OBITUARIES

Walter H. Brattain

Walter H. Brattain, co-inventor of the transistor and a Nobel laureate, died 13 October 1987 at the age of 85 after a long illness. He spent the bulk of his career at Bell Telephone Laboratories, returning to teach at his *alma mater*, Whitman College, in his retirement years.

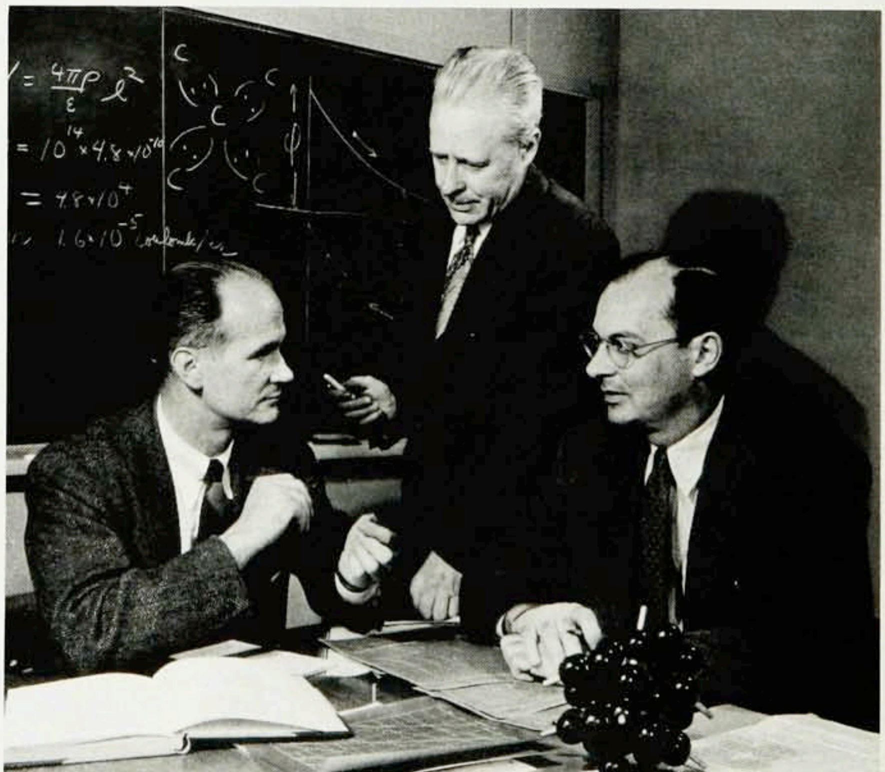
A descendent of a pioneer Western family, Brattain spent his childhood on a homestead cattle ranch in Tonasket, Washington, and was always proud of his Western heritage. He graduated from nearby Whitman College in 1924, one of a famous class of four students of Benjamin H. Brown, an exceptional teacher of physics. The other three also went on to distinguished careers: Walker Bleakney at Princeton, Vladimir Rojanski at Union College and at Harvey Mudd College, and E. John Workman as president of the New Mexico Institute of Mining and Technology. Brattain's parents had also attended Whitman and taken courses under Brown.

After graduating in 1926 with an MS from the University of Oregon, Brattain took a sheep train east to attend the University of Minnesota. He was a research student of John T. Tate, doing his PhD thesis on "Efficiency of Excitation by Electron Impact and Anomalous Scattering in Mercury Vapor." While at Minnesota, he took one of the first courses in quantum theory given in the United States, under John H. Van Vleck, and he never lost interest in the subject. Brattain received his PhD in 1929. Before joining Bell Laboratories that year, he spent eight months with the radio division of the National Bureau of Standards.

Prior to World War II, Brattain worked at Bell Labs with Joseph A. Becker on thermionic emission and on semiconductor rectifiers. After the war he was selected to be an initial member of the newly formed solid-state division, founded to exploit the understanding of solids at the microscopic level made possible by quantum mechanics. His main interests both before and after the war were on problems of surface physics.

