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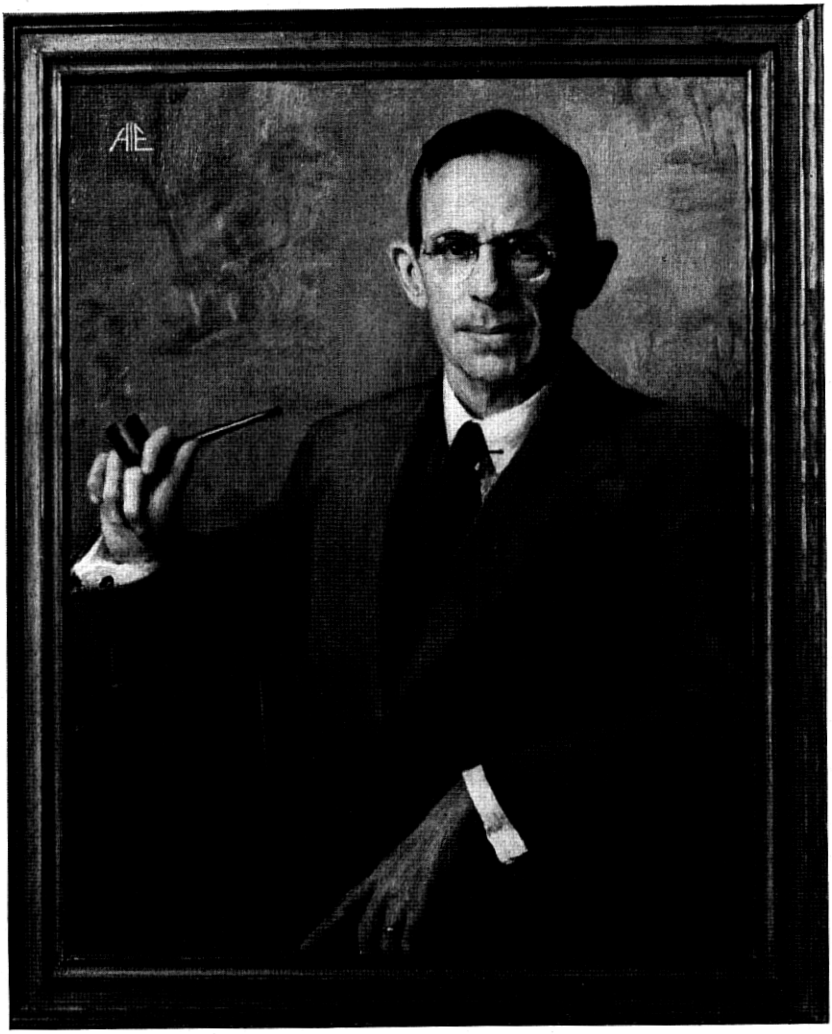
THIS ISSUE OF

THE JOURNAL CELEBRATES THE

SEVENTIETH BIRTHDAY OF

CLINTON JOSEPH DAVISSON

IT IS CONTRIBUTED BY SOME OF HIS MANY FRIENDS AND FORMER ASSOCIATES IN THE BELL TELEPHONE LABORATORIES AS A TOKEN OF THEIR AFFECTION AND OF THEIR RECOGNITION OF THE VALUE OF HIS MANY CONTRIBUTIONS IN THE FIELD OF PHYSICAL RESEARCH



C. J. DAVISSON
From a portrait by H. E. Ives
of about 1938

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Dr. C. J. Davisson

By M. J. KELLY

DR. DAVISSON, affectionately known to his large circle of friends as "Davy," joined the research section of the Engineering Department of the Western Electric Company in March, 1917 to participate in its World War I programs. He came on leave of absence from Carnegie Institute of Technology with the intention of returning to his academic post at the close of the war, but remained with its engineering organization, later to become Bell Telephone Laboratories, until 1946, when he retired at the age of sixty-five. He then accepted a research professorship in the Department of Physics at the University of Virginia.

When I joined Western's Engineering Department at the beginning of 1918, I had the good fortune to be assigned an office with Davisson. This was the beginning of a lifelong intimate friendship and an uninterrupted and close professional association terminated by his retirement.

