Platinum for Glass Making at Jena

A REPUTATION FOR EXCELLENCE WAS BUILT UPON EARLY RESEARCH BY DÖBEREINER, SCHOTT AND ABBE

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The use of platinum for the preparation of optical glass can be traced back to Michael Faraday who, in 1824, investigated ways of improving the manufacture of optical glass. During this work he began to use platinum for containment vessels, stirrers and ladles. Prior to this Johann Wolfgang Döbereiner had been appointed Professor of Chemistry at the University of Jena and was later supplied with platinum crucibles by his patrons. Crucibles and stirrers made from platinum were also used when Otto Schott was collaborating with Ernst Abbe on the development of new optical glasses. Their work led to a revolutionary upsurge in the optical industry in Jena and, following the involvement of Carl and Roderich Zeiss, the establishment of a reputation for optical-mechanical excellence which has been maintained ever since.

In the early years of the nineteenth century Joseph von Fraunhofer (1787–1826), and Pierre Louis Guinand (1748–1824) succeeded in producing optical glasses of a higher quality than had been attained previously, by utilising a more effective technique which they had developed for stirring molten glass. This was the principal reason why England lost its leading role in the production of telescopes to Germany and France during the first quarter of the nineteenth century. One result of this was the work undertaken by Michael Faraday (1791–1867), funded by the British government through the Royal Society, to improve the quality of optical glasses, especially of flint glasses.

At that time it was extremely difficult to produce optical glasses that were sufficiently homogeneous, uncoloured, and with only a low concentration of schlieren and bubbles, all of which were necessary for the production of a high yield of material suitable for optical purposes. Faraday must have deduced that the uptake of impurities from the ceramic melting pots by the molten glass could be a reason for defects in the glass produced, and he was the first to employ platinum crucibles and stirrers for the production of optical glass. In the 1829 Bakerian lecture to the Royal Society, Faraday reported that he had succeeded in producing a series of new optical glasses of exceptional purity (1–3).

Shortly after, in 1834, the English pastor and natural philosopher W. V. Harcourt (1789–1871) commenced a systematic investigation aimed at developing improved optical glasses. His work lasted for 35 years during which time he tested a wide variety of chemicals for their glass forming properties, introducing no fewer than 29 new substances into glass making. In order to ensure homogeneous heating during his melting experiments Harcourt used a piece of apparatus which he had made himself. This consisted of a platinum crucible suspended by wires in the flame of an oxygen-hydrogen torch, the crucible being rotated around its axis by a clockwork mechanism (4).

Since homogenisation of the molten glass was still not satisfactorily achieved, the experiments of Faraday and Harcourt did not in fact result in a decisive improvement in the production of optical glass. Furthermore the new glasses produced by Harcourt were so unstable in the normal atmosphere that polished lenses made from them could be used for only a short time (5).

Platinum Crucibles at the Time of Goethe and Döbereiner

In 1810 Carl August von Sachsen-Weimar, the Grand Duke of Sachsen-Weimar-Eisenach, together with his Minister of State with responsibility for science and the arts – the famous German poet Johann Wolfgang von Goethe – had appointed Johann Wolfgang Döbereiner (1780–1849) as Professor of Chemistry at the University of Jena. His scientific and technological capability combined with the support that he received from both the Grand Duke and the Minister accounted for the rapid surge in chemical research in Jena (6, 7). Indeed, Goethe later achieved world fame not only as a poet but also as a promoter of the arts, science and industry, as a result of his untiring efforts as a government minister and head of "Unmittelbaren Anstalten für Wissenschaft und Kunst", a department at the Court of the Grand Duchess Sachsen-Weimar responsible in some way for research and development.

