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GEORGIĬ VYACHESLAVOVICH KURDYUMOV

(On his seventieth birthday)

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FEBRUARY 14, 1972 is the seventieth birthday of Georgiĭ Vyacheslavovich Kurdyumov, a prominent Soviet physicist, one of the major specialists in the field of metallurgical physics and metallurgical science. Kurdyumov devoted almost fifty years to scientific work. His major research works are devoted to a wide range of problems in the science of metals: the crystalline structure of martensite, the mechanics and kinetics of phase transformations, the fine structure of phases, the processes of strengthening and weakening, the influence of various treatments and alloying upon the structure and upon the properties of steels and alloys, and others.

In the field of solid state physics, Kurdyumov is a recognized authority among Soviet scientists, who hold him in a high and well earned esteem. Like many of the leading Soviet physicists, Kurdyumov was trained in Abram Fedorovich Ioffe's school and during his many years in the field of science he continued to demonstrate all the characteristic traits of the representatives of this distinguished scientific school: clarity of thought, great experimental skill, ability for wide scientific generalization.

Kurdyumov was born in the town of Ryl'sk in the Kursk province. To 1918 he studied in Ryl'sk's Secondary School and then in the Edinaya Labor School of the second level, from which he was graduated in 1919, at the height of the Civil war. During these grim years of his youth, Kurdyumov worked in various Soviet institutions, mainly in the field of public education—as a teacher in a village and in a Red Army school, and as a school instructor in a small rural district. He was one of the initiators in the founding in Ryl'sk of a People's University (1920), and served as its council chairman. But his irrepressible thirst for learning led him in 1921 into the ranks of students in the Petrograd Polytechnic Institute, from which he was graduated in 1926. In 1924, still a student, Kurdyumov began his scientific work at Leningrad Physico-technical Institute—first as a laboratory assistant, then as an engineer and physicist in N. Ya. Selyakov's laboratory, and, finally, in charge of the x-ray metallographical laboratory. From the very beginning Kurdyumov showed great interest in the x-ray studies of the atomic and crystalline structure of solids. He was particularly interested in the problem of structural changes produced in steel by heat treatment. Kurdyumov began his work in this field in collaboration with the Putilovo factory laboratory.

At that time the question of the nature of martensite, as the basic structural component defining the properties of hardened steels, was one of the most discussed. This can be seen by the answers given in 1926 to a questionnaire of an American scientist, Sower, by the world's most prominent metallurgists. A wide range of assumptions was expressed, and in particular, that martensite is either an unstable hard solution of carbon with α and

γ iron, or that martensite consists of α iron with a small amount of carbon in the solution and iron carbide in a minutely broken-up state. After expounding different points of view, Sower came to the following conclusion: "The opinion survey of scientists who have devoted much time to the study of the hardening of steel makes it impossible, in my opinion, to come to a definite conclusion as to which point of view is the predominant one... Obviously, those who believe that they have solved the problem of the hardening of steel, can say it only for their own satisfaction or to the satisfaction of some of their followers."

Kurdyumov's very first works, now classics in their field, gave a brilliant answer to the question of the nature of martensite. In them he proved definitely that martensite of steel, formed during its hardening, is a supersaturated solid solution of carbon in alpha-iron, having a tetragonal crystalline lattice with an axis ratio that depends on the amount of carbon in the solution.

The unique connection between the crystal lattice constants of martensite and the concentration of carbon in the initial austenite, and their independence of the cooling rate, have brought Kurdyumov to the assumption of the diffusionless nature of martensite transformations.

At the height of this research, Kurdyumov, as many of the other young Soviet scientists at that time, was sent on a foreign scientific trip. He was to spend one year in Germany. After appraising the possibilities of various German scientific organizations in the field of physics of metals, Kurdyumov's choice fell on professor Sachs's laboratory in Berlin. This laboratory was experienced in the study of the structure of the metallic single crystals and the texture of metals after deformation and recrystallization. While working in Sachs's laboratory, Kurdyumov utilized the methodology of pole figures for the study of the orientation of the martensite crystals formed during the hardening. After a short period of intensive work Kurdyumov was able to establish, by direct experiments on the obtained single crystals of hardened steel, the existence of a crystall-geometrical connection between the lattices of the martensite and the initial austenite. These studies, which very soon became known throughout the world to the experts in metal physics, corroborated the assumption of the diffusionless nature of martensitic transformations in steel and confirmed the atomic mechanism of the transformation of austenite into martensite. After returning to Leningrad in 1930, Kurdyumov continued his work on the improvement and development of methods of x-ray structure analysis as applied to metal research. At that time, at A. F. Ioffe's initiative, physico-technical research institutes were being organized in the Ukraine, in the Urals, and in Siberia. Ioffe sent many of his students to manage these institutes, and that is how, in 1932, Kurdyumov found himself in Dnepropetrovsk where, together with B. N. Finkel'shteĭn, and V. I. Danilov, he took part in founding of the Dnepropetrosk Physico-technical Institute. This was the beginning of Kurdyumov's fruitful period of scientific work in the Ukraine. After moving to Dnepropetrovsk and organizing there an experimental base, Kurdyumov carried out extensive experiments on phase transitions in copper alloys. These works helped determine more general features of martensitic transformations as a special class of phase transitions in the solid state. On the basis of the work done in 1936, Kurdyumov drew the conclusion that "...the martensitic transformation consists of a regular reorganization of the lattice, in which the atoms do not interchange their places, but are only shifted relative to one another by a distance not larger than the interatomic distance." This conclusion was confirmed, in particular, by the theoretical determination of the martensitic phase structure in copper-aluminum alloys, which turned out to be in the complete accord with the experimental observation.

