WALTER C. MARSHALL

1932–1996

Elected in 1979

"Contributions to the technology and direction of nuclear energy programs and to the transfer of the technology to industry."

BY DAVID FISHLOCK AND L.E.J. ROBERTS
SUBMITTED BY THE NAE HOME SECRETARY

WALTER CHARLES MARSHALL died February 20, 1996, at age 63 in London. He was recognized by the scientific community at an early age as one of the outstanding theoretical physicists of his generation. But he is more likely to be remembered for his distinguished career in public service, which led to a knighthood in 1981 and a life peerage in 1985, and for his forthright public advocacy of nuclear power.

Early Years: Pure and Then Applied Scientist

Walter Marshall was born March 5, 1932, in Rumney, near Cardiff, the youngest child of three. In later years, he delighted to recall that he had insisted on "doing sums" on his first day in primary school. His mathematical promise was recognized by his mathematics teacher, Mr. Wustenholme, in grammar school, St. Illtyd's College in Cardiff. He also developed a serious interest in chess at the age of 11 and became the Welsh Junior Chess Champion at 15.

He left school with a major county scholarship in 1949 to study mathematical physics at the University of Birmingham,

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where, after taking his first degree, he remained to write a thesis on "Antiferromagnetism and Neutron Scattering from Ferromagnets," for which he was awarded a PhD at the early age of 22. He acknowledged that the guidance of his supervisor, Sir Rudolf E. Peierls, FRS, was the major influence on his career.

Marshall was recruited to the Theoretical Physics Division at AERE Harwell in 1954. His first assignment was to the Plasma Physics Group, where his research on the difficult problems posed by shock waves in magnetically confined plasma discharges confirmed his powers as a theoretician. But he soon returned to his initial interest in condensed matter physics.

His abilities as an inspirational manager and natural leader who "made things happen" had emerged early in his career. At 30 he spent a sabbatical year at the Oak Ridge National Laboratory in Tennessee. The director, Alvin Weinberg, was later to reflect, "I think if Walter had stayed any longer, he would have taken over this laboratory."

At Harwell, Marshall became leader of the Solid State Theory Group and, in 1960 at the age of 28, head of the Theoretical Physics Division. Under his leadership, the division attracted a large number of visiting scientists, particularly from the United States. His intellectual strengths and forceful personality also made him a prominent participant at international conferences.

His principal contributions to the theory of the solid state related to magnetic properties, ranging from the very mathematical (the statistical mechanics of magnetic phase transitions and in particular their critical properties) to more phenomenological treatments of the molecular orbitals in magnetic salts and the theory of magnetism in transition metals (particularly in alloys). He became convinced of the value of the applications of neutron scattering. Here again, his main interest was in magnetic substances, where he encouraged experiments on inelastic scattering from spin waves, on the magnetic structure factors around impurities, and many others, including an early interest in the Mossbauer effect.

His main impact arose from his interactions with experimentalists and in programs to test and expand the theoretical understanding of real materials. His outstanding abilities as a manager of research later transferred successfully to the commercial sector.

By 1969 he had published over 60 papers, with many collaborators, and lectured extensively and lucidly on the applications of neutron scattering. His book *The Theory of Thermal Neutron Scattering* (with Stephen Lovesey; Oxford Clarendon Press, 1971) remained the definitive text on the subject for 20 years.

His 1964 Kelvin Lecture, "The Study of Solids and Liquids Using Thermal Neutrons," showed his characteristic delight in explaining scientific concepts to a nonspecialist audience. That year he also became a fellow of the Institute of Physics as well as the second recipient of its Maxwell Medal for outstanding contributions to theoretical physics. He was elected to the Royal Society in 1971—the youngest fellow at the time—and in 1973 was made a Commander of the British Empire (CBE). In 1977 he was elected a foreign associate of the US National Academy of Engineering and in 1979 a fellow of the Royal Swedish Academy of Engineering Sciences.

He worked on problems in superconductivity and magnetism as mental relaxation, during periods of leave in the United States, at home, and in airport lounges and other unlikely places. He recorded it all in his neat handwriting in a number of notebooks.

Diversification and Industrial Research

The success and international reputation of Harwell's Theoretical Physics Division under Marshall's leadership confirmed his ability to lead scientific programs and to motivate others. This led to a significant switch in his career, from pure science to the administration of applied science and technology, with his promotion to deputy director of AERE Harwell in 1966 and to director in 1968.