I first met Brattain in the early 1930s, when I was a graduate student at Princeton and he was working at Bell's West Street laboratories. When I joined Bell Labs in the fall of 1945, because of wartime crowding, I shared an office with him and with Gerald L. Pearson (who survivied Brattain by less than two weeks). Through them I became interested in semiconductors, and I worked closely with both of them during my six years at Bell.

Brattain's first work with Becker



William Shockley, Walter H. Brattain and John Bardeen in 1948, shortly after the invention of the transistor.

was on effects of adsorbed layers on emission from tungsten cathodes. Later he did experiments to try to understand the physics of copper-oxide rectifiers. One of his last projects before the war was a study of the oxidation of copper using a radioactive copper tracer. As the war was coming on, interest shifted to silicon cat's whisker detectors for radar. He was involved with some of the early work; in particular he noted a large photoeffect on the contact potential of a silicon surface. During the war Brattain worked on the design of airborne magnetometers for submarine detection under the National Defense Research Committee at Columbia University.

The Bell solid-state division was formed in late 1945 as staff members returned from various wartime activities. The semiconductor group, of which Brattain and Pearson were members, was one of several in a broad program of solid-state research. William Shockley was cohead of the division and head of the group. Other members in the initial semiconductor group were Robert B. Gibney, a physical chemist, and Hilbert R. Moore, an electrical engineer.

In the summer of 1945 Shockley had suggested making a solid-state amplifier by exploiting the field-effect principle—namely by altering the conductance of a thin semiconducting film via application of a transverse field. In a simple form, the film is one plate of a parallel-plate condenser. Shockley's calculation indicated that if the induced charge in the film came from mobile carriers (conduction electrons or holes) the effect should be large enough to give amplification. When attempts to observe the effect failed, I suggested that the reason might be that the induced charge was in the form of electrons in states at the surface that shielded the interior of the film from the transverse field. This hypothesis of surface states led to several predictions that could be tested experimentally. In accordance with his background, Brattain decided to concentrate on surface problems, while Pearson studied bulk phenomena. Brattain's experiments helped to verify the existence of the surface states.

In experiments done with Gibney, Brattain found that one could bypass the surface states if one applied the field through an electrolyte adjacent to the surface. He and I showed that the current to a cat's whisker point contact on a silicon surface biased in the reverse (high resistance) direction could be controlled by a voltage applied through an electrolyte insulated from, but surrounding, the cat's whisker. Later experiments showed even larger effects when silicon was replaced with germanium.

To avoid the slow response time of the electrolyte, we tried to apply the field across a thin oxide layer on germanium. We found that the oxide, if present, was not insulating, but that there was a small effect on the reverse current in a direction opposite to what one expected from the field effect. We had discovered a new way to control the current flowing across a rectifying contact: the bipolar principle, which involves flow of both types of carrier—conduction electrons and holes.

It did not take long to create an amplifier that used the new principle. The point-contact transistor was demonstrated on 23 December 1947. A month later Shockley conceived of the superior junction transistor geometry, in which all of the action takes place with the bulk of a semiconductor rather than at metal–semiconductor contacts. For these discoveries Brattain shared the 1956 Nobel Prize in Physics with Shockley and me. Unfortunately Brattain did not live to see the 40th anniversary of his invention.

Through his remaining years at Bell, Brattain continued to work on surface problems. He devised methods for measuring the energy distributions of surface states and the cross sections for trapping of electrons and holes. His work was on "real" surfaces—ones on which there is the usual thin oxide layer—rather than the "clean" surfaces that are of current interest. I collaborated with him for some time after I went to Illinois in 1951, and he later worked with Charles G. B. Garrett and with Phillip J. Boddy.

