CHAPTER 20

Germany

by E. E. Hellner and P. P. Ewald

When M. von Laue left Munich in the fall of 1912 to go to Zürich, W. Friedrich remained as experimental assistant to Sommerfeld at the Institute for Theoretical Physics. P. Knipping obtained his doctoral degree soon after the publication of the Laue-Friedrich-Knipping paper and took a job in the Siemens Laboratory in Berlin for development work on Coolidge type X-ray tubes. He later became assistant to J. Franck in the Kaiser-Wilhelm-Institute for Physical and Electrochemistry in Berlin-Dahlem during the war, and after that settled in Darmstadt as Lecturer at the Technical University; in one of the following years, however, he had a fatal collision with a truck while riding his motorbicycle.

Friedrich left Munich in 1913 to become the X-ray specialist in Prof. Krönig's Gynaecological Section of the Freiburg University Clinic, then—as today—famous for its advanced methods of operating and of radium and X-ray treatment. Friedrich was soon fully absorbed by the medical problems and eventually became Head of a special medical X-ray Institute attached to Berlin's most renowned hospital, the Charité.

The Munich equipment remained in the hands of Ewald, but was soon diverted from its original purpose by being transferred (including Ewald) to an emergency hospital which was set up in a Munich elementary school at the outbreak of war. The initial experience in medical use led, a year later, to the appointment of Ewald (and similarly to that of Glocker and other physicists) to the newly created position of Field X-ray Mechanic of the Army. While Glocker, Regener, Spiess and others saw heavy fighting and had plenty of work on the frontier with France, Ewald was assigned to the northern part of the Russian front and when he arrived by the fall of 1915, fighting had practically ceased. The tranquillity, together with the isolation of the field hospital enabled Ewald to carry through his dynamical

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theory of X-ray diffraction which he then used as thesis (Habilitationsschrift) for becoming a lecturer (Privatdozent) in Physics at the University in Munich in 1917.

Compared with the progress made by W. H. and W. L. Bragg by August 1914, the progress made in Germany was not spectacular. The Munich group worked exclusively with 'white' X-rays and Laue diagrams. The photographs could be explained in detail, once the crystal structure was known, but they proved little suited for finding the structure. On Friedrich's excellent Laue photos of pyrites (FeS_2) and hauerite (MnS_2) Ewald developed a method of determining a parameter with great accuracy, but this could only be achieved while checking the type of structure found by W. L. Bragg. Much later work, by Parker and Whitehouse in Manchester (1932) confirmed by Fourier methods the accuracy of the parameter determination.

In Röntgen's Institute his senior lecturer, E. Wagner, took up diffraction work. Wagner was an experimentalist who had great understanding for physical argument and practically none for mathematical proof. He would not be convinced by any formula that a diffracted ray in a Laue diagram contains only a single wave-length or perhaps also an overtone or two. So he asked his student, R. Glocker, to analyse one of the rays by reflecting it on a second, parallel crystal. When the second crystal gave a diagram with only a few spots, this finally convinced Wagner. Later (1920) Wagner did important work on X-ray spectra; in particular he showed the influence of the silver bromine absorption edges on the photographically recorded spectral intensity. In the course of this work he found that spectra, obtained from a slowly rotating crystal, were traversed not only by the dark lines of the intensive characteristic radiation, but also by faint white lines ('Aufhellungslinien'), less dark than the continuous background. These were either parallel to the dark lines or inclined at definite angles. The faint lines, it was soon shown, occur whenever the Bragg condition is fulfilled for more than one atomic net plane, so that energy is deviated into a further direction. O. Berg, working in the laboratories of the Siemens concern in Berlin, made a very thorough study of these 'Aufhellungslinien' in 1926.

