WALTER CHARLES MARSHALL, C.B.E.
LORD MARSHALL OF GORING

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Walter Marshall 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, THEN APPLIED SCIENTIST

Walter Charles Marshall was born on 5 March 1932 in Rumney, near Cardiff, the youngest child in a family 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 his grammar school, St Illtyd's College in Cardiff. He also developed a serious interest in chess at the age of 11 and became 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 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 Ph.D at the early age of 22. He acknowledged that the guidance of his supervisor, Professor (later Sir Rudolf) R.E. Peierls, F.R.S.,was the major influence on his career.

Walter Marshall was recruited to the Theoretical Physics Division at AERE Harwell by Dr B.H. Flowers (now Lord Flowers, F.R.S.) in 1954. His first assignment was to the Plasma

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Physics Group, where his research on the difficult problems posed by shock waves in magnetically confined plasma discharges confirmed his powers as a theoretician (1)[‡]. But he soon returned to his initial interest in condensed matter physics, which was developed by two periods of study leave in the USA, visiting Berkeley, Livermore and Harvard, where he made a profound impression.

On his return to Harwell, Marshall became Leader of the Solid State Theory Group and, in 1960, at the age of 28, the Head of Theoretical Physics Division, which included a number of outstanding theoreticians from across a range of subjects. Under his leadership, the Division attracted a large number of visiting scientists, particularly from the USA, and maintained good collaboration with the theoretical physicists in Oxford, including Peierls, who had moved from Birmingham, and Roger Elliott (later Sir Roger Elliott, F.R.S.). Marshall's intellectual strengths and forceful personality also made him a prominent participant at international conferences.

Marshall's main personal contributions to the theory of the solid state related to magnetic properties, ranging from the very mathematical in discussing the statistical mechanics of magnetic phase transitions, and in particular their critical properties, to much more phenomenological treatments of the molecular orbitals in magnetic salts, and to the theory of magnetism in transition metals, in particular in alloys (2, 3). He became convinced of the value of the applications of neutron scattering. Here again, his main but not exclusive interest was in magnetic substances, where he encouraged experiments on the inelastic scattering from spin waves, on the magnetic structure factors around impurities, and many other studies, including an early interest in the Mössbauer effect (5).

Walter Marshall's main impact arose from his strong interaction with experimentalists and the driving through of programmes to test and expand the theoretical understanding of real materials. His outstanding abilities as a manager of research were later to transfer successfully to the commercial sector. He had published over 60 papers, with many collaborators, by 1969 and lectured extensively and lucidly on the applications of neutron scattering. His book *The theory of thermal neutron scattering*, which he wrote with Stephen Lovesey, remained the definitive text on the subject for 20 years (6). He gave the Kelvin Lecture in 1964 on thermal neutron research, showing his characteristic delight in explaining scientific concepts to a non-specialist or non-scientific audience (4). He was the second recipient of the Maxwell Medal for outstanding contributions to theoretical physics from the Institute of Physics in 1964, the first having been Abdus Salam in 1962. He was elected to the Royal Society in 1971—the youngest Fellow at that time.

Walter Marshall continued to work on problems in superconductivity and magnetism after 1970 as mental relaxation, during periods of leave in the USA, at home, and in airport lounges and other unlikely places. He recorded it all in his neat handwriting in a number of notebooks. One for 21 July 1985 records a resolution to work on these problems for half an hour a night, although by that date he was immersed in the politics and management of nuclear power.

Diversificaton and industrial research

The success and international reputation of the Theoretical Physics Division under his leadership confirmed Marshall's ability to lead scientific programmes and to motivate the work of others. This led to a significant switch in his career, from pure science to the

[‡]Numbers in this form refer to the bibliography at the end of the text.

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. Much of the pioneering nuclear work was moving away 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 of expanding its programme beyond the terms allowed under the 1954 Atomic Energy Act was provided, in principle, by the Science and Technology Act of 1965. However, the first new proposals in which Marshall was involved, at the invitation of Dr F.A. Vick, followed from his own research interests—to establish at Harwell a high magnetic field laboratory (HMFL) and a high flux neutron beam reactor (HFBR).

Marshall saw these proposals as an opportunity for further collaboration with university laboratories, which would establish Harwell as a national centre for materials research. But there were problems both of finance and of remit. The HMFL could be built at Harwell only under a broad Requirement under the 1965 Act for materials science and this the Ministry of Technology was unwilling to provide. The HFBR could have been built under the 1954 Act, since neutron beam research was well supported at Harwell, but the Ministry 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 to be contributing to the national welfare at a time when the UK economy was perceived to be falling behind those of other industrialized nations. So he directed his formidable energies towards transforming Harwell into a laboratory aimed at improving industrial performance generally and meeting defined government needs. For this, he had the authority of Dr (later Sir) John Hill, F.R.S. Chairman of the UK Atomic Energy Authority, and his Board. Marshall wrote:

> My plans are founded on the belief that the future of one of the world's great multidisciplinary laboratories is largely dependent on the extent to which we are able to exploit the technological spin off from our nuclear research and development (7).

