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ALFRED STOCK AND THE RENAISSANCE OF INORGANIC CHEMISTRY

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When, a hundred years ago on the 16th July 1876, a 'Sunday child', baptised Alfred, was born to the Danzig insurance official Hugo Stock and his wife Hildegard, a heart began to beat which was destined, in the course of its 70 years' existence, to live through all the heights and depths of its earthly fate. A human being entered life, whose extraordinary research and organisational ability swiftly raised him to scientific fame and international recognition. His physical strength was increasingly consumed in the service of chemistry until he closed his eyes for the last time on the 12th August 1946 in a small town on the river Elbe, at the end of a life full of successes and honours, extensively paralysed after indescribable suffering from the hardships of refuge during the aftermath of the last war and the loss of his very last possessions, in the simplest of surroundings, quiet and unrecognised in the confusion of the postwar period.

Let us follow the changing fate on his long road from the unhindered start to the bitter end, a life which bridged the wide span of four periods of German history from the 'Kaiserreich' through the 'Weimarer Republik', the 'Drittes Reich' to post-war Germany, and whose course saw the introduction of significant developments in inorganic chemistry. But it was Alfred Stock and his congenial contemporary Otto Ruff who, by their modern working methods and successful achievements, rescued Inorganic Chemistry - which, after the great discoveries of the 18th and the beginning of the 19th century, gradually became more and more insignificant and, at the turn of the century, was living a Cinderella's existence beside its two more attractive sisters, Organic Chemistry, already in full bloom, and Physical Chemistry, which was just beginning to flower - from the rôle of the serving maid and raised it to the ranks of equal status.

Alfred Stock spent his school years in Berlin, to where his parents moved two years after his birth. At that time he was already beginning to love this active, lively and gay town, in which he spent a total of nearly five decades of his life. It is surely no coincidence that he started his 'Lehrjahre' (Student years) (Berlin, Paris), 'Gesellenjahre' (early research period) (Berlin, Breslau), 'Meisterjahre' (years as Professor) (Berlin, Karlsruhe) and 'Ruhejahre' (retirement) (Berlin, Warmbrunn), each time from this same city, always returning and beginning again at a higher, more mature and more enlightened stage of his life.

'Lehrjahre'

Berlin (1878-1899). That Alfred Stock was to dedicate himself to the natural sciences, in particular to chemistry, was evident to him right from his schooldays. And thus it was as an 18-year old student, that he was registered in 1894 at the University of Berlin, where he devoted himself to eight semesters of chemistry in the chemical institute led for two years by Emil Fischer. His thesis, finished four years later, was concerned with problems in organic chemistry. At the solemn PhD examination in May 1899, the 23-year old Stock successfully defended his thesis in front of three opponents, among them his five-year senior Otto Ruff, the same Otto Ruff who, as a congenial inorganic chemist, later dared to make the following witty comment at the height of his own scientific fame:"I know only two important German inorganic chemists - the other is Alfred Stock!"

As Fischer's former institute had long been inadequate with regard to the increasing demands of education in chemistry, Fischer was promised for the occasion of his move to Berlin a new chemistry building, for which the plans had already been started and which was due to be moved into by 1900. It was

then that Fischer intended to give greater emphasis to the unfairly neglected subject of inorganic chemistry. He therefore sent two of his teaching assistants to outside laboratories to learn modern inorganic experimental methods prior to the completion of the new building. It is a tribute to Emil Fischer's scientific far-sightedness and perspicacity that his choice fell on Alfred Stock and Otto Ruff whose achievements were later to pioneer the new golden age of inorganic chemistry in Germany. Stock went to Henri Moissan in Paris and Ruff to Wilhelm Ostwald in Leipzig.

