Friedrichs' Joints
Fritz Paul Walter Friedrichs (1886-1958)

There aren't many films based on chemistry. My favourite is the Ealing comedy "The Man in the White Suit", a dystopian story of an obsessive chemist who invents an indestructible fibre. Written before microplastics and industrial off-shoring, it eerily documents a by-gone age. The stark black and white photography captures misty urban-industrial landscapes, deep chiaroscuro shows factory interiors, and detailed closeups capture polymer processing and weaving.

In a key moment that chemists should watch in slow motion, a clutch of managers enters the technical laboratory of the factory. A slow panning shot reveals a world of volumetric glassware, and a chemist pipetting by mouth while others tinker with flasks and clipboards. In a corner sits a brooding apparatus featuring a glass spiral, glass tubes and flasks, accompanied by a peculiar bubbling musical *leitmotif*, at once mocking and sinister, and the obligatory dry ice "smoke".

What is striking is that even in the 1950s there is no sign of the standard ground glass joints – known in the UK as Quickfit – that are ubiquitous in our labs. Today we take these joints completely for granted. But their arrival took decades, from the first halting attempts to eventual mass production.

The rise of chemistry in the 19th century was made possible by the growth of a whole industry of glass equipment firms together with a cadre of highly skilled glassblowers whose work gradually shifted from ornamental work making chandeliers and wine glasses, to the technical. The origins of some of these firms can be traced back to the high Renaissance. Bohemian glass, from what is now the region straddling the Czech Repubic and Germany, was particularly prized, but specialist scientific glassblowing emerged in Thuringia, the region around Jena in the southern part of Prussia.

The first of these scientific glassblowers may have been Franz Ferdinand Greiner (1808-1855) from the village of Stützerbach. After meeting the itinerant glassblower Wilhelm Berkes, who had spent time in Paris, Greiner began making thermometers in the 1830s eventually expanding to make 64 different models in addition to lab glassware and even chemical toys. His success resulted in many local firms switching to the more profitable scientific work. Among the most famous Thuringian glassblowers are Hermann Geissler, the inventor of the eponymous pump and discharge tubes (CK 139 May 2019), and Otto Baumbach, who made the delicate glassware that Ernest Rutherford used to prove that radioactivity involved transmutation.

The rise of the electric lamp industry at the end of the 19th century gave further impetus to the industry and resulted in a sudden demand for skilled glassblowers across Europe. The firm of Greiner and Friedrichs (the relation to the earlier Greiners is uncertain), whose activities can be traced back to the 17th century, was established in 1852. James Dewar (CK 12 August 2008) famously entrusted them with the manufacture of vacuum flasks which, to Dewar's chagrin, they marketed under the name Thermos. The firm also made Conrad Röntgen's first X-ray tubes. Among the many glassblowers who worked with or were trained by the firm was Otto Schott (CK 93 May 2015) who conducted some of his experiments on glass composition in collaboration with them. This collaboration led to the reputation of the hard and chemically resistant Jena glass in the late 19th and early 20th centuries. The Jena glass logo was the pride of many a British distributor in the 1920s.

The owner of the firm, Ferdinand Friedrichs, had two sons, Fritz and Josef, both of whom would enter the business. Little is known about Josef but Fritz studied inorganic chemistry in Stuttgart and then researched binary mixtures of water, ammonia and/or hydrazine at the Carnegie Institute at Cornell University in the US. It is clear that he was already a fine glassblower. He had published several papers on new glassware, including on describing the only device that still bears his name:[1] a condenser with an angular screwthreaded core which caused the solvent vapour to follow a spiral path upwards. Friedrichs would reuse the design in several other devices including a gas washing device and a modified Kaliapparat (see Liebig, CK 25 Sept 2009).