During the war, 1914–18, experimental research came to a near standstill, except in Göttingen where P. Debye, of Dutch nationality, and a Swiss postgraduate worker, P. Scherrer, were not affected by conscription. They discovered in 1916 the method of powder diagrams while trying to obtain evidence of the electron clouds surrounding the atoms in lithium fluoride—but this story is better read in Part VII in

Scherrer's Personal Reminiscences. The enthusiasm which this method provoked is well shown by the remark of one of the leading crystallographers, A. Johnsen, then professor in Kiel, later in Berlin. When he explained the method to the writer, he ended up by saying in all seriousness—to his listener's horror—: 'We have now got rid of all troubles of finding crystals good enough for structure analysis, we simply go to the collection of minerals and grind up whatever crystal we find, good or bad.' Two interesting papers in *Physikalische Zeitschrift* 1917 and 1918 on the indexing of powder diagrams appeared, by C. Runge the first, and the later by A. Johnsen and O. Toeplitz.

At that time the nature of the brightly coloured colloidal metals was still unknown and a matter of speculation by Szigmondy, the Professor of Colloid Chemistry in Göttingen. Scherrer, employing his new means of investigation, showed that colloidal gold gave essentially the same diagram as gold filings, but with much broadened lines. The broadening he interpreted as due to very small particle size and developed a formula by which the particle size could be determined from the broadening. This opened up a field of research which was to lead later to many important applications, especially in relation to catalysts (R. Brill).

Also during the war, H. Seemann, then in Würzburg, began an extensive series of studies of the geometry of image formation by the diffracted rays. This led him to the construction of new types of cameras, both for the conventional methods of obtaining photographic diagrams, and for wide-angle and 'complete' diagrams. He later manufactured in his own laboratory, and still does so, demountable X-ray tubes and cameras of many types and great workmanship. The wide-angle method gives no easily interpreted intensity data and is therefore not so suitable for structure analysis as for the precision determination of lattice constants.

After the war many changes took place. E. Wagner became professor in Würzburg and, after Röntgen's death in 1923, organized a small museum in memory of Röntgen's discovery in the very house where it was made. This museum, later looked after by Wagner's successor H. Ott, miraculously survived the fierce bombing which destroyed large parts of Würzburg in 1945 in one of the last bombing attacks of the Second World War; it has now been partly transferred to the museum in Röntgen's birthplace Lennep.

R. Glocker, after his discharge as Field X-ray Mechanic, settled in 1919 in his native Stuttgart and began building up an X-ray laboratory attached to the Technical University and financed largely by contributions, in kind or in money, of industry. In spite of the post-war financial crisis this became in a few years the best equipped and best staffed X-ray laboratory. Often the factories of X-ray equipment sent there, for a test period, the latest improved high tension and stabilizing machines, and its choice of X-ray tubes of a variety of shapes, form of focus, and target material roused the envy of visitors, especially from U.S.A., where the production of tubes was standardized to meet medical needs, and the importing of foreign makes required special permits. (Besides, the C. H. F. Müller tubes were half the price of the American ones.) An excellent workshop with first-rate instrument makers formed an important section of the institute. Apart from routine and testing work necessary at times for its financing, the work of the institute was largely governed by Glocker's own interests. These were:

1) Metal structures and textures, in particular hardening by annealing, and the effect of impurities on recrystallization.
2) From about 1935 onwards, the X-ray determination of stress in built-up parts, for instance in the girder of a bridge in situ. Portable X-ray tubes and backreflection cameras were constructed and tested in the laboratory.
3) The study of the photographic and biological action of X-rays, and later of penetrating electron rays.
4) Dosimetry and radiation protection. As a long-time member of the Association of Radiologist's Commission on this subject, Glocker and his co-workers made valuable contributions to the definition of the practical units like the röntgen and rad, and to the correct method of their measurement.

