FRANK REGINALD NUNES NABARRO

1916–2006

Elected in 1996

"For contributions to the understanding of crystal plasticity."

BY ALI S. ARGON

FRANK REGINALD NUNES NABARRO was born on March 7, 1916, in London, England. He received his early schooling in Nottingham and, in 1934, went up to New College, Oxford, to study physics. Recognizing that his strength was in theory, he proceeded to take first-class honors in mathematics and physics.

Early Career

In a very real sense, Nabarro was "present at the creation" of dislocation theory of crystal plasticity, and he continued to be a primary contributor to this important area of physics and materials science. Guided by Nevill Mott, a future Nobel laureate, in 1940 he published the first quantitative model of the flow stress of crystals hardened by a solid solution. To show the importance of the flexibility of dislocation lines in sampling solute atoms on the glide plane, he introduced the concept of "line tension" of dislocations, an important tool in dislocation theory in problems of flow stress.

During the Second World War, Nabarro worked for the British Army Operational Research Group (AORG) headed by Brigadier Basil Schonland, who later became the first president of the South African Council for Scientific and Industrial Research. Schonland later played an important part in recruiting Nabarro for the University of the Witwatersrand (Wits) in Johannesburg. For his wartime services, Nabarro was awarded the Member of the Order of the British Empire (MBE) in 1946.

After the war, Nabarro resumed his academic career in Mott's group at Bristol University, as a Royal Society Warren Research Fellow. During his Bristol period, he made important advances in the theory of metal plasticity and dislocation theory of work hardening. He also pioneered the landmark development referred to as "diffusional flow" independent of the work of Herring. Other firsts during this period included collaboration with F. C. Frank and J. D. Eshelby in considering dislocation pile-ups that were thought to play an important part in work hardening of crystals and in fracture. He also provided a fundamental reevaluation of the model of Rudolph Peierls for the lattice resistance to slip, referred to since as the "Peierls-Nabarro force."

In 1948, Frank Nabarro married Margaret Dalziel, who had been Schonland's personal assistant. In 1949, he joined Birmingham University to take up a lectureship in the Metallurgy Department. While at Birmingham, he published the first definitive review of the mathematical theory of stationary dislocations. In recognition of his considerable achievements, Birmingham University honored him with a D.Sc. in 1953.

The Move to South Africa

In 1953, in response to personal inducements by Schonland, Nabarro moved to South Africa to head the Department of Physics at Wits, where he built up the Physics Department to considerable strength in several areas. He often advised students on their experimental work, but he was at his best, as always, on theory. If an elaborate calculation had been performed, he quickly recognized anything that was false or incorrect.

Even though the responsibilities of running a department took him out of the scientific mainstream for some years, through prodigious effort he remained on the cutting edge of his field. During those years, he returned to the writing of his monograph, *Theory of Crystal Dislocations*, which was published by Clarendon Press: Oxford, in 1967. The book was an important resource on basic concepts for many years.

As the demands of his position as department head eased, Nabarro was able to devote more of his time to research, and

over the years, he contributed key ideas to many areas of dislocation physics. In later years, he turned his attention to quasi-crystals, dislocation patterning in plastic deformation, and creep-resistant materials and rafting in superalloys. The latter interest eventually resulted in his more recent monograph, *The Physics of Creep*, (CRC, 1995), which he wrote in collaboration with deVilliers.

In 1961, Nabarro became the director of the Solid State Physics Research Unit (SSPRU) of South Africa, which was responsible for coordinating sponsored research activities at universities in collaboration with industrial research organizations. From the outset, the activities of SSPRU were divided between basic physics and projects with a direct bearing on the South African economy.

In the 1970s, after a short stay in Orsay, France, Nabarro developed an interest in liquid crystals and in the role of dislocations and disclinations in biological materials. This led, among other things, to an analysis of the structure of an insect muscle and its flexure, which appears to have anticipated the ideas of some biologists and, later, during a sabbatical leave in Berkeley in 1977, to a successful mechanistic description of the crenation of red blood cells by drugs.