Paris (1899-1900). The then 47-year old Henri Moissan, at the zenith of his career, was professor at the school of pharmacy where, as an inorganic chemist, he had held the chair in - toxicology for 13 years, and was appointed professor of inorganic chemistry shortly before Stock's arrival. It was a happy group of people that Stock joined in Moissan's laboratory. America, England, Austria, Norway, Germany, France and Russia were - in some cases multiply - represented, all wanting to learn his techniques, in particular the use of his 'four électrique'. But the possibility did not exist at the Ecole de Pharmacie itself of operating such an electric furnace due to inadequate power installations. If one wanted to 'faire du four', one had to go on a 3/4 hour romantic coach drive through Paris, with all the necessary equipment in several vehicles, to the distant power station belonging to the electricity company, in order to be able to run the oven. As a second representative of Germany, Stock was then able to welcome into Moissan's group the recently graduated Dr.Franz Fischer, later to become co-inventor of the Fischer-Tropsch Synthesis. With the stature of a guardsman, at 1,93 m tall, the French found Fischer very striking and Alfred Stock, 1/4 m shorter, was unfortunately no match for him.
His training with Moissan had a decisive influence on Stock's later career. Moissan gave him the task of synthesising boron-silicon compounds, Stock's first contact with these two elements which were later to become his dominant professional interest. He became acquainted with the mercury bath (for collecting gases), containing vast quantities of mercury, which he used in his future research and which constituted the source of his eventual mercury poisoning. His association with the numerous professional colleagues in Moissan's research group contributed significantly to his future negociating skills at German and international meetings. Moissan's great concern for orderliness, his wealth of ideas for developing laboratory apparatus and his exceptional oratory gifts aroused and strengthened comparable talents in Stock. In particular, Moissan's principal lectures on inorganic chemistry gave him great aesthetic enjoyment by virtue of their claritv and the elegant often humorous and rhetorically sparkling presentation. An equal ability was thus inspired in Stock, whose lectures and speeches similarly distinguished themselves by a masterful, subtle and elegant command of speech, by lucid exposition of the material and by a sense of humour appropriate to all situations, quick-witted and, if the need arose, also sarcastic.
After enjoying the splendid Jubilee World Exhibition in Paris in 1900, Alfred Stock returned to Berlin enriched with lasting impressions and experiences and half a dozen publications and became teaching assistant in Fischer's institute, which had just moved into the recently completed new building.

'Gesellenjahre'

Berlin (1900-1909). The move from the romantic, lively, cosmopolitan Parisian atmosphere and the pastoral, idyllically situated laboratory of Moissan to the new, basic and simple home of the Berlin University chemistry faculty, which was situated amongst large blocks of houses in a lonely corner of the city and, according to Emil Fischer's wishes, devoid of any architectural inspiration, posed initial difficulties for the 24-year old assistant. In Paris everything was poetry: the environment, the city, the people; in Berlin everything was plain. But he soon became involved again in his scientific work, and there followed a hectic nine-year period producing over 60 worthy publications on various problems and characterised by a search for his own research field, without the desired breakthrough which was only to follow later in Breslau with his eventual decision to work on the chemistry of boron and silicon hydrides.
The greater part of the work carried out during the Berlin years was concerned with the elements phosphorus, arsenic and antimony and gave him a thorough knowledge of their many allotropes and their compounds with hydrogen, sulphur and nitrogen. Further experiments of that period involved reactions of boron bromide and boron sulphide. The numerous publications on improvements to

apparatus contain a wealth of suggestions, which proved for the most part to be very valid ideas, and which were developed in the time to come into 'Stock's High Vacuum Technique', proving of use to many researchers in their experimental work.
Despite these many varied and time-consuming experimental commitments, the 30-year old 'Privatdozent' still found time to write a 152-paged book 'Praktikum der quantitativen anorganischen Analyse', which survived many editions, was translated into numerous languages and, since Stock's death, has been reproduced in extended form by Hermann Lux, one of his coworkers.
So, in the nine years in Berlin, Stock changed those memorable words of Plinius "multum, non multa" with youthful exuberance into "multum et multa".
In 1904, at the age of 28, he became a 'Dozent' together with his contemporary colleague Otto Diels, later a Nobel prize laureate; in 1906 he was appointed head of his research group and professor in succession to Otto Ruff, who moved to Danzig.
This provided the possibility of marriage, and Alfred Stock sealed a lifelong bond in 1906 with Clara Venzky, a friend from his youth. Two daughters, Hildegard and Ursula, were to result from this union.
In 1907 he was given the honourable task by the Prussian minister of cultural affairs of equipping the institute of inorganic chemistry of the 'Technische Hochschule' in Breslau, which was then being built and was due to be opened in 1909. The 31-year old research worker thus achieved general recognition. Two years later he received the official appointment of full professor at the 'Technische Hochschule' in Breslau. The 33-year old head of department enjoyed relatively favourable conditions: a salary of 6000 Marks (per year, not per month!) plus a living allowance and a guaranteed teaching stipend.

