British "technology inspectors"⁷ did not see the construction. However, here are some interesting details from their report dated January 1946:

- The number of employees was given as 225 (350 before the war), of which 80% worked in the production of balances and weights.
- The apprenticeship program with 5½ hours of vocational school per week was praised in particular.
- The highest hourly wage (for weights and measures verification foremen) was 0.92 reichsmark⁸ +15%.
- Production was approximately 100 balances and 120–150 sets of weights (200–300 before and during the war) per month.
- The shortage in copper, gold and platinum is referred to, so many parts were made from aluminum.

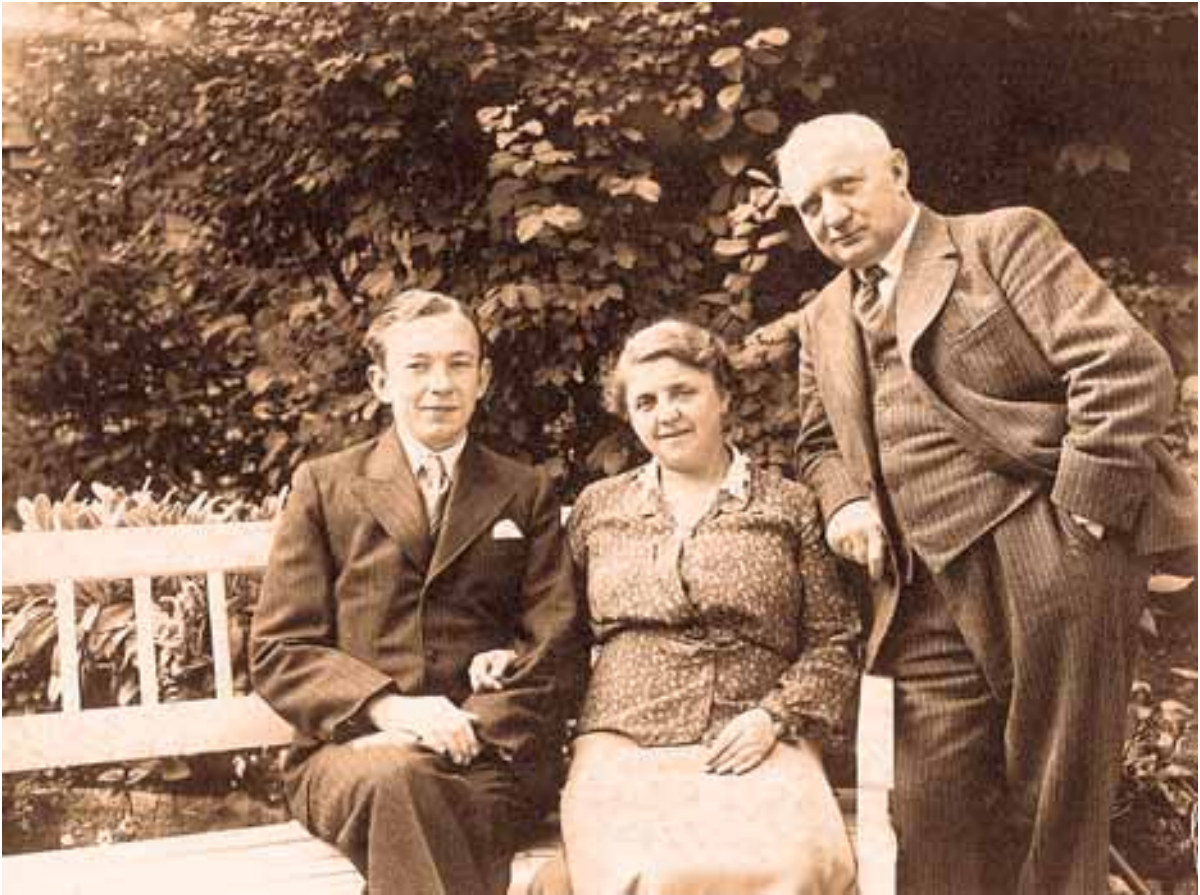
According to company tradition, contacts were re-established with customers and trade partners at home and abroad. The Sartorius name had not suffered internationally.



Assembly of the SELECTA analytical balance around 1955

⁷ British Intelligence objectives sub-committee, "The German Fine Balance Industry"; London H.M. Stationary Office 1946

⁸ In 1914, one American dollar bought 4.2 reichsmarks; source: "Conversion to the Euro" by John F. Kihlstrom



Erich and Frida Sartorius with their son Horst



Erich Sartorius

Erich Sartorius died suddenly in 1947. He had managed Sartorius for 41 years. Together with his father and his brother Wilhelm, he had been able to stave off most of the wartime ravages during the First World War, and alone he did the same as the head of the company during the Second World War.

His wife Frida, née Höfgen (*1881–†1968), was always at his side and is remembered by the "Sartorians" for her energetic style. His son, Horst Sartorius, took over company management during a period characterized by the rebuilding after Second World War.



Erich Sartorius was particularly successful as the technical mastermind behind the company: he held more than 80 global patents.



SARTORIUS - WERKE A-G
IMMECHANISCHER GERÄTEBAU

Rebuilding and Internationalization

- The postwar period
- Exports: the "key to success" once again
- Insights into administration
- Identification of "Sartorians" with their company and management
- Focus on core skills and expertise



Factory gate of Sartorius-Werke A.G. on Weender Landstrasse in Göttingen; at the end of the '50s



Busy "traffic" at the factory gate; the sign reads, "Warning! Bicycle crossing!"

The Post-war Period

Horst Sartorius assumed management of the Sartorius Group in 1947 at the age of 37. Following the family tradition, he had already worked in several positions in the group of companies before being appointed to the top.

The basic survival period after the war was slowly coming to an end. In today's world, it is hard to imagine how difficult the procurement of rare materials, in particular, was in the time leading up to the currency reform. Even paperclips were only available with "iron ration coupons." The fact that Sartorius had always "made everything in-house" helped to rebuild production in this situation. The product range included different designs of analytical balances, microtomes and products for the preparation of microscopic transections, material testing apparatus primarily for the textile industry, dust monitoring equipment and membrane filters.

Sartorius was driven by a strong ambition to make the company as significant as it had been before. Göttingen was a good location for this. The university and the Max-Planck Institutes were the first to be fully operational again in Germany, and leading scientists lived and worked here: Max Planck, Max von Laue, Werner Heisenberg, Carl Friedrich von Weizsäcker and Otto Hahn, to name only a few. The 1957 "Göttingen Declaration" against the nuclear armament of the German armed forces, the Bundeswehr, is a good example of their influence.

It is reported that Horst Sartorius stood in front of his employees on several occasions during the post-war era and said: "I do not have any money, but at least my factory is warm and we still have something to eat and drink. All those who wish to join us are warmly invited to do so. When we have money again, we will pay you." No one stayed at home.



The town was known for its prominent industry for producing teaching aids used at schools and universities. In addition, pharmacies, public institutions and industry all needed new equipment. "Genuine Sartorius products" were in demand once again. The currency reform soon brought with it both money and courage for the future, but financing the private group of companies remained a big problem.

Above all, it was important to Sartorius to commit his employees to the company and to win them over with regard to necessary changes. His management style was tough but fair. His wife Elfriede, née Jantze, (*1917–†1981) actively supported him in his activities, showing great enthusiasm and dedication as the "good soul of the company" in looking after the employees and their families.

The introduction of the new SELECTA generation of balances, with metal housings and important new advantages, was a complete success, and the company began to stabilize.

The PROJECTA (produced in 1948) was the predecessor of the legendary SELECTA, the successful model of the '50s and '60s.





Sartorius returned to international trade fairs at a very early stage.

Exports: The “Key to Success” Once Again

Directly after the war, Sartorius did everything to regain the company's former export strengths. As an initial step, contact was re-established with foreign trade partners, and new branches abroad were then gradually set up, often in cooperation with large German companies, such as Zeiss. An important element of managing foreign branches was the intensive training of specialists at the Göttingen training center. In addition to this service, experienced Sartorius instructors increasingly traveled abroad to provide on-site training.

At the end of the '60s, Sartorius began to establish own subsidiaries abroad, first in Europe and later overseas.

The necessity of being able to provide services for customers locally at short notice played an important role in this decision, as did country-specific regulations in the context of weights and measures legislation governing weighing instruments. The first subsidiary was founded in Austria in 1971, followed by companies in the Netherlands, Great Britain and France. The U.S. subsidiary was established as of 1975, starting in a hotel room in San Francisco. A production plant for filter technology was founded in Puerto Rico in 1982 and focused on supplying the U.S. dollar market.

“The boss” maintained intensive contacts with universities, scientific institutions and authorities in Göttingen, throughout Germany and abroad.

Horst Sartorius conducted a special form of market research from his regulars' table in the Ratskeller: professors from various faculties presented their projects to him and it was then up to his experts to analyze the flood of ideas and filter out those that were useful to the company. An example: during one of these dinners, Otto Hahn, President of the Max Planck Society, presented Horst Sartorius with the idea of commercializing hydrodynamic bearing technology in 1948, developed by the Institute for Flow Dynamics. This project resulted in a highly successful enterprise.



Company brochure from 1953

A company brochure from 1953 states:

“Decades of experience in building analytical balances, precision balances and microtomes, exchanging experiences with our customers all around the world, scientifically investigating all weighing errors in our own laboratory, carefully selecting microtomes for various materials for microscopic examination and strict monitoring of all outgoing equipment, as well as many more measures, form the basis of the internationally-renowned ORIGINAL SARTORIUS apparatuses.”

Besides the development of new product ideas, business with universities was also very important as people who had worked with Sartorius equipment as students would also prefer working with it in their professional lives.

Horst Sartorius was particularly interested in Eastern Europe for business opportunities: he was one of the German pioneers in West German-Russian business after the war. Looking to the future, he used the technical and scientific cooperation with different institutes to build long-term business relationships in this difficult market.

Insights into Administration



Bookkeeping department

The business administration of the company, which was a pioneer in electronics thanks to its products, was very hesitant to introduce electronic data processing. Index cards were used in the different bookkeeping departments for a long time at Sartorius, and mechanical calculators were used for job scheduling, payroll accounting and calculations, later followed by electric calculators.



Pay office

The entire company operations accounting sheet was handwritten on "long rolls of paper." All administration was exclusively programmed to business processes, as illustrated in the example below.