Beginning in 1912 the Western Electric Company under the able leadership of Dr. H. D. Arnold pioneered in the development of the thermionic high-vacuum tube for communications applications. Although such devices already had important application as voice-frequency amplifiers in long-distance circuits at the time of our entrance into World War I, tubes were really not yet out of the laboratory, and the relatively few that were required for extending and maintaining service were made in the laboratories of the Engineering Department. Research and development programs directed to military applications of these new devices brought about a large expansion in the work of the laboratories. Davisson and I were assigned to the development of tubes for military use.

Important applications resulted from this work, and thermionic high-vacuum tubes had to be produced in what was for that time astronomical quantities. The science, technology, and art essential to such quantity production did not exist, and had to be created concurrently with a most rapid build-up in production. All of the tubes employed an oxide-coated cathode, which was later to become the universal standard the world over for low-power thermionic vacuum tubes.

Davisson early took a position of leadership in problems of fundamental physics relating to the emitter and high-vacuum techniques. We were forced to move so rapidly that much of the work was necessarily empirical. Even in this atmosphere of empiricism Davisson's work was unusually fundamental and analytical. Increasingly all of us went to him to discuss fundamental problems that were in urgent need of an answer. He was always available and displayed a friendly interest; we rarely left him without benefit from the discussion. Frequently he would continue his study of the problem and come later to give the benefit of his more mature consideration.

During this period of intensive work performed in an atmosphere of urgency, Davisson displayed the characteristics that were important in determining the pattern of his work through the years and the nature of his contributions to our laboratories and to science. His inner driving force was always seeking complete and exact knowledge of the physical phenomena under study. Thoroughness was an outstanding characteristic. The rapid tempo of the work with the necessity of accepting partial answers and following one's nose in an empirical fashion were foreign to his way of doing things. As a war necessity he yielded to it, and performed as a good soldier. His interests were almost wholly scientific, but the needs of the situation forced upon him somewhat of an engineering role for which he had little appetite. As an adviser and consultant, he was unusually effective. In this he has few equals among scientists of my acquaintance. I believe that his success here is due to the high level of his interest in solving problems, to his broad area of curiosity about physical phenomena, and to his warm, friendly, and unselfish interest in the scientific aspects of the work of his associates.

Industry's scientific and technologic support of the war effort led to a rapid expansion of industrial laboratories in the postwar period. Our laboratories had expanded during the war period, and this was continued at a rapid rate throughout the following decade. The scientists who had come to the Laboratories during the war and the years immediately preceding it, with few exceptions moved out of the laboratory and assumed places of management and leadership in the research and development sections of the Laboratories' organization. At that early period in the life of industrial laboratories, the major emphasis was on applied research and development: there was very little research of a pure scientific nature.

Davisson was one of the few who did not gravitate to positions of management and leadership. His compelling interest in scientific research led Dr. Arnold to make a place in it for him, very rare in industrial laboratories of the time. A pattern of work of his own choosing gradually evolved, and he worked within it throughout his career. One or two young physicists and a few laboratory technicians made up the team that worked on his research problems. The young physicists and technicians did most of the work in the laboratory, although Davisson would frequently be found in the laboratory making observations in association with his co-workers. He took a leading part in planning the experiments and in designing the apparatus. His thoroughness and absorbing interest in detail were especially rewarding in this area for his experiments were always well conceived and their instrumentation was beautiful.

The maximum of reliability, long life (measured in years) and the highest electron-emitting efficiency from the cathode were early recognized as important to the full utilization of the thermionic high-vacuum tube in telecommunications. For several years after the close of the war, Davisson's researches were directed at a complete understanding of the emission phenomena of oxide-coated cathodes. This emitter is an unusually complex system. Chemical, metallurgical, and physical problems of great complexity are interleaved. Over the years, our laboratories have made great progress in reliability, long life, and high electron-emitting efficiency of thermionic vacuum tubes for telecommunication uses. The benefits of this work to the telephone user have been large, and annual savings to the Bell System of many millions of dollars have resulted. Davisson's researches during the five years following the close of the war. and his continuing advice to others through a longer period were significant in the advances that our laboratories have made.

