NATIONAL ACADEMY OF SCIENCES

# LELAND JOHN HAWORTH

*1904—1979*

*A Biographical Memoir by*

MAURICE GOLDHABER AND GERALD F. TAPE



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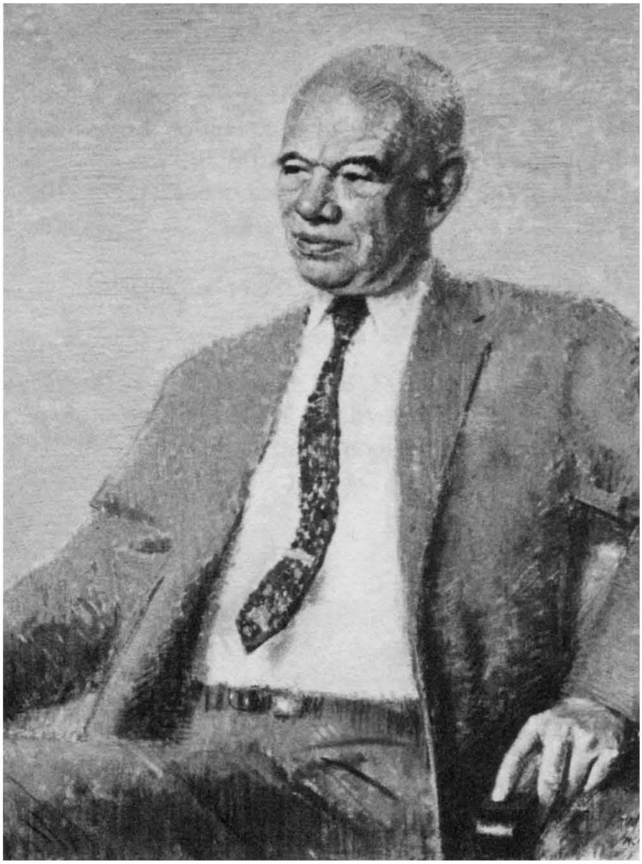

Courtesy, National Science Foundation

Leland J. Haworth

# LELAND JOHN HAWORTH

*July 11, 1904–March 5, 1979*

BY MAURICE GOLDHABER AND GERALD F. TAPE

LELAND J. HAWORTH will be remembered as a master builder of research facilities, a foremost scientific administrator, and, above all, as a man of exceptional integrity and selflessness. His professional career, extending over almost fifty years, started during the depression of the thirties. Over the years it included teaching and research in academia; wartime research, development, and administration at the Massachusetts Institute of Technology Radiation Laboratory, and later at Brookhaven National Laboratory; and governmental service to science, first as a commissioner of the Atomic Energy Commission and then as director of the National Science Foundation. The name of Haworth is synonymous with the meticulous care and concern with which he approached the work at hand. His traits of objectivity, attention to detail, and sensitivity to the problems and concerns of others influenced all who worked with him. The organizations in which he played an important part have been left with a Haworth tradition, and they are the better for it.

## THE EARLY YEARS

Leland Haworth was born in Flint, Michigan, on July 11, 1904, though the home of his parents at that time was New

York City. His father, Paul Leland Haworth, was a graduate student and lecturer in history at Columbia University. His mother, Martha Ackerman Haworth, a former teacher, elected to "go home" for the birth of their first child. In 1907 the family moved to Cleveland, Ohio, and in 1910 to West Newton, Indiana. Leland resided in Indiana until 1928, by which time he had received his A.B. and A.M. in physics from Indiana University and had taught for two years in an Indianapolis high school.

Leland Haworth came from a Quaker background, not one with a strong religious bent, but one that stressed integrity, honesty, fairness, hard work, and self-discipline, all personal characteristics that he demonstrated throughout his life. He was strongly influenced by his father, a professional historian whose career was interspersed with teaching, research, writing, and lecturing. Leland was fascinated by history, especially U.S. Civil War history; the family library was a great resource for him. He was proud of his Native American ancestry (through a great-great-grandmother, who was a Cherokee Indian).

The family lived in a farming community near West Newton, Indiana, where Leland's father raised apples and peaches as an avocation and supplement to his somewhat erratic income from writing. A combination of harvesting and marketing fruit in the summer and fall, running trap lines in the winter, and going to school at the same time taught Leland the meaning of hard work and long hours.