During this period before the first world war, the US and British patent literature contains numerous methods to make ground glass stoppers and connections. Machines for making bottle necks and stoppers make up most of these, but there are also a few attempts to connect tubing with a variety of shaped joints, sometimes with gaskets. Glassblowing texts of the period also refer to methods for making ground glass joints and close-fitting stopcocks. It was a fairly laborious process which

[1] F. Friedrichs, *Angew. Chem.*, **1910**, *33*, 2425-2426; *J. Am. Chem. Soc.* **1912**, *34*, 285-286,

typically involved making the two halves separately and then carefully grinding them together with silicon carbide to achieve a good it. The joints and the valves worked well but were not interchangeable; breakages were disastrous as both parts had to be replaced and the joint reground from scratch. It is noteworthy that several of Friedrichs inventions include ground glass joints.
When the first world war broke out Friedrichs served as an artillery officer, but he returned to the family firm after the armistice. Austria-Hungary's defeat brought hard times to the industry but also frustration at the limitations of ground glass. In the United States Solomon Acree, an agricultural chemist who had studied in Berlin, proposed a set of steel dies to be used to make interchangeable glass joints on a lathe.[2] He proposed using the widely used 1:10 Morse taper for the conical joints. His paper was followed a few months later in *Angew. Chem.* by a manifesto written by Johannes Dathe the secretary of a committee set up by the German Chemical Society linking academics and industrialists to standardise glassware.[3] Dathe explained that the myriad devices on sale in Germany were both highly confusing for the buyer but also very impractical. Every manufacturer had different screw threads and wing-nuts on their clamps. Flasks and condensers were all of different diameters so you couldn't even use the same cork from one experiment to the next. Hose connections never matched. Such a system made life impossible not just for chemists in the lab but also for wholesalers and distributors who had to stock endless variants. Above all the lack of standardisation was a massive constraint on profitability especially if German products were to break in to that huge emerging market, the United States. He praised the Schott company that had already developed a standard set of moulds for flasks. He concluded his tract by emphasising that his colleagues proposed to address standards in a range of areas from glass itself, glassware, to metal labware, and even optics. With his unique experience of laboratory chemistry and industrial manufacture, Fritz Friedrichs was on the case, especially as his time in the US may have been a strategic move by his family to break into the American market. A member of the committee, he wrote five articles in successive issues of Angewandte Chemie[4] laying down standard dimensions for glassware. Stopcocks, filters, extractors, separating funnels, condenser and so on, were all addressed and it marked the beginning of a gradual convergence of laboratory equipment in Germany. Greiner and Frierichs were now one of the major producers in Stützerbach, building expanded works in 1921 and references to their products appear in most of the guides and textbooks of synthetic techniques, such as Houben-Weyl.
In 1924 another firm in Stützerbach, Wilhelm K Heinz began production of standard glass joints and of a range glassware equipped with it. So proud was the owner, Werner Heinz of their product that the firm's logo was designed with a crossed cone and socket. In 1927 WK Heinz took out a series of advertisements in Nature illustrating their innovative products. They would not go unnoticed in the UK. Their catalogue from 1934 looks thoroughly modern, using cross-sectional diagrams showing cones and sockets, rather than the more traditional artistic woodcuts. Greiner & Friedrich too began producing their own at the same time, but I have been unable to find an example of their catalogue for comparison. By 1929 there was a German DIN standard for tapered ground glass joints and their use would gradually spread as production increased and costs dropped.
Both firms continued production up until the Second World War. Although apparently undamaged by the fighting, both firms found themselves on the eastern, Soviet, side of the Iron Curtain. Both the Heinz's and the Friedrichs fled to the West, their factories taken over. G&F would become known as . Fritz would work with the Americans to outline how the glass industry could be rebuilt as part of the Marshall Plan. At the same time, he and his brother Josef would set up a new glassworks called, appropriately Normschliff Glasgeräte Gmbh (the Standard Ground Joint Glass Equipment Company) in the town of Wertheim which would employ several thousand. It would continue production into the 2000s when it finally vanished. W K Heinz on the other hand still exists, making scientific glassware and ground glass joints under family management.
Friedrichs died in 1958 leaving behind a wealth of glassware designs and standards. His 1951 book "Das Glas im Chemischen Laboratorium", which he dedicated to his father, Ferdinand, is a glorious, technical tribute to the contribution that glassblowers have made to modern science.