Among the many long-time co-workers of Glocker are U. Dehlinger (Stuttgart), K. Schäfer (now at I. G. Farbenindustrie, Ludwigshafen), R. Berthold (now manufacturing X-ray equipment in Bietigheim), H. Kiessig, W. Frohnmayer, L. Graf, R. Glauner, E. Oswald. In fact, this institute, besides those in Dahlem, was the main seed-bed for X-ray crystallographers. Structure analysis was only incidental and remained on a primitive level; the emphasis lay on problems of an engineering type which require a physicist's training for their solution. When a Kaiser-Wilhelm-Institute for Metals was created in Stuttgart in 1932, it was built next to Glocker's Institute which then became an independent section of the K.W.I. for Metals, and this is its present state. The close association works out well to the advantage of both parties. Under the direction of Köster and with the aid of Scheil, Nowotny (now in Vienna), Schubert, etc., a great number of intermetallic systems were investigated, their crystal structures and other physical properties determined. Glocker, supported by Richter, Hendus and others, was in addition interested in the structure of liquid metals and alloys. Dehlinger, Ganzhorn and Bader developed a theory of bond structure of transition elements in respect to their ferromagnetic properties. In the section of Grube, Kubatschewski (now in England) and Weibke did research on the physico-chemical properties of metals and alloys; Kochendörfer pointed out a theory of fracture and elastic constants of crystals in relation to vacancy energy and surface energy. Seeger in his section has published several papers about the electron theory causes of defects in metals and the interpretation of small-angle scattering of X-rays in plastically deformed metals. A recently opened section for 'Sondermetalle' is going to investigate systems of alloys of uranium, zirconium, etc.—Glocker's textbook on the Testing of Materials with X-rays, now in its fourth edition, and Dehlingers book *Theoretische Metallkunde*, 1955, should be mentioned as a valuable outcome of the Institute's work.

In 1930 an Institute for Theoretical Physics was established at the Technical University in Stuttgart, headed by P. P. Ewald, and modelled after the Munich example in that it provided for modest experimental work, mainly on crystals. The experimental assistant was M. Ruhemann (now in Manchester), who had just graduated under F. Simon in Berlin. His construction of a simple low-temperature camera for the growing of nitrogen crystals in a capillary tube at the centre of the camera was a very original contribution which may be well worth resuming and developing further. After two years Ruhemann was succeeded by M. Renninger (now at Marburg) who constructed a double-crystal spectrometer for the investigation of the intriguing 222 reflex of diamond which was first noticed by Sir William Bragg and which, since it cannot occur for point atoms, gives an indication of the actual shape of the carbon atom in diamond. In the course of these experiments Renninger discovered that the intensity reflected under the Bragg angle from an octahedral face of the crystal varied, if this face is turned in itself, that is, by changing the plane or azimuth of incidence without changing the Bragg angle. The normally very weak 222 reflexion becomes ten times stronger under certain azimuths. It was soon shown that this happened when by simultaneous reflection on other planes energy was being chanelled into the direction of the direct 222 reflection; this phenomenon, named 'Umweganregung' (simultaneous reflection), is thus a counterpart of the faint lines which Wagner found crossing the spectra.

The theoretical work at this institute comprised the collection of known structures (*Strukturbericht*) by Ewald and C. Hermann, the co-editing of *Zeitschrift für Kristallographie*, the planning, and later the editing of the *International Tables for the Determination of Crystal Structures* (Hermann), review articles on X-ray Diffraction in *Handbuch der Physik* and on Solid State in Müller-Pouillet, and C. Hermann's papers on Structure Theory which paved the way for the replacement of the Schoenflies space-group symbols by the more systematic modern ones. H. Hönl developed the theory of the atomic factor including dispersion, which, very much later, gave the theoretical foundation of Bijvoet's elegant method of distinguishing the atomic arrangements in d- and l-crystals of optically active compounds

Before Ewald left Germany in 1937 Hermann had already joined R. Brill at the I. G. Farben Laboratory in Oppau and Renninger soon followed; the Institute passed to the hands of U. Dehlinger and was closely linked to the K.W.I. für Metallforschung. It was fully destroyed by a direct hit during the bombings of Stuttgart.