The 1960s were a time of profound change in the Harwell Laboratory. Many of the urgent scientific objectives that had led to its establishment in 1946 had been met, and much of the pioneering nuclear work was moving to other nuclear establishments and enterprises. Less than 20 years after it was founded, Harwell had to find a major new additional mission or face considerable reduction. The chance to expand its program beyond the terms allowed under the 1954 Atomic Energy Act was provided, in principle, by the Science and Technology Act of 1965. But the first new proposals in which Marshall was involved followed from his own research interests—to establish at Harwell a high magnetic field laboratory (HMFL) and a high flux neutron beam reactor (HFBR).

He saw these proposals as an opportunity for further collaboration with university laboratories, which would establish Harwell as a national center for materials research. But the Ministry of Technology could provide funds only for research aimed at industrial development and was not convinced that industrial applications of neutron beam research would arise for many years.

Marshall was undoubtedly disappointed but he accepted the general position that a laboratory spending much public money had to be seen as contributing to the national welfare at a time when the UK economy was perceived to be falling behind that of other industrialized nations. So he directed his formidable energies toward transforming Harwell into a laboratory aimed at improving industrial performance generally and meeting defined government needs.

He realized that this amounted to a revolutionary shift in the objectives of many of the scientists at Harwell, and that it would involve administrative as well as technical changes. Harwell seemed too expensive, lacking in commercial expertise and organization, and unused to marketing its research. Furthermore, there was little external support for the idea.

There were also strengths to exploit, however. Close involvement with the technology of nuclear power had accustomed many at Harwell to the need to meet technological problems on a tight timescale. This "applied nuclear" work was expanded and given sharper objectives, transformed from "missionary" to "mission-oriented" work and pursued with industrial partners. The expertise of the laboratory was much broader. Nuclear energy technology had demanded development at the cutting edge of many disciplines—in metallurgy, ceramics, heat transfer, nondestructive testing, and atmospheric pollution, for example.

Marshall saw that the most pressing need was to establish good communications with a large number of potential industrial customers, and he put this responsibility on the project leaders themselves, insisting that the ultimate criterion of success would be financial. This forced Harwell scientists to acquire firsthand knowledge of industry and liberated unsuspected entrepreneurial talents in many of them. Industrial opposition fell away as more firms became involved.

The industrial program grew rapidly after 1967: by 1973 it accounted for 39 percent of the Harwell program, and 51 percent by 1976. The income was about equally from industry and government agencies. Diversification gave the laboratory a new lease on life and excited considerable national and international interest, 'though Marshall was always careful to say that the precise structure at Harwell arose from the circumstances and strengths of that laboratory and might not be applicable generally. His "outstanding contribution to the organization, utilization and application of science" was recognized with the Glazebrook Medal of the Institute of Physics in 1975.

In a retrospective lecture at the US National Academy of Sciences, Marshall claimed that the Harwell experience had proved that a multidisciplinary national laboratory was "an asset which should fully interact with the life of a country to help solve its most serious problems." But it was important to consider the proper mission of such a laboratory at regular intervals to anticipate the need for change.

Marshall could claim by the early 1970s that the discipline of having to earn money had improved the general morale of the laboratory. In a well-deserved tribute the headquarters of the reorganized UK Atomic Energy Authority (UKAEA) at Harwell was named the Marshall Building.

Energy Policy and Nuclear Power

Marshall became head of the UKAEA Research Group in 1969, responsible for the Culham and Harwell laboratories. During the 1970s he grew increasingly concerned with questions of energy policy and by 1980 was well known as an enthusiastic advocate of nuclear power. He was appointed to the UKAEA board in 1972 and became deputy chair in 1975 and chair in 1981.

He shared the optimism about the future of nuclear power that was current in the UKAEA at that time. Nuclear power was expected to provide a major part of the electricity generated in the UK by the end of the century, with substantial input from fast reactors. Fusion was seen as a bright hope for the longer term.

Marshall took part in reviews of the prospects for fusion during the 1970s and in the negotiations that ended with the siting of the Joint European Torus at Culham. He was convinced that "the incredibly complex technical problems associated with fusion are capable of solution on a reasonable timescale," but remained doubtful that fusion reactors would be economical.[1]

In 1974 he was appointed chief scientist at the newly established UK Department of Energy on a part-time basis. He chaired the Advisory Committee on the Energy Industries and the new Offshore Energy Technology Board, and organized a series of exercises designed to rank energy technologies against scenarios of supply projections and fuel mix. He inaugurated the Energy Technology Support Unit at Harwell to encourage energy conservation in industry and to evaluate the potential of "renewable" sources of energy.

