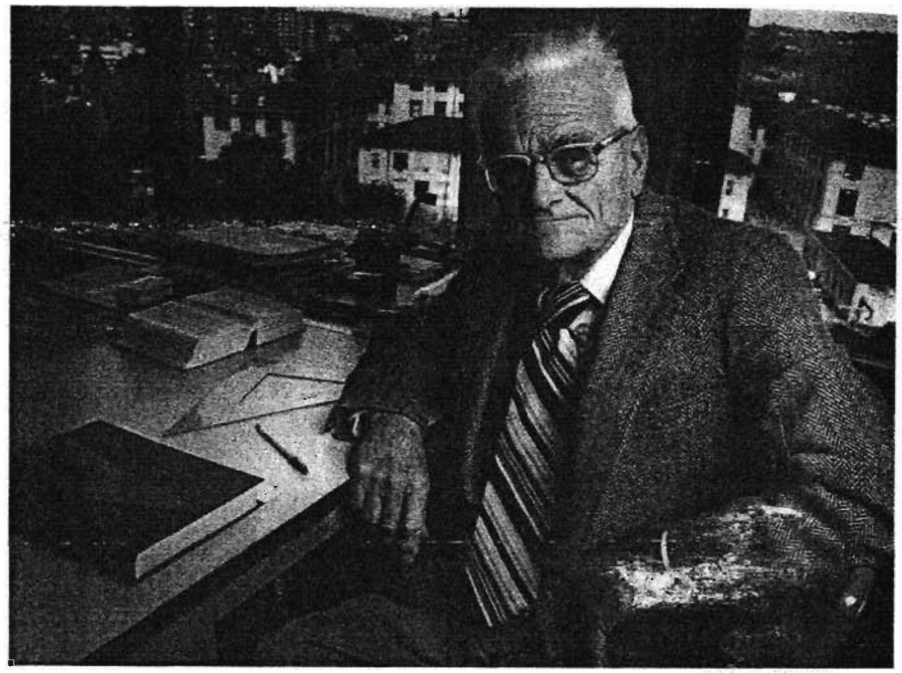
# Clarence Zener: A

by *Matthew Maguire*

Clarence Zener first encountered physics more than half a century ago as a youngster thumbing through the child's "Book of Knowledge." "I was hep on physics from the very beginning," he admits.

Seven decades later, physics – indeed, all of science – has come to be at least as hep on Zener. As he prepared to celebrate his 80th birthday Dec. 1, colleagues at Carnegie-Mellon were planning a special birthday party for him: an unusual symposium to honor one of the most distinguished scientists in the world. More than 100 scientists and engineers from around the globe were expected to attend the event Nov. [illegible] in Pittsburgh to review some of Zener's contributions to science and engineering and discuss his influence in these areas.



Clarence Zener: "One of the most distinguished scientists in the world." *Photo by Bill Redic*

A list of those contributions would span nearly six decades of unstinting activity and an astonishing range of fields. Indeed, Zener's fellows, when asked to describe the man and his work, abandon the reserve academics traditionally exude when discussing a colleague. Instead, they gush superlatives normally slung about by sportscasters. Zener, they exclaim, is a theoretician with astounding insight and matchless versatility. He's conducted noteworthy basic research and made his mark in applied research as well. He discovered an important electrical effect that led to the development of the voltage regulator that bears his name, the Zener diode, and he helped develop geometric programming, a standard technique for optimization that's useful in pure mathematical studies as well as real-world engineering problems. In fact, Zener is said to have invented entire fields of study that now occupy legions of scholars around the world.

The kudos offered by Hubert Aaronson, R.F. Mehl professor of metallurgical engineering and materials science at Carnegie-Mellon, is typical. "Zener," says Aaronson, "is a rare, strange genius.

"He's an unbelievably talented innovator. He's able to go into a fresh field, swiftly comprehend the central issues, address them as a theoretical physicist in a simple but incisive way and make, in a matter of a few months, important and useful contributions."

To illustrate his point, Aaronson pulls from his bookshelf a maroon volume containing two of Zener's seminal papers on physical metallurgy. Aaronson thumps the volume, which is tattered by decades of repeated references, for emphasis.

"Zener published two papers on physical metallurgy in the January 1946 issue of 'Transactions of the American Institute of Mining and Metallurgical Engineers' which have provided the theoretical underpinnings for much of the research on phase equilibria and phase transformation in steel and many other metals," Aaronson says. "These papers are still being mined. The revolution he produced still hasn't run its course. These papers still have 20, 30 or 40 years of life in them – which, considering that most of physical metallurgy has developed since these papers, is pretty incredible.

"For most people," Aaronson continues, "achievements like this would constitute a lifetime of work. They would sit back, relax, embroider the details, take an administrative position and do some consulting. But Zener shrugs all this off, goes on and takes off in another field."