One of the most brilliant physicist-crystallographers in Germany was Walter Kossel who, after his graduation with Lenard, came to Munich at the end of the First World War, joining Sommerfeld's group. He, as well as the Munich professor of physical chemistry, K. Fajans, discussed the early examples of crystal structures from the point o- view of chemical and electrical bonding forces, charges and polari. zabilities of the atoms according to the early stages of the Bohr theoryf In 1921 Kossel became professor in Kiel, and later the head of the physics laboratory at the Technical University in Danzig. It was here that he developed the 'crystal source diagrams', diffraction effects not of plane X-waves, but of the spherical waves emitted by atoms within the crystal on excitation by electron bombardment or by the incidence of harder X-rays. One of M. v. Laue's most elegant papers discusses these diagrams in terms of the dynamical theory of X-ray diffraction. Among Kossel's pupils and co-workers in Danzig are Möllenstedt, Borrmann and Voges. After the Second World War Kossel became professor of physics in Tübingen, where he died in 1956.

A very important centre of X-ray diffraction developed in Berlin-Dahlem (see the Reminiscences of H. Mark and M. Polanyi in Part VII). From 1920 onward the Kaiser-Wilhelm-Institut für Faserstoffchemie under R. O. Herzog was foremost in the application of diffraction methods to the study of fibres and other high-polymers. Herzog himself, and W. Jahnke, who had, while working with Scherrer in Göttingen, acquired the art of constructing reliable dismountable X-ray tubes, began the work and they were soon joined by M. Polanyi. Following the lead given by Nishikawa and Ono as early as 1913, diagrams were obtained of fibres of cellulose, silk fibroin and other materials which lent themselves to being partially orientated by stress. The repeat distances along the fibre axes could be determined, and Polanyi, Mark and Weissenberg were stimulated to using rotation diagrams also in single-crystal structure determinations.

Weissenberg developed the idea of spreading a single layer line to a picture in two dimensions in the goniometer, and he constructed the first such instrument. Meanwhile the analogy between the diffraction pictures of fibres and of work-deformed metals prompted Polanyi to investigate the deformation of single metal crystals. He and H. Mark discovered the slip properties of single-crystal tin, and soon after that E. Schmid found the dynamical condition of slip, namely the law of the critical shear stress component along the slip direction in a slip plane.

When Herzog's institute was discontinued in 1926, its buildings and installations were taken over by W. Eitel for a new K.W.I. for Silicate Chemistry. Mark, who had brought into being a vigorous school for crystal structure analysis, left Dahlem in 1927 and created a prominent industrial X-ray laboratory in the Ludwigshafen works of the I. G. Farbenindustries. This firm had already one X-ray laboratory at its Oppau works, headed by R. Brill.

After F. Haber's dismissal (see Laue autobiography, pg. 298) the Kaiser-Wilhelm-Institut for Physical and Electro-chemistry in Dahlem came under the direction of Thiessen. Here M. v. Ardenne developed a universal electron microscope, which was used mainly for research on high polymers. Later on, the name of this institute was changed into 'Fritz-Haber-Institut' and Max von Laue was its director until February 1959. In his section on X-ray optics G. Borrmann studied the effect, named after him, of anomalous transparency of a crystal under the conditions of Bragg reflection, adding later to his observations those on the effects of deformation and temperature gradients on the transparency of the crystal and the path of the energy flux in it. The latter was the subject of important theoretical studies of von Laue. A field electron microscope was developed by Müller at the Technical University in Berlin (now in Pennsylvania State University). His work is being continued in the Haber Institute by Drechsler. In the section of Molière, the interference-refraction of electron beams, especially in MgO crystals, was one of the important problems.

Besides the structure determination of claudelite, complex cobalt compounds and some organic substances, Stranski's section continues the calculation of surface energy of homopolar crystals and studies the influence of different conditions of crystallization and nucleation on the face combinations and other physico-chemical properties.