A precision mechanic working for the company was an amateur model maker in his spare time. He needed one meter of plastic tubing, which was available as a raw material at Sartorius. An honest man, he approached his superior to find out how to arrange to buy this in cash. The subsequent procedure took half a day, establishing availability (by consulting the index card in terms of bookkeeping), determining the price, cutting the material, producing the cash purchase receipt, delivery note and permit to leave the premises with company material, paying the invoice amount, delivering the material, etc. What was undisputed in the procedure was that the employee had to pay only for the production costs of the material.

It is not known whether this incident contributed to the fact that a shop was set up for employees at Sartorius in the '60s, where everyday items could be bought at a low cost. However, the cash sales procedure for employees was made much easier and transparent.

For several years, Sartorius cooperated with a data processing center in Göttingen. Compiling and forwarding the records was a regular problem. It was only in the mid-'70s that Sartorius installed its own electronic data processing (EDP) in Göttingen and launched it with various programs for different applications.

We have a record of the specifications of the first EDP equipment:

Purchase contract dated May 17, 1974

Siemens Unidata equipment with the following configuration:

1 central unit	7720-F 64 KB
1 card reader	3140 reading speed 300 cards/min.
1 high-speed printer	3320 print speed 200 lines/min.
3 magnetic plate storage devices	4596 storage capacity 29 million bytes each

Installation date September 1, 1975

Planned areas of use:

- Customer order processing
- Production planning and control
- Financial accounting
- Payroll accounting
- Various statistics

The data and targets speak for themselves. There was still a long way to go before EDP became a recognized tool taken for granted within the Sartorius organization.



Index cards were the "databases" of the time



Before the introduction of EDP, records were produced using Ormig machines. This wet copying procedure was very time-consuming and unpopular due to the unpleasant odors it produced.



Job scheduling department



Export department



A "boss" receives a report by telephone.



Company office

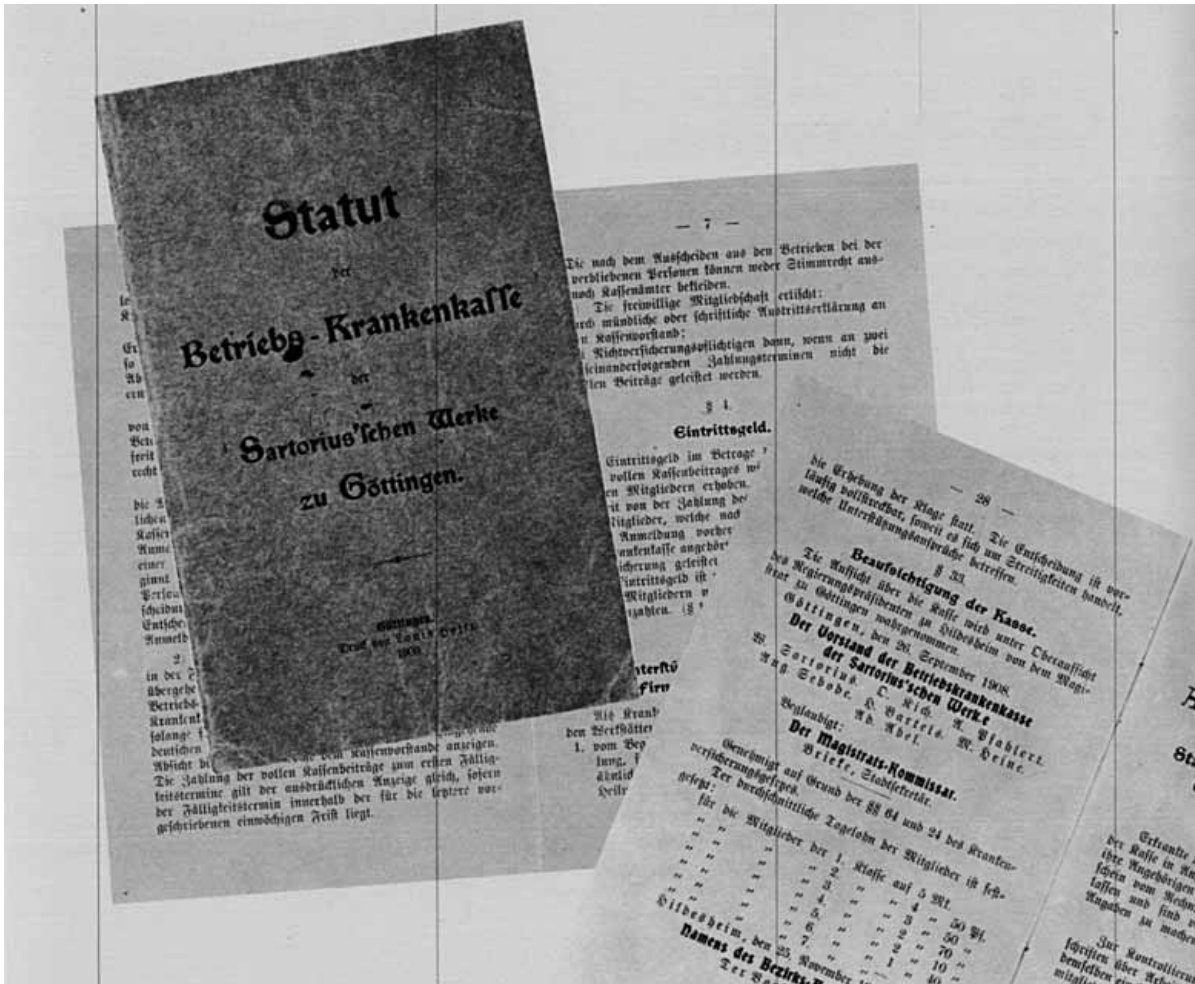


The classic drafting room in 1965; the designers wear white smocks.



Purchasing department

The classic social conflict between blue-collar and white-collar workers never really played a great role among "Sartorians." Because of the company's international reputation as a supplier of top-quality technical products, cooperation between technical and commercial staff was also constructive, as employees in administration and in sales and marketing highly respected their colleagues in production. The administration offices were furnished to be practical.



Statute of the Sartorius health insurance fund in 1909

Today, the Sartorius company health insurance fund, the Betriebskrankenkasse, is based in the building next to the company cafeteria. Although the Sartorius Betriebskrankenkasse that was founded in 1909 after merging with other schemes in the region now bears the name "BKK Technoform," the tradition of company health insurance is still upheld at Sartorius. The company has therefore looked after Sartorius employees for almost 100 years through the BKK.

Identification of “Sartorians” with Their Company and the Management

In times of great need, people learn that solidarity and teamwork help everyone. Sartorius employees from the post-war period all experienced this time differently in their private lives. Many employees came from the rural surroundings of the town.

Some of them also made a living from agriculture. They would offer their farming produce for sale to their colleagues at Sartorius.

The zone border between Eastern and Western Germany ran through Eichsfeld, the area southeast of Göttingen. This eventually became the Iron Curtain, which then posed its own problems.

The residents of Göttingen might have had a room to let in order to earn extra money. Everyone did what he or she could to get organized again.



This washroom was established during the '30s. Often, these circumstances were significantly better than in most people's homes directly after the war.

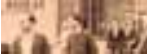


Factory cafeteria at Weender Landstrasse; the "factory chronicle" can be seen on the walls (1965).



The Sartorant cafeteria has been a modern, appealing restaurant since the '90s.

The factory cafeteria, "Sartorant," is located at Weender Landstrasse in an old half-timbered house. There was originally an independent tavern here, where "Sartorians" often spent part of their pay on beer. It is reported that Horst Sartorius had a certain level of understanding for this use of funds – lively celebrations were always held at Sartorius – but that he was annoyed that the revenues did not stay within the company. He therefore bought the tavern, along with its clientele, and turned it into an attractive factory cafeteria. Due to his love of Tegernsee in Bavaria, the range offered was extended to include his favorite Bavarian beer and radish. We have no evidence that this establishment was also used to monitor "internal company matters" besides to recycle Sartorius wages and salaries.



In this social environment, working for Sartorius, a company that soon moved forward again, played an important role. A community of interests formed at Sartorius, which was motivated by success and in which most problems were solved without affecting employee morale.

Circumstances and skilled management had bonded the "Sartorians" into a team that achieved international success once again. To use two simple sociological expressions to describe this, a strong sense of "belonging to the same stable" and a unique "pecking order" developed.



A wide range of food and drink to choose in the days of the '50s



The Christmas party for the employees' children has a long tradition at Sartorius; some of them became future "Sartorians" already at this tender age.



The Sartorius cafeteria shop based its assortment of wares on the wishes of the "Sartorians." Eichsfelder Wurst, a famous salami-type sausage from the region, was also available here.



A book should perhaps be written on the details of the formal and informal networks at Sartorius sometime. We can only give a few impressions here. However, one thing is certain: no matter how tough things were, Sartorians always found a reason to celebrate together.



The Sartorius music band "Sartoriana" strikes up ('50s).

The company's 100th anniversary in 1970 was to be a big occasion to celebrate with both employees and friends of the company. As the "Sartorians" often found opportunities to celebrate, it comes as no surprise that they formed their own music band recruited from members of the workforce, which often provided the ambience. This was good because it strengthened the bond between the members of the workforce, thus helping them to carry the company through good and bad times together.



Jevgeni Yelomolajev, Secretary of the Soviet Union FONDA-MIRA foundation, awards Horst Sartorius with the peace prize (Moscow 1985).

The Sartorius production range was streamlined during the '70s and focused on the core areas of expertise in weighing technology, membrane filter technology and hydrodynamic bearing technology. Microtomes and dust monitoring equipment were discontinued, following suit of the egg incubator business that had been stopped in the '50s.

Horst Sartorius received many national and international awards and distinctions during his forty years of service at Sartorius. He was particularly proud of the German Grand Federal Cross of Merit ("Bundesverdienstkreuz"), honorary citizenship of the university and city of Göttingen and high-ranking Polish and Russian medals of honor. A modest man, typical of the Sartorius family, he always considered it important that his success be viewed as the success of his company and his employees.

After his attempts to find a successor from his family to run the company proved to be in vain, Horst Sartorius eventually came to the conclusion that the future development of the company could only be secured if the firm was transformed into a public company listed on the stock exchange. Therefore, Sartorius went public and became a joint stock company once again in 1990. The major shareholder Horst Sartorius continued to take an active role in the company as Honorary Chairman of the Supervisory Board until his death in 1998.