Döbereiner was provided with a laboratory at the castle in Jena and an auditorium where he could lecture and carry out experiments, with state assistance. In a report dated 7th November, 1811, Goethe recorded that "The chemical institution developed quite successfully due to the diligence and efforts of Professor Döbereiner." (8)

With untiring attention to detail Goethe made sure that Döbereiner got the equipment he needed for his laboratory. This included platinum pieces obtained from Paris and a silver evaporating dish. His extremely careful and conscientious handling of the situation is documented in a volume concerned with the procurement of physical and chemical instruments (9) and in his diary.

These records show that several meetings took place to consider the equipment needed for the chemical laboratory. In fact Goethe frequently went to Jena to discuss purchases and to check on the work being carried out. As well as having discussions with Döbereiner, Goethe sought the advice of specialists living in the area. Among these was his friend Thomas Johann Seebeck (1770–1831), noted for his discovery of thermoelectricity, who lived as a private lecturer in Jena between 1802 and 1811. Others involved in these meetings included the Jena Court coppersmith, Christoph Gottlieb Pflug (1747–1825) and two Court mechanics, Alexander Franz Joseph Otteny (?–1820) and Johann Christian Friedrich Körner (1778–1847), the latter also being a teacher of Carl Zeiss – founder of the world famous mechanical-optical factory at Jena.

A list was compiled of all the equipment and its accessories, and what it was used for. Descriptions given in various chemical journals were noted and information about supply houses provided. Where Körner, Otteny and Pflug were able to make the instruments required for the chemical laboratory, they had to supply drawings and give prices. If equipment had to be obtained from outside sources the reasons why had to be given.

Financing the purchase of equipment for Döbereiner's chemical laboratory caused problems for Goethe. Valuable assistance was, however, provided by the Grand Duchess Maria Paulowna (1786–1859) a daughter of Tsar Paul I of Russia, who had in 1804 married Carl Freidrich von Sachsen-Weimar the son of Döbereiner's patron. From her own considerable resources she provided Goethe with 1000 Thaler, for which he ordered a separate account to be opened and from which physical and chemical requirements could be satisfied. Over the years Maria Paulowna provided Goethe with appreciable sums of money "as a contribution to the needs of science and the arts". These enabled him to satisfy the requirements of the laboratory, which far exceeded the normal budget of his ministry. In 1828 Goethe wrote to Johann Peter Eckermann (1792–1854):

> "She has been a good angel for our country, and becomes even more so the longer she is connected with it. She is one of the most imposing ladies of our time and would be so even if she were not a Duchess" (10).

When Goethe travelled to Karlsbad in April 1812, as he did regularly during the latter years of his life in order to improve his health, he stayed in Jena for several days checking up on things before continuing on to Bohemia. Finally he transferred the responsibility for the Döbereiner laboratory to his son Julius August Walter von Goethe (1789–1830), who had studied law at Heidelberg and Jena, and who became an indispensable assistant to his father. Part of the detailed instructions written to the son on 28th April, 1812, states:

> "If the equipment arrives from Paris, the Court commissioner Ullmann has orders to send them to Prof. Döbereiner in Jena and hand the bill for them – which may be near 70 Rthlr [Reichsthaler] – to His Excellency der Geheime Rath von Voigt asking him to be so kind as to authorise it with the addition of the separate account."

In a report to the main control agency dated November 22nd, Goethe gives a summary of the supplies and purchases for the year 1812. Item six on this list relates to platinum equipment costing a total of 113 Reichsthaler, 2 Groschen and 8 Denar, a Denar being equivalent to a Pfennig.

It is clear from the documents that have been examined by the authors during the preparation of this article that Goethe contributed much more than might have been expected of a poet and state minister. Despite his gigantic efforts on behalf of the arts and science he still found the energy to consider carefully and conscientiously the smallest details of the tasks given to him. In the first decades of the 19th century it was very difficult to obtain good quality glass for use in optical instruments. The Fraunhofer Glass Works in Benediktbeuren, which had been founded in 1804 in Munich by G. v. Reichenbach, J. v. Utzschneider and J. Liebherr, did produce excellent glass at that time but this was supplied almost exclusively to the optical shops of the "Mathematical-Mechanical Institute" which formed part of the Glass Works. As a result Jena had to obtain supplies from France and England. This material was not only expensive but the quality was often poor; quite frequently makers of optical instruments found it to be totally useless (5–7).