Hosemann and collaborators were interested in several fields: the calculation of the electron-density distributions in crystals with the help of convolution operations, the analysis of small-angle scattering by means of the folding operation (Faltungsintegral), and its application to high polymer and colloidal substances, paracrystalline structure, etc. His work with S. N. Bagchi on the theory of Fourier transforms and unfolding procedures has recently been summarized in a book *Direct Analysis of Diffraction by Matter* (North-Holland Publ. Co., 1962).

In 1959 the Fritz-Haber-Institut came under the direction of R. Brill, who returned from the U.S.A., where he had gone in 1946. Among many other topics he is interested in the influence of bonding electrons in diamond on X-ray intensities (anisotropic atomic scattering factor). A new section for the determination of crystal structures has been created in the institute, including a group for neutron diffraction.

In the K.W.I. für Silikatforschung under W. Eitel, Schusterius, Radczewski and O'Daniel were interested in the application of the electron microscope to mineralogy, especially to clay minerals and phases in cement. Dietzel's interest belonged to the investigation of glasses and the different industrial applications. Eitel, (now in Toledo, U.S.A.), wrote his important book *Physikalische Chemie der Silikate*, which appeared after the war in a new edition in the U.S.A. (1954). During the Second World War the institute was partly transferred to the Rhön and from here Dietzel created a new institute in Würzburg. Since 1952 Jagodzinski (who since 1959 is also professor in Karlsruhe) formed a special section for the investigation of crystal structure where he continued his research of order and disorder problems, of chrysotile asbestos and antigorite (the latter problem was continued in Darmstadt by Kunze). Flörke and Saalfeld too belonged to this institute at that time, working on the modification of SiO_2, respectively $Al_2O_3.nH_2O$. (Flörke is since 1959 in Zürich, Saalfeld since 1960 in Saarbrücken.)

Among the other Kaiser-Wilhelm-Institutes, the Düsseldorf K.W.I. for Iron Research should be mentioned because of the intensive study of iron alloys phase diagrams and deformation properties of iron and steel there undertaken since 1922 by F. Wever.

The main industrial laboratories for X-ray work, besides those of the

I. G. Farben, were those of the electrical industry, especially the Siemens and the Osram works. Metals were also investigated in the Materialprüfamt (Materials Research Station) in Gross-Lichterfelde, close to Dahlem. G. Sachs worked there for some years before he joined the Metallgesellschaft in Frankfurt/Main.

In the Universities, crystallography was coupled to mineralogy, and some of the Departments of Mineralogy used X-ray methods, for instance R. Gross in Greifswald. In Leipzig F. Rinne and E. Schiebold developed the teaching aspect, contributed to the development of methods and instruments (the Schiebold-Sauter goniometer) and had a fair number of advanced students, among them E. Onorato (structure of gypsum, 1927).

Niggli with his broad and excellent survey of mineralogy recognized very early the importance of mathematical crystallography for the study of morphological, physical and chemical properties in crystals. Between 1915 and 1918 he was in Leipzig in Rinne's Institute. A year later he wrote in Tübingen *Geometrische Kristallographie des Diskontinuums*. In his famous textbook *Lehrbuch der Mineralogie und Kristallchemie*, which appeared in three editions, he pointed out the importance of crystal chemistry to mineralogy, geochemistry, etc. Besides his *Grundlagen der Stereochemie* (1945) he published in the following years (1949/50) a complete condensed symbolism of space groups which later formed the main subject of the book by P. Terpstra *Introduction to the Space Groups* (J. B. Wolters, Groningen 1955).

In 1929 V. M. Goldschmidt in Oslo accepted the chair of mineralogy and crystallography at the University of Göttingen; here he continued his fundamental work on the radii of elements and ions by the investigation of crystal structures. His results are published in the fundamental series *Geochemische Verteilungsgesetze der Elemente* by the Norwegian Academy of Sciences, Oslo. At that time, Ernst, Laves and Witte were his assistants. Early in 1935 V. M. Goldschmidt had to leave Germany for political reasons. The investigations of crystal structures were mainly continued by these three assistants who became lecturers later on. Laves together with Witte and Wallbaum did important work on intermetallic compounds. In addition, he developed his nomenclature of structure types, which is used in many textbooks.