Horst Sartorius at a ceremony in the Altes Rathaus (Old Town Hall) in Göttingen to celebrate his 85th birthday



Roses from MNTK, Vladimir, USSR, for the father of membrane filtration, Prof. Richard Zsigmondy (1987), Göttingen cemetery





Evolving from Weighing Technology to Mechatronics

- From craftsman's workshop to industrial enterprise
- "Smoke is coming from the chimney," ergo business is booming
- Assembly line production
- Hydrodynamic bearing technology
- Introduction of electronics
- A learning organization
- Moon rock samples in the Sartorius laboratory
- Monolithic weigh cells
- Process engineering solutions

Advanced Sartorius analytical balances can communicate with PCs via WLAN.

Sartorius has come a long way with regard to technology. In his previously mentioned memoir, Otto Berendsen⁹ describes the equipment and condition of Sartorius's production facilities as follows:

"Since 1898, Sartorius has created a magnificent establishment for balance production in front of the Weender Gate in which all machines are run by a 16-horsepower, gas-powered machine (with a Dawson gas engine). In addition to the actual mechanical workshops, which are extensive, special machine rooms have been set up especially for the production of all the tools (such as screws, drills, milling cutters, etc.) that are required in the manufacture of Sartorius products. Next to these rooms are carpenter's workshops equipped with modern planing and cutting machinery and similar tools. This is where the housings for the balances are produced. In the mechanical workshops, the division of labor principle is strictly enforced, which enables Sartorius to deliver completely accurate, excellent products at relatively inexpensive prices. Annexed to these mechanical workshops are halls in which balances are assembled, calibrated and adjusted. Of course, there are also rooms designated for painting, gold-plating and nickel-plating, in addition to other processes.

This factory is located in the city of Göttingen, Germany, and is run by the two elder Sartorius sons. Another plant that I mentioned previously is similar to this one and is located outside in Rauschenwasser. Here, Mr. Florenz Sartorius senior himself is in charge, and he personally manages and oversees the construction of the egg incubators. For the production of these units, fantastic carpentry and plumbing workshops have been set up, featuring the most modern machinery. Of course, an extensive mechanic's workshop is also on-site, in which not only all the fine mechanical parts of the incubators are produced, but also certain processes for the manufacture of balances are performed. In addition to a gasoline-powered engine, a hydropowered generator is used here to run the machinery. In both factories, 90 to 100 people are employed. The number of balances produced each month is 70–80; the number of egg incubators, 30 to 40."

⁹ Berendsen (1900)



Sartorius letterhead from 1899

The letterhead on the company stationery from 1899 provides some insight into what the factories were like at that time. In contemporary style, the stationery depicts several awards that Sartorius had won at international fairs alongside pictures of the factories with many smoking chimneys. At that time, smoke coming from chimneys was a sign of industrial activity in the sense of "if smoke is coming from the chimney, the company is active and business is booming."

In its thirty years of existence, Sartorius evolved from a pure craftsman's business into what would have been considered the most modern industrial plant in those days. It is interesting to note that all work was done in house, with the exception of certain specialized tasks and divisions of labor within the company's own group of businesses. The broad spectrum of competencies within the company was remarkable: experts in all handicrafts and technologies were employed here, ranging from all forms of metalworking in the company's own foundry, to a milling shop and lathing shop, as well as electroplating, a paint shop and in-house tool manufacture, culminating in woodworking and, particularly, the production of top-of-the-line housings made from exotic woods.



In 1936, technical employees proudly present their 40,000th balance.



In 1939, Sartorius completes its 50,000th balance in the history of the company.



Abt. Geo-Zusammenbau

Assembly of geodetic instruments



Polishing agate knife edges and bearings for balance beams

From today's point of view, the working conditions under which such world-renowned, high-quality products were manufactured were amazing: the extensive vertical range of manufacture inevitably led to certain areas being exposed to considerable levels of temperature, dust, noise and vibration, while especially in the calibration and adjustment rooms, extreme concentration and precision were required.

Photos taken of the factories at the Weender Landstrasse and Rauschenwasser locations and dating back to various periods depict the manufacturing conditions of the time far better than any description could.



Crucible furnace in the foundry



Microtome production room



Electroplating room



Balance assembly and adjustment room in 1934



Tool production



Balance housing polishing room, 1930

Carpenter's workshop at the
Rauschenwasser factory in 1898 ▶

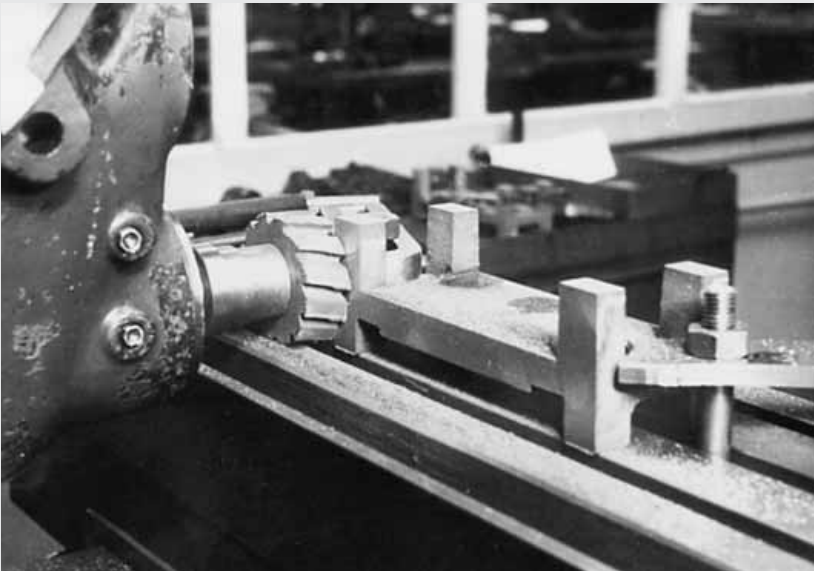
Production in Rauschenwasser

In 1938, Erich Sartorius received a photo album from his sons Fritz, Hans and Horst to commemorate the production of the 50,000th analytical balance. This album still exists today. We have compiled the following sequence of pictures using the album and translations of the original captions.





A foundry was also located at the Weender Landstrasse factory.



Milling base plates



Polishing agate components



Machine room for metalworking



Production at the Weender Landstrasse Location

The photos from the factory located on Weender Landstrasse come from highly diverse sources and different periods. In the manufacture of mechanical analytical balances, one particular specialty area was the production of knife edges and bearings from agate. Individual precision mechanical components were made of various metals and alloys. Above all, parts that came into direct contact with products were sometimes plated in platinum or gold and underwent an involved polishing process.



Attaching the reading scale



An employee calibrating and adjusting
a SELECTA series balance

Quality control of individual parts
under the microscope ▶





Assembly, calibration and adjustment of analytical balances in 1954



Assembly Line Production

Berendsen's statement, "In the mechanical workshops, the division of labor principle is strictly enforced," leads us to believe that even back then, larger series of balances were assembled in a manner similar to the assembly-line production of today. This was a logistics concept that was still viewed as economical and beneficial to product quality in the '70s.

However, we know from reports given by former employees that this type of labor was probably only related to the manufacture of balance components, while the assembly of mechanical analytical balances in the classic design was always a job for highly qualified "master craftsmen" who built "their" balances entirely and "immortalized" themselves by engraving the manufacture date and their own initials underneath the right-hand weighing pan. This integration included not only the mechanical parts of the instrument but also the balance housings, which, to some extent, were made of superior exotic woods.



An employee performs calibration and adjustment on a model DP3 analytical balance.

Here, all facets of the traditional precision mechanic's skills were required. This way of working, however, led to the master being personally responsible for his product, which did not allow for any concessions with regard to the quality of the product.

Despite this manner of working, employees were paid at piece-rate. However, one might suspect that something was odd about the overall numbers because the tradeoff between extreme quality demands, on the one hand, and compliance with stipulated timelines, on the other, was certainly recognized at that time as well.

Reports about the role of the REFA¹⁰ timekeepers and the tricks the skilled workers used to come up with to meet their target "times" bear witness to the priorities of company management in those days. It is very clear that the strict quality demands on Sartorius products took precedence in every case.

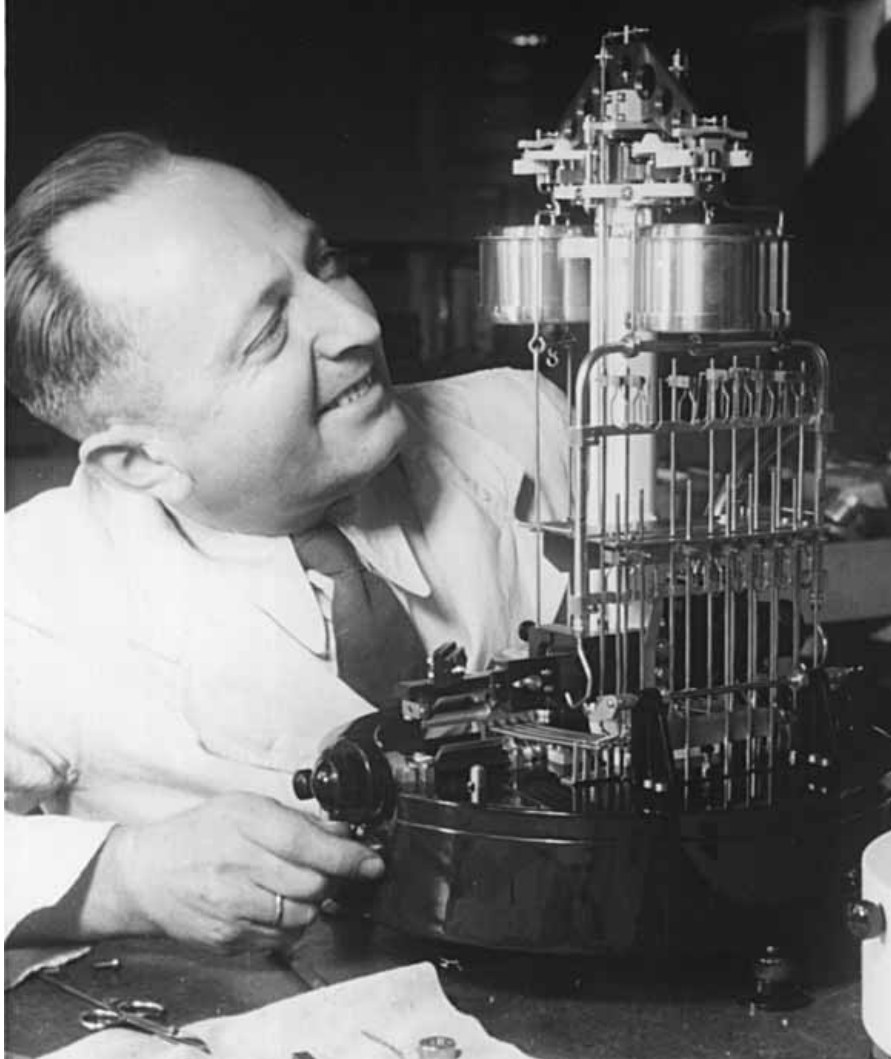
"Balance inspection," during which finished products were checked and approved for delivery, was a very crucial procedure in the course of business. It also reflected directly on the performance and, therefore, the reputation of the craftsman involved.