Breslau (1909-1916). The crude construction of the externally quite appealing Breslau institute, modelled on the five-year old chemical institute of the 'Technische Hochschule' in Danzig, was already built when Alfred Stock was entrusted with the job of equipping it. After the opening of the institute Stock reported in detail on the nature and extent of the arrangements - the masterful hand of an experienced experimenter and organizer was already evident. Many of the innovations which he introduced became models for other new laboratory buildings. In October 1910 the Breslau institute was opened; one month later, in the presence of the Emperor, came the inauguration of the entire 'Technische Hochschule', whose first Rector was the then 40-year old departmental colleague of Stock, the physical chemist Rudolf Schenck.
During his seven-year stay in Breslau a series of studies was started, which were to engage Stock for a quarter of a century and become his major scientific achievement: investigation of the boron hydrides. For a long time he had been concerned with the question of whether the immediate neighbour in the periodic table of the chemically so versatile carbon, the element boron, with which he first made contact under Moissan, was really as mundane and 'boring' in its behaviour as was then supposed, e.g. whether its chemical affinity was restricted to strongly electronegative elements such as oxygen and chlorine or whether it was indeed possible to uncover hidden affinities for other entities and create a boron chemistry similar to organic chemistry. And so it was that the first five publications on boron brought out in Breslau between 1912 and 1914, together with numerous other experiments, did in fact already prove that the outwardly 'shy' element possessed an unexpectedly rich 'inward existence', which it was however only prepared to reveal to the 'chosen few'.
Thus he discovered, by the decomposition of magnesium boride with acid, the first boron hydride, the liquid B_4H_{10}, which was thoroughly characterized both physically and chemically. On heating, this boron hydride could be converted into the gaseous compound B_2H_6, which was likewise characterized and proved to be the simplest member of the boron hydride series. The thermal decomposition of B_2H_6 yielded the crystalline compound $B_{10}H_{14}$. Investigations into the action of alkali and halogens on the newly isolated boron hydrides led to information on hypoborates and halogenated boron hydrides. At the outbreak of the World War in 1914 the work was temporarily interrupted. Moreover, it became essential for a more detailed investigation of boron hydride chemistry to initially study the silicon hydrides, which - as contaminants in the preparation of boron hydrides - made the purification of the latter difficult. Following the last boron hydride publication in Breslau (1914), nine years were to elapse until the next paper appeared from Berlin (1923), the interval being filled with 16 Berlin publications on silicon hydrides to which I will shortly make further reference. In an experimental lecture on boron hydrides in 1913, Stock reviewed the results achieved thus far, which represented a more than exploratory - if not in every sense masterful - drive

forward into a hitherto still unknown and unchartered territory.
Additional work of the Breslau period was concerned with the carbon chalcogens and produced the compounds C_3S_2, CSTe and CSSe. Manipulation of the last compound proved to be exceptionally tiresome, as the inhalation of small amounts of vapour gave Stock and his coworkers highly unsociable garlic-smelling breath for days on end.
The outbreak of the World War in the autumn of 1914 caused a considerable drop in the number of students at the institute, slowed down the research productivity and increased Stock's willingness to seek a fresh place of work. He therefore decided in 1915 to accept a position at the Kaiser-Wilhelm Institute for chemistry in Berlin-Dahlem as successor to Richard Willstätter, who had moved to Munich to replace Adolf von Baeyer.
The possibility of undisturbed research activity, the exceptionally attractive financial proposition and the assurance of an immediate chair at Berlin University induced him to make this decision.

'Meisterjahre'

Berlin (1916-1926). At the beginning of 1914, the now 40-year old research chemist took over Willstätter's laboratory at the Kaiser-Wilhelm Institute. The institute was then just four years old and consisted of three independent sections, the Physical Chemistry department under Ernst Beckmann, the Organic Chemistry department supervised until then by Richard Willstätter and the Radioactivity department headed by Otto Hahn. The following ten years allowed Stock, aided by the disappearance of the unfavourable conditions of the war, to fully explore the chemistry of the silicon and boron hydrides, that experimental masterpiece which rapidly brought his name to fame at home and abroad and elevated him to professional immortality.
Study of the silicon hydrides, as already mentioned, was a necessary sequel to the series of investigations on boron hydrides as prepared from borides. By optimising the yield of silicon hydrides from magnesium silicide and hydrochloric acid, it was possible to detect and characterize two liquid silanes of formulae Si_3H_8 and Si_4H_{10} as well as the already known gaseous monosilane SiH_4 and the then only superficially studied gaseous disilane, Si_2H_6. Moreover, the existence of two additional liquid homologues, a pentasilane Si_5H_{12} and a hexasilane Si_6H_{14} was ascertained, and it was demonstrated that silicon, in analogy to its lighter neighbour carbon, formed a series of saturated silicon hydrides of general formula Si_nH_{2n+2}. Halogenation of these compounds led to information on the many halogen derivatives, which could be obtained pure and be fully characterized, these in turn being starting materials for the preparation of many other interesting and largely unknown derivatives. Among these can be mentioned compounds such as silicomethylether, $(SiH_3)_2O$, silicoformaldehyde, SiH_2O, silicoethylether, $(Si_2H_5)_2O$ and silicotrimethylamine, $(SiH_3)_3N$, accordingly distinct from the corresponding carbon compounds. Thus a silicon chemistry, comparable in its wealth of formulae to organic chemistry, was created which, owing to silicon's dominating affinity for oxygen, was essentially laboratory born and could only be brought to life by the wand of an experimental magician such as Alfred Stock. But the results also had numerous and fruitful practical uses, as witnessed by the siloxane class of compounds, whose organic derivatives, in the form of silicones, have today achieved technical importance as man-made materials. It had been clearly demonstrated for the first time that silicon reacted in a far more versatile manner in the chemical laboratory than in nature where, due to its tendency to polymerise and oxidise, it is forced into the rigid straitjacket of 'petrification', and where it is deprived of the rich harmony and varied character which create, in the broadest sense, 'organic' chemistry from its carbon homologue.
With the experience gained from the study of silanes, Alfred Stock was able to take up again in Berlin the work on boranes, which he started in Breslau in 1912 and which was temporarily interrupted in 1914. Right from the start, significant progress was made with the preparation and characterization of the simplest members B_2H_6 and B_4H_{10} as well as with the detection of the higher boranes B_5H_9, B_5H_{11} and B_6H_{10}, whose properties along with those of $B_{10}H_{14}$ facilitated a classification into two groups B_nH_{n+4} and B_nH_{n+6}. Study of the chemical behaviour of various boranes towards water, hydrogen halides, ammonia, alkali metals, alkali metal hydroxides and organic substances, and of their intrinsic decomposition at ambient temperature and on warming, led to a whole host of compounds, reactions and observations, which I am unable to report in greater detail in this lecture. In this way it was possible to build up an