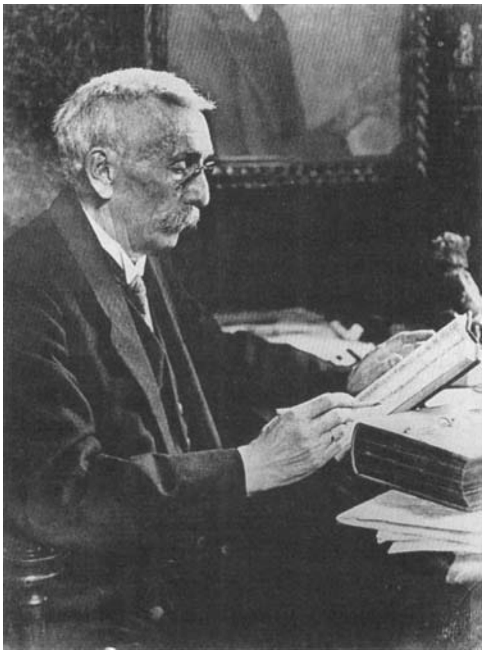
These problems caused Körner, the Jena Court mechanic, to realise a long planned idea, which was to build a small glass shop where melts could be tested, and where later optical glass was produced. In this endeavour he was supported by both the Grand Duke Carl August von Sachsen-Weimar and by Goethe. The Grand Duke, as Head of State, was personally interested in the development of the glass melting experiment. For example, he sought the opinion of Fraunhofer on the glass samples made by Körner, as is shown by his letter to Goethe dated July 24th, 1825. The work was also of great interest to the latter who mentioned it frequently in his diary as well as in correspondence with Carl August. The export of top quality optical glass and optical precision instruments would have been of utmost economic importance to the German "Mini-State", especially since Körner used only indigenous raw materials.

Although Körner first tried to prepare flint glass, he began to melt crown glass in 1828. When sending a sample to Goethe he wrote:

> "Continuing in the spirit and sense of our most saintly master we began to melt crown glass and, in order to be capable to present most humbly your Most Honourable Excellency with a sample – before taking out the big glass pot – I scooped out with a platinum crucible a piece and let it solidify immediately...."

In all probability the beginning of Döbereiner's participation in Körner's glass melting experiments would have been initiated by Goethe. While Körner tried to improve the procedures used for the production of optical glass, Döbereiner tended to put the experiments on a sound scientific basis. He changed the mixing ratios of the raw materials keeping stoichiometric considerations in mind, introduced new components into the melts and studied their influence on the properties of the glasses. Further clues to the use of platinum in the glass chemical laboratories of both Döbereiner and Körner are not known. Otherwise platinum crucibles were mostly used for the decomposition of substances for analytical purposes.

The experiments of Döbereiner and Körner failed, at least in part, because of technical difficulties and incomplete physical evaluation of their results. On several occasions Goethe suggested that systematic measurements should be made



Otto Schott
1851–1935

Shown here in his study at the age of 70, Schott pioneered important developments in optical and technical glasses which had properties superior to those previously attainable. The quality of these glasses was largely responsible for the "Jenaer Glaswerk Schott & Gen." becoming a world renowned industrial corporation. In addition, the new Schott glasses contributed significantly to the world reputation of Jena as the home of precision optical instrument production. Schott presided over the Company as chief manager until after his 75th birthday

Photograph by A. Bischoff of Jena

of refractive indices and the optical dispersion of the glasses. In most cases the small size of the test melts resulted in schlieren-containing glasses, so that optical values could not be determined. Apparently Döbereiner and Körner did not pursue this task far enough, although they did get close to their aim of producing optical glass of a high quality. But glass research can be proud of the fact that such a genius as Goethe took an interest in it.