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2 S. F. Acree, *J. Ind. Eng. Chem.,* **1919**, *11*, 338-339.
3 J. Dathe, *Angew. Chem.* **1919**, *32*, 207-208.
4 F. Friedrichs, *Angew. Chem.* **1920**, *33*, 56; *ibid.* 151; *ibid.* 157; *ibid.* 163; *ibid.* 186.

Were any chemistry film made today, there would not be a cork or a bung anywhere in sight. Tapered joints would be everywhere. But a close look at the joints might reveal a stylized blue logo in the shape of a double-walled letter Q, the logo of Quickfit, a story we will explore next month.

Acknowledgements
I am hugely indebted to a huge number of people who helped with this article. Among them, David Allan and glassblowers John Cowley, Reece Bramley, Ian Pearson (BSSG), and Alan Gall. Anna Hillier found company information about G&F while Christoph Salzmann and Timoer Frelinck made ultimately fruitless efforts to get information and images from WK Heinz.

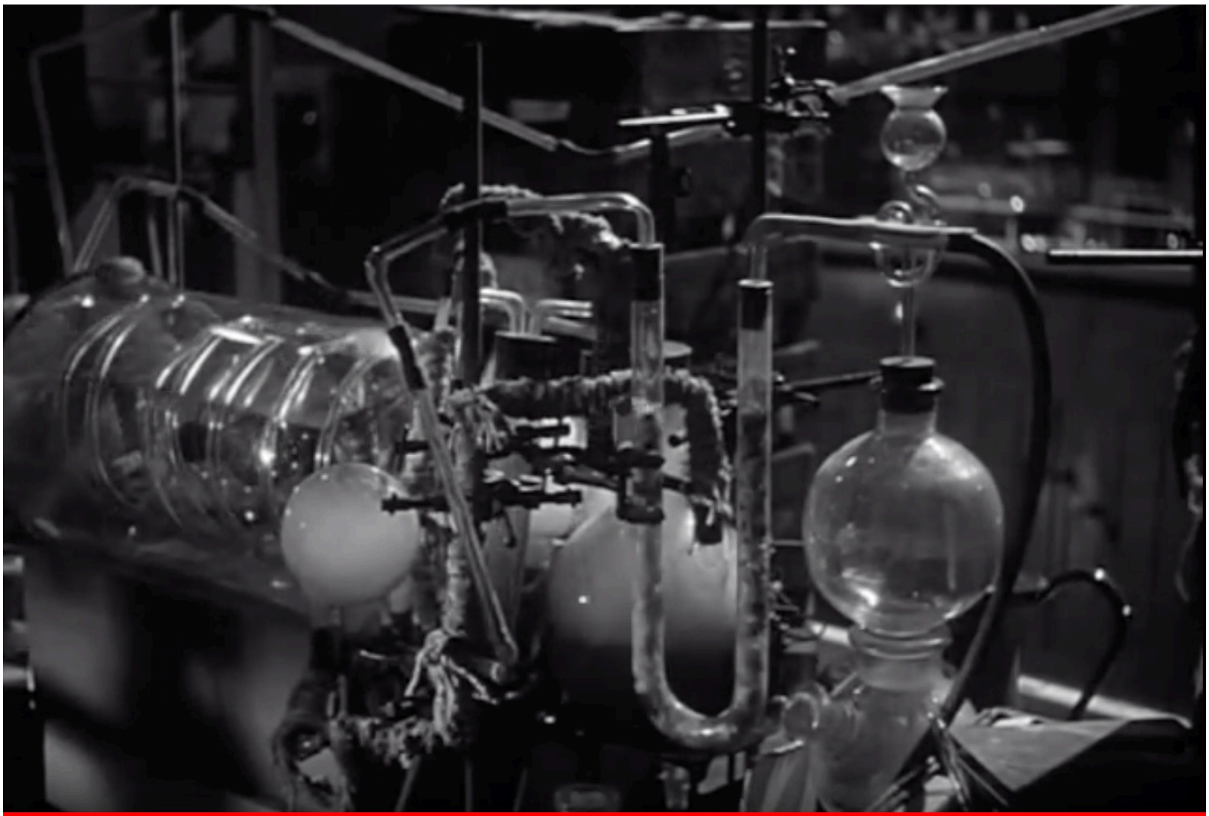

Abb. 90. Übergangsstücke.

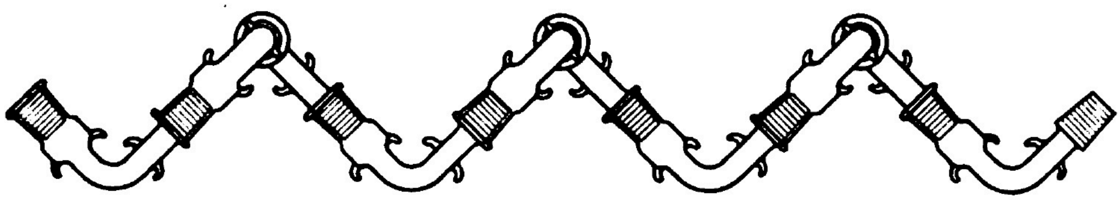

Abb. 92. Schliffkette nach FRIEDRICHS.