astonishingly varied borane empire - although again restricted to the laboratory as was the case with silicon - an achievement which was worthy of its master, like the work on the silanes before it, and which for the first time permitted a comparison of the chemistry of carbon's immediate neighbours in the periodic table, boron, silicon and nitrogen. To quote Alfred Stock, "The chemistry of each of these elements is in its own way a distorted and simplified image of the chemistry of carbon, that king of the elements in which the chemical abilities of its neighbours are simultaneously magnified and focussed into harmonious unity" thus contributing to the 'triumph of carbon'.
Numerous technical improvements together with the development of a special high vacuum system were the further fruits of the then extensive involvement with the chemistry of boron and silicon. 'Stock's High Vacuum Technique' enabled the precise and quantitative purification and investigation of the smallest amounts of volatile, sensitive materials under high vacuum by the exclusion of air, moisture and grease in a completely closed, adaptable and easy to operate mercury-sealed glass construction, an apparatus later to become an indispensable and much-used aid in modern science and engineering laboratories, and which was to make many researchers, both inside and outside Germany, disciples of Alfred Stock. Amongst the countless features and items of subsidiary apparatus pertaining to the high vacuum technique, only the following will be emphasized: the grease-free mercury valve, the vapour pressure thermometer, the buoyant gas balance, the mercury collecting pump, the vacuum tube opener, the apparatus for tensimetric molecular weight measurements in liquid ammonia and the zinc electric arc as a powerful reducing agent in preparative chemistry.
Besides extending the chemistry of the boranes and silanes and the development of the high vacuum technique, other lines of research were also being pursued at that time, concerned on the one hand with the preparation of pure metallic beryllium, and on the other hand with continuing the studies on carbon chalcogens, originally begun in Breslau. The beryllium work later became industrially important and introduced the metal and its alloys into the field of the applied sciences.
He who assumes that the enormous amount of time spent on scientific research during the Berlin decade rendered extra-curricular activities physically impossible greatly underestimates the drive of this energetic man and the pleasure he took in his work. For in conjunction with his experimental undertakings, he carried out countless organisational tasks, which would alone have been sufficient to fully occupy one's time. The number of honorary positions which he held in learned societies, organisations, education committees etc. was almost uncountable. To mention them all would alone require an entire lecture. And he took each and every job seriously, for he did not belong to those whom Schiller described with the words: "I only hold an office and don't give opinions!" Instead he vigorously attacked all problems without regard for himself or his health and, after World War I, he earned himself lasting esteem for reforming the then depressed state of German chemistry and for supporting the new generation of young chemists.
These almost superhuman scientific and administrative achievements were accomplished by a physically rather delicate man, who was then no longer in full possession of his physical strength. For Stock was already suffering severely at that time from the effects of progressive mercury poisoning - as yet unrecognised - without which, as he later regrettably recorded in his diary notes, "I could have achieved much more in every respect"(!). Especially disturbing was the damage to the upper part of the wind pipe which involved a year long - unsuccessful - treatment "by etching, burning, massage, electric shocks and bloody surgery", also the deterioration of his previously excellent memory and his growing deafness, to such an extent that he began to doubt whether he could continue his scientific work. Then, in 1924, after surviving an almost unbearable winter, he found and recognised quite by chance (when one of his coworkers suddenly fell ill) the cause of all his afflictions - the continuous inhalation of a very small amount of mercury vapour in the laboratory atmosphere (a few thousandths of a milligramme per cubic metre) was responsible for the disease. With characteristic zest Stock immediately began to investigate the insidious mercury disease to which, as he was then able to establish, many other scientists such as Faraday, Pascal, Berzelius, Liebig, Wöhler, Hertz and Ostwald had also apparently fallen victim. In an extensive publication he warned emphatically of the dangers of the volatile, odourless, mercilessly attacking mercury metal, with its enduring after-effects, proposed the first precautionary measures and drew attention to the possible dangers of amalgam tooth fillings.
The prospect of escaping from the mercury-contaminated laboratories of the