His interest in sports developed in high school, and continued through college and beyond. Tennis and baseball were his favorites. He played both varsity tennis and baseball at Indiana University and regretted that, because both were spring sports, he had to choose between them. He was fond of recalling the time that he and an Indiana partner played tennis doubles against Bill Tilden and a partner. He was also proud that he once took one set from Vince Richards. These were the tennis greats of the twenties, and the opportunity to play against them was in itself a thrill. Leland was on the Indiana baseball team that won the University's first Big Ten championship in a major sport. His skill and interest in baseball later carried him into industrial leagues (semi-pros), a source of income he desperately needed ($20–25 per game!).

It was a physics professor who taught sophomores at Indiana University who first interested Haworth in physics. He continued in physics, receiving his A.B. in 1925 and his A.M. in 1926. During his last year at the University, he became engaged to and, in 1927, married Barbara Mottier, the daughter of the chairman of the Botany Department. They had two children, Jane and John.

Haworth wanted to go on to more advanced studies but decided that he must first accumulate some savings; even then he would need a scholarship. He taught for two years in the Indianapolis Arsenal Technical High School, then the second largest high school in the United States. In 1928 he obtained a scholarship at the University of Wisconsin and started on his doctorate there. Although at the time he did not realize it, Wisconsin had one of the foremost physics programs among the midwestern universities from which he had sought assistance.

Haworth received his Ph.D. in 1931. His thesis advisor was Professor Charles Mendenhall, a well-known physicist of that period. The thesis was titled "Secondary Electrons from Very Clean Metal Surfaces when Bombarded with Primary Electrons."

In his last year as a graduate student, Haworth also served as an instructor. Those were difficult times, hard times indeed. When he received his Ph.D., he was eligible for a $200 raise to $2000 a year, the standard salary for an instructor. But there was no money for the raise. Another instructor who earlier had received the raise insisted that his raise be shared so that each got $100. There was a real spirit of camaraderie and sharing in those troubled times. Leland continued at Wisconsin as an instructor until 1937.

Haworth enjoyed teaching, which he liked not only in its own right but also for the coupling with research. His study of electron bombardment of surfaces required painstaking work, and progress was slow. In 1934 some interest developed at Wisconsin in building an accelerator to produce energetic particles. The chairman of the Department asked Haworth to become associated with the project. The most active member of the group was a young graduate student (Ph.D. 1935), Ray Herb, who became an outstanding designer of Van de Graaff accelerators. This was Haworth's first contact with accelerators; it was a turning point in his professional career, marking his switch to nuclear physics. Although there would be interruptions, accelerator development and nuclear physics remained his abiding interests in science.

The job market in physics remained difficult through the late thirties. Haworth recognized that he should move on from Wisconsin, but permanent positions were almost impossible to obtain. In 1937, at the suggestion of one of his Wisconsin professors, he applied for and received a Lalor Fellowship in the Chemistry Department at Massachusetts Institute of Technology. His work there was in low-temperature physical chemistry. That same year in an adjacent laboratory, Samuel Collins developed the hydrogen and helium liquification equipment that has become a world standard. Haworth made many friends during the year at both MIT and Harvard. He remained at MIT for only one year. Two events brought about his departure: his father died, leaving his mother with the orchards in Indiana, and he was offered a faculty position at the University of Illinois, about a hundred miles from his family home.

## THE ILLINOIS YEARS, 1938–1947

Haworth was a member of the University of Illinois Physics Department from 1938 to 1947, although he was in residence for less than four years. During the remaining time (1941–1946) he was on leave, engaged in wartime R&D at the MIT Radiation Laboratory.

In the late thirties the Illinois Physics Department was undergoing a significant rejuvenation. Haworth was one of several new additions, which included John Manley, Robert Serber, Reginald Richardson, Don Kerst, Norman Ramsey, Ernest Lyman, Maurice Goldhaber, and others. They were all hired by Wheeler Loomis, the head of the Physics Department. With John Manley, who came to Illinois a year earlier, Haworth completed a Cockcroft-Walton generator. They used it for important measurements on elements with small cross-sections for thermal neutrons. After Los Alamos got underway, the generator, with associated time-of-flight equipment, was packed up and shipped there "for the duration"—but it never returned.

Haworth and Loomis developed great respect and admiration for each other, and soon after Loomis left for war work at the MIT Radiation Laboratory he asked Haworth to follow him. Haworth admired Loomis's ability as a scientific administrator and felt that he had learned much from him. After his return from the Radiation Laboratory to Illinois, Haworth worked for a while (1946–1947) on magnet design and procurement for the 300-MeV betatron Don Kerst had begun to build. Soon, however, Haworth was called to Brookhaven.