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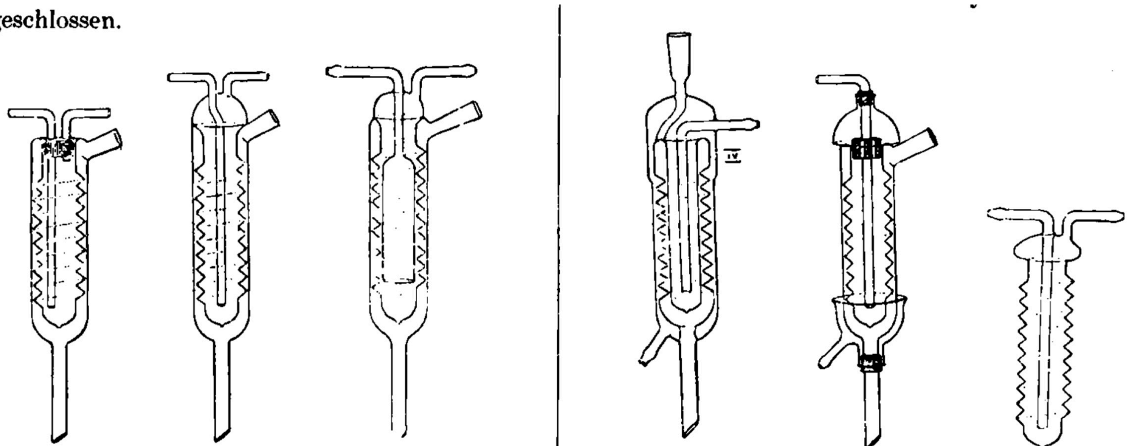