Kaiser-Wilhelm Institute in Berlin, and moving into new and healthy rooms was partly responsible for his decision to accept the appointment offered to him in 1926 by the 'Technische Hochschule' in Karlsruhe to succeed his colleague Karl Freudenberg, who moved to Heidelberg. Now 50 years of age, he thus settled in Karlsruhe and a new era of his life began.

Karlsruhe (1926-1936). Cautioned by the severe damage to his health in Berlin, Alfred Stock started immediately in Karlsruhe with the setting up of exemplary mercury-protected private laboratories, which were later to become the object of interest for visitors from both home and abroad. To avoid the accidental accumulation of mercury in cracks and inaccessible places, all the floors were laid with continuous linoleum covering up to a height of about 10 cm. at the walls, and all furniture and desks were fixed on wall brackets, so as to facilitate the continuous monitoring and cleaning of the floor surfaces beneath them. The equipment cupboards were constructed as hoods and built so as to use the ventilated walls as the back. An air-conditioning system equipped with a filter device and able to be heated in the winter, was mounted under the windows and enabled, together with an effective ventilating system, the constant and highly efficient circulation of air without draughts. With the suction at full strength, the laboratory's double doors could only be opened by force, owing to prevailing low pressure inside the rooms. With these and other precautionary measures, he succeeded in keeping the laboratory atmosphere free from mercury vapour, despite the very large volumes of mercury in baths and hundreds of valves, and in fully protecting his coworkers from the consequences of mercury poisoning. Unfortunately, this did not concern Alfred Stock himself, who was already suffering from a pronounced mercury idiosyncrasy and was in addition obliged to consistently spend time in many other rooms in the institute which were not purged of mercury. His fear of the "damned Mercurius and his followers", as he used to call it, drove him at that time to, for example, conduct departmental meetings with the windows open, even in winter (footmuffs were available for those who particularly felt the cold!) and, when he was at home (which also by the irony of fate turned out to be severely contaminated with mercury) to do his important literature work partly out in the cold on the terrace. Evil tongues attributed the chronic catarrhal condition of his respiratory system not to mercury poisoning but to his drastic methods of preventing it! I suppose in this case, as in many others, the 'devil' had to be driven out by the 'demon', and those close to Stock knew how badly he really suffered from the effects of mercury.

The Karlsruhe 'Hochschule' was soon to recognize the exceptional abilities of their new colleague from Berlin, and he was elected Rector of the 'Hochschule' only 2 1/2 years after he had taken up office. Now as always, he was not content to simply take over the official business but made use of his term of office to introduce a decisive educational reform. In his inaugural speech as rector: 'Technical Universities at the Cross-roads', he pointed to the clearly recognisable deficiencies in the curricula and teaching methods at the technical universities and suggested a reduction of the specialisation in applied sciences in favour of a stronger emphasis on a general scientific grounding, a freer, less school-oriented type of education and greater attention to the creativeness of the individual. And Stock was not a man to just leave his ideas to be criticised. Already during his period as Rector, a basic educational reform was discussed in collaboration with all the other faculties in the 'Hochschule', decided upon and approved by the ministry of cultural affairs in Baden. Stock deployed just as much energy as Dean of the chemistry faculty on the smooth reorganisation of all administrative tasks. If in this context one of Stock's characteristics is to be singled out, then it must be his concern for punctuality. For him, punctuality was not only the 'politeness of the kings' but of superiors in general. Despite the overburden of his countless other professional and administrative jobs, he never arrived even so much as one minute late for a departmental discussion, a meeting, a lecture or a colloquium, and some assistants would set their watches 'by Stock'. Of similar exactitude and punctuality, both in appearance and content, were his letters and publications, which he always took care to write by hand, whereupon over the years his writing became more and more microscopic, until in the end he had to use a pointed fountain pen with the back bent downwards in order to still be able to achieve the detail of all the basic strokes and hair lines.

