Morse's autobiography: The story of a remarkable career

In at the Beginnings: A Physicist's Life

P. M. Morse
375 pp. MIT, Cambridge, 1977. $15.00

Reviewed by Herman Feshbach

Phil Morse's autobiography is aptly entitled *In at the Beginnings.* Together with Edward U. Condon, he wrote the first American text on quantum mechanics. Morse was one of the founders of modern acoustics and his book *Vibration and Sound* (its present reincarnation is *Theoretical Acoustics*, written with Karl U. Ingard) educated several generations of students. He was one of the pioneers in the war-generated discipline of operations research, which he and his colleagues employed so effectively against the German submarines. He helped to transform the MIT physics department from a second-rate appendage of the Engineering School into its present state, holding premier rank in both research and education. At MIT he organized the Operations Research Center and was the first director of the Computation Laboratory, which helped to introduce modern computational methods to MIT researchers and students. Morse was also the first director of the Brookhaven National Laboratory. He is held in high regard by his colleagues, having served as president of The American Physical Society, of the Acoustical Society of America and of the Operation Research Society and as Chairman of the Board of the American Institute of Physics. By any standards, a remarkable career!

It is the beginning chapters of the book that I find particularly fascinating, for they recount the youthful ambitions, attitudes, and experiences that are so much more revealing than the actions of the mature adult. It was a very different America that Phil Morse lived in as a boy. (He was not quite fourteen when the United States entered the first World War.) It was a simpler, less complex society. The countryside was far less crowded, and the beaches of Lake Erie were reached easily. And it was the "land of opportunity." It was possible to be an entrepreneur. It was less difficult for a young man to get a job.

It was possible for Morse (who was not yet eighteen) to join with friends to establish a Radioelectric Shop, which catered at first to the amateur operators but later got caught up in the radio craze that developed around 1922. It was possible for him to leave the Case School of Applied Science after his freshman year and spend a year to earn enough money to continue his studies, without any penalty and, indeed, with some profit. College classes were small. Only three students in his class majored in physics, and they got individual attention from one of the great American physicists of that era, Dayton C. Miller. Morse was able to help Miller in one of his ether-drift experiments, an experience that is beautifully described. Case required a senior thesis, and Morse's involved a determination of the Sun's motion with respect to the neighboring stars. It was published.

These rather early research experiences were clearly inspiring. Morse developed at a very early stage that mark of the truly educated person, the passion to know and to understand. To this day it is his habit to read five books a week, in a wide variety of subjects.

Graduate school at Princeton meant an involvement in a much more sophisticated and cosmopolitan world. The physics was, of course, more challenging; the graduate students, closer in ability; the faculty, widely traveled and among the leaders of the American physics community. In addition, there was New York City with its museums, theater and music. It was the "roaring twenties," the era of the speakeasy and the friendly bootlegger. It was a wonderful, stimulating world, and it is clear that Morse took full advantage of it and had a glorious time.

But he didn't neglect his physics. The physics graduate school was small and interaction with the faculty was easy. In fact, Morse's first Princeton paper was written with Karl T. Compton, head of the physics department! Under Compton's influence, Morse's research at the beginning was, for the most part, in the theory of gas discharges. However, his interests were to change. The summer following his second year of graduate work he spent at Michigan, and—more important—he participated in the famous Michigan Summer School. Here he met George E. Uhlenbeck, Samuel Goudsmit, H. A. Kramers and Paul Ehrenfest. And, as important, he was introduced to the new quantum theory, and this now became the focus of his attention. It was during this period that he discovered the "Morse potential" for diatomic molecules. And it is during this period that Condon and he wrote their text on quantum mechanics. Not a bad record for a graduate student!

The doctoral degree was followed by a summer at the Bell Telephone Laboratories with Clinton J. Davisson, developing a theory of the reflection of electron waves from a crystal that successfully explained the Nobel-award-winning Davisson–Germer experiments. A year as a Princeton instructor and a summer at Michigan (where the new attraction was Enrico Fermi, who gave a course on quantum electrodynamics that I presume formed the basis for his famous review article) were followed by a year in Europe. At Munich and Cambridge he worked mostly on electron scattering by atoms. Then on to MIT in the autumn of 1931, to a new Department of Physics with a new department head, John C. Slater.