He also chaired a study group looking at the potential role of combined heat and power (CHP) linked to district heating schemes in the UK, following the example of proven CHP schemes in several European countries. The study was organized because energy efficiency and conservation were seen as key objectives in the aftermath of the oil shocks of the early 1970s. The study group's report in 1979 concluded that there was no immediate economic argument for CHP and district

[1] Marshall WC. 1973. Prospects for fusion research in Britain. *Nature* 243:384–388.

heating in the UK, but that there would be opportunities for CHP in the longer term if gas prices increased substantially. (In the event, gas remains cheap and supplies are perceived to be secure.)

In 1977 Marshall was abruptly asked to return to full-time duties with the UKAEA, although he continued to chair the CHP group. He considered a growing nuclear component with a strong industrial base essential for a stable UK energy policy. He got involved in the debate about thermal reactor choice—whether the next round of civil stations should be pressurized water reactors (PWRs), steam-generating heavy water reactors, or more advanced gas-cooled reactors (AGRs)—and became convinced that the right choice would be PWRs. He had been impressed by the amount of PWR fabrication that could be accomplished in a factory rather than on-site during one of his visits to US Westinghouse facilities, and he thought the UK nuclear industry would do better in foreign markets if it too were building the most popular reactor in the world.

He was invited to set up a study group to review the integrity of PWR pressure vessels and determine the mathematical probability of vessel failure and the factors affecting that probability. He saw that this concern could be addressed only by a rigorous analysis of all relevant features of design, fabrication, fracture analysis, nondestructive test analysis, and quality assurance. The probabilities of failure under operational fault and emergency conditions were estimated by taking into account the probable distribution of crack sizes in vessels entering service, the distribution of materials properties, and possible crack growth rates in service. A report, *An Assessment of the Integrity of PWR Pressure Vessels*, underwent extensive external review and was published in 1976.

In 1982 a follow-up report (of the same title, *Second Report*), provided 57 "essential" recommendations and 26 topics that should be pursued to improve understanding. The UK government's chief scientific advisor, Sir Alan Cottrell, accepted the conclusion that a PWR pressure vessel subject to all these conditions would have high integrity and reliability in service and welcomed particularly the report's emphasis on the need for rigorous ultrasonic inspection backed by independent validation of the techniques used.

Marshall also participated vigorously in 1970s debates about the safety of the nuclear fuel cycle. The debates were prompted by worries about the safety of fast reactors and the dangers of plutonium theft or diversion if it became a common article of nuclear trade. But broader questions of the future need for nuclear power and for fast reactors as a means of extending uranium supplies were also raised. Most significantly, official opinion in the United States turned against reprocessing nuclear fuel and even against the worldwide growth of nuclear power. President Jimmy Carter postponed indefinitely the reprocessing of civilian spent fuel in 1977 and deferred the development of fast reactors. He launched the International Nuclear Fuel Cycle Evaluation Exercise (INFCE) to assess and reduce the danger of the proliferation of nuclear weapons arising from civilian nuclear power installations. Marshall became involved as cochair of INFCE Working Group 4, dealing with reprocessing, plutonium handling, and recycling.

Marshall was convinced that a larger nuclear power program was essential ("a moral imperative") to meet the energy requirements of an expanding world population and that a gradual change to fast reactors and an efficient, closed fuel cycle would therefore be necessary. He thought the fears expressed about fast reactors were exaggerated. He saw fast reactors as a means of controlling the total stocks of plutonium in the world, since they could be designed to consume plutonium or to "breed" plutonium slowly, but never to produce as much plutonium as thermal reactors for the same energy output. He disliked the regime of storing spent fuel indefinitely, as advocated by the United States, fearing that the stores could become plutonium sources of increasing accessibility and thus a target for diversion or theft.

Marshall envisioned an international regime of interdependence in which a few countries with large enough numbers of thermal reactors would set up reprocessing plants and use the separated plutonium to fuel fast reactors. Much depended on the political leadership of the United States, and Marshall gave several lectures there to explain his views.

The INFCE ended without making any universal policy recommendations, 'though the need for international cooperation in strengthening safeguards against proliferation was emphasized. It was seen as a satisfactory result for the United Kingdom. Marshall was thanked for his contribution by the UK Department of Energy.

Years of Technical Management

Marshall's life changed dramatically when, in 1983, energy secretary Nigel Lawson summoned him: "The prime minister and I have decided that in the national interest you should be the next chairman of the CEGB [Central Electricity Generating Board]."

The challenges were to get nuclear power relaunched and to reorganize a business whose generating capacity had changed dramatically since it was unified in the 1940s. An inventory of 278 power stations had shrunk to 70. Lawson explained privately that Marshall was seen by the government as "Mr. Nuclear." It was the start of some of the happiest years of Marshall's life.

