uation from Dunkirk he added much to morale by introducing techniques for rapid degaussing, which were at the very least reassuring. Following this very hectic period he was transferred to head the Anti-Mining Division of the Admiralty in Scotland and played an important role in defensive measures against acoustic mines. Some of this work involved quite a little geophysics, and several of Bullard's assistants in the division became well-known figures in this subject after the war. Bullard left the Anti-Mining Division to join the new and vigorous operational research group working under P. M. S. Blackett's direction in the Admiralty. Here again he served with distinction.

After the war he returned to Cambridge as a reader in experimental geophysics but in 1948 accepted the post of professor of physics at Toronto. He remained there for only one year before returning to Britain as director of the National Physical Laboratory, a post he held until 1955. It was during this period that he was especially concerned with the dynamo theory of the Earth's magnetism. Through his position as director he was able to deploy the entire resources (by no means inconsiderable) of the computing division to carry out extensive numerical work required for the development of his theory.

Bullard left the National Physical Laboratory to return to Cambridge first as assistant director of research, then as reader in geophysics, and finally as professor of geophysics, a post he held till his retirement in 1974. By that time he had spent long periods in California at La Jolla and eventually settled there.

Apart from his best-known work on the origin of the Earth's magnetism Bullard made major contributions to the development of studies of the deep oceans and also played an important part in the emergence of plate tectonics. His versatility was once again revealed by his work on heat flow from the Earth and his use of seismic techniques for structural studies.

Bullard also spent much time as a scientific adviser to the Ministry of Defence. I found myself in close association with him during the early 1960's when he was chairman of the steering group for space research, set up by the Department of Science as the first body within the British Government concerned with the coordination of space research. In this capacity he was involved in decision making on such matters as the Anglo-American satellite cooperation, the European Space Research Organization and so on. He was also at one time a director of IBM and had substantial business interests.

Bullard was a remarkably versatile physicist who had a very deep understanding of the subject. At the same time he was an excellent designer of instruments and a much better mathematician that perhaps even he imagined. He was a very good person to work with. His strong sense of humor, which was sometimes quirkish and usually ironic or even satirical, may have put some people off, but he was in fact extremely generous both in ordinary life and in giving credit to others for scientific work. He was one of the great figures of his generation.

H. S. W. Massey
University College London

Raymond Thayer Birge

Raymond T. Birge, an authority on the general physical constants, former chairman of the department of physics at the University of California, Berkeley and former president of The American Physical Society, died in Berkeley on 22 March 1980.

Birge was born in Brooklyn on 13 March 1887. He went to the University of Wisconsin, where he received his AB degree in 1909, his MA in 1910 and his PhD in 1914. Birge's interests were in spectroscopy. In 1913, having finished his academic work, he accepted a position at the University of Syracuse as an instructor in part because of the presence there of F. A. Saunders (of Russell–Saunders coupling fame). Unfortunately for Birge, Saunders left for Vassar and then Harvard the year Birge came to Syracuse. Birge was promoted to assistant professor in 1915, but when an opportunity came in 1918 to go to Berkeley, he accepted it and stayed for the rest of his life. He came as an instructor and was promoted rapidly to assistant, associate and full professor, the last in 1926. When E. E. Hall, chairman of the department, died suddenly in November 1932, Birge was named acting chairman. His appointment as chairman was confirmed the following year and he continued in this position until his retirement in 1955. After his retirement, he stayed in Berkeley with his wife, Irene Walsh Birge, who died just three weeks before him.

Much of Birge's early work at Wisconsin, Syracuse and Berkeley was applying the recently developed quantum theory to diatomic molecular spectra. In 1926, he devised with Hertha Sponer a method of extrapolating the observed separation of vibrational levels to give the heat of dissociation of diatomic molecules. This important method was particularly useful in physical chemistry where, for stable molecules such as oxygen, nitrogen, carbon monoxide and nitric oxide, the ordinary temperature methods could not be used to find the heat of dissociation.

His painstaking analysis of these molecular spectra led Birge to apply the most careful numerical checks to the degree of agreement between theory and experiment. This heavy computational work brought with it a critical analysis of the methods of fitting data, and, with W. E. Deming, he published several papers providing physicists with useful methods of least squares fitting and maximum likelihood. His work also forced on his logical mind the fact that a careful analysis had never been made of the various means of determining the fundamental physical constants such as the speed of light, the charge of the electron and Planck's constant. His 1929 paper, "Probable Values of the General Physical Constants," which, incidentally, was the first paper in the first issue of the *Reviews of Modern Physics*, is a classic pioneering work in the field of determining the best values of the constants.

