in his own way, introducing the important quantity known as the Courant–Snyder invariant. (Unbeknowst to Bell, Nicholas Christofilos had discovered strong focusing earlier.) Furthermore, Bell decisively clarified a subject (the effect of accelerator gaps) in the theory of linear accelerators that had received the attention of John Slater, Robert Serber and Wolfgang "Pief" Panofsky. At CERN Bell contributed, in papers published in 1981–82, to the theory of cooling and, together with his wife, Mary, in 1987–89, to the theory of quantum "beamstrahlung." In both areas he displayed once more his ability to solve complicated and partially controversial questions.

Another of Bell's accomplishments in accelerator theory, perhaps of broader general interest, was his explanation (arrived at in collaboration with Richard Hughes and Jon Leinaas) of the fact that the spontanteous polarization of electrons in a synchrotron can, even under ideal circumstances, never obtain 100%. This explanation was an application of theoretical demonstrations by Stephen Fulling and William G. Unruh that an observer who is accelerated in a region of space–time containing an electromagnetic vacuum will detect blackbody radiation whose temperature is proportional to the acceleration. According to Bell and his collaborators, the effective blackbody radiation "observed" by the electrons has a depolarizing effect. This use of abstract considerations to explain a concrete terrestrial phenomenon was a wonderful achievement. John Bell influenced a generation of physicists and natural philosophers as much by the force of his character and personality as by his intellect. Although he was a reserved man, his speech was eloquent, precise, playful and pungent, enhanced by his lilting Irish accent. His combination of commitment, open-mindedness, daring and complete intellectual honesty had a direct effect upon everyone who was fortunate enough to know him, and an indirect effect upon a wide circle of readers. His early death was an irreparable loss to his profession, and a cause of deep sadness to his countless admirers.

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Darrell W. Osborne

Darrell W. Osborne, friend and colleague, was released from his suffering on 3 December 1989 after a progressively debilitating illness. He was 75 years old.

During World War II Darrell did research on rockets for the National Defense Research Council for which work he received a certificate of merit from President Truman. After the war he joined Argonne National Laboratory, where he worked until his illness forced him to retire in 1980.

In 1948 Darrell, Bernard Abraham and Bernard Weinstock began a collaboration to study the properties of liquid ^{3}He that continued for almost a quarter of a century. This group was the first to work with macroscopic quantities of pure ^{3}He. Until the mid-1950s the knowledge that tritium, the parent of ^{3}He, was being stockpiled was a military secret. Therefore the quantity of ^{3}He that could be mentioned in a publication was severely restricted. Experiments to measure the vapor pressure, boiling point, critical temperature and flow of ^{3}He were performed with 28 cc of gas at STP (or about 0.04 cc of liquid). The flow experiment showed that down to 1 K liquid ^{3}He did not display the superfluid properties of liquid ^{4}He. The vapor pressure measurements produced a correction to the thermodynamic temperature scale below 2.2 K. This correction was timely as anomalies were showing up around 2 K in heat capacity measurements because of an error in the temperature scale. Darrell's expertise as a calorimetrist guided the group in determining the heat of vaporization and the heat capacity over the range 0.25–1.5 K.

Although now regarded as fundamental, the role of particle statistics in determining the properties of liquid helium was at that time a subject of much debate, as is clearly brought out in the second volume of London's treatise, "Superfluids." The hugh low-temperature heat capacity of ^{3}He provided an essential clue to Lev Landau that ^{3}He could be modeled as a Fermi liquid. In the second of his famous Fermi-liquid papers, Landau used the heat capacity measured by Darrell's group to make the first estimate of the Fermi-liquid parameter, F1.

Darrell was a first-rank calorimetrist, and he created one of the world's outstanding calorimetry laboratories at Argonne. I can safely say that none of his measurements has been superseded. He served on the National Research Council's Evaluation Committee of the heat division of the National Bureau of Standards, and he was chairman of the Calorimetry Conference. He spent the academic year 1958-59 at Oxford University as a Guggenheim Fellow.

Darrell Osborne made seminal contributions to experimental low-temperature physics. In doing so, he set a standard of competence and ethics for all to meet. It was a privilege to have known him and to have worked with him.

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Harrison E. Farnsworth

Harrison Edward Farnsworth died in Tucson, Arizona, on 14 November 1989, at the age of 93. One of the founders of modern surface physics, his active research career spanned an incredible period of nearly 70 years. With his passing, the world has lost its last direct contact with the events that led to the discovery of the wave nature of the electron in 1927.

As a graduate student of the University of Wisconsin, Farnsworth began work on the secondary emission of electrons from metals. In his first paper, published in 1922, the year he received his PhD, Farnsworth reported that some secondary electrons were "reflected" without loss of energy—a result that was inexplicable by classical physics. Among those who were initially critical of the young scientist's claim was Charles Davisson, who argued that the scattered electrons surely must lose some energy. Davisson would later confirm Farnsworth's observation and go on to share the Nobel Prize with George P. Thomson for the discovery of electron diffraction.

The years following graduate school were difficult for Farnsworth. His teaching responsibilities at the University of Maine left little time for research, and he returned to Wisconsin in the summers—without pay—to continue his studies of the anomalies of secondary emission. In 1926 he moved to Brown University, where he would remain until his retirement in 1970. After Davisson and Lester Germer's elegant demonstration of electron diffraction from the surface of a nickel crystal in 1927, Farnsworth embraced the new technique of low-energy electron diffraction. While other physicists, including Germer, moved on to high-energy electron diffraction, Farnsworth and his students continued to develop LEED and other methods of studying clean single-crystal surfaces, convinced that surface studies would yield important new science. During the years of the Great Depression, he supported his research with donations from Providence, Rhode Island businessmen.

With Farnsworth's discovery in the 1950s that the surfaces of the elemental semiconductors germanium and silicon are reconstructed relative to the underlying crystal (that is, that their atomic arrangements differ from those of the bulk material), the field of surface physics abruptly blossomed, and funding ceased to be a serious limitation. Ironically, that discovery too was greeted with initial skepticism. Critics claimed the reconstruction, if it existed, must have been caused by the novel ion-bombardment cleaning technique, a method that Farnsworth had also pioneered. The ideas of reconstruction, however, were soon confirmed. There are few areas of surface science today that do not bear traces of Farnsworth's pioneering work.

Harry Farnsworth was a stern taskmaster in his laboratory, demanding total commitment from his students and husbanding every piece of wire, every item of glassware and every chemical as if it were a found treasure. Haunted by the memory of how close he had come to the discovery of electron diffraction, he seemed always to be working against a deadline. But for his students there was an intensity and excitement (perhaps tinged with fear) to working with him that cannot be recalled without nostalgia. No one emerged from that trial unprepared for the rigors of experimental physics.

An intensely private man with few intimate friends, Farnsworth was a stiff and uncomfortable speaker who dreaded public appearances. Recognition for his accomplishments was slow or even grudging. In 1981 he was honored by the American Vacuum Society with the Medard Welch Award.

Following his retirement from Brown in 1970, Farnsworth moved to Tucson, where he set up a laboratory at the University of Arizona. When it became difficult to commute each day to the university, he moved his laboratory into his home. He continued research and consulting almost to the end.

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