## MIT RADIATION LABORATORY, 1941–1946

The Radiation Laboratory of the Massachusetts Institute of Technology was established under the auspices of the National Defense Research Committee (NDRC) on a crash basis in 1940 to exploit, through rapid development and application, microwave radar made possible by the British invention of the cavity magnetron. In the early forties, the largest pool of recruitable talent resided in university physics departments. The Radiation Laboratory director, L. A. DuBridge (Rochester), and the associate director, Wheeler Loomis (Illinois), with the assistance of other active eminent scientists such as I. I. Rabi (Columbia) and E. O. Lawrence (California), recruited vigorously. Nuclear physicists, especially those experienced in design and use of "fast" electronic circuitry, were in greatest demand. Haworth's involvement with time-of-flight electronics at Illinois made him a prime candidate for recruitment. The Illinois Physics Department, however, had already lost a number of its staff to the war effort, and it was not until late 1941 that a leave of absence could be arranged so that he could join the Radiation Laboratory.

Haworth was immediately involved in the development of the indicator for a lightweight aircraft intercept radar suitable for use by single-seat fighter aircraft. As a consequence of Britian's experience, high priority was placed on the development of defensive systems, such as airborne radar capable of making nighttime intercepts of enemy aircraft. The system was complex, and two modes of operation were required, first "search" and then "shoot down." The display for the pilot had to be informative and simple. Haworth was designer, builder, troubleshooter, industry liaison, and project leader for this component of the airborne interception radar.

He soon (1942) became leader of the Indicator Group; he was thus responsible for indicator development for most of the radar systems. The use of the cathode ray tube (CRT) as an information interface between equipment and man was relatively new. CRT displays in test equipment generally utilized line traces; prewar television was still in an early stage. Much work was needed on the development of the CRT itself, as well as on methods for displaying several parameters simultaneously. This was but one responsibility of Haworth's Indicator Group.

Haworth's leadership and managerial capabilities were further recognized when he was made a division head and member of the Laboratory Steering Committee in 1943, a position he held until the Radiation Laboratory was disbanded in 1946. Division 6, Receiver Components, which he headed, included work on all components concerned with the radar echo. At the war's end it consisted of five groups: receivers; indicators; precision and indicator components; trainers, trainer development, and personnel training; and moving target indicators. The Receiver Division developed and engineered radar components for production and acted as consultants to the armed services, manufacturers, and laboratory systems divisions. Because its components were particularly important for the display and interpretation of radar information, the division necessarily did much tactical thinking to be ready to meet systems or service requests.

The Steering Committee, of which Haworth was a member, was a most important element of the Laboratory's management structure. The setup was uncomplicated and informal. Director L. A. DuBridge received broad technical policies from the NDRC Microwave Committee and was responsible to MIT for proper handling of contracts. Associate director F. W. Loomis handled personnel, and associate director I. I. Rabi forwarded advanced design. Major decisions were made by the Steering Committee, and the members of the committee themselves put these decisions into effect by assigning specific jobs. On paper the organization looked rigid, but in real life it was anything but that. The organization was built around the men available, who, moreover, had much individual freedom.

This was an outstanding training ground for the then forty-year-old Haworth, who was later to become director of Brookhaven National Laboratory, a commissioner of the Atomic Energy Commission, and director of the National Science Foundation. Further, he met and worked with many of the people who would also play important roles in the life of Brookhaven and the work of the government in support of science and national security.

A great heritage left by the Radiation Laboratory was the twenty-seven-volume technical set entitled *Radiation Laboratory Series*. It was an extremely valuable technical contribution, and it rapidly became a necessary reference work for those engaged in further development and use of microwaves and electronics. Haworth was a significant contributor, writing several chapters for the series.

## BROOKHAVEN NATIONAL LABORATORY AND ASSOCIATED UNIVERSITIES, INC., 1947–1961

Haworth joined the newly created Brookhaven National Laboratory (BNL) at Upton, New York, in July 1947 as assistant director for special projects under the first director, P. M. Morse. In that capacity Haworth was responsible for construction of the Laboratory's major research facilities, such as the 30 MW graphite research reactor (BGRR) and the 3-GeV proton accelerator (Cosmotron). A year later, following Morse's return to MIT, he was made acting director of the Laboratory, and in October 1948 was named director, a post he held until 1961. For a decade G. F. Tape was his deputy.

Among the early appointments of the AUI Initiatory Group was Mariette Kuper. She had known Haworth at the Radiation Laboratory and was helpful to him in the transition between directors. She continued as Haworth's trusted assistant throughout his tenure as director.