An important result of this research was the establishment of the "reversibility" of the martensitic transformations, that is, these transformations proceed in both directions (during the cooling and heating). The transformations of the martensitic phases into the initial ones during the heating possess all the features of the martensitic transformations. This led Kurdyumov to the idea that martensitic transformations can be considered as phase transitions in a single-component system.

Kurdyumov's scientific work at the Dnepropetrovsk Physico-technical Institute received wide recognition. In 1934 Kurdyumov was given the rank of professor, and in 1937 he was awarded the degree of Doctor of Physico-mathematical Sciences. In 1939 he was elected a member of the Ukrainian Academy of Sciences and also a member of its Presidium. Simultaneously with this fruitful scientific work, Kurdyumov has engaged in extensive pedagogical work as a professor and as the head of the Metal-physics Department at the Dnepropetrovsk State University. When one speaks of Kurdyumov's work of that period, one has to take a separate look at the enormous role he played in the introduction of x-ray analysis methods in the laboratories of our country's metallurgical and machine-building factories. One can state, without exaggeration, that during the years of the five-year plans a large number of workers of the factories' x-ray laboratories made use of his most generous help and, to a large extent, could be considered his pupils. Kurdyumov spent much energy and time on organizing and running in 1936 of the First All-union Conference on the Uses of X-rays in Industry, having initiated its convocation and serving as chairman of the Organizing Committee.

During the grim years of the war, the Dnepropetrovsk Physico-technical Institute, which was under Kurdyumov's management, was evacuated to Magnitogorsk, where its work was directed toward the country's defense interests. In addition to his own most intensive industrial research work while in charge of creating new alloys for the armored tanks, he carried out extensive organizational activities as chairman of the Scientists' Committee for the aid to the front in the Magnitogorsk City Party Committee. Kurdyumov's work during the war period was greatly appreciated, and for the successful fulfillment of the Defense State Committ Committee's task in the field of ferrous metal industry he was honored by a government award.

In 1944, following a joint proposal by I. P. Bardin and G. V. Kurdyumov, the Dnepropetrovsk Physico-technical Institute became part of the Central Scientific-research Industry of the Ferrous Metal Industry and became known as the Institute of Metallurgy and Metal Physics, and its staff was moved to Moscow. Since 1945, Kurdyumov has been the director of this institute. To this day, however, he is also closely connected with the work of the Ukrainian Academy of Sciences. He is the founder of the Ukrainian Academy of Sciences Metal-physics Laboratory, which was changed to the Institute of Metal Physics of the Ukrainian Academy of Sciences and which, at the present time, is one of the largest scientific research organizations in the Ukraine. For almost ten years Kurdyumov was a member of the Presidium of the Ukrainian Academy of Sciences.

At that time, the problem was not only of the further research on the determination of the distinguishing features of martensitic transformations, which place them in a distinctive class of phase transformations in solids, but also the problem of explaining these features on the basis of the general laws of phase transformations. In this connection, Kurdyumov predicted in 1947 two new phenomena: the isothermal transformation of austenite

into martensite at low temperatures and the thermoelastic equilibrium in martensitic transformations. Both of these phenomena were experimentally discovered in 1948 by Kurdyumov and co-workers, and were later confirmed by researches in many countries.

Kurdyumov's further research was devoted to the reasons and the moving forces of the transformation of austenite into martensite, to the temperature dependence of the rate of transformation, and to the conditions for the realization of the mechanics of the "normal" and martensitic transformation mechanism.

