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JOSEPH SLEPIAN
1891–1969

A Biographical Memoir by

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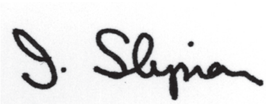
J. Slepian

JOSEPH SLEPIAN

February 11, 1891–December 19, 1969

BY T. KENNETH FOWLER

JOSEPH SLEPIAN, INVENTOR of the ignitron and other mainstays of the electric power industry, after a lifetime career at the Research Laboratories of the Westinghouse Electric Corporation, died on December 19, 1969. Elected to the National Academy of Sciences in 1941, Slepian was a member of Section 31, now called Engineering Sciences. Indeed, his career exemplified the union of these disciplines.

Holder of 204 patents at Westinghouse, Slepian began his career as a pure mathematician. He was born in Boston on February 11, 1891, son of Russian immigrants. Advanced student status in high school allowed him to enroll at Harvard University at age 16; he made Phi Beta Kappa and received his bachelor's degree in 1911, his master's degree in 1912, and a Ph.D. in mathematics in 1913. All during this time he maintained odd jobs to help support himself, including a stint as a licensed motorman on the Boston Electric Railway.

After Harvard Slepian was able to continue a year of postdoctoral studies as a Sheldon fellow, first at the University of Gottingen in Germany and then at the Sorbonne in Paris. He returned to the United States in 1915 and accepted a position as instructor of mathematics at Cornell

University. After only a year at Cornell he resigned his position to join the Westinghouse company at its East Pittsburgh Works as a student apprentice in the railway motor department. By 1917 the company had moved Slepian to the research department, shortly before the establishment of its pioneering independent research facility at Forest Hills in 1918. He advanced quickly, as head of the General Research Section in l922, research consulting engineer in 1926, and associate director for research from 1938 until his retirement in 1956.

Slepian's move to Westinghouse proved a happy transition for all concerned, his prolific output of patentable inventions for the company being exceeded only by those of George Westinghouse himself. According to colleagues Slepian made maximum use of his mathematical talents in his new career, his inventions invariably being the consequence of careful science and theoretical analysis. In fact his talent for invention had already emerged at Cornell, where in 1915 he filed a patent for a device to measure the speed of a boat by means of magnetohydrodynamics. By 1919 he had produced his first patent at Westinghouse, for circuit interrupters. He was still pursuing inventions when I first met him, late in his career, when he was developing a new plasma method of isotopic separation, his ionic centrifuge that he pursued before and after retirement, with 20 publications on this topic alone, most of them in the *Proceedings of the National Academy of Sciences*.

Slepian's first major success at Westinghouse led to the autovalve lightning arrester, at a time when the cost and maintenance of conventional electrolytic arresters no longer served the needs of a growing industry. His pioneering research on lightning arresters began in 1920, three years after his transition to a career of engineering research. Characteristically, when presented with the problem, Slepian first conducted a thorough analysis of the operation of electrolytic lightning arresters during a discharge—research that disclosed the need for surge protection that he would solve with a countervoltage produced by a glow discharge in air. This in turn led to his many experimental and theoretical contributions to the field of electrical conduction through gases and a familiarity with plasma physics that inspired even his later work on the ionic centrifuge. Slepian's careful study of ionized gases also prepared the way for other notable inventions, including the deion circuit breaker and the workhorse ignitron mercury rectifier familiar to me from my earliest contact with laboratory experiments on plasmas.

Slepian's contributions to the ignitron followed a pattern established in his work on arresters. Though already commercial, mercury rectifiers had reached an impasse: unacceptable "arc-backs" that required deep analysis to unravel. Slepian provided this analysis, leading him to propose separating the multiple rectifier anodes into individual chambers, which was the first step toward the ignitron design. There followed an intensive period of research to provide a means of extinguishing and then initiating anew the mercury arc on each operation cycle, dependably, when required, without appreciable time lag. More than 4 million kVA in ignitrons had been installed by the late 1940s.

The deion circuit breaker was also the result of detailed scientific research, in this instance on the nature and origin of arcs. As in his other research his work always involved observation and experiment as well as theory. Though first a mathematician Slepian had also become a productive and careful experimentalist in the laboratory. It was he who discovered plasma arc regimes not requiring thermionic emission of electrons from the cathode, at gas densities well below those thought possible before his work on cold-cathode heavy-current arcs. The practical result was the deion circuit breaker, employing the cold-cathode technique together with ingenious annular electrodes and voltage distribution that avoided thermionic hotspot emission that would otherwise spoil the almost instantaneous buildup characteristic of the cold-cathode operating regime.

A highlight in Slepian's career was his receipt of the Edison Medal in 1947, in part for his inventions of the autovalve lightning arrester, deion circuit breaker, and ignitron cited above. Marveling that a one-time pure mathematician would receive an award honoring a man like Edison, Slepian in his acceptance speech reflected wisely on the productive interplay of mathematics, science, and engineering. It is appropriate to quote here excerpts from his remarks, published in full in *Electrical Engineering* (67[1949]:258-61).

That a man with my particular kind of talents, abilities and personality should win a high engineering honor may seem very remarkable. . . . The dominant interest of my youth, and the kind of formal education it led me to acquire, certainly did not presage distinction in such fields.

I have pondered on what rightly may be called the really distinctive features of the mathematician, scientist and engineer. There seem to be two ways of logically distinguishing among them. One . . . is by the kinds of skills they display . . . their crafts. The other, and which I think strikes deeper, is by their motivations or compelling interests.

Let me proceed then to ask these questions. When the mathematician is doing that which is uniquely mathematics, and cannot possibly be said to be physics, or chemistry or other science; when the physicist, as a typical scientist, is doing that which is uniquely physics and cannot be said to be mathematics or engineering; when the engineer is doing that which is certainly engineering; what are their respective distinctive motivations and compelling interests?