Associated Universities, Inc. (AUI), with the financial support of the federal government, created BNL, a multidisciplinary research institution. The primary purpose was to provide facilities essential for basic research in the nuclear and related sciences, facilities so large, complex, and costly as to render inadvisable their operation on the campus of a single university. The programs now encompass research in physics, chemistry, engineering and applied sciences, biology, and medicine. The facilities are available to all qualified scientists, including the resident scientific staff, without regard to affiliation. Initially under AEC sponsorship, BNL is now operated under contract with the Department of Energy.

AUI also operates the National Radio Astronomy Observatory (NRAO) under contract with the National Science Foundation. NRAO is headquartered in Charlottesville, Virginia, and has observing sites in West Virginia, New Mexico, and Arizona.

The objectives of AUI in the management of BNL, as originally set forth by Haworth, have changed little. They have been modified slightly over the years to reflect the changes in BNL missions with the transition from Atomic Energy Commission to Department of Energy sponsorship. In brief, in the management of BNL and NRAO, AUI pursues the following objectives:

- to seek new knowledge in scientific and technical fields;
- to emphasize the development, acquisition, and use of large-scale research tools and other specialized equip-

ment and laboratories, whose complexity and cost make them inappropriate for construction and operation by an individual university;

- to assist the government in the solution of problems and the performance of tasks for which the available facilities and personnel are appropriate;
- to promote the use of its facilities by qualified scientists and engineers without regard to affiliation;
- to make available the facilities, laboratories, and staff of its operating institutions for the training of scientists and engineers; and
- to assist in the dissemination of scientific and technical knowledge.

Haworth's directorship was dedicated to these objectives, and under his leadership the Laboratory gained worldwide recognition.

Upon joining Brookhaven, Haworth was immediately immersed in the ongoing design and construction of the Brookhaven Graphite Research Reactor (BGRR) and the planning for a major accelerator for high-energy physics research. In spite of many difficulties associated with the construction of the reactor, it took only three years from groundbreaking to criticality, including one year devoted to correction of a design error. Haworth's attention to detail brought the project around and won the confidence of the sponsoring agency.

The solution to the problem of what kind of accelerator to build at BNL was reached in a cooperative way with the AEC. The physics community recognized the need for two accelerators, one having an energy sufficient to produce antiprotons and a second that could be constructed with less risk and in less time, but with proton energies over 1 GeV. The decision led to the 3 GeV Cosmotron at BNL and the 6 GeV

Bevatron at the Berkeley Radiation Laboratory (now known as the Lawrence Berkeley Laboratory).

The Cosmotron and the Research Reactor provided the foundation for Brookhaven's major research efforts, as well as extensive user programs. During this same formative period, the multidisciplinary aspect of Brookhaven's researches evolved with the development of programs in biology and medicine, as well as in the physical sciences and engineering. The legislated mandate of the Atomic Energy Commission, that it should promote the use of atomic energy, and the promise of new techniques using radioisotopes and radiations in the life sciences were rapidly exploited at BNL and other national laboratories.

Haworth welcomed the opportunity to speak annually to the staff on the state of the Laboratory. The time chosen for his presentation was usually toward the end of the calendar year. Two of these occasions were memorable. At the end of 1954, he reviewed the progress of the Laboratory, pointing out the growth that had occurred in the early fifties. He listed the various research facilities, emphasizing the vigorous research programs involving the reactor and the Cosmotron, and stated that the next years would be ones of exploitation of the Laboratory's capabilities. But at the conclusion of his talk, he announced AEC authorization for the Laboratory to proceed with the design and construction of a 30 GeV alternating gradient accelerator, which was to become the AGS. Much work had, of course, preceded the AEC decision, but the early favorable action on the famous five-page proposal by Haworth was indeed a welcome surprise and an expression of confidence in Brookhaven and its director.

Much has been written on the history of the alternating gradient-strong focusing principle. For our purposes, it is enough to recount that all of the elements that made possible its formulation were present at Brookhaven in the summer of 1952. As soon as the Cosmotron became operational, people began to think about higher energy machines. The Europeans were contemplating a Cosmotron-like machine of perhaps 10 GeV, and they sent a team to Brookhaven to discuss possibilities. Dr. M. S. Livingston, then at MIT, returned to BNL for the summer. From questions, discussion, and analysis, E. D. Courant, M. S. Livingston, and H. S. Snyder set forth the new strong-focusing principle that would permit even higher energy machines to be constructed at reasonable cost. Later it was found that N. Christofilos, an American citizen residing in Greece, had independently discovered the same principle. Christofilos later joined BNL and became a member of the team that designed the AGS. The alternating gradient principle has had a major impact on the design and cost of accelerators; its application has been extended by Blewett to linear accelerators, and later to beam transport in general.