Machatschki, who had been working with V. M. Goldschmidt in Oslo and also with W. L. Bragg in Manchester, Professor of Mineralogy at the University in Tübingen, where he continued his work on structure analysis of silicates and oxides, the discussion of the chemical formulas of silicates with respect to their atomic structures and the relationship between silicate structures. After a three years' period in Munich, he became director of the Mineralogical Institute in Vienna in 1944.

After the Second World War, Laves began to create a centre for structure analysis in Marburg/Lahn, by expanding his Mineralogical Institute with the assistance of Jagodzinski and Hellner. In 1947 he succeeded in negotiating with the Government the creation of a second part of the centre, a new Institute for Crystal Structure Research which was headed by C. Hermann.

Hermann's work was mainly theoretical, applying group theory to mathematical crystallography in three and more dimensions and devising a nomenclature for lattice complexes. In connection with Ludwigshafen, in particular with H.-U. Lenné, he also did interesting structural work on urea adducts. At the beginning of the war, Hermann and Renninger had both been working under R. Brill at the Oppau Laboratory of I. G. Farben. It was here that the well-known investigation was undertaken by Brill, Grimm, Hermann and Peters (*Ann. d. Phys.*, Lpz., 1939) to learn as much as possible of the electron distribution in simple crystals by accurate intensity measurements and critical discussion of the Fourier syntheses. Renninger made additional intensity measurements at 20°K on rocksalt, but owing to the war, publication was delayed. Now, having joined Hermann at the new institute in Marburg, Renninger constructed a three crystal spectrograph with which he measured the reflection curve of a near-perfect crystal with greater accuracy than ever before.

At the end of 1948 Laves left Marburg for Chicago, and H. Winkler succeeded him. He discovered the crystal structure of eukryptite and of some alkali-fluoroaluminates in connection with the structural discussion of thermal polymorphism. E. Hellner started his research on sulfide structures in Marburg; after a short interlude in Chicago, he is now continuing them, since 1959, in Kiel.

O'Daniel became director of the Mineralogical Institute in Frankfurt in 1947 where he continued to investigate problems of cement and other silicates which he had begun at the K.W.I. für Silikatforschung. Together with Th. Hahn he created a new school for the X-ray investigation of analogues of silicate structures, such as the fluoroberyllates. The programming of electronic computers and the correction of measured X-ray intensities were other fields of interest.

As a student of A. Johnsen in Berlin, G. Menzer succeeded 1926 in the structure determination of garnet. At the end of the Second World

War—after seven years in the K.W.I. of Physics—he left Berlin and became after a two years' stay in Tübingen Professor of Crystallography in Munich at the University, where he continued his structural work together with Dachs and others. Like that of C. Hermann, his interest belongs to homometry, nomenclature of space groups and lattice complexes. As a possible example for homometry the structure of bixbyite was reexamined. Besides X-ray work he applied neutron diffraction to the location of hydrogen atoms in crystal structures.

In Göttingen a new center for X-ray analysis grew up, when Zemann became director in 1952. A large number of structures of silicates, phosphates and sulfates have been determined in his school.

Apart from the application of X-ray analysis, much of interesting work is being done in mineralogical institutes in such classical fields of crystallography as crystal growth and solubility, twinning, epitaxy, etc., for instance by Neuhaus in Darmstadt, later Bonn; Spangenberg in Breslau, Kiel and Tübingen; Seifert in Halle and Münster; Kleber in Bonn and since 1953 in Berlin, etc.