In 1981 Britain's nuclear design and construction industry was in disarray, as was evident in attempts to get ready for public inquiry a design for a "British PWR." As the new UKAEA chair Marshall was asked to lead a task force to sort out an agreed design. After 18 months the task force settled the design for Sizewell B, seen as Britain's lead PWR station.

Marshall demonstrated that he could lead a divided and quarrelsome industry. But in so doing he inevitably made himself the target of groups opposed to nuclear energy. He met criticism with a disconcerting mixture of jolly good humor and abrupt dismissal. When a group called the Scottish Committee for Resisting the Atomic Menace (SCRAM) published a postcard featuring a sketch of a PWR with Marshall's features drawn on the containment dome, he considered it good fun and ordered a batch. But in public debate, when opponents abandoned logic or dismissed his science, he could lose patience.

While he was leading the PWR task force there was a turning point in UK relations with the US nuclear industry. The earlier disarray had convinced the industry that Britain was not serious about adopting the PWR. Marshall invited two senior engineers from Westinghouse and Bechtel to audit progress by his task force, especially in accommodating British safety requirements. He also promised his guests a meeting with the energy secretary, but the visit coincided with rumors of a cabinet reshuffle involving the energy secretary. The US engineers found themselves at 10 Downing Street meeting not only the new energy secretary but also the prime minister, Margaret Thatcher, who began by stating that she understood the critical issue was detecting cracks only an inch long in the pressure vessel. Finally, the Americans were convinced that Britain was serious about the PWR.

In 1985 Marshall was selected by the American Nuclear Society and Nuclear Energy Institute to receive their Henry DeWolf Smyth Nuclear Statesman Award, recognizing outstanding and statesmanlike contributions to nuclear energy activities. In 1985 he was elevated to Lord Marshall of Goring, the town on the Thames where he lived for most of his career.

He had a flair for public relations. Shortly after he became CEGB chair, antinuclear critics charged that the spent-fuel shipping casks in use would not survive a serious transportation accident. Marshall agreed to a dramatic public demonstration of the casks' integrity. An empty cask was placed on a railway siding and a locomotive driven into it at full speed. The event was well attended and accompanied by a racecourse-style commentary. The cask bounced up in the air and came down intact. The locomotive did not fare so well. The event generated enormous publicity and was a remarkably successful public relations exercise.

In 1986 the headmaster of Westminster School, close to the Palace of Westminster in London, invited Marshall to talk to his pupils. Marshall saw it as an opportunity to put the perceived hazards of radioactive waste into better perspective. His address became known as "the garden lecture" and he went on to deliver it throughout Britain. It involved bringing samples of nuclear waste, suitably contained, into the hall, within a few meters of his audience, and using a very audible signal from a Geiger counter to dramatize their presence. An enthusiastic gardener himself, he showed that a garden always contains substantial quantities of radioactive materials. Marshall's consummate skill at putting across complex technical matters in simple terms, and often with wit and humor, was greatly appreciated at all levels, from the schoolchildren who received his first garden lecture to the prime minister.

In 1981, as UKAEA chair (before he joined the CEGB), he set down his thoughts on management for his senior executives. His experience at senior level had been in high technology and in areas where there was a high degree of public accountability, he said. He was convinced that the most senior people in an organization must strive constantly to ensure that they had enough time to think about problems beyond that day and week. It was also important for management to avoid anonymity—big organizations so easily became remote and impersonal. Marshall's boundless enthusiasm and energy left no one in doubt that it was natural for him to avoid anonymity, and that this forceful personality revelled in being seen as the leader.

The Chernobyl Explosion

On April 27, 1986, a Soviet-designed RBMK reactor exploded at Chernobyl in the Ukraine, releasing radioactivity that spread worldwide. Speaking to nuclear industry executives and MPs on May 1, Marshall said the reactor had unsatisfactory safety characteristics, which ensured that the design could never be licensed in Britain. He called it a unique design with no counterpart in the West. But by the end of May, he acknowledged that the accident had badly shaken public confidence in nuclear power.

He led the British delegation to the special conference convened by the International Atomic Energy Agency in Vienna in August 1986, when the Soviet government presented its analysis of the accident. In a dramatic presentation, which included color film of the burning reactor core, Valery Legasov, leading the large Soviet delegation, spoke of a "tremendous psychological mistake on the part of the designers of this reactor" and admitted several crucial design weaknesses. Legasov sought help from the West, and Marshall played a leading role in helping the Soviet government modify its RBMKs and its operating practices to ensure that such an accident could not happen again.