As multigrid structures came into use and the tubes came to be used in circuits of ever increasing complexity, unwanted secondary electron emission from the grid structures became a major problem. The presence of this emission and its variation in amount from tube to tube brought about malfunctioning and unreliability. If it were to be controlled, its complete understanding was essential. A basic study of secondary emission was Davisson's next area of research. In these studies he came upon patterns of emission from the surface of single crystals of nickel that aroused his curiosity. His examination of these patterns led to his discovery of electron diffraction and the wave properties of electrons. In recognition of this masterful research with its important and highly significant results, he was awarded the Nobel Prize in 1937.

After the discovery of electron diffraction, Dr. L. H. Germer, who had worked with Davisson on the secondary emission researches, took the problem of applying electron diffraction to the study of the structure of thin surface films. He was the pioneer in utilizing electron diffraction in studies of surface structure, and made a large contribution to the science and technology of this new and important analysis technique. While Germer, graduating from his place as an aide to Davisson, worked independently on this problem, he benefited from frequent discussions with Davisson. After Germer had perfected an electron diffraction spectrometer, he operated it for a number of years as an analytical aid to many of the research and development projects of the Laboratories. The interpretation of the patterns and the determination of the crystalline structure of surface films were complex problems. During the period that Germer was developing techniques and getting order into the analysis of the patterns, Davisson often joined him in puzzling out the crystal structure revealed in photographs of the diffraction patterns of many different kinds of surfaces.

As a logical consequence of Davisson's interest in electron diffraction, he next concerned himself with a variety of problems in electron optics. He was one of the first to develop analytical procedures in the design of structures for sharply focusing electron beams. For many years, beginning in the early 1930's, Davisson gave much attention to the analytical side of electron optics and designed and constructed many structures for electron focusing. Prior to his work much of the vacuum-tube development work in our laboratories, as elsewhere where electron focusing was required, was largely empirical. Unfortunately he did not publish much of the fine work that he did, although he reported on portions of it to scientific and technical groups. However, the effect of his work and his ever increasing knowledge of electron optics on the programs and men of our laboratories concerned with electron dynamics was large. Dr. J. B. Fisk, Dr. J. R. Pierce, Dr. L. A. MacColl, Dr. Frank Gray and others of our laboratory obtained guidance and inspiration from Davisson, the consultant and adviser.

His work in electron optics came at a fortunate time in relation to our laboratories' studies of the transmission of television signals over coaxial conductor systems. Although it was possible to measure the amount and characteristics of the electrical distortion of signal currents, there were not available cathode ray tubes precise enough in their design for evaluating the degradation in the picture's quality resulting from the passage of the signal through the coaxial system. He undertook the development of a cathode-ray tube for this test purpose employing the principles of electron optics that he had worked out. In doing this he made one of his few excursions into technology. There resulted from his work a cathode-ray tube of great precision. By virtue of the fundamental design of the beam and deflecting system, the tube provided an extremely small rectangular spot on the flourescent screen that remained in sharp focus over the entire screen area and had a much improved response characteristic. He took unusual pride in this project, and played a leading part in the design of every element of the complicated structure. The tube proved to be a useful tool in the evaluation of picture impairment resulting from different types of signal distortion.

Our laboratories steadily increased their participation in research and development activities for the military beginning in 1938. This effort expanded with terrific speed at the beginning of World War II, and soon became our major activity, continuing until the close of hostilities. Davisson was most anxious to contribute in any way that he could in our military work. While continuing his researches, he gave attention to the new and important multicavity magnetron that was receiving increasing attention. His background in electron optics made him invaluable as a consultant to Fisk, who led our magnetron work. As in World War I, speed was again the driving force in our programs, and substantially all of our research people turned to development. By keeping aloof from the rapidly moving development stream, he was able to give unhurried consideration to many of the basic electron dynamics problems of the magnetron.