A number of institutes of inorganic chemistry took up the determination of crystal structures. Thilo, since 1938 in Berlin except for a short period in Graz (1943–46), was interested in the chemical and structural properties of silicates and their analogues, the phosphates and arsenates. After the Second World War an Institute for Crystal Structure Research was founded with the aid of the Deutsche Akademie der Wissenschaften, in (East-) Berlin, headed by Mrs. K. Boll-Dornberger. Besides structure determination she is especially interested in disordered structures and their interpretation by 'order-disorder' or OD-groupoïds.

Starting with the investigation of alcali alloys in liquid ammonia, Zintl (1933) created a school for inorganic and physical chemistry at the Technical University in Darmstadt. He was especially interested in the crystal chemistry of alloys of those elements which form anions in crystal structures (Zintl-Grenze). A lot of new structure types were found. Zintl died in 1941, at the age of only 43. Brill became his successor up to the end of the war. After the war Witte succeeded Brill and together with Wölfel he reexamined the Fourier synthesis of NaCl, LiF, Al etc. by measuring the intensities even more accurately.

Another inorganic school was founded by Klemm, first in Danzig and after the Second World War in Kiel and later in Münster; he correlated magnetic properties and crystal structures. A book (*Magne-*

tochemie, 1936) gave first results in this field and a lot of inspiring suggestions.

A centre for structure investigation of organic and biochemical substances was founded in 1959 in the Max-Planck-Institut für Eiweiss und Lederforschung headed by W. Hoppe, who is also lecturer in the physico-chemical institute of the Technical University in Munich. The interpretation of diffuse thermal-wave scattering outside the directions of Bragg scattering, and the determination of crystal structures by the convolution molecule method are two of his favourite subjects. A goniometer for automatic recording of X-ray intensities of single crystals is under development. In addition schools were created by Bauer in Freiburg (1944), by Juza in Heidelberg (1942) (since 1952 in Kiel); and by Krebs in Bonn.

The important theoretical development represented by Max Born's books *Dynamik der Kristallgitter* (1915) and *Atomtheorie des festen Zustands* (1923) opened up the understanding of many of the physical properties of the solid state, first based on the principles of classical dynamics, and later on quantum and wave mechanics. A new field of physics developed rapidly and concurrently with, if not always closely related to, the increasing knowledge of crystal structures. In the work of Mott and his school in Bristol a second great step forward was taken in the years before World War II. A. Smekal in Halle had stressed the difference between physical properties which are explainable by the model of a perfectly periodic crystal, as used by Born, and the 'structure-sensitive properties' (by this he meant properties determined by imperfections, impurities, or domain structure of crystals) for which Born's theory is evidently inadequate. Among the latter are mechanical strength, diffusion, fluorescence and phosphorescence, often dielectric properties and surface tension, etc. The new ideas applied by Mott centered around the energyband picture of the crystal as a wave-mechanical system; besides, for the explanation of the mechanical properties 'dislocations' of various types in the crystal structure became essential. During and after the Second World War the structure sensitive properties of Smekal's classification underwent intensive study, especially in U.S.A., because of their technical importance (phosphors, rectifiers, transistors, ferromagnetic and ferroelectric materials). But also the German industrial laboratories, especially those of the Siemens concern, now near Erlangen, contributed their share to these advances.

The various facets of solid state physics and the New Crystallography were repeatedly summarized in the well-known German Hand- and Yearbooks.

Before ending this report the support of the entire field of research by the 'Notgemeinschaft der Deutschen Wissenschaft', now renamed 'Deutsche Forschungsgemeinschaft', which began more than four decades ago, should be gratefully acknowledged. This support included in 1956 the first electronic computers, and in 1960 also an IBM 704, available for basic research.

In recognition of the need to promote basic research in Germany the 'Wissenschaftsrat', a council created by the President of the German Federal Republic, recommended in 1960 an expansion in German universities, especially with respect to the number of staff and assistants, but also including facilities and housing. It may be expected that this improvement will prove beneficial also to the field of crystal structure research.

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