The "lord and master" calibrators and adjusters also occupied a special place in the hierarchy of the business. Using weights verified for legal metrology (in addition to a great deal of skill and expenditure of time), their assignment was to calibrate and adjust every balance so that the weights measured were displayed accurately and the results could be reproduced.

¹⁰ German Association for Work Studies and Manufacturing Organization



Assembly line production of precision balances



Assembly of a SELECTA series balance

A translated excerpt from the 1953 company brochure, which was previously quoted:

SELECTA fast analytical balance featuring "Standard," "Rapid," and "Semi-Micro" models. An instrument that meets all the demands of modern weighing technology. Fully mechanized placement of weights on the weighing pan and projection readout in one viewing direction. Easy to operate.



With the SELECTA series, assembly line production was increasingly introduced into balance manufacture in the '50s. Photos from the '70s show balances moving along assembly lines past individual assembly stations where certain components were installed on the units.

However, the assembly line did not dictate the speed of the individual production steps – as one would expect. Instead, a balance would only be forwarded on to the next station on the assembly line once a particular production step had been completed. Therefore, the assembly line adapted to the speed of the employees. The effects on process organization were positive, but the employees needed time to get used to this new way of working. At the individual assembly stations, only certain assembly steps were performed based on the division of labor. For many skilled workers, this was not challenging enough.

However, it remains clear that "Sartorians" and Sartorius management were not willing to make concessions in the quality of Sartorius products due to time constraints or deadlines.



In 1958, Sartorius produced its 100,000th analytical balance. This SELECTA balance featuring gold-plated operating controls is showcased today in the collection of balances at Sartorius College in Göttingen, Germany.

Incorporation of Hydrodynamic Bearing Technology



This brochure was published in 1998 for the 50th anniversary of the company. It contains interesting details about the development of this field.



From Sartorius trainee to production manager for hydrodynamic bearing technology; more than 45 years of service with the company (photo from 1958 in the lathing shop).

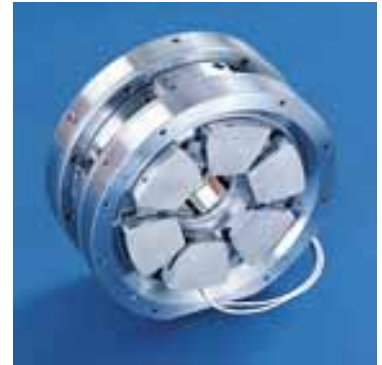
The history of hydrodynamic bearing technology in Göttingen began in the '30s when Dr. Wilhelm Frössel, the theoretical father of the "multi-lobe hydrodynamic bearing," began experiments on hydrodynamic lubrication procedures at the Max Planck Institute for Flow Dynamics Research in Göttingen.

After the Second World War, Nobel Prize winner Otto Hahn became the first president of the Max Planck Society based in Göttingen. In this capacity, he negotiated with Horst Sartorius about an exclusive manufacturing and marketing license for these hydrodynamic bearings. This led to the founding of the private limited hydrodynamic bearing company "Gleitlager-gesellschaft mbH" in December 1948. For Sartorius, this product line was especially attractive because the production of hydrodynamic bearings required the same manufacturing skills in principle as did the manufacture of mechanical balances according to the design of that time.

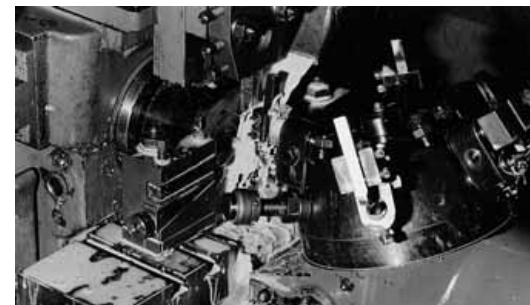
The hydrodynamic bearings business, especially for turbochargers, large stationary diesel engines, gas turbines, ship engines and similar applications, was developed systematically at Sartorius. Characteristically, construction details had to be defined in close contact with the customer, a policy continued up to the present. Then as well as today, a made-to-order bearing is produced.



The hydrodynamic bearings business area was organized as a separate legal corporate entity called "Sartorius Gleitlager GmbH," a limited liability company. Like the membrane filter company "Membranfiltergesellschaft m.b.H.," this firm was first merged with the Sartorius factories in 1978 to form Sartorius GmbH. Since then, this merged business area has been spun off again as a subsidiary, Sartorius Bearing Technology GmbH, on account of its special product portfolio and associated applications.



Compressor combination bearings (thrust/journal/thrust) with equalizers for high-speed compressors.
End user: Atlas-Copco Energas



Where capstan lathes were used in the past, complete machine centers stand today.

Introduction of Electronics into Weighing Technology

The most dramatic and riskiest business decision made in the history of the company was the introduction of electronics into weighing technology.

While the term "electronic weighing" was already commonly used in America at the end of the Second World War, in Göttingen efforts were being made to re-establish the production of conventional mechanical balances in wooden housings. However, prototypes of electromagnetic force-compensating (EMC) balances and scales were showing promise at the same time. The "coil-magnet principle" had been known for centuries, but had not found specific use in the industrial sector.



Elektrono 1 nicknamed
"the Anhalter train station";
year of manufacture: 1954

A "registering microbalance" that had already been described in 1944 by R. Vieweg and Professor Th. Gast was now being produced in small series by Sartorius in 1954. The "Elektrono 1" – also referred to in laboratory jargon as the "Anhalter train station" (after the train station in Berlin) because of its unusual housing geometry – was ideal for scientific applications. It featured a torsion-band quartz beam and could display results for applications such as oxidation, absorption and diffusion processes in the microgram to ultra-microgram range up to a 25-g maximum capacity readable to 1 g. Results of rapid process sequences could easily be documented via the analog data output port. Very soon afterwards, vacuum and high-pressure versions of this electronic balance were produced.



Further developments led to the creation of the 4100 and 4400 model series in which torsion beam weighing systems stood the test of time. The design of these models did not even have to be changed for years. By contrast, however, the control and evaluation electronics were constantly adapted to the latest technology, which evolved from voluminous tube amplifiers to electronic modules equipped with semiconductors all the way to microprocessor-controlled electronics in the early '80s.

Today, the vacuum- and high-pressure versions of these balances, in particular, are appreciated by scientists and students in many research and scientific laboratories around the world.

With the production of this electronic microbalance, the research and development department emerged from the electronics workshop in the '60s as an extension of the mechanically oriented design engineering department, with specially skilled personnel. However, it was expected to take years before the EMC principle would be encountered again in the precision and analytical balance sector, where the mechanical triple-knife edge principle dominated until late '60s. Finally in 1960, Sartorius adopted the substitution method with an asymmetrical double-knife beam system (2600 series), which had been known since the 19th century. This method was also quickly adopted by the more extensive top-loading precision balance market segment (2200 series). Time-intensive balance operating routines were performed by qualified laboratory employees (almost every weighing procedure required manual operation of the weight application mechanism and the fine-adjustment micrometer knob).



Vacuum ultra-microbalance;
year of manufacture: 1962; weighing
capacity: 3 g; readability: 0.1 µg



Precision balance 1264 004 (display
model with plexiglass cover);
year of manufacture: 1977; weighing
capacity: 2,200 g; readability: 0.01 g

Over many decades, the Guinness Book of World Records has listed a Gast nanogram version built by Sartorius as the most accurate balance in the world.



Electronic ultra-microbalance;
year of manufacture: 1974;
capacity: 3 g; readability: 0.3 μg

The force compensation measurement principle, which had been used for measuring small masses up to this point, was now carried over to the tried and tested mechanical precision balances with higher weighing capacities (series 3100 in 1963). Readouts were still analog, but measured values could also be transmitted to x-y recorders and printers, controllers and display units for documentation purposes. In this way, registering weighing systems were available to help automate laboratory and production processes.

At the same time that these developments were taking place in the precision balance sector, analytical balances that were still knife-edge-supported were being converted to the coil/magnet system in the mid-'60s. However, it was still necessary for weights to be manually switched in higher load ranges.

In 1971, weights were determined fully automatically over the entire weighing range (from a maximum capacity of 150 g, readable to three decimal places, to 6,000 g, readable to one decimal place) on the 3000 series of precision balances.



Within a few seconds, weights were displayed digitally and made available for further digital processing without additional operating steps. This simplified the weighing procedure considerably, which greatly reduced weighing times.

The combination of the mechanical weighing function with (opto-) electronic readout and processing of weighing data is referred to as a hybrid balance. Today, you can still run across these in industrial areas. Processing electronics that featured transistor-transistor logic (TTL), which were modern in those days, accounted for about one third of the volume inside the balance housing. This led to a considerable build-up of heat, which had to be offset through temperature-compensating measures inside the balance.