Pioneering Work by Otto Schott and Ernst Abbe

Otto Schott was born in Witten, Ruhr, on 17th December, 1851, the son of an owner of a plate glass factory. From childhood onward, therefore, he had an opportunity to obtain a detailed practical knowledge of glass making and the problems associated with it. After finishing his studies at Aachen, Würzburg and Leipzig he obtained his doctorate in 1875 at Jena for a thesis on a "Contribution to the Theory and Practice of Glassmaking". After working in various factories, in 1878 he began to carry out glass melting experiments in his parents' house, while at the same time looking for a permanent position.

In this way he obtained skills and knowledge which far exceeded those necessary for the routine running of a glass melting factory. His aim was to establish the "chemistry of the fiery fluxes" (5, 12, 13). It was only later that he became interested in the optical properties of glasses and their application. Even before this Schott had introduced compounds of new chemical elements into glass, the effects of which on glass making had not been investigated previously. Apparently his investigations were carried out to satisfy his scientific curiosity and determine if glasses with useful properties could be produced by new chemical compositions.

After Schott succeeded in melting a lithium glass, which he expected to have improved optical properties, he wrote to Ernst Abbe (1840–1905), who was Professor of Physics and Director of the observatory at the University of Jena, asking him to study the properties of this glass (5, 12, 14). The first letter sent from Witten on 27th May, 1871, begins:

> "A short time ago I produced a glass which contained an appreciable amount of lithium. It had a fairly low specific gravity. I guess that this glass shows excellent optical properties in one or other direction and in this letter I dare to ask you if it would be possible for you to test these or ask one of your associates to test it for refractive or diffractive properties in so far as it may confirm or contradict my earlier surmise." (12)

This was the start of a very fruitful collaboration. Fortunately Schott was not discouraged by early failures. The problem of excessively high schlieren concentrations in the new glass, the difficulty that defeated Harcourt after over 30 years' work, was finally solved by Schott who stirred the melt intensively until it became homogeneous.

In a letter dated 3rd August, 1879, Ernst Abbe wrote to Schott:

> "I consider it a tremendous success that you succeeded in making test melts in small crucibles in such quality that a complete optical investigation of the product becomes possible.... For the progress in the production of optical glass it looks to me however as if the most essential presupposition to have a possibility to generate useful (optically measurable) test glass melts, since this is the only way in which methodical testing can be carried out." (14)

Schott did not give up when his new lithium-containing glass did not prove to be as successful for optical purposes as he had hoped. At that time the flourishing German optical industry depended upon glass imported from a few factories in France and England, and there was an obvious desire to change this situation. In addition, Ernst Abbe had already observed that the construction of top quality optical instruments was dependent upon the development of glasses having improved optical properties. It was perceived to be especially important to develop optical glasses which were superior to the existing crown and flint glasses, by having a rather low refractive index at a high dispersion, or vice versa, or glasses which when used in combination would compensate for the individual defects that were then unavoidable, such as chromatic and spherical aberration, and astigmatism (15).

In response to this situation, Otto Schott in 1881, first working at home in Witten, began a series of careful and systematic melting experiments set up jointly with Ernst Abbe. Schott's aim was to investigate the dependence of the optical properties of a glass on its chemical composition. In the course of his work he intended to select from all the compounds available to him – and which dissolved in glass – those which might improve optical glasses. He saw this as the way to produce deliberately, on a sound scientific basis, top quality glasses with the required optical properties. For the very first experiments Abbe provided Schott with platinum crucibles, at his own cost, and he immediately began optical measurements on Schott's test melts. At first both scientists worked to establish the formulations of the glasses to be prepared so that the attack on the crucible walls by the glass melt was minimised, and contamination by the crucible material avoided (15). In general, dissolution of the ceramic refractories worsened the optical properties of the glass. For example, discolouration reduced transmission and schlieren formation resulted from local differences in the composition of the melt. Abbe and Schott tried to avoid such defects by using platinum as the crucible material. In this connection, Abbe wrote to Schott on 3rd October 1881:

> "Concerning the prisms presently under investigation, I may preliminary remark that No.XCI (cryolite) does not permit a determination of the dispersion, since the piece consists totally of schlieren. In view of the greatest interest in this sample... you should prepare a new melt in platinum crucibles... First do a melt in your small crucible; today I ordered in Frankfurt a larger sized crucible – 50-60 ccm volume, with lid and a piece of thick wire for stirring....." (14).

Another letter from Abbe to Schott states:

> "A platinum crucible of about 60 ccm volume, with lid and a thick platinum rod for stirring – the whole for about 100 Mark – I do hope to receive in the next few days – possibly this crucible may provide you some help in your next melts...." (14).

A letter of reply sent at about this time gives the important results of the first 100 test melts:

> "We succeeded in preparing from boric acid and strontium oxide, as well as from boric acid and thallium oxide, glasses which can be used practically to obtain complete achromaticity in field glass objectives, which means that the up to now unavoidable colour diffraction can be avoided and images result which do not contain any coloured edges."

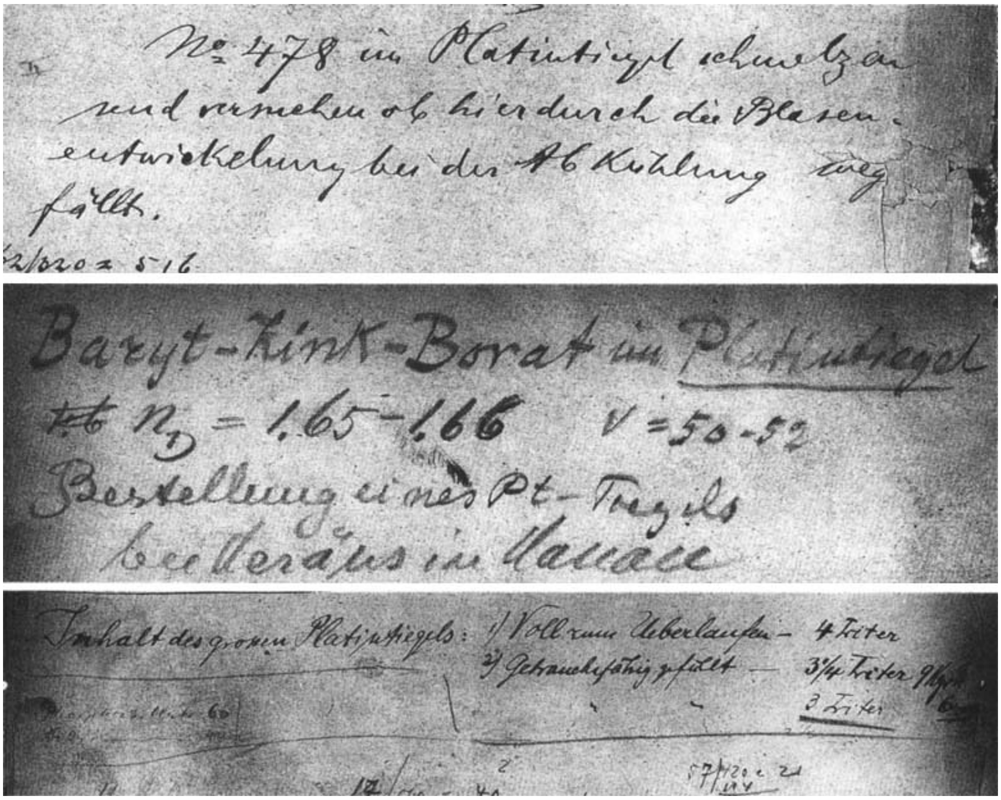
This success encouraged both scientists to continue their investigations. Schott later summarises his feelings:

> "One year after the start of our work we obtained enough material to predict with certainty that a purposeful continuation of our researches in our field of interest must lead to a widening of our knowledge and research in practical optics." (15)

Schott and Abbe went on to establish their own private laboratory in Jena, where they formulated the technical basis for a continuation of their experiments on a wide basis. In addition to furnaces this involved a steam engine and bellows in order to obtain high melting temperatures. In January 1882 Schott moved his residence from Witten to Jena. As well as the help provided by Abbe, during the build-up and operation of his laboratory Schott received support from Carl Zeiss and his son Roderich, the owners of the Jena optical works who urgently needed indigenous sources of glasses with improved properties for the development of new top quality optical instruments.

During extensive melting tests Schott investigated a total of 28 chemical elements in addition to seven glass forming oxides. By his extraordinary experimental skill he succeeded in producing on a small laboratory-scale glass samples having excellent homogeneity, thus enabling their optical values to be determined completely. In this way Schott raised glass chemical work from a trial-and-error basis to the level of scientific experimentation. The results convinced him that the refractive index and dispersion of glasses could be varied significantly by changing their chemical composition.

In order to avoid contamination of the melt by dissolution of the crucible walls, Schott often used crucibles and stirrers made from platinum and in this way he obtained glass of a higher quality. In his laboratory notebooks and his correspondence we find extensive reference to this. For example, Schott's



No. 478 im Platintiegel schmelzen und versuchen ob hierdurch die Blasenentwickelung bei der Abkühlung weg fällt.

Baryt-Zink-Borat im Platintiegel
n_D = 1,65–1,66 ν = 50–52
Bestellung eines Pt-Tiegels bei Heraeus in Hanau

Inhalt des grossen Platintiegels: 1/ Vollkommen Ueberlaufen – 4 Liter
2/ Gebrauchsfähig gefüllt – 3¼ Liter 9 kg
3 Liter 6

These excerpts from Schott's laboratory notebooks are a limited selection of the instances where he recorded his use of platinum: (top) By the use of a platinum crucible he tried to avoid bubble formation in melt No.478 as it was cooled; (middle) A barytes-zinc-borate glass which had been melted in a platinum crucible was found to have a refractive index of 1.65 to 1.66, and an Abbe number of 50 to 52. Schott also records that a platinum crucible was ordered from Heraeus in Hanau; (bottom) A particular large platinum crucible contained 4 litres if filled to overflowing, but generally it was used for only 3.25 litres, 9 kilogrammes, of flint glass or 3 litres, 6 kilogrammes, of glass composition 645

notebook No.II contains an entry indicating the need to determine if bubble formation during cooling could be avoided by melting a glass sample in a platinum crucible. In another place we find "ordering a platinum crucible with Heraeus in Hanau". Heraeus was, of course, Wilhelm-Carl Heraeus (1827–1904), founder of the leading special metals firm. Here, and in other places, optical data of glass melted in platinum were listed ("barytes-zinc-borate in platinum crucibles"). In his laboratory diary, Schott gives the wall thickness of a crucible as 3/4 to 1 mm. From his notes we can deduce that he used platinum containers inside graphite heaters (16).

Concerning the supply of platinum equipment, on 28th October 1883, Abbe wrote to Schott who was in Witten for his mother's birthday:

> "found here on my desk a platinum crucible from Heraeus (326 gr. billed at 345 Mark). Apparently quite close to the specification, only it looks thicker (scrap platinum at 800 Mark per kilo taken back). Was told from London by 26th (as mailed): crucible 716 gr. stirrer 1098 gr. 1814 gr. to 2267.5 frcs..." (16).