When Dr. J. C. Slater joined us in 1943 to participate with Fisk in the basic magnetron problems, Davisson turned his attention to problems of crystal physics in relation to our programs on quartz crystal plates as circuit elements. Our laboratories were the focal point of a large national effort for the development, design, and production of quartz crystal plates for a multitude of electronic circuit applications. Drs. W. P. Mason, W. L. Bond, G. W. Willard, and Armstrong-Wood were the basic science team working on a multitude of problems that arose with the tremendous expansion of quartz plate production and use.

Davisson spent the major portion of his time from 1943 until his retirement in 1946 on a variety of crystal physics problems. He brought a fresh viewpoint into the crystal physics area. Through consultation, analyses, and experiments, he was of material assistance to our crystal physics group in the large contribution they made to the application of quartz plates to electronic systems for the military.

Davisson exerted a constructive influence on programs and men in the research and development areas of our laboratories throughout the thirty years of his active service. His door was open to all, and through his constructive interest in the problems presented, he developed large and continuing consulting contacts. This was not an assigned task but rather one that was personal to him, and its amount and continuance through the years were expressions of a facet of his personality. His contribution to the adjustment of the young men to their change in environment from the university to industry as they came to our laboratories was considerable. It became a habit of the research directors to place with him for a year or so junior scientists on their entrance into our laboratories. Dr. J. A. Becker and Dr. William Shockley are typical of the men who were introduced into the Laboratories through a period of association with him.

We have always welcomed young scientists from the graduate schools of our universities for summer work. This gives them a view of the operation of an industrial laboratory, and is an aid to us in the selection of young research men from the schools. Several of them were assigned to work with Davisson. Some have since had distinguished careers in science. Drs. Lee A. DuBridge, Merle Tuve, and Philip Morse are among the graduate students who worked with Davisson during their summer employment with us.

It was fortunate that Davisson, who had come to stay for the duration of the war, elected to stay with the laboratories to work as a scientist in areas of physics important to our programs rather than return to university life. He established a pattern of fundamental research that has continued and enlarged in scope as our laboratories have evolved and reached maturity. Across the forefronts of the physics, mathematics, and chemistry, which are basic to telecommunication technology, we now have many scientists whose programs are directed, as was Davisson's, only at expanding fundamental knowledge, and who do not divert their energies even to the fundamental development phases of our technology. It is a tribute to Davisson's overpowering interest in science, and to his steadfastness in the pursuit of knowledge through the scientific method of experiment and analysis that during the pioneering and rapid expansion years of our laboratories, when development demanded the attention of most of our scientists, he gave almost undivided attention to the scientific aspects of our work. Throughout his career he has remained a scientist and has maintained a working knowledge at the forefront of a wide area of physics.

Throughout his thirty years at the Laboratories, Davisson's circle of friends among scientists steadily grew, not only within his own country but extending to Europe and the Orient. His capacity for friendships is large, and each of us at the Laboratories in daily contact with him has enjoyed a close friendship of exceptional warmth. The integrity and quality of his work are universally appreciated. He is held in high regard, not only for it but also because of his fine personal qualities. He is shy and modest. Because of this, it requires an association of some duration to know Davisson the man. He has a keen sense of humor, which flashes upon you in most unexpected ways. Unusually slight in stature with a fragile physical frame, his weight never exceeded 115 pounds, and for many years it hovered around 100. While his health has been good, his store of energy has been limited, and it has been necessary for him to husband it carefully.

Davisson's modesty causes him to undervalue the importance and scope of his contributions. This characteristic, the low level of his energy, and the high standard he has always set for his work have combined to limit the amount of his publication. His influence on science and technology generally has, therefore, not been at so high a level as it has attained within the Laboratories, where his personal contact with individuals and their work has been more effective than publication.

In recognition of his constructive influence on the evolution of the basic science programs of our laboratories and his contribution of important new knowledge in the areas of thermionic emission, secondary electron emission, electron diffraction, and electron optics, the editors and the editorial board of The Bell System Technical Journal have invited members of our staff whose work and careers have benefited through association with Davisson to contribute papers to this issue of the Journal in celebration of his seventieth birthday.