Electronic analytical balance, model 2003 MP1 (with the top cover lifted);
year of manufacture: 1977;
capacity: 160 g; readability: 0.01 mg



Precision balance, model 3713 MP;
year of manufacture: 1977;
capacity: 3,000 g/300 g;
readability: 0.1 g/0.01 g



Electromechanical precision balance
"Sartomat"; year of manufacture: 1978;
capacity: 160 g; readability: 1 mg

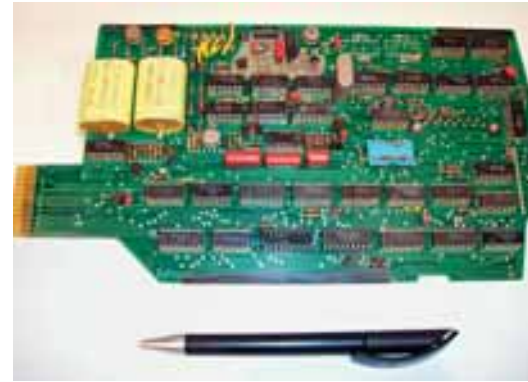
In 1975, mass production began on the first "real" series of electronic precision balances, the "3700 C-MOS." Despite a retail price that was twice that of a comparable mechanical balance, users worldwide recognized the significant reduction in weighing time, user-friendly operation and, to an increasing degree, the availability of digital interfaces. Alongside an attractive model series with various weighing capacities, an extensive range of accessories emerged as well. Interface converters enabled the most diverse data processing devices to be connected to the balance. In a very short time, more balances with market-dominating designs were launched.

In 1976, Sartorius was again the forerunner in the field of weighing technology when it introduced the first industrially manufactured microprocessor (in the 4000 series). Reliability was increased as more and more components continued to be integrated, and the user-friendliness and measuring accuracy of the balances were considerably improved through automatic calibration of the weighing range. The requirements for electronic balances and scales that were specified in regulations for legal metrology were fulfilled as well.



The 1200 MP series of precision scales (which was advertised as being smaller than an A4 or 8.5" × 11" sheet of paper) debuted in 1977 and featured a microprocessor manufactured especially for Sartorius that already covered the capacity range of 80 g, readable to four decimal places, to 4,000 g, readable to two decimal places. The 2000 MP series of analytical balances, developed at the same time, set – and remained – the standard for years in the analytical laboratory. In 1977, electronic balances and scales already accounted for 50% of the total production at Sartorius.

The yellow color chosen for balance and scale housings in 1975 gave these Sartorius instruments a familiar appearance for almost 20 years. In 1990, Sartorius set another milestone in weighing technology: quality-defining components – such as A/D converter, EEPROM and balance processor – were made to fit all on a single chip that had been developed in cooperation with Texas Instruments, the MC 1 microcontroller. This tremendous integration of functions once again minimized the size of the balance electronics. Built-in, user-oriented operating programs opened up additional application areas in the laboratory and industry (e.g., density determination, formulation, counting and statistics programs). Modern service software (Computer Aided Service [CAS] software) made it possible to diagnose, calibrate, adjust and document data from balances and scales worldwide in the exact same way as in actual production.



The constantly increasing capacity of integrated electronic components delivers more and more performance while allowing ever-shrinking designs and production costs.

Today, the Sartorius product portfolio ranges from the ultra-microbalance to the 100-ton capacity weighing system for use in manufacturing plants and production lines. In addition, requirements in the chemical and pharmaceutical industries and other areas are being fulfilled with increasing accuracy. This "triumphant conquest by electronics" in the field of weighing technology, which from today's standpoint is inevitable, is comparable to application areas like the clock-making or camera industry, where German manufacturers that originally led the market could not hold their international position.



From a 1975 photo album, unfortunately without exact dates

Taken from an internal report to company management in late 1975:

“With the drastic changes in production have also come some significant personnel problems. Production is no longer defined by our reliable precision mechanics but much more by the electronics technician. This is an unfortunate situation for those senior employees who no longer can or want to work with the new technology. However, we were glad to hear that some of the more seasoned employees were able to be transferred to the electronics department during the last months of 1975.”



We should not underestimate the fact that the company has undergone an entire range of changes that can only be outlined here:

- A team of employees who could assess the new technology had to be formed to implement it in balances and scales for various applications.
- A decision had to be made that Sartorius would no longer dominate the entire manufacturing process by itself as it had in the past, but would be dependent on suppliers of electronic chips.
- Even more important was the decision that Sartorius should form its own development team of electronics experts who would be able to work successfully with suppliers.

Both technologies, i.e., mechanical scales featuring a field-proven design and electronic balances, had to be produced and marketed simultaneously for a long period until the acceptance of these new electronic products on the market allowed the old technology to be discontinued.

This transitional process created tension among staff at an organizational and social level and, in turn, placed enormous demands on the company's ability to learn and adapt. This was a concept that only later was to become highly significant in economical literature: "the learning organization."

Moreover, the financial contribution for this project was so large that other projects at the company had to take a backseat. This phase was also accompanied by additional technological evolution, such as the replacement of the classic wooden housings on analytical balances by metal housings and the associated consequences with regard to employee qualifications.

Sartorius passed this probationary period with flying colors and was able not only to maintain its international reputation for quality products at the highest level but also to expand it.



The Gravimat team

A great moment and turning point for Sartorius weighing technology

In 1969, a very special assignment that was performed in the technical application laboratory at Sartorius caused a worldwide stir. Apollo 11 had collected samples of moon rocks during its moon mission, and NASA made sure that only the top scientific institutes in the world could conduct experiments on this extremely rare material. At Sartorius in Göttingen, the absolute surface of 20.2 mg of moon material was measured. The Sartorius Gravimat weighing system, which had a level of precision that was only attainable in Göttingen, was used in this analysis.

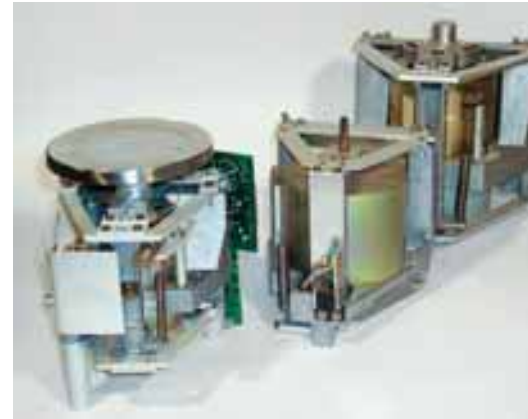


Introduction of Monolithic Weigh Cells

From the very beginning, the heart of a Sartorius analytical balance had been its mechanical components. The production of individual parts, subsequent processing of these parts into precision components and the assembly of a functioning system placed the highest demands on skilled technicians and justifiably provided the basis for pride in their work. With the introduction of the first machining centers, the number of hours spent manufacturing a product could be reduced considerably, while the quality of the product could be improved and costs reduced.

The diverse materials used in the manufacture of individual components presented an additional problem. Within the scope of the entire weighing system, varying performance properties of the materials under fluctuating operating conditions (e.g., temperature) created sources of error that required elaborate control.

Only once monolithic weigh cells (intricate lever systems cut from one metal block) were used in semi-micro- and analytical balances in 1994 was quality significantly increased while costs were, in turn, decreased. This was based on continuous research and development that spanned decades.



Weighing systems of electronic balances in conventional designs, 1975 – 1982



Precision measurement of system supports



promet

promet

promet

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Above all, close cooperation with the manufacturers of the machining centers used by Sartorius was essential to this successful development. Complex solutions of this kind are only possible through mutual efforts when the manufacturer of the machinery knows exactly what Sartorius needs and, vice versa, Sartorius understands precisely what the particular manufacturer can provide. This includes the manufacturer responding immediately to problems at the center by providing competent customer service, since downtime of these expensive machines naturally has to be prevented.

Today, fully automated machining centers manufacture complete subassemblies out of semi-finished products in less than an hour. Previously, it would have taken several employees to assemble these from approx. 100 components. At the same time, costs have been reduced and the quality of the product dramatically improved. In the process, the R&D, production, and quality control departments can constantly monitor electronic data to ensure that all production parameters, such as tolerances, are observed. It goes without saying that error messages are generated automatically.

These highly integrated components have made modularization of production possible in various international locations.

◀ Today, fully automated machining centers define the manufacture of components in the Mechatronics Division.



Monolithic weigh cells



The control panel of a machining center





Process-Engineering Solutions

So far, we have mainly traced the technological development of analytical balances as stand-alone instruments in various applications up to the standards of today. At the same time as this development has progressed, Sartorius has been playing a decisive role in shaping the process for integrating weighing equipment into manufacturing processes. The following example describes this development:

A multitude of modern automobiles in trendy colors can be found on our streets. If the body of a car needs to be repaired and repainted, of course the exact, original shade of color should be restored. Sartorius paint-mixing scales make this possible.

In cooperation with leading paint manufacturers, Sartorius has developed special scales with electronic programs that can retrieve the original formula based on the first date of manufacture.

The scale then controls the composition of the required amount of paint from the standard components that are available. When these programs were being written, it became clear that a higher level of precision could be attained on the basis of gravimetric (weight measurement) methods as opposed to volumetric mixing.

Of course, a great number of other process solutions were developed based on these experiences. These processes now constitute a separate business area within the Weighing Technology Division, which has recently evolved into the "Mechatronics Division."

When individual components of a medicine are mixed together according to a formula in the pharmaceutical industry, utmost precision plays a decisive role in ensuring that the desired dose of active ingredients is added. At the same time, the manufacturing process must be documented so that individual ingredients can be traced within each batch of a product. Both of these requirements can be fulfilled optimally when scales for formulation are used that document every step of weighing with an article number, a batch number and an operator ID.



Gold and carat scales (one carat is equal to 0.2 gram) are a Sartorius specialty.

In July of 1986, a Sartorius 1858 MP8 carat scale was used to weigh, document and present the heaviest rough diamond in the world in those days, the Christ diamond. It weighed 889.70 ct, and its value could not be appraised at that time. A second weighing demonstration using a historical double-beam, two-pan balance (Sartorius DP3) compared the Christ diamond to a group of cut diamonds with an equal weight worth about ten million U.S. dollars. This presentation was given at the Senckenberg Research Institute and Natural History Museum in Frankfurt am Main – which is well known for its dinosaur collection – because diamonds formed at about the same time as the dinosaurs existed. The Christ diamond was not used later to make the largest cut diamond in the world – that honor is still held by the Cullinan diamond in the British crown jewels, which weighs 530.2 ct. Instead, the Christ diamond was cut into several gemstones, the largest of which at 378 ct was ranked highly among the world's largest diamonds. (By the way, the diamond in the photograph is a copy. For security reasons, we were not allowed to photograph the original.)