At BNL an atmosphere for national and international cooperation existed, which was unique at the time. It continued with Haworth's encouraging support of the CERN 28-GeV Proton Synchrotron (PS) and the exchange of personnel, design information, and experience. Haworth worked extraordinarily hard to permit uncleared and alien visitors to work at BNL, and he arranged for the declassification of the classified part of the BGRR. Thus, he was responsible for a significant opening of U.S. science after World War II, which led to the friendly competition that has been healthy for both the United States and Europe.

With the authorization of the Alternating Gradient Synchrotron, a second generation of major research facilities was initiated at Brookhaven. The air-cooled BGRR had been upgraded in flux to $2 \times 10^{13}$ neutrons/cm$^2$-sec when highly enriched uranium became available for fuel in 1957. Although the BGRR was a major radioisotope producer, its real specialty was the provision of external neutron beams; nevertheless, the flux was still lower than that needed for more advanced studies involving neutron interactions. In 1959, construction of a high flux beam reactor (HFBR) was initiated. This reactor is moderated and cooled by heavy water and generates a number of high intensity ($7 \times 10^{14}$ thermal and $10^{15}$ epithermal neutrons/$cm^2$-sec) beams. Thus, during his tenure as director, Haworth provided for advanced research facilities that continue today as major elements of the national program for support of basic research.

Accelerators and reactors were not his only interest, although they brought about the greatest user participation. Other Brookhaven facilities included, for example, the 60" cyclotron, the 3-MeV electrostatic accelerator, the medical research reactor, and the high intensity radiation laboratory.

The advanced facilities and excellent resident staff under Haworth's leadership attracted many outstanding visitors. The ultimate objective was program excellence involving the wider scientific community of users. The active participation of scientists and engineers with different backgrounds, experience, and points of view was encouraged. Haworth saw this as a necessary ingredient in national laboratory programs, especially those emphasizing forefront research. Brookhaven became known as the model for user participation in research. As national research facilities became more concentrated in centers, the BNL pattern was followed not only in AEC national laboratories but also in NSF centers.

Although Haworth devoted himself primarily to BNL, he made time available to assist with national problems, especially in defense. Among the projects on which he served were the Vista Project, Department of Defense, 1951; East River Project, Department of Defense, 1952; Ad Hoc Committee on Combat Developments (chairman), Army, 1954;

Technological Capabilities Panel, President's Science Advisory Committee, 1954–55; Project Atlantis (head), Navy, 1959. Also, his strong interest and leadership role in accelerator development placed him on the Inter-Agency Advisory Panel on High Energy Accelerators, 1952–1961 (chairman, 1954–1961), and the Joint (GAC-PSAC) Panel on High Energy Accelerator Physics, 1958–1961.

Two personal events of tragic proportions affected Haworth in the late fifties and early sixties. In the fall of 1959 he was advised that he had a malignancy of the colon; he immediately underwent extensive surgery. He was determined to return full time to his Brookhaven and AUI duties. He postponed the normal year-end state of the Laboratory talk so that he could deliver it personally. It was the second of the most memorable annual events when he did so in January 1960, demonstrating that he had no intention of giving in to a health problem that might have caused many others to do so. A year later, in February 1961, his wife Barbara, who had been in poor health for many years, died. For Leland, a devoted family man, it was a low point in his life.

In November 1960, the president of AUI, Lloyd V. Berkner, resigned, and Haworth was named to succeed him. Haworth insisted that he was only filling in and had no desire to leave the directorship of BNL. As president, he was also responsible for NRAO matters, and at that time he was faced with a difficult engineering problem for the 140 ft radio telescope under construction at Green Bank, West Virginia. The issue was the effect of brittle fracture on long-term structural integrity. In his usual fashion, he marshalled competent technical resources and convinced the NSF that, with certain modifications, the project was salvageable and should go forward. Haworth was not able to see the project through to its successful completion; in response to a request from President Kennedy, he resigned on April 1, 1961, to become a commissioner of the Atomic Energy Commission.

Leland Haworth inspired confidence and loyalty in his associates, an invaluable asset. His leadership and management of the Laboratory created respect for Brookhaven in Washington. He forged close links between university researchers and the Laboratory, providing an example much imitated the world over. He is credited with being the man who brought the "big machines" to Brookhaven and with building a fledgling Laboratory into a world-renowned center for research, especially in high energy physics.

