structure determinations. The outstanding one among these is the analysis of the urea adducts. This work was done during his prison term in Halle from where he was, on the representation of the I. G. Farben, daily escorted by a guard to their Leuna works for 'work of national importance'. In these urea adducts long-chain molecules like paraffins are imbedded in cylindrical tubes formed by spiralling polyurea chains—an entirely unforeseen type of structure at the time.

Hermann's lectures on crystallography are said to have been very stimulating. They contained some of the material he could not bring himself to publish, and parts of his course were worked out by his students and checked by him. Perhaps, some day, they can be published, but they will now always remain a fragment.—Max Born, in a short obituary notice on his friend and pupil mentions his profound and expressive addresses at the Friends meetings which testified to his sincere search of truth, clarity of mind and moral fortitude. The longer the more, matters spiritual took precedence in Hermann's unfinished work and brought him nearer to the peace for which he always strove.

P. P. Ewald

Gösta Phragmén

1898-1944

Dr. Gösta Phragmén, who died on 21 August 1944, was born on 29 April 1898. He took his first degree in chemistry, physics and mathematics at the University of Stockholm in 1921. By this time he was already associated with the newly established Institute of Metallography where he acted as assistant first to Professor C. Benedicks and subsequently to Professor A. Westgren. In 1927 he succeeded Westgren as principal metallographer at the Institute, and when the Institute was reorganized in 1933 he was appointed head of its technical department. In 1934 he was awarded the degree of Licentiate of Philosophy in physics by the University of Stockholm. From 1939 he was assistant professor in metallography at the Royal Technical University of Stockholm, where from 1942 he lectured in physical metallurgy. When the Institute of Metallography was reorganized as a result of its expansion, he was appointed its head in 1943.

Even in his youth Phragmén showed unique qualities. In spite of

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remarkable personal modesty he had marked confidence in his knowledge and judgement and in consequence he was highly critical of the concept of authority. These characteristics were evidently inherited from his father, the distinguished mathematician Edvard Phragmén, and they were strengthened by an education free of all constraint. In addition to his critical scientific disposition, he soon showed a strong technical interest, and this probably influenced his choice of the new Institute in spite of all his prospects for a successful academic career. It is probable that his dislike of academic formality also contributed to this choice.

Phragmén's first efforts as an X-ray crystallographer were made in 1920, when G. Aminoff, then assistant professor at the University of Stockholm, and he investigated the structure of the mineral alloy osmiridium. The new techniques captured his interest, and when they were later used for alloy investigations at the Institute of Metallography, where Phragmén entered as a pupil, he very soon contributed to their development and application. His efforts in this field assured the success of the X-ray structure research carried out at the new Institute.

Phragmén used his considerable experimental skill to construct a reliable and simply operated apparatus for obtaining powder photographs. He constructed a rotation camera which was primitive but adequate for the first investigations of relatively simple crystal structures. During his experiments with different types of powder camera he also gradually improved the technique of powder photography, and finally he built a series of focussing cameras which, with their high resolution and very good line definition, proved particularly well suited for alloy investigations.

Studies of the crystal structures of the iron modifications and of steel, which were begun by Westgren in Professor Siegbahn's laboratory in Lund, were continued by Westgren and Phragmén together. They found that δ-iron is isostructural with α-iron, and they determined the crystal symmetry of cementite and also the unit-cell dimensions of martensite and austenite.

In 1923 Phragmén reported an X-ray investigation of the iron-silicon system which had led to the determination of the structures of FeSi and $FeSi_2$. In the course of further investigations of the same alloy system Phragmén found that silicon atoms substituting for iron atoms in the solid solution of silicon in α-iron tend to arrange themselves in a regular way when the silicon content exceeds about 7%. In this way a superstructure is formed which is fully established at a composition corresponding to the formula Fe_3Si. In 1926 Phragmén published a final report on his work on the iron-silicon system, a model combination of metallurgical microscopy and X-ray crystallography.

Together with Westgren, Phragmén studied the crystal structure of manganese. They found that this metal occurs in three different modifications. The X-ray data collected by Westgren and Phragmén, which were published in a paper in 1925, were later used by A. J. Bradley for a determination of the complicated crystal structures of α- and β-manganese.

As a preliminary to investigations of the technically important systems Fe—Cr—C, Fe—W—C and Fe—Mo—C, Phragmén and Westgren carried out X-ray analyses of chromium, tungsten, and molybdenum carbides; they also devoted a special study to the carbide occurring in high speed steel, which was later found to have the formula Fe_3W_3C. In cooperation with T. Negresco, a Rumanian guest at the Institute of Metallography, an investigation of the equilibria in the system Fe—Cr—C was undertaken, in which Phragmén took a particularly active part. It was no simple task to construct the equilibrium diagram for this complicated system from data provided by micro-structures and X-ray photographs, but in this very fact lay its appeal for Phragmén. This central part of the study was carried out mainly by him and he also wrote the section of the report dealing with equilibrium conditions in the system.