Another typical example of how weighing systems are used involves checkweighers that perform average weight control of parts within the scope of quality control or monitor filling procedures to ensure that quantities filled are correct according to prepackaging regulations or those for checking the accuracy of net content statements on packages.

Process solutions involving weighing technology have also been successful in the Biotechnology Division: within the context of upstream processing in fermentation, the exact dosage of added culture media is critical. For this purpose, the entire fermenter or bioreactor is mounted on weigh cells that can control the amount of added culture media much more precisely than would be possible via volumetric control of the feed pumps.



Average weight control of butter at a dairy in the '70s

Any fan of modular furniture knows the frustration of not being able to complete the assembly of a new bookcase because a connecting piece is missing from the bag containing the small parts. Since the respective furniture manufacturers began using precision scales to check the completeness of their small part assortments, this problem has been solved. The scale can determine exactly whether all pieces are included in the specified quantities, even if the assortment is made up of many different parts.





Evolving from Membrane Filtration Technology to Biotechnology

- The membrane filtration method
- Casting machines for membrane production
- Disposable filters
- From laboratory supplier to process and service provider for biotechnology
- GMP-compliant manufacturing
- Products resulting from synergies between mechatronics and biotechnology

Producing blood fractions at the Red Cross Blood Donor Service in Hagen, Germany



The Membrane Filtration Method



The employees at Membranfilter-gesellschaft m.b.H. saw themselves as a separate team.



The boss herself worked in the laboratory.



Right from the start, the company's commitment to quality assurance was reflected in samples retained from each production lot, batch traceability, data protection and trend analysis.

During the era from the Second World War to the '60s, the business of the membrane filter company Membranfilter-gesellschaft m.b.H. was significantly shaped by applications in the laboratory sector. This created positive synergy effects in sales and marketing within the Sartorius group of companies, because considerably congruent customer segments were addressed. The brochures issued by Sartorius-Werke A.G. therefore not only presented scales, balances and microtomes, but focused on the membrane filtration method as well.

The new international distribution network set up at this time by Sartorius was also generally responsible for representing Membranfiltergesellschaft m.b.H. At trade fairs for laboratory supplies and equipment, all products offered by the Sartorius group were always exhibited simultaneously. During that time, a great deal of attention and support was given to the newly emerging laboratory dealers and distributors.

In the '60s, the introduction of electronics into weighing technology put an extreme strain on resources at the Sartorius group, particularly in terms of finances and personnel, pushing everybody to their utmost limits. (To read up on more details, please refer to the chapter "Introduction of Electronics into Weighing Technology.") As a consequence, the profits meanwhile being generated by Membranfilter-gesellschaft m.b.H. were fully utilized to finance this project.



From the perspective of the membrane filtration business, this was all the more painful as, exactly around this time, major breakthroughs were being achieved in industrial process-scale filtration applications. Membrane filtration established itself as a "cross-sectional" technology in innovative markets. In this context, the semiconductor industry played a decisive role, where the production of initially discrete, and later integrated, components made it necessary to implement previously unheard of cleanliness levels for the production environment (cleanroom technology) and process media (water for cleaning steps, chemicals and process gases).

Initially, Membranfiltergesellschaft m.b.H., which had thus far concentrated strongly on the pharmaceutical, medical and food sectors, was not able to shape developments in this field of electronics for lack of resources. Instead, competitors, particularly from the U.S., established themselves as leaders of this technology.



Test filtration in the laboratory

Back then, when asked by a business friend from the cleanroom technology sector, "Can Sartorius also supply filter cartridges for DI water filtration in semiconductor component manufacturing?" the sales and marketing manager of the membrane filter company responded, "The development side of the program is finalized, but there is currently no budget available for implementing it into the production stage. In the Weighing Technology Division, we are now rolling out electronic scales and balances; this is turning the whole company upside down, and every mark earned is being channeled into this fascinating project."

Nevertheless, in its home markets – the pharmaceutical and beverage industries – Sartorius did achieve important breakthroughs, notably the first "plate-and-frame" crossflow ultrafiltration system based on Professor Strohmeier's design for processing relatively large volumes, which was introduced already in 1969. This technology opened up new possibilities for harnessing knowledge in molecular biology and applications for removal of extremely small and harmful molecules, such as viruses and pyrogens from pharmaceutical products.

Groundbreaking work in the sterility testing of pharmaceutical solutions utilizing membrane filters (Schiller system) and on the characterization of sterilizing-grade membrane filters was carried out in cooperation with scientific institutes and the German pharmaceutical industry.

Around the same time, the first large-volume microfiltration systems for cold sterilization of wine were introduced. A new quality standard, particularly with respect to the shelf-life of wines, had become available, an application that Prof. Zsigmondy had already predicted in 1926 in his essay entitled "Von neuen Filtern" (About New Filters).



In the '70s, the applications laboratory was already excellently equipped; it also served as a training and education center for the company's employees and customers.



Development of Casting Machines for Membrane Production

As previously mentioned, membrane filters were originally manufactured by casting a solution of polymers and solvents on glass plates. Obviously, this method led to inconsistencies in product thickness and pore size. In this field as well, Sartorius was again a forerunner in the development of membrane casting machines for the industrial manufacture of filter membranes.

Although it was possible to borrow know-how from the production processes for paper and films, the production of porous, extremely thin films was something completely new. In this regard, the solvents involved in this process posed a particular problem, since they had to be effectively maintained in the machine to protect personnel and the environment. A team of chemical process engineers spent years working on the development of processes that guaranteed the homogeneous quality of the product and profitable yields while ensuring the reliable protection of personnel and the environment. Simultaneously, chemists were and are still doing their best to change formulas so that non-hazardous solvents can be used.

This is not the kind of technology you can buy off the shelf. Close cooperation among experts from the most varied of disciplines is the key to success here. In the days when membrane filters were still manufactured on glass plates, production was very dependent on the experience of the men and women employed in the processes.



A view across the control station on a membrane casting machine and vats containing casting solutions.





With the introduction of casting machines, it became necessary to explore the interdependencies between product properties and production parameters and to convert this knowledge into control systems that guarantee consistently stable products of specification-compliant quality. Today, our casting machines run nearly fully automatically, allowing the machine operators themselves to simultaneously carry out a good portion of the quality control tests on the product. In this way, they can determine at the earliest point whether all specification parameters are within the tolerances, or if any readjustments are required.

Naturally, these tasks are performed under the supervision of the Quality Assurance Department. Product releases are issued by this department only after all test reports and other batch records have been reviewed.

For the production of filtration membranes, Sartorius uses both the evaporation process (for cellulose derivatives) and the quenching process (for synthetic polymers and ultra-filters). Thus, an exceptionally wide spectrum of technical membranes is covered. In addition, Sartorius has proprietary methods for the surface modification of membranes, which are specifically utilized for the membrane adsorber product range. Particularly in this field, important new product solutions are in the pipeline that promise greater performance and easier use.



In the '70s, Sartorius membrane filters bore the logo of the Membranfiltergesellschaft m.b.H. Even then, the label on the packaging contained all the batch traceability information required under GMP regulations. The packaging was red. In the '80s, the more eye-catching yellow shade was introduced.

SARTORIUS iris diaphragm photometer



SARTORIUS iris diaphragm photometer, purchased in 1958;
1966 digital data printouts (punched tape); 1975 digital calibration;
1979 online connection to a KSR 4100 mini-computer

On November 28, 2005, Dr. Reinhard E. Schielicke of the Astrophysics Institute and the University Observatory of Jena gave a lecture at Sartorius College about Ernst Abbe. (Abbe studied mathematics and physics under Riemann and Weber in Göttingen from 1859–1861.) The first slide of the lecture showed a Sartorius photometer that was delivered in 1958 and that Dr. Schielicke had worked with in Jena for 15 years.

In the '50s, Sartorius had built up a product line of "dust monitoring equipment," including aerosol generators and photometers used to detect airborne impurities. As the synergies with the membrane-based detection method for airborne microbes did not pan out, this product line was phased out in the '70s.



The Road to Disposable Filter Elements

Originally, membrane filters were utilized as filter discs in reusable stainless steel filter holders. Before every filtration run, the entire filter holder had to be cleaned and/or sterilized – a time- and cost-intensive procedure. Beyond this, the performance of filter systems was limited by a maximum disc diameter of 293 mm, which was unsatisfactory, particularly in process filtration applications. This limitation was overcome by the use of cylindrical filter cartridges, with the direction of flow progressing from the outside to the inside, in stainless steel filter housings.

Sartorius was the first manufacturer of membrane filter cartridges with pleated media – i.e., arranged in a zigzag shape – a space-saving design well known in air filter technology. This innovation set today's standards for membrane filter cartridges that are still state-of-the-art today. The challenging aspect was to find a construction that could be sterilized in-place. In other words, the filter cartridge, installed in a stainless steel filter housing, would be steamed for a longer period at a temperature exceeding 121°C, cooled down and used at room temperature without damage to the filter and/or gaskets.



Final preparation and packaging ("confectioning") in the '70s



Filter cartridge production in the early '80s



Minisart® is the name of Sartorius syringe filter holders.



Capsules are filter cartridges incorporated into ready-to-connect polypropylene housings.

The next step consisted of incorporating the filter cartridge directly into a polypropylene housing and of sterilizing it in the final stage of production. These "filter capsules" can be used directly "out of the box" without preparation by customers, avoiding the use of filter housings. Sartorius achieved a similar development with filters usually used in conjunction with syringes. If necessary, these so-called syringe filter holders can also be packaged individually and sterilized.

Apparently, this trend could collide with the rightful interests of environmental protection, because the entire filter unit is disposed of after use. Yet extensive energy balance studies have shown that the total energy and water consumption is clearly much higher when filter discs in combination with reusable filter holders are used compared with disposable filters. Likewise, the reuse of the filters is not justifiable because one fundamental element of GMP regulations is the avoidance of cross contamination between production batches.



From Laboratory Equipment Supplier to Process and Service Provider for Biotechnology

Up into the '70s of the last century, Sartorius products – both in the Weighing Technology and Filtration Technology Divisions – were essentially laboratory products. Accordingly, the national and international sales and marketing network was systematically set up so that close cooperation with laboratory dealers played a key role.

While Sartorius subsidiaries were being founded in Europe, beginning with Austria, the Netherlands, Great Britain and France, sales and marketing agreements were signed with well-established organizations outside Europe, which were already supplying the laboratory sector with other products.