## ATOMIC ENERGY COMMISSION, 1961–1963

President Kennedy's first two appointments to the Atomic Energy Commission in 1961 were Chairman Glenn T. Seaborg and Leland J. Haworth. They joined the Commission at an exciting and challenging time: the U.S. and U.S.S.R. were in a period of voluntary suspension of nuclear weapons testing; civil nuclear power development was moving toward larger, but not yet economical, power plants; several nuclear reactor concepts were being developed and tested; the first two nuclear-powered fighting surface ships were commissioned by the Navy and the nuclear-powered merchant ship was being fueled; the first radioisotopic electric generators were being used in space programs; and the first high-energy physics facility costing more than $100 million, the Stanford Linear Accelerator, was before Congress for approval.

Haworth's intense interest in basic research, in the tools of big science, accelerators and reactors, and in national security rapidly immersed him in the major issues confronting the AEC. He worked endless hours, in part because of his dedication to the job and in part to fill the void caused by the loss of his wife only a few months earlier. By the end of his tenure as commissioner, he had "specialized," as was the informal practice of the commissioners; he had prime responsibility for the nuclear weapons program, the technical aspects of arms control and disarmament, R&D planning for nuclear power, and basic research generally. This was in no way carried out to the exclusion of other aspects of the AEC program requiring Commission guidance and approval.

When the U.S.S.R. broke the moratorium on testing in the atmosphere and the U.S., after almost three years of suspension, resumed testing in September 1961, Haworth became heavily involved with environmental issues associated with weapons testing. The test program included both underground and atmospheric detonations, the latter involving some very high-yield devices. The question of effects in the upper atmosphere was a major one, and Haworth pulled together the resources and talent necessary to study the possible consequences of such tests.

Haworth also went to Alaska to study the possibility of digging a harbor there (Project Chariot) as part of Project Plowshare. In a letter to his former secretary at Brookhaven, Anna Kissel, he wrote (July 30, 1961): "We spent yesterday in two Eskimo villages—at Point Hope and at Kivalina to the south—explaining the project to them and trying to calm their worries. There are careful biological and other studies going on to determine any possible effects. Unless it is shown to be quite safe it will never be carried out." Project Chariot was soon abandoned.

Haworth was a firm believer in an adequate national defense. At the same time, he was very conscious of the dangers of a nuclear arms race and the advantages of reasoned arms control. He was one of the first to recognize that a restriction on conducting nuclear tests in the atmosphere or in the oceans could be adequately monitored unilaterally by national means, whereas the verification of underground tests would be most difficult, especially at lower yields.

The concept of a monitored ban on atmospheric testing was not only technically sound, but also politically acceptable. For those who were opposed to a comprehensive test ban, some testing was still possible. For those who were strongly oriented toward arms control, a significant step was taken toward a reduction in what had been major test activities. This approach did not require intrusion by one nation into another nation's territory; it was, in a way, self-policing. It had the further beneficial effect of eliminating atmospheric pollution from nuclear testing, a health concern of many. This pragmatic approach of achieving the possible led to the execution and ultimate ratification of the Limited Test Ban Treaty in the summer and fall of 1963.

In March 1962, President Kennedy requested the AEC to "take a new and hard look at the role of nuclear power in our economy" and to submit a report. The Commission asked Haworth to take major responsibility for the preparation of the report. The resulting document, *Civilian Nuclear Power—A Report to the President—1962*, was typical of Haworth—factual, logical, concise, and evenhanded. Previously the general approach had been to look at the future role of nuclear power only in the light of economic competitiveness. Haworth introduced other factors including conservation of resources, a concept that was far ahead of its time. Haworth's logic was that, while economics is important, the government was not investing in nuclear R&D just to provide a cheaper source of electrical energy. The marketplace is where the economics would be demonstrated. His argument centered on the development of an additional energy source, one that, it was hoped, would find its ultimate market position through competition.

The following is an excerpt from the *Report*'s summary:

> Our technological society requires ample sources of energy. Although large, the supplies of fossil fuels are not unlimited and, furthermore, these materials are especially valuable for many specific purposes such as transportation, small isolated heat and power installations, and as sources of industrial chemicals. Reasonable amounts should be preserved for future generations.

The *Report* was well received. It proposed orderly, continuing development of the civilian nuclear power program; it recognized the need for utilization of all of the nation's energy resources. The time was still one of low-cost oil; fossil and nuclear resources were the only near-term options. The *Report* stimulated a request by the Congress to the government for development of R&D priorities for all potential energy resources. That study was done under the auspices of the White House Office of Science and Technology, because it cut across many agency lines. Haworth was a member of the Steering Committee.

Haworth was pleased with his work on the AEC *Report* and the influence it had on government policies and plans for energy R&D. He considered the preparation of that report and his efforts to provide a rational basis for the Limited Test Ban as his two most important contributions during his twenty-seven months as a member of the Atomic Energy Commission.