Again on Schott's notebook No.II we find among other entries from the same time: "volume of a small platinum crucible (filled) – 720 ccm, usable filled 600 ccm" and "volume of the large platinum crucible: 1) before flowing over 4 litres, 2) usable filled 3.25 litres 9 kg flint"; see also (16) page 358.

The comments on the large platinum crucible are contained in the above illustration. From a note in a letter by Abbe to Schott dated 29th October 1883, the dimensions of this crucible can be estimated to be 15 cm diameter at the bottom, 16 cm diameter at the upper rim and with a height of 22 cm (16).

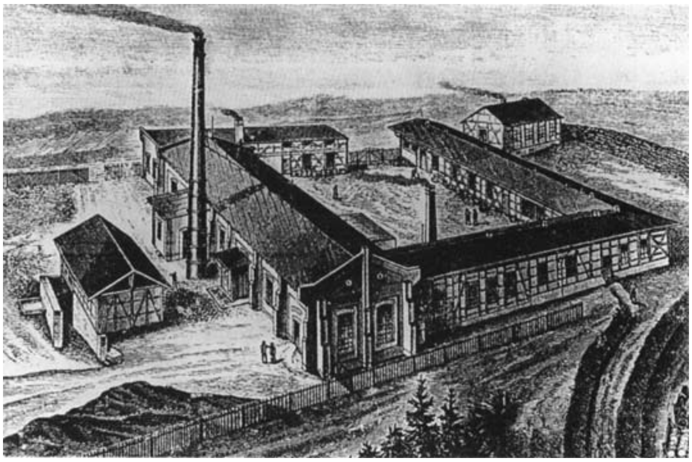
It is not the purpose of this paper to examine in detail the continuation of the work by Schott with glass melts of varying compositions and the influence of individual constituents on the optical properties of the glass, nor to give a full report of his life and works. From his many investigations we will consider only those which involved the use of platinum.

Schott observed that the introduction of fluorine into glass would be very important for optical use since for crown glasses it made possible an advantageous reduction in optical dispersion. In many tests he succeeded in forming colourless glasses with high fluorine content, bound to lithium, barium, cadmium and aluminium with phosphoric acid. Due to the strong chemical attack by the fluorine compounds on silicate-containing crucible materials, and the decomposition of the fluorides as gaseous compounds developed, Schott processed such materials using crucibles and stirrers made from platinum. Even in platinum equipment, however, reactions with oxygen and moisture in the air as the glass melts were being stirred resulted in the formation of gaseous fluorine compounds. As the volatile constituents of the glass evaporated inhomogeneities (schlieren) were generated in the glass, ruining it. Schott therefore considered it necessary to experiment further on a larger scale, although this would be very expensive because of the need for even larger platinum crucibles (15).

Despite the attention given to the stirring of the melts, at first Schott did not succeed in producing homogeneous pieces of glass sufficiently large to be used for telescope objective lenses from the borate, borosilicate and phosphate glasses he had developed. As he remarked in a lecture entitled "on melting glass for optical and other scientific purposes", the dissolution of the porcelain crucible material was the reason why small agglomerates of schlieren occurred in the whole melt, dispersing when the molten glass was poured. Therefore only small pieces of homogeneous glass could be obtained. Schott hoped to solve this problem by the use of platinum apparatus. In his lecture he talked of:

> "expecting to produce something perfect in spite of this problem we decided to replace the soluble porcelain wall and the porcelain stirrer, regardless of the cost, by a platinum crucible of 3 litre volume and a platinum stirrer weighing 1.5 kg" (15).

Initially, the use of a platinum crucible proved to be unsuccessful. Where the molten glass was in contact with the platinum excessive bubble formation was observed, the glass became useless and the platinum brittle, with the crucible



Registered at the official court in Jena on 22nd July, 1885, by 1886 Glastechnisches Laboratorium Schott & Gen. was well established on this site in Jena, producing high quality glass which was soon manufactured in sufficiently large quantities to satisfy the total German demand for optical glass

cracking after three or four melts. Schott reported in his lecture that further experiments using a smaller, thicker-walled crucible avoided bubble and crack formation, so demonstrating that platinum could be used for the production of optical glasses, the constituents of which when molten strongly attacked ceramic refractories. He subsequently restricted the use of platinum to the melting of borate glasses. With phosphate glasses, however, the dissolution of metallic platinum, and its subsequent precipitation as a greyish substance on cooling, was observed (15).