At the beginning of the '70s, it became clear that a huge growth potential for membrane filter techniques was emerging in the process sector. Requirements on the purity of media not only sharply increased in the semiconductor technology sector, but also in the pharmaceutical and beverage industries, accompanied by needs for higher flow rates achievable by filter systems.

This development was particularly driven by the fast pace of miniaturization in semiconductor component manufacturing along with the introduction of more stringent quality requirements (GMP¹¹). Membrane filtration systems are characterized by sharp cut-off rates and systems testability under operating conditions. Thanks to these features, this technology has become the state of the art in media filtration for semiconductor manufacturing and for sterile filtration in the pharmaceutical and beverage industries.

Within the scope of its membrane filtration development, Sartorius had already laid very solid groundwork for the successful implementation of sterile filtration systems. Through this process, the company learned that operating conditions vary greatly from product to product, especially in the pharmaceutical industry – conditions that must be intensively tested in order to verify that production processes reliably comply with product specifications.

¹¹ GMP = Good Manufacturing Practice for the production of pharmaceuticals, the pharmaceutical industry's philosophy of quality

Under these conditions, cooperation between suppliers and customers takes on a completely different meaning than that involved with the supply of standardized products. The supplier must have highly experienced applications specialists in order to develop the optimal solution for the customer's specifications. In collaboration with the German pharmaceutical industry, the experts in filtration technology at Sartorius accomplished important pioneering work on this subject and also actively contributed to the wording of relevant passages of GMP standards. This step was key to getting membrane filter technology established. At the same time, a qualified training center was built in line with GMP requirements, which, as a testimony to the state of the art, has made this technology accessible to both company insiders and outsiders.



Training course at the Biotechnology Training Center in Göttingen in 1990



As early as the mid-'70s, the sales volume in process filtration exceeded that of laboratory filtration. While cooperation with dealers has been of particular importance in the laboratory business, each process filtration customer has always required personalized support and custom-tailored advice. Sometimes, experiments and trials even have to be carried out to determine the parameters for designing a filtration system.

With the knowledge that the American pharmaceutical industry would play a commanding role on the global pharmaceutical market, not least because of the dominating role played by the FDA¹² worldwide, a technical office was opened up in California in the mid-'70s, which later became Sartorius Inc. This office was established with the purpose of building up a competent U.S.-based sales and marketing organization of its own for serving the filtration technology sector and for targeting the pharmaceutical industry.

In the '80s of the last century, the pharmaceutical industry started undergoing a process of extreme consolidation. The wave of mergers and acquisitions had led to the creation of global players, which were designing new elements for their corporate strategies. The concept of "time to market" was taking hold – in other words, shortening the time between new product development and getting it launched on the market. The definitive catchphrase was "pipeline," describing the long process spanning from drug discovery to marketing of the finished product.

¹² FDA = Food and Drug Administration, American supervisory authority governing the markets for foods and pharmaceuticals

The pipeline process is defined by individual phases that encompass the conduct of animal experiments, then the phase of clinical trials on patient populations parallel to the development of process-scale production facilities. In this regard, considerable time and effort goes into the validation of processes – i.e., proof that the product can be manufactured safely in every aspect, that its efficacy has been demonstrated and that side effects can be ruled out. Characteristically, the supervisory authorities responsible monitor this entire process, with the manufacturers continuously submitting reports and the authorities conducting approval proceedings.

Under the time constraints described, the definition of a company's proprietary know-how that had to be protected was often changed so that all steps in the long-drawn-out validation process for new products and the engineering of the process systems no longer had to be carried out in-house, but could be contracted out to competent suppliers.

These developments released new market potential for Sartorius, according to which the Filtration Technology Division's strategy was systematically aligned. This was also reflected in the renaming of the division to "Separation Technology." The aim was to make clear the programmatic nature of the move, which extended the spectrum of products and services offered to include systems engineering (the term "fluid management" was coined in this connection), a widened offering of validation services and training courses (FACTS) as well as a new membrane-based technology for the adsorptive separation of molecules (membrane adsorbers). All these additions to the portfolio were developed in-house. At the same time, additional target products were specified in a catalog of requirements to enable Sartorius to offer customers a complete range of process solutions from a single source.

When the year 1999 brought the opportunity for Sartorius to acquire the BBI subsidiary of B. Braun AG, Melsungen, the Number 1 in fermenter and cell culture technology, Sartorius was prepared to take a decisive step towards implementation of its strategy to becoming a process solution provider for the biotech industry.



For bioprocessing in the pharmaceutical industry, fermentation and separation technology constitute complementary steps, which means that customers reap major benefits whenever one supplier can provide the entire process solution. The customer obtains ideally coordinated process steps that, if desired, can be driven by one integrated operating control system. The system's development and qualification at the customer's facility as well as its documentation are greatly accelerated. The customer is spared the complicated process of integrating each of the separate process components.

This step was followed by a more delineated focus on biotechnological processes in the pharmaceutical industry at a time when public acceptance for "red" (medically oriented) biotechnology was growing as it had become clear that major advances in the diagnosis and treatment of previously incurable diseases could not be expected from the pharmaceutical sector without the use of biotechnology. Consequently, the division was again renamed "Biotechnology" to clearly signal the division's dedication as a supplier to this user group.



A BBI bioreactor is inoculated during the production of veterinary vaccines.

Setting Up GMP-compliant Manufacturing in the Biotechnology Division



Before starting work in the clean room, the employees put on cleanroom clothing (gloves and masks required) in special changing rooms.



On the way to a cleanroom workplace

The end of the '70s was when GMP regulations went into effect for the pharmaceutical industry and its suppliers. Regulated process sequences, formalized quality management systems, auditing procedures and batch traceability are just some of the requirements that characterize quality management in the pharmaceutical industry. Compliance with GMP requirements is inspected – i.e., audited regularly by national institutions – where, internationally, the American Food and Drug Administration (FDA) sets the standard.

Given their diversity, membrane filter products cannot be classified into one single field of application. However, Sartorius recognized very early and clearly in line with its pronounced focus on the applications of membrane filters that pharmaceutical customers would also expect their suppliers to comply with GMP requirements in their own production.

Accordingly, the organization of production, including quality assurance, was restructured to comply with GMP regulations, and the company's production facilities were equipped so that the products were protected against contaminants during manufacturing. At the same time, methods for product sterilization were introduced to allow them to be used in aseptic processes.



The introduction of these procedures naturally required that their effectiveness be demonstrated to the customers. In other words, the manufacturing processes were validated and documented on the basis of standardized methods pertinent to the respective applications. As a consequence, the next step was to obtain production certification from the German GMP authorities – which happened in the year 1987.

Since Sartorius does not supply pharmaceuticals, but rather products used for their manufacture, it was not possible to further expand GMP certification on legal grounds. As a result, in 1994, the division's Quality Management System was extensively restructured and certified on the basis of DIN EN ISO 9001.

The figure illustrates the road taken and where we are today. At the end of the '80s, it became clear that the possibilities for expanding the manufacturing facilities at the company's traditional location at Weender Landstrasse had been exhausted. To achieve sustained sales growth, a new location was opened in 1990 in Göttingen's industrial area, in the direct vicinity of the major German north-south freeway, A7. Here, the first construction stage included separate membrane production facilities that were built alongside the mechanical production plant for the Weighing Technology Division. This was the follow-up to the many years of development work that led to a completely new generation of membrane production systems. The new casting machines are capable of manufacturing products with considerably enhanced consistency. At the same time, the prerequisites were created for reproducible manufacturing of membranes with relatively large pores, required, e.g., for rapid diagnostic kits.



Individual testing of membrane filter cartridges



The "New Plant" ("Werk 2000"); first construction stage, 1990



The "New Plant" was a benchmark in environmentally friendly membrane production, as was demonstrated by a grant for the innovative solvent recovery system funded by the Germany's Federal Environment Ministry. The plant is equipped with facilities designed for the safe processing of all chemicals required. Measuring instruments monitor their use. If an accident ever occurred, the chemicals would be collected in a safety containment area within the building. Environmental contamination of air, soil and the groundwater is thus prevented.

In the first half of the '90s, this plant also started with the process-scale production of membranes based on the quenching method. This method is especially used to manufacture membranes from synthetic polymers like polyamide and polyethersulfone.



Second-generation casting machine based on the quenching method





In 2001, "Plant 2001" went into operation. Within this second construction phase, all technical departments of the Biotechnology Division in Göttingen were concentrated at one location. This investment released capacities that allowed sales to continue their vigorous upward trend, while enabling new pipeline products to be manufactured.

Above all, one of the main achievements of "Plant 2001" was a system implemented for the manufacture of membrane products that was compliant with the latest cGMP requirements (current Good Manufacturing Practices). Production takes place under classified cleanroom conditions; the rooms and machines comply with technical requirements for clean rooms, and all staff members wear standard cleanroom clothing. The production audits routinely conducted by customers from all over the world constantly reaffirm that manufacturing operations at "Plant 2001" are exemplary in every way.

Products Resulting from Synergies Between Mechatronics and Biotechnology



Treating a patient with kidney failure using the Sartorius Hemoprocessor®

In the '60s, Sartorius worked in very close cooperation with leading specialist clinics and hospitals to develop a range of hemofiltration products for patients with impaired renal function or kidney failure. The filter units involved in this process were crossflow-designed ultrafilters used in an extracorporeal system to separate human blood into its solid constituents (red and white blood cells and platelets) and blood serum in which harmful substances are present in solution. In this case, the filters featured a special design for dynamic ultrafiltration – a standard product of the Biotechnology Division.

Patients are treated by hooking them up to a Sartorius Hemoprocessor®, which channels off an extracorporeal blood stream, replaces the toxin-containing serum separated by the filter with an equivalent volume of substitution solution and then infuses this solution with the extracorporeal blood back into the patient's own blood stream. Substitution is carried out using two scales, which precisely balance the serum removed and the substitution solution added to ensure equilibrium. Both Sartorius divisions contributed their expertise to creating this product. Doctors have come to appreciate this treatment especially as it is gentle on their patients. Later, this product line was relinquished as part of the corporate realignment into core areas of expertise, because of the interrelated problems of product liability and the lack of a sustainable portfolio for the hospital care sector.