In parallel with these investigations connected with the physical metallurgy of steels, Phragmén also participated in a series of X-ray analyses of the systems Cu—Al, Cu—Zn, Ag—Zn, Au—Zn and Cu—Sn. In cooperation with Westgren he also published several papers in which the discovery of the structural analogies and the connection between valence electron concentration and structure type were reported.

Phragmén again showed his eminent skill as an experimenter in an investigation by X-ray diffraction techniques of the thermal expansion of invar, which he reported in 1931. For this purpose he constructed a camera, which recorded the X-ray reflections of a thin sheet of invar, which was heated electrically to about 200°C. He found that the reflections were so slightly displaced in relation to their positions at room temperature that the abnormally low thermal expansion of the alloy could not be ascribed to a partial phase transition. Thus, as Chevenard had already assumed, the practically constant volume of invar when heated depends on an expansion anomaly of the constituent γ-Fe-Ni-phase.

Phragmén was probably not by nature a good teacher, but his interest in teaching increased markedly as the years went by. One might perhaps say that he lacked a psychological interest in ignorance and stupidity. In his writing his presentation was concentrated and went straight to the point. Great concentration and a considerable amount of knowledge was needed in order to follow it. Phragmén sometimes showed an astonishing indifference to the publication of his own results. He probably thought that the whole thing was so simple that other people should be able to obtain the same results without difficulty. To strive for honours was unfamiliar and even repulsive to him.

One of Phragmén's earlier collaborators gives his impression of him as a leader in these words: 'Phragmén was to an unusually high degree a master of the theoretical basis of his field of research. This, when added to his requirement of consistency, order and clarity in reasoning and ideas, made all discussions with him extraordinarily instructive and interesting. Speculations without factual basis were aims of his quietly ironical scepticism. He was very much interested in the ideas of his assistants on aspects of the work, and stimulated their activities by demonstrating the gaps in their knowledge and the weakness in their reasoning. He permitted great freedom in the work, but in spite of this he was interested in every detail and one could always count on his assistance in all difficulties. When experimental problems occurred he always had simple and practical solutions to propose. With his considerable knowledge, his critical judgement and his mental balance he inspired a degree of confidence which made work with him very agreeable.'

Phragmén's experimental skill and interest in instrument construction has already been mentioned. Another of his collaborators testifies to these qualities, but adds that although Phragmén made exacting demands on the performance of an instrument, he was less concerned with its convenience in application.

Phragmén was an excellent adviser on scientific research. In this connection, the qualities which were particularly evident, in addition to his wide knowledge and critical outlook, were his never failing helpfulness and a lightning power of apprehension. One sometimes had the impression that he knew in advance what one intended to say. He was speculative within the limits imposed by known facts, but his imagination was always strictly controlled by observation. It is possible that Phragmén made his best contributions when he cooperated with a more optimistic and less critical colleague. It is quite natural that he turned out to be, as someone has said, 'an oracle, to whom one turned with all observations and ideas'.

With the years, Phragmén also became increasingly acknowledged abroad for his penetrating contributions to scientific discussion. In the field of theoretical metallurgy in particular, there are many proofs of his authoritative position. A list of 53 of his publications may be found in *Jernkontorets Annaler* 1944, *128*, 533–535.

In a relatively short working life, Gösta Phragmén was able to give a lustre to Swedish research in metallurgy and metallography through his scientific contributions. The level in this field of research was markedly raised under the influence of his example and criticism. His colleagues remember him with gratitude and admiration as an incomparable fellow-worker, and a straightforward and honest man.

A. Hultgren, B. Kalling, A. Westgren

Victor Moritz Goldschmidt

1888-1947

Victor Moritz Goldschmidt was born 1 January 1888 in Zürich. His father Heinrich J. Goldschmidt named his son after his teacher Victor Meyer. The Goldschmidt family came to Norway 1901 when Heinrich Goldschmidt took over a chair as Professor of Chemistry in Kristiania (Oslo).

Goldschmidt's first important contribution was within the field of geology and mineralogy. His two first larger works were his doctor thesis *Die Kontaktmetamorphose im Kristianiagebiet* and *Geologisch-petrographische Studien im Hochgebirge des südlichen Norwegens.*

Goldschmidt has been named the founder of modern geochemistry and crystal chemistry. A series of publications under the title *Geochemische Verteilungsgesetze der Elemente* is usually referred to as the start of geochemistry, the science that describes the distribution of the chemical elements in nature. The geochemistry has not only greatly inspired the field of mineralogy and geology but also theoretical chemistry and crystallography.—Goldschmidt's work on atom and ion radii has been of enormous importance for crystallography. His work in this area has no doubt inspired the introduction of the Pauling covalent, ionic, and van der Waals radii.

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