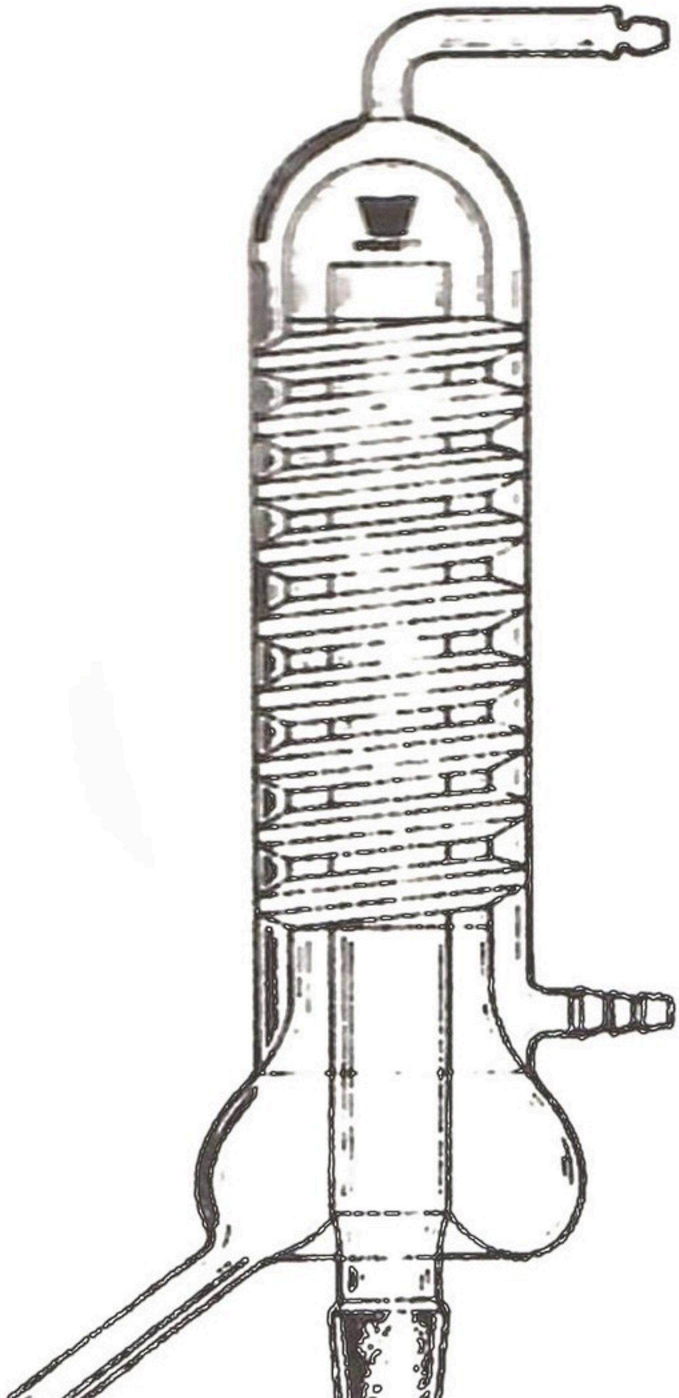
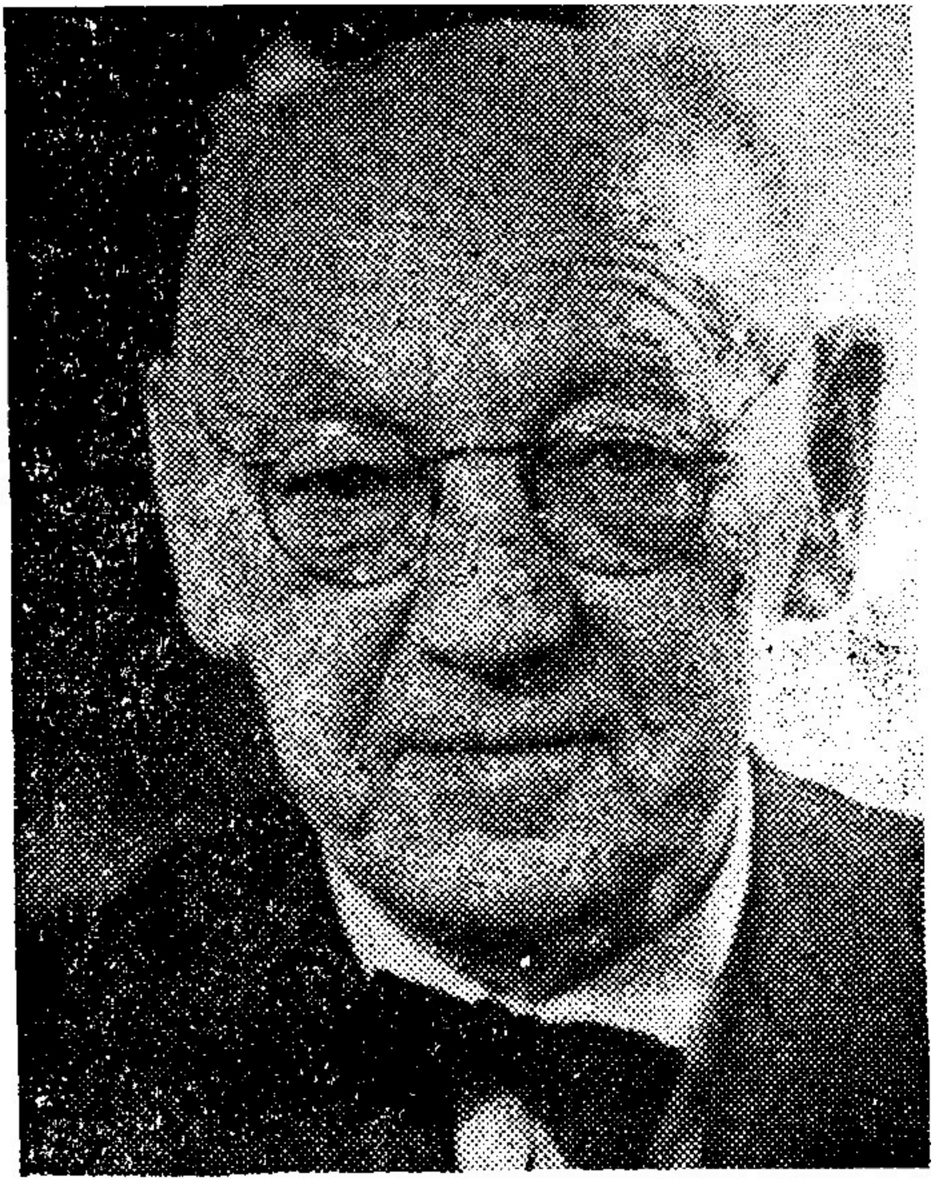
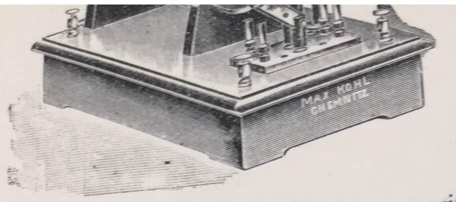