Another example of joint engineering products in mechatronics and biotechnology is the development of the integrity tester Sartocheck®. The integrity of membrane filters is tested by applying air under pressure to the membrane when wet and installed in a filter holder or housing.

As an established manufacturer of electronic instruments, the Sartorius Weighing Technology Division back then was naturally the ideal partner for developing the corresponding measuring instrument. The development of the Sartocheck® – notably in very close cooperation with a key customer – was a resounding success. After several further developments, today's Sartocheck® 4 continues to be the benchmark for integrity testers in the pharmaceutical industry.

Laboratories across a diverse range of specialties require water of a consistently high purity grade to ensure that the tests and experiments carried out are not distorted by impurities in the water. The arium® range is another example of a joint development project between the Mechatronics and Biotechnology Divisions: arium® is a ready-to-connect unit that uses normal tap water to produce water of the required purity grade in the quantities needed in any laboratory. Water quality is monitored constantly and, as required, documented. Depending on the application, different purification components are employed in order to keep the various grades of water within the specified tolerances. The arium® system is a new benchmark product in the supply of ultrapure water for laboratories.



Integrity testing of filter systems using Sartocheck® 4



These arium® systems produce ultrapure water.





Globalization of the Sartorius Group

- Changes in the markets due to globalization
- Customer orientation and proximity
- Globalization of the Sartorius Group
- Development of our electronic data processing platform
- Growth driven by own developments, acquisitions and strategic alliances
- International supply chain management
- International knowledge management
- The learning organization

"Plant 2001" viewed from the north:
Left: the laboratory building complex;
right: final assembly in the clean rooms



One element is a central thread woven throughout the history of Sartorius: the pronounced export orientation of the company. For a medium-sized firm from a small city like Göttingen, it is by no means a matter of fact that the company was able to do successful business with America already during its first years of existence and could immediately resume exports following the total collapse after the two World Wars. And Sartorius achieved this not only in European countries outside Germany, but also particularly in high-risk markets, such as North and South America, Russia, the Near East, Africa and Asia.

In addition to realizing growth opportunities, the company certainly recognized that only those who orient their business toward global standards and are successful in exports are immune from overestimating regional trends or fashions.



In the summer of 2004, a service employee at our Tokyo-based subsidiary sent an inquiry to Göttingen: "Did Sartorius supply theodolites in the past?"

He wrote an explanatory note accompanying his photo as follows:

"At the municipal planetarium in Akashi, historical instruments are on display. The second from left was used in 1928 to measure the meridian. This is an F. Sartorius theodolite from Göttingen, and it has a lens diameter of 37 mm."



We already discovered that the export organization had fanned out through Sartorius's own subsidiaries in key countries and commercial agencies in practically all countries of the world. Beyond this, the laboratory business, in particular, was sustained by close cooperation with national and international lab dealer organizations.

Not least, the company's export business was traditionally supported by regular participation in national trade fairs (above all, the ACHEMA in Frankfurt and the Hanover Trade Fair) and in international shows, symposia and specialist conferences. In this context, cooperation with important national and international regulatory authorities, associations and standard commissions was also part of these activities. The international ACHEMA trade fair has always been a milestone marking the presentation of new Sartorius developments.

In the key market of both the Mechatronics and Biotechnology Divisions, the international GMP regulations apply, in which the American Food and Drug Administration (FDA) plays a governing role worldwide. Thus, globally harmonized standards are given for products and quality assurance in the pharmaceutical field, and also directly apply to the food and beverage sector. Beyond this, these standards are recognized as a generally exemplary quality management system.



ACHEMA in 1974 in Frankfurt, Germany

The most important element of globalization that has come to dominate not only the pharmaceutical market is the growing concentration of suppliers through mergers and acquisitions, however. This development is considerably supported by the "pipeline," the development pattern of pharmaceutical products. As a rule, it takes at least ten years before these products are ready to be marketed, and double-digit amounts in the millions are spent before the first euro is generated from sales in the market. Only large companies can afford this.

As a consequence of this globalization, the customer needs of this sector of industry have substantially changed: activities are being increasingly outsourced; i.e., everything that cannot be made competitively by a company itself is procured from competent suppliers at global market conditions. Here, the following objectives play a special role: (1) time-to-market (acceleration of the pipeline), (2) procurement of complete production lines to reduce a company's own capital expenditures for engineering and validation, and (3) compliance with GMP requirements.

For suppliers to global players, this means that only globally operating companies that can offer locally competent services and responses to the objectives stated above have the opportunity of being accepted as preferred suppliers. This requires a consistent strategy and a "critical company size" in order to join the global players.

In the '80s, Sartorius grew so strongly that it became clear that its business could not be maintained within the confines of its traditional location at Weender Landstrasse. Following intensive studies to find an optimal location, the decision was made to build the first stage of the new plant ("Werk 2000") on the "greenfield site" in Göttingen's industrial zone. Initially, a plant for manufacturing mechanical components in the Weighing Technology Division and for producing filter membranes in the Separation Technology Division was built.



In the wake of progressive globalization, Sartorius then invested powerfully at the end of the '90s in order to continue growing, based on its own developments and the acquisitions of companies with products that complemented the Sartorius range, and to make its offer even more attractive to customers. The acquisition of Filtrak, Vivascience and B. Braun Biotech International reinforced the Biotechnology Division both in the laboratory range and in the process sector. The Mechatronics Division was expanded by the Scaltec, Acculab and Denver Instruments brand laboratory products. Essentially, the Sartorius industrial line was extended by GWT and Boekels.

The acquisition of the new Sartorius companies also brought substantial improvement in the export presence of both divisions, including manufacturing sites abroad. The individual acquisitions were possible under highly diverse conditions; the integration effort into the Sartorius Group was correspondingly complex. By nature, the economic success of the individual stages within our expansion strategy varied; in this way, the bottom line was that the Sartorius Group achieved its critical company size, enabling it to continue developing successfully under the conditions of globalization.

Perhaps we should add a few words at this point about the ethics of globalization: this process is often critically associated with "exporting jobs." Not least, our investment in Plant 2001 based in Göttingen, located in a country known for its relatively high wages, is proof positive that globalization has to be assessed in a differentiated manner.

At its Göttingen location, Sartorius has a long-standing team of knowledgeable, competent and loyal staff, and takes the opportunities available to cooperate with local technical and scientific institutes both in the development and training of junior employees.

For products that do not require extremely labor-intensive manufacture and are not bulky, the distance from a specific market plays a subordinate role. Rather, the motivation, quality consciousness of our employees and use of the most advanced technologies in production are decisive. These conditions apply to the majority of Sartorius products.



In Yauco, Puerto Rico, Sartorius produces membranes and filter elements for U.S. customers.



In Bangalore, India, bioreactors, fermenters and filter systems are manufactured for the Asian market.



In Arvada, Colorado, USA, balances, scales, moisture analyzers, pH meters and calibration weights are produced.

However, Sartorius also needs production facilities in close proximity to its customers. Therefore, the company also manufactures systems in India and the USA besides producing these in Germany. For the U.S. market, we manufacture filter elements in Puerto Rico, bioreactors and fermenters in Bethlehem, Pennsylvania, and laboratory instruments in Arvada near Denver, Colorado, USA; in Russia, Sartorius weights are manufactured, and in Beijing, China, we build balances and scales. In each instance, the technological core areas of expertise are contributed from Göttingen, Germany.

Upon the introduction of electronic data processing to the company, an expert department was set up to ensure smooth computing operations in the event of error messages or interference. Uniform EDP standards for the various applications of the group of companies were not launched until the end of the '70s; today, Sartorius is a reference customer. In recent years, our central IT department systematically dedicated its efforts towards networking all Sartorius Group companies on a common EDP platform to enable optimal flow and access of data throughout the entire Group.

Naturally, global sourcing is systematically performed in the procurement of components that are not manufactured by the company itself.

The Sartorius sales and marketing organization is, of course, globally set up close to our local customers. This includes our service bases as well as training and validation laboratories.



Sartorius customers have access to its expertise, no matter where they are located in the world, if not through its own subsidiaries, then through qualified representatives thoroughly trained by Sartorius and who can enlist the help of further Sartorius experts.

In dealing with customers – and it also goes without saying in dealing with people in its own Group – Sartorius has developed respect for the cultures of its partner countries, and is proud of its international network.

Sartorius College, officially opened in 2001, provides knowledge not only for the continuous education and ongoing training of its own employees. It also serves to train customers and partners from our markets in seminars covering both theory and practice. Above all, it is an important institution for technical, economic and cultural exchange within the Group, with business partners and the public. Thus, Sartorius College is available to the Göttingen University and other institutions and companies. Seminars and scientific congresses at Sartorius College have meanwhile become a "permanent fixture." Therefore, an extended range of training courses is offered to Sartorius employees, and the College plays an active role in the scientific and social communities.

Sartorius "exports" this form of knowledge management that we live by exactly as it does its products to the world. In America and Asia, corresponding centers are being built up. Today, Sartorius is a globally learning organization, whose heart beats in Göttingen.



In Bethlehem, Pennsylvania, USA, bioreactors and fermenters are manufactured.



In Beijing, China, Sartorius manufactures laboratory balances and industrial scales.



Sartorius College stands for knowledge management that we live by.



Pavilion at an agricultural exhibition (country fair) around the turn of the century



ACHEMA in 1930 in Frankfurt, Germany



In Bangkok in 1954



In Saloniki in 1955



Hanover Trade Fair in 1948



German Chancellor Ludwig Erhard visits the Sartorius booth in 1964 at the Hanover Trade Fair

Sartorius: A Regular Exhibitor at International Trade Shows



At the Medicina|Technika trade show in Zagreb in 2005



- Sales
- Production and sales



Sartorius Today

Today, Sartorius is an internationally leading laboratory and process technology provider with core areas of expertise in biotechnology and mechatronics.

Sartorius is a preferred partner to the pharmaceutical|biotech and chemical industries as well as to food and beverage producers thanks to our technological prowess, the outstanding quality of our products and services and our global presence as experts.

With over 3,700 employees and sales revenue of approx. 470 million euros, Sartorius has earned a top position in global markets.

Sartorius today means:
consistent focus on customers,
high innovative strength,
global presence and respect in
dealing with employees and
business partners.



The Sartorius Logo Changing with the Times

1912	1912	1929

1952	1954

1968	1970	1970



1929



1933



1936



1959



1960



1985



1994



2000



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