There is an interesting story about Birge's part in the discovery of the isotope of C^{13} which he published with A. S. King in 1929. King, who was at the Mount Wilson Observatory in Pasadena, had come to Berkeley for a meeting, bringing a picture of the spectrum of some bands of carbon that he had taken in his laboratory. He showed it to Birge, mentioning that there were some faint lines that he thought might be due to an isotope of carbon. Birge at once measured them, did the necessary calculations and interpretations to show they were from C^{13}, typed up the paper himself and mailed it to *Nature* and the *Physical Review*, all in eight hours. In his history of the Berkeley department of physics, he points out that this is probably some sort of record. In 1931, with D. H. Menzel, he wrote a paper on atomic weights, pointing out that the discrepancy between the physical and the chemical atomic weights of hydrogen could be due to a hydrogen isotope of mass two. Their prediction, later found to be based on two compensating errors in the experimental measurements, nevertheless led Harold Urey to his discovery of deuterium. Birge continued his research on correlating and determining the most precise values of the physical constants into the 1950's.

In the late 1920's, Birge took an active part in recruiting new members for the Berkeley physics department, so it was natural that he was asked to become chairman in 1932. E. O. Lawrence came to Berkeley in 1928, and Robert Oppenheimer in 1929, at first dividing his time between Berkeley and Caltech. Both the faculty and the numbers of graduate students grew. Birge worked hard to develop an outstanding physics department. When he retired in 1955, he could say that his efforts had been successful. During World War II there were many departmental problems. Much of the faculty went off to work in other places, and the separation of uranium isotopes at the Radiation Laboratory took the full time of almost all physicists present at Berkeley. Nevertheless, Birge managed to staff the physics courses for the Army and Navy programs as well as to keep some graduate work going. When the war was over, he provided vigorous leadership for the expanding department. In the years that he was chairman, the cumulative number of PhD's granted in Berkeley grew from 63 to 400. The new physics building, finished in 1964, was named Birge Hall and was dedicated on 21 December 1964 at a special session of the Berkeley meeting of The American Physical Society.

From 1942 to 1947 Birge served as the Pacific Coast secretary of The American Physical Society. In those days of less and slower travel, there were two meetings of APS each year on the west coast; Birge arranged for the speakers, programs, and so on. In 1954 he became the APS vice president and succeeded to the presidency in 1955.

Birge was a man of utmost honesty and of the very highest integrity. He was known throughout the world of physics and the campus for this honesty and for his scrupulous accuracy. As is natural for men of strong character, there are many stories about him; perhaps the most famous is that told by Harold Urey at the dedication of Birge Hall. It seems that Dick Crane of Michigan came to Berkeley to teach physics in the summer of 1949. When he came to Birge to ask about his classroom assignment, Birge thought a moment and then answered, "Let's see. You're teaching 121. Last year Fermi taught that course and we had to move the class twice to larger rooms. But we won't have that trouble with you teaching the course, will we?" He loved to teach and took care the teaching in the department of physics was good. His own lectures were models of accuracy and clarity. He believed in a nice balance between teaching and research and, in addition, he himself was outstanding in campus and university service.

In one of his last papers, presented at the Avogadro Centenary Symposium in Italy in September 1956, he spoke the following words: "Now to me the study of science is, in a sense, a religion. For there can scarcely be anything more marvelous than the structure of nature, nor anything more satisfying than to aid, even in the smallest way, in the gradual unfolding of the intricacies of our universe. From the beginning of the human race, man has speculated on the wonders of his environment, but there is and can be nothing in even his wildest speculation in any way comparable to the actual facts of nature. For just this reason, the true objective study of science offers a never ending and wholly satisfying human endeavor; at least I have found it so."

A. Carl Helmholz
University of California, Berkeley

Robert V. Pole

The physics community lost one of its most creative thinkers and one of its finest people when Robert Pole's private plane crashed in a snow storm in the Sierra Nevada mountains on 16 February 1980. Born in Yugoslavia, Pole received his degree in electrical engineering in 1953 from the University of Zagreb. He showed early evidence of his creativity and independence when, in the Cold War days of 1955, he obtained the plans for the disposition of the Yugoslav border guards from a good friend and then climbed out over the Alps to settle in West Germany.

After two years with ELNA Gmbh in Hamburg, Pole emigrated to the US and joined General Electric in Syracuse, N.Y. Upon his arrival, he took the first four letters of his very long, difficult to pronounce Slavic name and changed his first name to Robert (after Hemingway's hero in *For Whom the Bell Tolls*). In 1961 he moved to the IBM Watson Research Center, where he quickly established his reputation for inventiveness. Some 20 US patents in laser scanning, holography and optical information processing have been issued in his name. Pole's work led IBM to honor him with two Outstanding Invention Awards and an Outstanding Contribution Award.