Dr. Ing. Fritz Friedrichs
(Aufnahme: Archiv)



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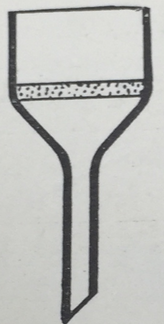

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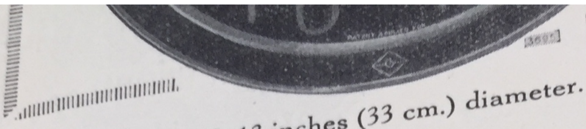

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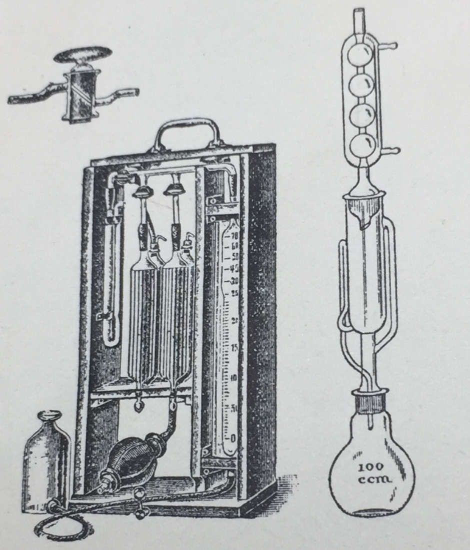

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