In the early 1960s, Brattain returned to Whitman College on a part-time basis, and he joined the faculty there after his retirement from Bell in 1967. One of his favorite courses to teach was one taught earlier by Benjamin Brown: "Understanding Science for Non-Science Majors." At Whitman, Brattain became interested in problems of biophysics. He collaborated with scientists at Battelle Pacific Northwest Laboratories in Richland, Washington, on studies of ion flow through lipid bilayers.

Very receptive to new ideas, Brattain was always ready to cooperate on suggestions for experiments on proposed new devices even when he had reservations about the outcome. He was one of the first experimenters with a good understanding of the Mott–Schottky theories of contact

rectification developed just prior to World War II. One has the feeling that if he had not engaged in the particular series of experiments that led to the transistor, he would have been involved in another series that would have been successful not much later.

Brattain often expressed the view that the transistor radio might help bring the peoples of the world closer together: "All people can listen to what they wish independent of what dictatorial leaders might want them to hear and I feel that this will eventually benefit society."

Brattain was a member of the Commission on Semiconductors of the International Union of Pure and Applied Physics, and he served as its chairman in 1966. He was also a member of the Defense Science Board and of various advisory committees.

While history will remember Walter Brattain for his achievements, I will remember him as a close personal friend, golf and bridge partner, and colleague.

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Arthur H. Cooke

Arthur Hafford Cooke, born 13 December 1912, died in Oxford, England, on 30 July 1987. He had recently retired as warden of New College, Oxford, a position he had held since 1976. Prior to this, he had been associated with the Clarendon Laboratory, Oxford, for more than 40 years as an undergraduate, graduate student, university demonstrator and lecturer, and finally as a reader in physics.

His early work before World War II, under Frederick A. Lindemann (later Lord Cherwell) and Francis Simon, was concerned with the production of low temperatures, and he helped to establish Oxford as one of the early centers of cryogenic research. Most of his later work was also devoted to low-temperature physics and, in particular, to the magnetic and thermal properties of rare earth and transition metal salts. His work on paramagnetic relaxation and hyperfine effects led in 1953 to the discovery of cerium magnesium nitrate, which soon became the accepted standard for the production and measurement of temperatures in the millikelvin range. His insight also led to the discovery of the first Ising-like material, cerium ethyl sulfate, in 1951, and in 1959 to the recognition of the first dipolar ferromagnet, dysprosium ethyl sulfate. In 1970, Cooke and his associates found another prototypical material, dysprosium vanadate—the first example of a crystal with a magnetically controllable Jahn–Teller distortion.

All of these studies stemmed from the same common thread: a detailed understanding of the macroscopic properties in terms of microscopic interactions as revealed by microwave paramagnetic experiments then being developed in the Clarendon Laboratory. Cooke's contact with microwaves started during the Second World War, when he worked on radar for the Admiralty team at Oxford. He designed the "transmit–receive" cell, which played an important part in the battle against U-boats. For his wartime services, he received a royal award: He was made a Member of the Order of the British Empire.

Cooke was an inspiring teacher. His enthusiasm for physics was infectious and he was unusually effective in persuading the student to think for himself, constantly checking the reasonableness of each idea. Cooke had a clear and intuitive feel for physics that never led him astray. Where others became bogged down in formalism he proceeded by common sense. He used the backs of many envelopes to explain observed effects.

This same common sense also made him an outstanding administrator. He served from 1969 to 1983 as a member of the Hebdomadal Council of Oxford University and for ten years on the General Board of Faculties, including a period as *de facto* chairman. His thoughtful and fair approach to all matters and his tactful and witty manner earned the respect of all who knew him.

Cooke was by nature a shy man, but he had many friends. Everyone around him appreciated his engaging sense of humor and his even temperament. There must be some with whom he battled, but they would be hard to find. He cared for people and they cared for him. His terminal illness was diagnosed three months before the end, and during this time a constant stream of friends and colleagues came to see him, some traveling from far away. His unfailing courtesy and his personal interest in each visitor continued up to the end, and his ex-students, now well on in their own professional lives, found they could still learn from this witty, wise and gentle man.

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