The evening hours, in which Stock, as a great socialiser, often gathered friends and colleagues around him in his hospitable home, were a pleasant compensation for the strains of a day's work. It is with a certain melancholy that I recall the unforgettable summer evenings in Stock's garden, to which

his wife, always conscientiously looking after her guests, added her very personal touch. -
During the Karlsruhe decade, Stock's experimental devotion was turned principally to the boranes and research on mercury poisoning.
The experiments on boron hydrides, which had been restricted in Breslau to an exploratory advance into a new work area and then expanded in Berlin to the purification and characterization of the most important members, were now in this third and last professional era to be concerned with the study in depth of some of the more structurally important reactions. The following may be mentioned here: improvement of the preparative methods, studies on the effect of alkali and alkaline earth metal amalgams on boranes, work on the electrolysis of boranes in liquid ammonia, work on 'inorganic benzene', $B_3N_3H_6$, effect of halogens and hydrogen halides on boranes etc. And so in 1937 Stock was able to look back contentedly over a quarter of a century of successful research in the area of boron hydride chemistry, and close this chapter of his experimental activities with the feeling that all the necessary foundations had been laid for a theoretical rationalisation of this group of compounds, the boron hydrides, which were so puzzling from a valence point of view. As a dedicated preparative chemist he engaged himself very little in the theoretical evaluation of the accumulated factual material. His preference was here, as in other cases, for the discovery of new compounds and the exploration of unknown reactions. The theoretical evaluation was for him a 'cura posterior', which he willingly left to other people. For he did not in general think highly of speculative considerations and theoretical explanations. He once said:"The value of theories should not be overestimated, even if they seem very attractive and bring intellectual satisfaction. So often it is only a case of old wine in new skins!", a concept with which one must agree in certain cases, since the cutting remark of Johann Heinrich Voss holds even today for certain theoretical speculations, that what is good is not new, and what is new is not good. I still have vivid memories of the occasion when, as a young assistant, I showed Stock the reprint of one of my publications on the structure of boron hydrides and other boron compounds, in which I proposed that a pair of electrons could bind more than two atoms and that the boron-chlorine bond in boron chloride was stronger than a single bond. He looked at me with a generous forgiving smile; because ideas such as 'multicentre bonding' and 'back-donation' had at that time, roughly half a century ago, not yet been conceived. Stock was motivated in all his experimental work by the sheer enjoyment of discovery. He showed no desire whatsoever for material exploitation, and the mere thought of, for instance, using boranes as rocket propellants, an idea which later stimulated research in this area in America for some time, would have struck him as quite absurd. "The value of a significant new scientific fact bears the same relation to applied research as the discovery of a valuable ore deposit to its exploitation", he once said; and Stock always derived much greater satisfaction from the location of an 'ore deposit' than from exploiting the mine. To him science was, in Schiller's words, always "the high and heavenly Goddess" and not the "efficient cow that supplied him with butter". Thus he was always careful, in his speeches and writings, to convert young people to the same idealistic interpretation of 'researchdom'. "National pride in scientific success should not be considered less important than football victories!" he once warned in his pertinent fashion.
During the working period in Karlsruhe, the problem of mercury poisoning, as well as borane chemistry, became the subject of a thorough investigation. In his laboratories he quietly began his offensive against the merciless metal. First, reliable microtechniques were developed to determine quantities of mercury down to one hundred thousandth of a milligramme. Subsequent experiments on the distribution of mercury indicated that the metal was ubiquitous in nature. Tests on animals already yielded, during the initial stages in Karlsruhe, important information on the location and pathway of mercury poisoning in the organism, whereby it could be unambiguously proved that the nervous and physical afflictions arising from mercury disease were due not to the metal which enters the circulation via the digestive system but to the vapour breathed through the nose, which penetrates the frontal part of the brain and accumulates in the hypophysis. It might also be mentioned that, as a devoted scientist, Stock did not restrict his experiments only to guinea-pigs, rabbits and dogs, but also made himself available as an experimental subject. Although, due to his hypersensitivity to mercury, he suffered particularly severely from its effects, he admirably did not shy away from the 'experimentum crucis', the injection of a dilute solution of mercuric chloride into the nose, the result of which - as he was "pleased" to observe - was to cause the expected typical, unbearable symptoms of mercury poisoning. A comprehensive and remarkably bulky review of the results obtained in Karlsruhe and, by Stock's instigation, in