In spite of his heavy commitments to IBM Research, Pole found the time to become a major contributor to the affairs of the Optical Society of America, of which he was a fellow. At the time of his death he was on the steering committee for the CLEOS (Conference on Lasers and Electro-optical Systems) meeting and chairman of the OSA Nominating Committee. Indeed, he was returning from selecting a site for a future CLEOS meeting when his plane went down. Although the scientific community at large knows of Pole through his many technical contributions, his family and friends remember him as a cheerful, fun-loving man who lived his life to the fullest. It was after he transferred to the IBM San Jose Research Laboratory in 1972 that he began his love affair with flying that was ultimately to prove his undoing. He took to flying with the same infectious enthusiasm and imagination that he showed in everything he liked to do. We will all greatly miss the pleasure of his company and the challenge of his mind.

Robert A. Myers
IBM Watson Research Center
Yorktown Heights, NY

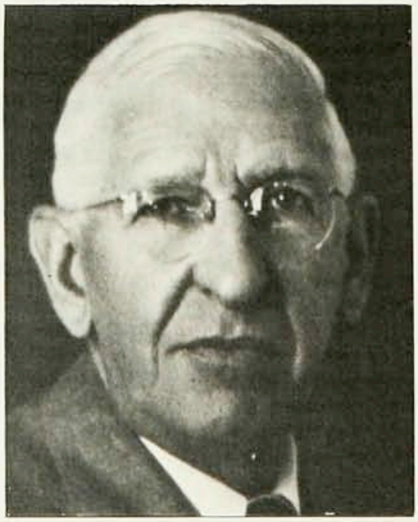
W. H. Zachariasen

W. H. (Willie) Zachariasen died last Christmas at the age of 73. His contributions, extending over half a century, were vast and crucial. They range from being the father of the theory of glass to the first accurate and concise atomic picture of the melting process.

His scientific contributions are so rich and varied that here we can list only a few of them. He was a leader in the field of x-ray diffraction, both as experimenter and theorist, as well as a master at deducing structures from x-ray powder diffraction data. Zachariasen was the first to establish the ionic radii, and he identified the contraction that established the then new 5f series. Throughout his life, he continued to refine bond-distance formulations and studied stacking disorder, high-pressure phases, and thermal diffuse scattering. As Linus Pauling said "I feel that he [Zachariasen] is to be classed among the outstanding scientists of the twentieth century."

Zachariasen published his first paper at age 19, beginning his 55-year period of unique contributions to the scientific literature. Three years later, in 1922, the University of Oslo granted him his PhD. In 1928–29 he was a fellow at the laboratory of Sir Lawrence Bragg. The following year, Zachariasen, still only 24 years old, joined the faculty of physics at the University of Chicago. There during the next 44 years, he was a professor, department head during the critical post-war years and also dean of the physical sciences.

ZACHARIASEN



During World War II he played a role for which he was uniquely suited. In the course of the Manhattan Project's urgent effort to understand the new element plutonium, he examined hundreds of samples. His brilliant work in unravelling the mysteries of plutonium could hardly have been carried out by anyone else. The complexities connected with the plutonium metal phases, their large number (six) and the ease of transfer among the four plutonium aqueous valence states were at first unbelievable. He showed magnificent intuition in deducing the complicated metallic structures from x-ray powder data alone. For example, Beta-plutonium is monoclinic and the first 17 x-ray reflections are absent. Nevertheless, Zachariasen went on to solve the structure, which consisted of locating seven types of plutonium atoms in the asymmetric unit. Indeed, he solved the structure using only a slide rule, pen and paper. Even in competition with others using the largest computers, he was unsurpassed. *The Theory of X-Ray Diffraction in Crystals*, a landmark advance in x-ray crystallography, was his outstanding book. Zachariasen was the first to solve crystal structures using "direct methods." His work on extinction was fundamental and showed the way to deeper understanding.

Without him science in general, and x-ray crystallography in particular, would have been a much poorer discipline than it is today. In so many ways, he was the authority, whether it was a question of ethics or a problem in science. We will miss him greatly.

Massimo Marezio
National Center for Scientific Research
Paris, France
Bernd Matthias
University of California, San Diego
Bell Laboratories
Robert Penneman
Los Alamos Scientific Laboratory

Lyle W. Phillips

Lyle W. Phillips, 69, a former National Science Foundation official who retired in 1978, died at his home in Chevy Chase, Maryland on 31 March 1980.

Phillips was one of the physicists who responded to the post-Sputnik call for broad improvements in American science. At that time he headed the department of physics at the University of Buffalo. Acutely aware of the needs of secondary-school teachers in that area, he established for them a special training program in physics.