Another important section of Kurdyumov's scientific work was the study of the tempering processes of hardened steel (1929–1955). Before Kurdyumov's work in this field, the main ideas concerning the tempering processes were based on the observations of the changes in the properties of the steel. Instead of attributing these changes to changes in the crystal structure, one had to do the reverse. Only parallel studies of the changes in the crystal structure and of the properties revealed a new more complete picture of the tempering processes. A more general picture of the structural changes at different tempering stages was established. The research on the hardened "single crystals," in connection with a regular orientation of the martensite lattice relative to the initial austenite helped to eliminate the difficulties raised in the x-ray structure analysis of the tempering processes by the superposition of interference doublet lines of the tetragonal lattice. It was established that the first tempering stage is of a two-phase nature; the decay half-life of martensite was established for various temperatures, and the influence of the alloying elements on the martensite decay kinetics was also established.

For the formulation of a general theory of the tempering processes, the studies of Kurdyumov and his co-workers on the state of carbon in the tempered steel, on the structure of the carbide phases, and on the carbide-forming processes were of great importance.

The x-ray structure researches of Kurdyumov and his co-workers made it possible to determine not only the martensite crystalline lattice, but also many of the distinguishing properties of the martensite fine structure (substructure), namely, the presence of blocks (regions of coherent scattering), elastic microdeformation, violations of the regular periodicity by the intrusion of carbon atoms, and so forth. Subsequently, transmission electron microscopy and of diffraction methods have made it possible to observe directly the block structure, twinning, and the dislocation structure, to determine the disorientation angles, and other details of substructure elements.

In recent years, new experimental studies have shown that in martensite, even before the decay proper with segregation of the carbide phases, there can occur at relatively low temperatures processes of carbon redistribution in the martensite crystal lattice, namely, the displacement of the carbon atoms towards the defects and redistribution of the carbon atoms in the pores of bcc lattice (ordering). New effects of the change of the martensite structure were established under various influences—plastic deformation, radiation, high hydrostatic pressures and others.

The study of the strengthening and weakening processes of alloys under heat, conducted by Kurdyumov and his co-workers, revealed the decisive part that the interatomic interaction force plays in the preservation of the strengthened state up to the high temperatures (heat endurance).

Kurdyumov and his co-workers used extensively, besides x-ray structure analysis, also various methods of physical research, such as electron microscopy and diffraction, radioactive tracers, calorimetry, internal friction, and others.

The research of Kurdyumov and of the scientific school under his leadership constitutes a most important part of the contemporary scientific views on the processes of the heat treatment of steels and alloys, has a wide practical application, and has won international recognition. In the last decade, its exceptional importance was particularly stressed once more during the development of methods for raising the strength of the structural steels. These methods (the thermomechanical steel treatment, development of low-carbon martensitic-aging steels, the usage of the phase case hardening for strengthening, and others) are based to a large and often decisive extent on the results of the studies conducted by Kurdyumov and his scientific school on the nature of the structural changes.

In 1946 Kurdyumov was elected a corresponding member of the USSR Academy of Sciences and in 1953 he became a full member. In 1949 he was awarded a State Prize of the First Degree.

In 1961 the USSR Academy of Sciences entrusted him with the coordination of research on solid state physics, and he became chairman of the Scientific Council for this subject. Remaining in this position to the present day, Kurdyumov has accomplished a great deal in the development of research in this important and widest field of contemporary physics. In 1962 he became director and organizer of still another new scientific institution, the Solid State Physics Institute of the USSR Academy of Sciences. In a very short time, under Kurdyumov's guidance, an institute was established with capabilities for conducting pure basic research in such fields as the electronic structure and the electronic properties of metals, the physics of semiconductors, optics and spectroscopy, physics dislocations in crystals, and high-pressure physics, combined with a technologically developed base and applied research on the development of materials to fill the needs of modern engineering.

Kurdyumov's scientific credits are very many, but his personal prestige, as a scientist and as a man, among his scientific co-workers and workers in the industry, is not any less. This is due to a great extent to Kurdyumov's exceptional personality traits. His benevolence, availability, sincerity and gentleness of manner combine with his scientific principles and his consistency in upholding his point of view when he believes it to be the right one. All of these qualities have won him love and deep esteem of all the people with whom he comes into an everyday contact with, from the venerable scientist to the young people who are only beginning their scientific work.

Kurdyumov meets his seventieth birthday full of energy and creative plans amidst the atmosphere of recognition of his scientific achievements. He was decorated

with three Orders of Lenin, two Orders of the Red Banner of Labor, and in 1969 he was named Hero of Socialist Labor.

He enjoys a very high international reputation. He is a member of academies and scientific societies, and has been awarded many honorable prizes and medals by many countries of the world.

Many a young scientist can envy him his energy, the clarity and depth of his thoughts, and his joy of living.

Kurdyumov's friends, colleagues, students and co-workers all join in wishing him, from the depth of their hearts, health and new successes in all the fields of his versatile work.

Translated by N. Krizanowskaja