the mercury research centre of the Berlin Charité, impressively revealed the great progress hitherto achieved.
During the time in Karlsruhe, the Stock high vacuum apparatus was also further developed and improved. Here, the department's glassblower provided valuable services; he was both a master of his craft and a hearty drinker, whom Stock once approvingly acknowledged in a report with the words:"he manipulates glass superbly".
Stock was to receive innumerable honours during his period in Karlsruhe. His election as president of the 'Deutsche Chemische Gesellschaft' will alone be mentioned here. Many memorable meetings occurred during his presidency, and participants at the lectures remember with a grin so many of Stock's all-embracing votes of thanks, which eloquently revealed the quickness of repartee and unstraying accuracy of his witty sense of humour. As an example may be quoted the lecture held by Professor Schoeller of the Schering Company on the isolation of sex hormones from human and animal urine, which caused Stock to comment with the slightly modified Schiller citation:"Das Alte stürzt, es ändert sich die Zeit, und neues Leben blüht aus den - Urinen!" (originally 'Ruinen').[1]
Numerous lecture invitations took Stock abroad, to France, Holland, Belgium, Switzerland, America, Austria and Russia. He was so impressed by his stay in Russia that, on his return, he lectured objectively and unbiasedly on everything he had seen and experienced. I still remember vividly that moment in his lecture when, while describing the travel comfort which the Russians offered to their visitors (and at the same time throwing an ironical side-glance in the direction of the not very russophile representatives of the Third Reich) he left it open to question whether the express train coaches which they used might not have been Potemkin façades.[2]
All the successes, commitments and honours which I have portrayed could not however cover the fact that Stock's state of health was deteriorating as a result of mercury disease. The professional teaching duties and administrative departmental tasks were gradually becoming more and more burdensome, on the grounds of which he decided at the age of sixty to move into retirement, and this was duly granted. He was immediately asked to accept a research commission as an emeritus professor at the University of Berlin to study mercury poisoning.
In 1936 at his farewell celebration attended by research assistants, former pupils, colleagues and students, Stock spoke in a special lecture of his life's work in science. Very evident was the great love, respect and gratitude, which was felt for this great researcher and warm-hearted promoter of young students. And then there was the unforgettable moment when, in the main lecture theatre, decorated with flowers, overpowered by the wave of venerable gratitude, he said in his typical way:"But please, I am almost beginning to feel like Max Schmeling!", a statement which, in view of his slender stature, not at all in keeping with a world boxing champion, was particularly amusing. On the other hand, considering the overemphasis on physical capability and underemphasis on intellectual capacity which were then typical in the Third Reich, it somehow made good sense.
At the end of 1936 Stock moved with his family back to Berlin and thereby returned, as he had so often done before, to the heart of this old yet eternally young city of his childhood.

'Ruhejahre'

Berlin (1936-1943). In order to finish his work on mercury poisoning, Stock set up two special laboratories, the first in the 'Reichsgesundheitsamt', the second in the Kaiser-Wilhelm Institute for physical chemistry, where with the help of two female assistants he was able to investigate the nature of mercury poisoning more thoroughly than hitherto possible. Thus, in 1943, he was able to make a final report on this subject and look back contentedly on the facts he had discovered, the long and tedious investigation having been inspired only by the desire to save other people from the bitter consequences which were so afflicting the latter years of his own life.

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1) "The old gives way, times change, and new life springs out of the - urine!" (originally 'ruin').

2) The former Russian prince, Potemkin, built impressive façades for the villages in his province to deceive the Empress Katharina on the occasion of a state visit.

For Stock's state of health grew visibly worse during his time in Berlin. After unsuccessful throat operations, walking became gradually increasingly difficult, which was recognised as an after-effect of mercury poisoning. When in 1940, I had the opportunity of meeting Alfred Stock on the occasion of a medical consultation in Munich, I was shattered to witness the extensive physical disability of a man who earlier was so lively. This was in sharp contrast to his mental agility, which had remained as before. He was as full now as ever he had been of plans for the future, and must therefore have found his physical helplessness doubly trying.
How one must admire the will-power of this man who, despite his increasing suffering, found enough strength in this Berlin period to undertake all kinds of scientific and social commitments and deliver numerous lectures in Germany, Italy, Sweden, Finland and Austria.