Haworth's advice and counsel were widely sought by the AEC staff. He was heavily involved in the national defense programs and basic research activities. He was active in resolving issues that would permit the Stanford Linear Accelerator construction to move forward. He was interested in applications, that is, the use of radioisotopes as energy sources and in research; the Plowshare Program, the civil use of nuclear explosives; private development of nuclear power for electrical generation; and others. If anything, he was overcommitted, but he found it challenging and rewarding.

In the spring of 1963, it was suggested that he become director of the National Science Foundation. It was at a time when the concept of a limited test ban had not been fully accepted, and he was reluctant to leave the AEC. Further, AEC was a big science agency and its science was his kind of science. He finally concluded that the decision was not to be his alone, however; it was a major one in which the president had to decide where he, Leland Haworth, could best serve the nation. As later reported, President Kennedy told Haworth that the AEC had five commissioners, while the NSF had only one director. The president preferred to have Haworth as the NSF director.

To digress from the professional to the personal, Haworth's work with the AEC caused him to interact frequently with the president's science advisor, J. B. Wiesner, with the president's Science Advisory Committee, and with others involved with OST activities. As a consequence, he was a frequent visitor to that office and became well acquainted with the advisor's secretary, Miss Irene Benik. There developed a mutual interest that led to an important turning point in Leland's life. He and Irene were married in May 1963, and this was the beginning of a deep companionship and a most successful marriage, which was to last until the end of his life.

## NATIONAL SCIENCE FOUNDATION, 1963–1969

Haworth became director of the National Science Foundation on July 1, 1963, following Dr. Allen T. Waterman, its first director. Haworth was generally acquainted with NSF programs through his contacts with the Washington scientific community and his earlier AUI work in the fields of physics and astronomy. Nevertheless, he recognized that he had a lot to learn, and he quickly responded to the challenges of the job.

Through the years Haworth had sought advice from others; he preferred to talk through problems, issues, and new ideas before making his decisions. At NSF the individual he turned to most often was Philip Handler, then the chairman of the Science Board, whose wise counsel was highly valued.

One of Haworth's first problems was Project Mohole, the deep ocean drilling program. His own experience helped him to bring the project around to a point where it became technically sound, with a management structure in place capable of carrying the project forward. Congressional support diminished, however, and the project was abandoned.

During his tenure as director, the Foundation's program flourished. This was accomplished in the face of an initial no-growth budget imposed by the Congress and several years of fiscal constraints, such as superimposed expenditure ceilings. Eventually, however, the NSF budget increased by more than 30 percent during a period of essentially zero inflation.

A number of programmatic changes took place. Haworth showed a serious and studious concern for imbalance in geographic and institutional distribution of federal research funds. While maintaining that NSF should uphold standards of high quality, which of course led to charges of "inequity," he nevertheless sought to increase the number of excellent universities in regions that lagged behind the Northeast and the West Coast. The Foundation's science development programs, in particular, showed this emphasis. With the backing of President Johnson, broad support was provided to the more promising institutions so that certain aspects of their science programs could expand and mature, thereby creating a national network of university centers of scientific excellence.

NSF's activities in "big science," as shown in national research centers and national research programs, grew substantially during Haworth's administration. There were great advances in optical and radio astronomy. The Very Large Array (VLA) was planned during this period; negotiations were conducted leading to joint funding by the NSF and the Ford Foundation of the large telescope at Cerro Tololo in Chile; and international research programs were carried forward (International Quiet Year of the Sun, International Biological Program, Global Atmospheric Research Program, Deep Sea Drilling).

Haworth pioneered NSF efforts to link fundamental science to applied science and technology. NSF's entry into fields of applied science and engineering was not without debate, and Haworth recognized it as an experiment—too little NSF support of applied science could prevent the country from reaping the benefits of the interactions with NSF's programs in fundamental science; too much could make NSF too programmatic and too project oriented, to the detriment of its support of basic sciences. Balance was essential. His concern was conveyed to the appropriate congressional committee, and the authorizing legislation endorsed the move toward NSF support of applied science, but included fairly restrictive limitations.

During this time Congressman Daddario was shepherding a major NSF reorganization bill through the Congress. Among other things, it increased the number of senior positions within the NSF that would fall within the category of "presidential appointees." Haworth had participated in drafting the organizational changes. He recognized both the hazards of making additional senior positions in the Foundation "political" and the advantages of giving them greater stature. Because of the long uncertainty as to when the new organization would go into effect, and a presidential election resulting in a change of administrations, staffing of the new arrangement of assistant directors had to be left to his successor.