American physics was a small enterprise in those days. It was the ambition of the new department to grow until it was graduating as many as six PhD's a year! The meetings of The American Physical Society could be held at universities, with the spring meeting at the National Bureau of Standards, rather than at the large hotels or convention centers where they now occur. It was relatively easy for an active young man like Morse to become acquainted with most of the principal physicists. It was clearly a heady atmosphere, especially as the stream of gifted refugee physicists began to grow.

There is a curious omission in Morse's account of these years. The Great Depression is simply not mentioned. Knowing Morse's strong commitment to the improvement of the human condition, I can only conclude that in some fashion those such as Morse who had successfully obtained university appointments were insulated from the Depression's direct effects as far as their research and teaching were concerned.

I arrived at MIT as a graduate student in the fall of 1938. Morse was the graduate-registration officer, and—after some pleading—I was allowed to take his course in methods of theoretical physics. During the second semester I started my research with him and eventually did my thesis under his supervision. This was the beginning of a long and fruitful collaboration, of which the book whose genesis was the aforementioned course is the most visible. It was still a very small department. We—that is, the graduate students and the staff, including the head of the department—met daily for tea. We all, as a matter of course, attended the weekly colloquium. It was a very pleasant world shadowed only by the dearth of positions in our chosen areas of interest.

The second half of this book chronicles Morse's part in World War II and the number of changes in American physics, particularly in the styles that developed following the war. Just what they were, how they developed, and how they were exemplified by Morse's postwar career are all related. These features are, of course, of great interest to those concerned with the history of science. It is, in fact, through the story of the transformation of American physics from a small, ivorytower endeavor into a large enterprise with strong interaction with society and its needs as seen in the career of one man who played a leading role that this book will have its most enduring impact. I heartily recommend it to the readers of PHYSICS TODAY.

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Solid State Diffusion

J. P. Stark
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Diffusion in the solid state is fundamental to a host of important technological processes, from ancient metallurgy (the smelting of ores, the tempering of steel) to semiconductor-device fabrication. Since diffusion in solids takes place by the motion of lattice defects, especially vacancies, diffusion is also a means of studying the behavior of lattice vacancies. Because the behavior of vacancies is of great importance to atomic energy (in the areas of radiation damage, creep and sintering, for instance), the study of diffusion—especially in simple solids—grew enormously in the 1950's and 60's. At the present time, diffusion in some solids (such as close-packed metals, alkali and silver halides and elemental semiconductors) is for the most part understood, although some details are not clear and some controversy remains. The understanding of diffusion in body-centered-cubic metals and simple oxides is less advanced, and studies of more complex systems are only beginning. All this knowledge is summarized primarily in conference proceedings and review articles; fewer than ten texts or specialized monographs on diffusion in solids have appeared in the past fifteen years.

John P. Stark's *Solid State Diffusion* is a rather restricted theoretical monograph. Stark, who is Professor of Mechanical Engineering at the University of Texas, has published widely on both experimental and theoretical subjects in the field of diffusion in metals, and the book largely reflects his research interests. Most of the book is confined to volume diffusion by vacancy motion in dilute metallic alloys. The first two chapters are introductory, giving some solutions to the diffusion equation and a discussion of jump frequencies and phenomenological equations. The next four chapters are primarily devoted to matrix-algebraic treatment of vacancy diffusion in pure metals and in dilute alloys. Matrix methods of calculating correlation factors are given in great detail. In addition, the equations of the thermodynamics of irreversible processes are used and the cross terms are thoroughly discussed. The book closes with a short chapter on ultrafast diffusion, diffusion along short-circuiting paths and the near-surface effect.

Stark's book treats in detail several of his own research contributions, including the concentrations of vacancies in a temperature gradient and diffusion of impurities by divacancies. One of his conclusions on the latter, that the presence of rapidly moving, tightly bound divacancies does not increase the diffusion coefficient, appears at first glance to contradict both physical intuition and experimentally observed nonlinear Arrhenius plots.

The approach throughout is kinetic rather than atomistic. Thus, vacancy concentrations and vacancy–impurity binding are discussed in statistical terms, without much inquiry into the nature of the vacancy formation or binding energies. Stark develops his equations from both the random-walk and the phenomenological formalisms and achieves some sort of a synthesis.