We now know more accurately why Schott had problems with the use of platinum apparatus. At that time the furnaces used for heating the containment vessels were fuelled by coal gas, and this caused some reduction of the constituents of the glass, which was one of the reasons for the damage that then occurred to platinum containers. It was only in the second half of this century when glass melting units heated by electricity became available that platinum crucibles and stirrers were applied on a large scale in the glass industry. Now nearly all top quality optical glass is melted in platinum crucibles.

The use of gas for heating Schott's furnaces explains not only the formation of gas bubbles but also the embrittlement and cracking of the platinum. Many of the chemicals present in glass compositions are harmless to platinum as long as they remain in the melt in the form of compounds, generally as oxides. If, however, they are reduced to their elementary form by the action of agents from outside the melt, then these elements may react and diffuse into the platinum along grain boundaries. Furthermore, platinum may catalyse reactions in the melt. In addition such "foreign" elements can form low melting compounds and eutectics of platinum alloys and these reactions are the cause of the embrittlement of platinum by intercrystalline cracking and corrosion. Elements detrimental to platinum in this way include phosphorus, lead, arsenic, antimony, boron, bismuth and even silicon.

Schott later summarised the wide ranging experiments he had carried out in the glass technical laboratory, claiming that after two-and-a-half years' work the main scientific foundations of optical glass technology had been established (15). The expenses for platinum equipment for melting experiments carried out between the Spring of 1881 and the end of 1883 amounted to 4000 Mark (16).

The next problem was to transfer the results obtained into usable products for practical optics. This required the establishment of a facility which could produce on an industrial scale, and with the same high quality properties, the glasses developed in the laboratory. It was anticipated that an expensive and time consuming experimental development programme would be required to scale-up production from a laboratory- to a factory-process. To achieve this Otto Schott, Ernst Abbe, Carl Zeiss and Roderich

Zeiss decided to establish a factory in Jena at their own expense. The fire in the first furnace was lit on September 1884 and this can be regarded as the birth of the Jenaer Glaswerk. The company first appeared in the Trade Register at the official Court of Jena on 22nd July 1885 as "Glastechnisches Laboratorium Schott & Gen. in Jena" and due to the great importance of this project to the optical industry in Germany, the four partners succeeded in obtaining a large subsidy of 60,000 Mark from the State of Prussia. This enabled them to fund a large part of the running costs of the factory during the first two years.

Within four years they had successfully developed their production processes and the company was able to supply the total German demand for optical glass. In addition strong interest was shown by the optical industries in other countries. In these early years, the company consisted of fourteen workers, one chemical assistant and two clerks. So began the organisation that has grown to become the world famous company "Jenaer Glaswerk Schott & Gen.", which was registered on 11th October, 1920, in the Trade Register of the Court in Jena.

Thus it can be claimed that Carl Zeiss, Ernst Abbe and Otto Schott together established the worldwide reputation of the German mechanical-optical industry for precision and excellence. To maintain this position, continuing research and development is required. Indeed recurring problems of corrosion and the relatively limited life of platinum crucibles used in the Jena Glassworks were among reasons for the founding of the technology section of the Friedrich-Schiller-University in Jena, in 1973. Since that time systematic investigations have been carried out on the use of platinum in the glass industry.

From 1992 collaborative work has been undertaken with the newly founded Jena Polytechnic Institution, and with W. C. Heraeus G.m.b.H. in Hanau, on stress rupture versus time data for both platinum and iridium at extremely high temperatures.

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