## THE LATER YEARS, 1969–1979

Haworth returned to his former home on Long Island, New York, in July 1969, following the completion of his six-year term as director of the National Science Foundation. He rejoined Associated Universities, Inc., serving as special assistant to the AUI president and as special consultant to the director of Brookhaven National Laboratory. He was truly an elder statesman; his wise counsel was of great value to the AUI trustees and officers and to the BNL director and staff.

His actions transcended those of a generalist; on several occasions he undertook project responsibility. When NSF wanted an external engineering review of the proposed resurfacing of the Arecibo radio telescope, Haworth pulled together a team of consultants connected with the AUI organization to carry out the assignment, quickly and expertly.

In 1970 it became clear that an analysis of energy demand and supply that would involve all energy resources and end-uses was essential for national R&D planning. A grand strategy was not desired at that time, but a start was needed at overall planning that would involve resources, conversion, distribution, end-uses, and, eventually, economic and environmental factors. Discussions by David Freeman of OSTP with AUI and MIT led to a small contract with AUI for the "Assessment of Energy Technologies." MIT's involvement was provided through an AUI subcontract. The project was headed by Haworth, with the MIT work headed by Dr. David White and the BNL work handled principally by Drs. Kenneth Hoffman, Philip Palmedo, and Warren Winsche. This pioneering effort gave rise to what later became a major element of planning—energy systems analysis. This work helped to bring together the diverse governmental agency interests, which more recently have been coordinated through reorganizations resulting first in the Energy Research and Development Administration (ERDA) and then the Department of Energy (DOE).

Although Haworth's AUI appointment was part time, he gave, as always, whatever time was necessary to get a job done. In 1976, at age seventy-two, his status changed to that of general consultant, but he still appeared in his Brookhaven office almost daily.

During this same period, Haworth was engaged in activities other than those for AUI. A significant one was membership on the Board of Directors of Oak Ridge Associated Universities, Inc. He had served as a director from 1959 to 1961, and he was delighted to rejoin the Board in 1971. In 1978 he was elected director emeritus—the first time a director had been so honored by ORAU.

At the time of Haworth's death, ten years after leaving NSF, Drs. Norman Hackerman, chairman of the National Science Board, and Richard Atkinson, director of the National Science Foundation, wrote:

> The Nation owes a deep debt to Leland Haworth. . . . Gifted with the capacity of coordinating the aspirations of individual scientists and engineers in their pursuit of excellence and their search for new knowledge, Dr. Haworth through his attention to detail provided the opportunity for them to reach those goals. Possessed of a deep sensitivity to people, he unified those members of the scientific community and the political arena who shared the responsibility of advancing the nation's science.

## HONORS AND DISTINCTIONS

### HONORARY DEGREES

| | |
|---|---|
| D.Sc. | Indiana University, 1961 |
| D.Sc. | Bucknell University, 1961 |
| Engring.D. | Stevens Institute of Technology, 1961 |
| D.Sc. | University of Wisconsin, 1962 |
| D.C.L. | Union College, 1964 |
| LL.D. | Rider College, 1964 |
| D.Sc. | Columbia University, 1965 |
| D.Sc. | University of Illinois, 1965 |
| LL.D. | Delaware State College, 1965 |
| LL.D. | Long Island University, 1965 |

### AWARDS

Certificate of Merit from President Harry S Truman, granted for work during World War II.

Personal Letter of Gratitude from President Dwight D. Eisenhower, for work done on a defense project in 1954 and 1955.

A mesa in the Antarctic and an asteroid have been named for Haworth.

### ORGANIZATIONS AND OTHER HONORS

American Physical Society (Fellow)

American Association for the Advancement of Science (Fellow)

New York Academy of Sciences (Fellow)

American Nuclear Society (Fellow, President 1957–1958, Director 1955–1960)

American Academy of Arts and Sciences (Fellow)

American Philosophical Society, 1965

National Academy of Sciences, 1965

As a member of the National Academy of Sciences, he served on a number of important committees, including COSPUP (Committee on Science and Public Policy).

Board of Directors, Oak Ridge Institute of Nuclear Studies, 1959–1961

Board of Directors, Oak Ridge Associated Universities, 1971–1978; Director Emeritus, 1978

Phi Beta Kappa
Sigma Xi
Gamma Alpha
Lambda Chi Alpha
Cosmos Club, Washington, D.C.

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1951

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1955

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1956

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With C. F. Dunbar and J. B. H. Kuper. Stimulating the development of basic research: The establishment and operation of Brookhaven National Laboratory. In: *Systems for Stimulating the Development of Fundamental Research* (National Research Council, National Academy of Sciences; prepared for the National Science Foundation), pp. VII-1–VII-146. Washington, D.C.: National Science Foundation.