Nabarro often passed on Mott's advice to young researchers: "Try to get a mental picture of what is going on, then find the simplest theory that contains the essential facts. When things become complicated, leave the details to someone else." Nabarro knew his limits and was always open to contributions from people whose skills complemented his own.

Nabarro served Wits in various capacities, including a term as deputy vice chancellor during which, in 1981, he drew up an Academic Plan, the first for any South African university, which anticipated a large influx of black students after the end of apartheid. His support never wavered for opening the doors of academe in South Africa to everyone who could benefit from higher education. In his graduation address to the University of Natal on April 28, 1988, he expressed his contempt for the Separate Universities Act: "The biggest blow that the government struck at the liberal universities of South Africa in 1959 was to deprive us of our right to be . . . " He often voiced

his belief that a university was a community of scholars and should be governed in a collegiate way, a view that differed somewhat from the later ethos that often valued more quality-control audits, and the like.

Nabarro was an inspiring teacher and mentor. A generation of physics graduates from Wits remembers fondly evening sessions at his home, where the human side of physics was revealed. His lectures were challenging and forced students to think. Through them, students saw that physics was not cut and dried, but an open-ended, evolving subject.

Retirement, Honors, and New Opportunities

Nabarro retired in 1984 but remained an active member of the Wits community, always generous with his time and wise counsel. Loyiso Nongxa, vice chancellor of Wits, in a farewell tribute to Nabarro, declared, "He was an inspiration to generations of scientists, and he had a significant influence on the thought and direction of this university. He was renowned for his brilliant mind, sharp intellect, meticulousness, and his unique sense of humor." Nabarro always cared deeply about South African people and their future.

Nabarro was elected to the Royal Society (London) in 1971. He was elected an honorary fellow of the Royal Society of South Africa in 1973 and served as its president from 1988 to 1991. He was a council member of the South African Institute of Physics for a number of years, and a vice president from 1988 to 1991. He was also a member of the Science and Engineering Academy of South Africa.

In 1966, he was elected a foreign associate member of the U.S. National Academy of Engineering, the only member on the African continent. In recognition of his local stature, he was awarded the South African Presidential Decoration of the Order of Mapungubwe. Among other honors, he was also the recipient of honorary doctorates (D.Scs) from Wits, University of Cape Town, University of Natal, and University of Pretoria.

Nabarro held visiting positions at several universities in the United States, Canada, and the United Kingdom. He was the

recipient of numerous awards, including the De Beers Gold Medal of the South African Institute of Physics, the Platinum Medal from the Institute of Materials, and the R. E. Mehl Award of the The Minerals, Metals & Materials Society (TMS) in the United States. Festschrifts in his honor were published by the Royal Society of South Africa in 2003 and by *Philosophical Magazine* in 2006.

Nabarro was not only an outstanding scientist, but was also a well-informed, cultured man. He shared a love of classical music with his wife Margaret, who was a notable musicologist. He was honorary president of the Johannesburg Musical Society, and in memory of Margaret, he established the Margaret Dalziel Nabarro Chamber Concert Fund.

Nabarro had an uncanny ability to get along with people across the political spectrum in South Africa. Many people admired him most for his sheer lust for life, his phenomenal energy and resilience, and his extraordinary intellectual vitality. He traveled extensively, attending conferences and giving lectures wherever he went. In the United States, he attended the Gordon Conferences on Physical Metallurgy for many years, many topical conferences of the TMS, and symposia of the Materials Research Society. Just months before his death, in spring 2006, in spite of serious health problems and a painful broken foot, he visited India and China. When he passed away on July 20, 2006, he was editing volumes 13 and 14 of *Dislocations in Solids*, a series of books he had edited over the years. His mind remained razor sharp to the end.

Acknowledgment

I am grateful to Professor Arthur Every of the Department of Physics of the University of the Witwatersrand, Johannesburg, South Africa, for his help in preparing this tribute.

Further Reading:

A. G. Every's obituary, "Frank Nabarro: A journey through science and society," *S. African J. Science,* 103, 99-103 (2007).