My answers lead to the following definitions.

The "mathematician" is one whose interests and activities lie in determining and studying how things *may* fit together, that is, what are *possible* systems of order, and what are the details of such possible systems of order.

The "scientist" is one whose interests and activities lie in determining what is the *actual* order of things in the physical world and studying the details of that order.

The "engineer" . . . is one whose interests and activities lie in devising, designing, constructing or controlling the operation of physical devices, machines, technical processes, or services which have practical utility . . . [making] use of the accumulated knowledge, skills and techniques of the "mathematician" and the "scientist."

We know now that while "mathematicians" and "scientists" carry on their activities for "their own sake," that is for aesthetic reasons or other intellectual satisfactions, nevertheless, their work will lead to radical and revolutionary advances in technology in the future. The invention of the number system in which all algebraic equations, including $x^2 + 1 = 0$, have solutions, had to be done by the "mathematician." The "engineer" could not anticipate its utility for solving practical A-C problems. Only a "physicist" would be engrossed with the faint glows given off by certain rare minerals. How would the "engineer" know that these faint glows were the indications of tremendous technically utilizable forces within the atom?

With these examples before us, we see that while there are also other important reasons, we must support "mathematics" and "science" in the United States because of the inevitable future advances in technology which they will induce. To make "mathematics" and "science" flourish, we must create for "mathematicians" and "scientists" a favorable atmosphere.

High above all other requirements in the favorable atmosphere is that of freedom; freedom to choose their work or object of interest, freedom to write and publish, freedom to communicate with their fellows.

Slepian found his own favorable atmosphere at the Westinghouse Research Laboratories, a model for other corporations at the time the Forest Hills laboratory was created. “Sometimes,” he wrote for his twenty-fifth class reunion at Harvard, “I look with envy at the apparently more leisurely and less harassed lives of acquaintances in university circles, and at one time I nearly changed over to this field, but on the whole I think I am in the work and place best suited to me . . .”

Besides his own research and inventions Slepian was a valued consultant, much sought for his advice by others in the company. During World War II he both participated in the Manhattan Project and served as consultant to the Office of Scientific Research and Development, and as a dollar-a-year man with the War Production Board.

Despite leaving academia as a profession Slepian never lost interest in teaching, fulfilled at Westinghouse by his own initiative in organizing informal courses on a variety of topics, including vector analysis, the theory of electricity and magnetism, the kinetic theory of gases, and the conduction of electricity through gases. In addition, besides practical inventions, in 1922 he filed for a patent, issued in 1927, for the idea of accelerating electrons by magnetic induction, later employed in the betatron accelerator developed by Donald Kerst at the University of Illinois and used widely in nuclear physics research.

Slepian published 121 technical papers, articles, and essays, some of which are listed below. In 1933 Westinghouse Electric Company published his book, *Conduction of Electricity in Gases*, a compilation of his lectures for Westinghouse colleagues. This book became a classic, used by physicists and educators throughout the world.

In addition to receiving the Edison Medal in 1947, Slepian was the recipient of the John Scott Medal at the Franklin Institute in 1932 and the American Institute of Electrical Engineers’ Benjamin Garver Lamme Medal in 1942. He was elected a fellow of AIEE in 1927 and the Institute of Radio

Engineers in 1945 (predecessors of the Institute of Electrical and Electronic Engineers). He received the Westinghouse Order of Merit in 1935. In 1939 his scientific contributions were recognized by the French with the title Officer de Academie. In 1949 he was awarded an honorary doctor of engineering degree by Case Institute of Technology (now Case Western Reserve) and in 1955 an honorary doctor of science by the University of Leeds.

At the Lamme medal ceremony L. W. Chubb, then Westinghouse director of research, painted a charming picture of the young mathematician turned engineer.

> When he first arrived at the engineering laboratories, I happened to be in charge and in a position to recognize his unusual qualities.
>
> On one occasion the rest of us were so busy on some development that I could not assign Doctor Slepian to a new job at the moment. Instead of marking time until we finished, Slepian asked my permission to study a complicated setup of large motors, electrolytic condensers, reactors, instruments, transformers and disorderly wiring and cables in a nearby room. Permission granted, he traced the circuits and made a complete schematic diagram of the system on a large piece of paper. He did not recognize the electrolytic condensers, and I explained them to him.
>
> Without further assistance, he deduced that the setup was designed to explore operation of polyphase induction motors from a single-phase power line. He not only learned about this specific problem but went on from there, in a short period analyzing the general problem of phase conversion, and making several inventions for both static and rotating phase splitters. His initiative and independence have not lessened during the years since then.

Slepian suffered a stroke in 1951, but though handicapped by health problems, he continued at the Westinghouse laboratory until his retirement on February 28, 1956. In private life he loved music, art, and literature. He was a season ticket holder for the Pittsburgh Symphony Orchestra for over 40 years. He liked to joke, and his friends enjoyed his incisive sense of humor.

He married Rose Myerson in 1918. They had two sons, Robert and David, both of whom followed with distinction in their father's footsteps, Robert at Westinghouse and David at Bell Laboratories. David was elected to the National Academy of Sciences in 1977.

I WISH TO THANK Joseph Slepian's son David for his help and comments. I also gratefully acknowledge the help of John Coltman, who was well acquainted with Joseph Slepian at Westinghouse, and F. A. Furfari for his help in resolving several questions. I have drawn liberally from Furfari's biographical article about Slepian in *IEEE Industry Applications Magazine* (November/December 2000) and from published comments by M. W. Smith at Slepian's Edison Medal ceremony and L. W. Chubb at his Lamme medal ceremony.

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