Zener's youthful zest for physics was matched by a distaste for experimental work, so he majored in mathematics at Stanford. ("I was attracted more by the concepts," he says.) After receiving his Stanford degree in 1926, he earned a Ph.D. in physics at Harvard in 1929, where his mentor Edwin Kemble, perhaps recognizing budding genius, fought special battles to shield Zener from the experimental work he considered drudgery. There followed a far-ranging career that often removed him from the university research setting and exposed him to a variety of scientific and administrative positions in government and industry. The wide range of problems he

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thus encountered explains in part the amazing breadth of his contributions.

Zener recalls that his choices of problems to pursue were often rooted in simple practical considerations. He recalls ruling out studies of fundamental physics early in his career after having a chance to dine with the great theoretical physicist J. Robert Oppenheimer. After being dazzled by Oppenheimer, Zener says, "It was clear to me that when it came to fundamental physics, there was no point in competing with a person like that.

"The only other way of getting along was to find phenomena that weren't explained and to explain them." So Zener devoured the physics literature in search of problems ripe for conquest by his theoretical insight. He took to this search a passion for thermodynamics and statistical mechanics, inculcated by Percy Bridgman, another Harvard professor whom Zener credits for much of his success.

It wasn't long before Zener found an unsolved problem suited to his talents: internal friction, the process by which the energy in a vibrating metal (e.g., a tuning fork) is converted to heat as the vibration fades.

"I recognized that here was an area that no one had touched, except doing experimental work, but not knowing what was going on," Zener says. "I was desperately in need of something to make a reputation in. So within the next three years, I put out several papers, laying the foundation." In that research, Zener became the first scientist to describe correctly and characterize this process, which is important to both pure scientists and practical researchers in physics. (As a result of Zener's work, internal friction evolved into a major field of study. Last summer, some 200 scientists from 17 countries, including Zener, attended a major periodic conference on this subject in Chicago.)

The excitement of tackling a problem important to both pure and applied science made a lasting impression on Zener.

"When I look back, I see that I was most productive scientifically when I was working on a practical problem," Zener says. "The reason is quite clear: If a scientist works on purely scientific problems, he reads what other scientists write and doesn't expose himself to problems outside of the current domain. But working on the practical problem, you're forced to think about problems that are not part of the scientific domain."

During World War II, Zener continued blending the pure with the applied while working at the Watertown Arsenal as part of the war effort. After the war, he continued his studies in physical metallurgy at the newly created Institute for the Study of Metals at the University of Chicago.

In 1951, he came to Pittsburgh as associate director of the research labs at Westinghouse Electric Corp. He became director of that major research operation in 1952. Even while handling the administrative headaches of a 1500-employee division, Zener continued to conduct his own research and make important contributions:

- Along with colleagues Richard Duffin, now University Professor of mathematical sciences at Carnegie-Mellon, and Elmore Peterson, he pioneered geometric programming. This problem-solving technique, which is useful both in pure mathematical studies as well as practical engineering and business administrative problems, simplifies the process of "optimizing" a system of problems.
- Using geometric programming, he showed that it would be possible to generate electric power from the ocean, economically, by taking advantage of differences in temperature between the warm surface water and colder waters below. John Fetkovich, a Carnegie-Mellon professor of physics who did much experimental work to complement Zener's theoretical studies, says Zener "almost single handedly started a whole new effort in ocean thermal energy conversion. Without the insight and enthusiasm of him and one or two other people, it never would have gotten off the ground." (Despite Zener's persistent admonitions, he says that the federal government has failed to recognize the significance of this potential energy source and has fallen behind the Japanese, who are working at full steam to develop the technology needed to mine this continuously renewable energy source.)

The list of scientific and engineering advances for which Zener is given credit is so vast, says his colleague Aaronson, that "there are probably several more fields where he's done dazzling things that he's probably too modest to admit – or he may even have forgotten."

Even as he earned his colleagues' esteem for his professional work, Zener also impressed them with his personal style.

"All of his colleagues think he's a great man," says William Mullins, also a University Professor at Carnegie-Mellon. "His insight is so profound on things that when you go to him with some problem, he really sees into it and makes remarks that really open it up for you."

If he has a fault, his colleagues say, it is unwarranted humility. "If anything, he gives others more credit than they deserve," says Fetkovich. "On projects we've worked together on, it's happened often that he's given me more credit for our results than I deserve and given himself less than he deserves."

For his part, Zener shrugs off the accolades of colleagues and says he'll just continue his work. Each year, he cuts the length of his work week by half-a-day and spends the time working his farm in Ligonier, Pa. But he says he never expects to retire fully. "I frankly get more pleasure from working on things which excite me," he says. "I don't see the end now because I see new excitement ahead."

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