In January 1987 the public inquiry into CEGB plans for a PWR at Sizewell (the so-called "British PWR") recommended the project. It was a personal triumph for Marshall as "Mr. Nuclear," although a fellow CEGB member, John Baker, had led its case before the inquiry. The government approved plans for the construction of Sizewell B as lead station of a £6 billion program of PWRs in March 1987. Marshall hailed the decision as the best buy for the electricity consumer, and forecast that the CEGB would make another PWR planning application that year.

In February 1988 the government published its white paper on the future of the electricity supply industry. The CEGB was to be split into two generating companies, and a third would own the transmission grid. Marshall was appointed chair-designate of National Power, the larger of the two generators and the one that was to run the nuclear reactors.

But in 1989 the government made three decisions that changed the situation profoundly. The first was to withdraw the aging Magnox reactors from privatization plans, on grounds that it was unrealistic to expect private investors to shoulder the high shutdown costs for plants already seen as relatively near the end of their economic life. The second decision was to abandon the PWR program, in light of the financial criteria by which the City of London was weighing electricity investment. Sizewell B, the lead PWR, 2½ years under construction, was to be completed but not replicated to replace Magnox reactors. The third decision was a consequence of the other two: there was little point in privatizing the AGRs when

Magnox and the PWR would remain in the public sector. Marshall was replaced as CEGB chair.

The Entrepreneurial Years

Several senior commercial friends rallied to the support of the deposed chair. Bill Lee, president of the US electricity company Duke Power, proposed that Marshall become executive chair of a new international nuclear organization, the World Association of Nuclear Operators (WANO), that the two of them had helped to found in the aftermath of Chernobyl. Having spent his life to the age of 57 in the public sector, Marshall embarked on a new phase, that of entrepreneur.

At the inauguration of WANO in Moscow in 1989, Marshall, as nonexecutive chair, had warned the 139 signatories, representing every one of the world's nuclear electricity companies: "All are agreed that public confidence in nuclear power will not survive another accident as severe as Chernobyl." The secret of WANO is peer pressure: no club member can risk being accused of failing to comply with the spirit of the organization. To kindle this spirit Marshall spent much of the early 1990s visiting member companies worldwide, accompanied by his wife, Ann. In 1994, the year the new Russian republics were created, he estimated that he was away from home on WANO business 60 percent of the time.

Marshall believed that WANO taught the Russian nuclear establishment how nuclear safety was managed in the West, and why the West was so confident that, although nuclear accidents would continue to happen—just like railway and aircraft accidents—a catastrophe like Chernobyl could not possibly happen in the West. When he relinquished his position as WANO's executive chair in 1993, the organization was persuaded by Eastern Bloc members to retain him as "ambassador" for further negotiations, so great was the rapport he had built with these countries. In 1994 he set up a users group specifically for operators of the 20 Chernobyl-type (RBMK) reactors.

In 1991 he was selected for the Canadian Nuclear Association's International Award, honoring "outstanding individuals outside Canada who have made an exemplary contribution to the international development of the nuclear fuel cycle." In 1992 Shiochiro Kobayashi, chair of Kansai Electric Power Company, a leading Japanese nuclear generator, approached Marshall for help in setting up a new technical venture aimed at reinforcing public confidence in the safeness of nuclear power. He sought an independent advisor of international standing, and Marshall was appointed advisor to the new Institute of Nuclear Safety System Inc. headed by Nobuaki Kumagai. In 1997 the institute dedicated the Marshall Conference Room. It has also named an eddy current flaw detector the Marshall Probe.

Concluding Observations

Walter Marshall was a person of considerable and unforgettable presence, a polymath, and much more. Even his tortured accent was unique, forged, he said, by consorting mostly with émigré European physicists in his late teens.

He made considerable efforts to develop the UK's international nuclear relations in the 1970s, much of which came to nothing, but this was followed by building an unusually warm and productive relationship with the Japanese. He was a self-confessed workaholic who enjoyed the exhilaration of power. Some found him overbearing, and his habit of working with a small number of trusted colleagues outside established lines of communication sometimes led to tension. He gave enormous attention to his public lectures and was a popular and entertaining speaker.

When it was suggested in the late 1980s that a book might be written about him, his first response was: "I would want you to start with a long talk with Ann." Ann V. Sheppard, who came from the same village, married Marshall when he took his first job and they remained together for 41 years, living beside the Thames at Goring from the mid-1960s. Bridleway House became famous for parties memorable for Ann's grace and elegance and Walter's boisterous good humor. Despite a crippling workload throughout his career he remained a family man to the end with a penchant for DIY projects and gardening. They had two children, a son who became a doctor and a daughter who became a scientist. For the last two decades Ann was his constant companion and aide on his travels, and finally also his nurse during a long terminal illness.

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