Warmbrunn (1943-1945). In 1943, in the middle of the second World War, then nearly at the end of its fourth year, Stock interrupted after seven years' activity his laboratory work in Berlin-Dahlem, as his two small work rooms were needed for war purposes. He now moved with his wife to Bad Warmbrunn in Schlesien into his brother-in-law's house.
At the beginning of 1945, as a result of the Russian advance, the approaching cannon fire became louder and more alarming in the meditative quietness of his stay in Warmbrunn, where he had now been for eighteen months. So, in the chaos of the last days of the war, Stock decided to leave Warmbrunn and seek refuge a few hundred kilometres to the west in Dessau on the Elbe at the home of a former coworker and friend, who then had a senior post in the nearby 'I.G. Magnesiumwerk' Aken. After a strenuous four-day land- and sea-crossing (which involved dozens of transfers), loaded down with the remainder of his possessions, he arrived physically exhausted in Dessau with his wife, who was extraordinarily capable, and they put up in a hotel. A few days later, the town was hit by a devastating air attack in which the hotel was so severely damaged, that Stock lost the luggage, so laboriously dragged all the way from Schlesien, and was able to rescue only a small suitcase, a brief case containing documents, and personal effects, which he carried round his waist. "Omnia mea mecum porto", he could then exclaim, as once his fellow sufferer, the Greek Bias had done, when he moved into a maintained hut at the Aken 'Magnesiumwerk', which had been vacated for him. Living conditions were primitive, and good friends had to help him out even with the simplest articles of clothing; after its conquest Dessau fell into Russian hands. The news which slowly got through from friends in other parts was nearly always bad: killed, dead, lost, poverty stricken!
But time is the almighty healer! Now almost seventy, Stock, more and more confined to his room, soon sought refuge in water-colour painting, something which he had pursued with considerable enthusiasm and talent in his youth. With only a pathetically simple paint-box he came out with charming little still-life pictures of the simple objects which were to be found in his humble dwellings. Interchange of ideas gradually got under way again with distant friends and colleagues, who had been spared by the deadly war. And in this way, Alfred Stock bore his truly bitter misfortune, the fall from the previously dazzling heights of social prosperity to the depths of the most primitive way of life and material needs, with the cheerful and heroic serenity of a sage. It is an enlightening example of Lessing's saying that the true beggar is the true king. But who can measure how much inner self-control and self-denial constituted the price he paid for this apparent calmness.
Already in January 1946, Stock gave a first lecture on boron chemistry to the chemists at the Bitterfeld works of the I.G. In February he launched an urgent plea to all those in responsible positions:"Save German chemistry!" In March, under circumstances, the details of which I shall omit, he and his wife had to leave their lodgings, to make room for - a troupe of artistes. Fortunately he was able to find shelter with some refugees from Sudeten in a well-kept house belonging to an I.G. engineering family in Aken, where he moved into a room with an open view to the south. Here he was well cared for and celebrated his 70th birthday in peace and quiet with only a few friends.
The future of the little town of Aken had meanwhile become rather gloomy. The 'I.G.Magnesiumwerk', which had given significant importance to the town, was to be pulled down, The same went for the nearby 'Aluminiumwerk'. After the first World War, Alfred Stock had struggled hard to repair the shattered condition of German chemistry and its organisations. It was soul-destroying for him to watch this recreation crumbling again bit by bit after the second World War. And with this came the gradual disintegration of his own will to live, which up to then had never weakened, despite the indescribable misfortunes and all the personal self-denial and disappointment. A letter which I received three weeks before his death showed the first signs of foreboding

and ended with the words:"My entire scientific notes were lost in Warmbrunn. I have only managed to save a summary of my complete publications together with some biographical notes in my portfolio, a fact which I am particularly keen to let you know. My wife and I send our very best wishes to you, my dear friend, and to your wife, Yours, Stock." Those were the last lines which I was to receive from my teacher and friend. Early on the 12th August 1946 thirty years ago, he closed his eyes quietly and peacefully for ever. A heart, which had known all the beauties and hardships of life and always relentlessly struggled for the values of German chemistry, had ceased to beat. A man, at whose bier innumerable friends, colleagues and organisations would normally have mourned, took his leave, unnoticed by the outside world, in peaceful loneliness with the life companion who through good and bad fortune had remained faithful to him, from a country which had become inhospitable and whose destiny compared to his own.

But this bitter end was fully compensated by the beauties, joys and successes of the road he left behind him. The final hours of his departure were surely brightened, as by a last ray of sunshine in the dark gateway to eternal peace, by memories of those days of youth and happiness, the time, when as a young man under Moissan in Paris amongst jovial friends, he enjoyed the splendours of this world; the time, when in Berlin he experienced the blissful period of his first scientific discoveries and stood before the altar with his young bride; the happy era of scientific and administrative achievements as professor in Breslau, Berlin and Karlsruhe; the time when - as yet physically unafflicted - he climbed the familiar Berchtesgaden mountains and looked bright-eyed at the world stretched out in front of him, the dazzling picture of important meetings at home and abroad, which he always made his focal point and to which he so willingly contributed a very personal touch through his good-humoured after-dinner speeches.

Thus he thankfully rendered into the hands of his creator a life, which had found its fulfilment and 'despite all and everything' had been magnificent. He was able to take his leave with the satisfaction of having, through his own life's work, laid the sure foundation of a future renaissance of inorganic chemistry.