Marshall realized that this change amounted to a revolutionary shift in the aims and objectives of many of the scientists at Harwell, and that it would involve administrative as well as technical changes. He later listed the difficulties in the way of creating an industrial programme large enough to employ about a third of the laboratory—more than any contract research organization in Europe at that time. 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: 'Industry simply did not want us and most people sought strongly to discourage us' (9).

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. And there had been some interaction with industry from the early days. Typically, it involved the use of radiation or radioactive isotopes and a small commercial office existed to draw up the necessary contracts. 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, non-destructive testing and atmospheric pollution, for example. Such skills could not be exploited without a Requirement under the 1965 Act. By 1969, 16 such Requirements had been granted. Authority to spend public money had to be won from the Requirements Boards set up by the Ministry. Marshall saw that the most pressing need was to establish good communications with a large number of potential industrial customers, and placed the responsibility of doing so on the project leaders themselves, insisting that the ultimate criterion of success would be financial. These were key decisions, which forced a large number of Harwell scientists to acquire first-hand knowledge of industry and liberated unsuspected entrepreneurial talents in many of them. Industrial opposition fell away as more firms became involved.

The industrial programme grew rapidly after 1967. By 1973, it accounted for 39% of the Harwell programme, and for 51% by 1976. The income came about equally from industry and government agencies. The new sources of funds allowed Marshall to stabilize the size of the laboratory after 1975, though the professional staff had been reduced by about 25% over 10 years. By far the greatest reduction had been in the areas of basic science connected with nuclear technology. Nevertheless, Marshall believed that a significant programme of this type was necessary to maintain the scientific standards of the laboratory.

Diversification gave the laboratory a new lease of life. It excited considerable national and international interest, though Marshall was always careful to say that the precise structure followed 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 marked by the award of the Glazebrook Medal of the Institute of Physics in 1975. In a retrospective lecture to the National Academy of Sciences in Washington, 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. Altering the orientation of the laboratory had been very difficult but 'it can be done if sufficient determination and will is applied to the task' (9).

Marshall could claim by the early 1970s that the discipline of having to earn money had improved the general morale of the laboratory. It is a well-deserved tribute that the headquarters of the reorganized UKAEA at Harwell has been named the Marshall Building.

Energy policy and nuclear power

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

Marshall shared the general 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 a substantial input from fast reactors. Fusion was seen as a bright hope for the longer term. Marshall took part in the reviews of the prospects for fusion during the 1970s and in the negotiations that ended with the siting of JET, 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 whether fusion reactors would be economic (8).

In 1974, Marshall was appointed Chief Scientist to the Department of Energy on a part-time basis. He worked extremely hard at this additional remit, chairing the Advisory Committee on the Energy Industries and the new Offshore Energy Technology Board. He 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 the 'renewable' sources of energy. This organization (ETSU) still exists.

Marshall also chaired a Study Group looking at the role that combined heat and power (CHP) linked to district heating schemes might play in the UK, following the example of proven CHP schemes in several European countries. This study was organized because energy efficiency and conservation were seen as key objectives in the aftermath of the 'oil shocks' of the early 1970s and the prospect that the UK would become a net importer of hydrocarbon fuels around the turn of the century. The Study Group comprised leading academics and senior members of the Electricity Supply Industry. Their final report in 1979 concluded that there was no immediate economic argument for CHP and district heating in the UK, but that there would be opportunities for CHP in the longer term if gas prices increased substantially. Marshall and the majority of the Group were in favour of starting one lead scheme in a city centre as soon as was practicable, and encouraging smaller schemes in industry (10). But, in the event, gas remains cheap and supplies are perceived to be secure.

In 1977, for reasons discussed later, Marshall was abruptly asked to return to full-time duties in the UKAEA, although he continued to chair the CHP Group. Marshall was deeply hurt but there was much to do. Marshall saw a growing nuclear component with a strong industrial base as essential for a stable energy policy in the UK. He became 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 (SGHWRs), or more advanced gas-cooled reactors (AGRs). He 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 Westinghouse facilities in the USA, and he thought that the UK nuclear industry would do better in foreign markets if it too were building the most popular reactor in the world.

The CEGB also favoured PWRs, but there were wider concerns about their safety, and Marshall gave increasing attention to questions of safety and large-scale accidents. In particular, the Government's Chief Scientific Adviser (Sir Alan Cottrell, F.R.S.) drew attention to the possibility of rapid fracture of the steel pressure vessels under operational or accident conditions. The Chairman of the UKAEA, Sir John Hill, had invited Marshall to set up a study group to review the integrity of PWR pressure vessels and draw conclusions about the mathematical probability of vessel failure and about the factors that affected that probability. Marshall saw that this concern could be addressed only by a rigorous analysis of all relevant features of design, fabrication, fracture analysis, non-destructive 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 was submitted to extensive external review and published in 1976.

The Study Group was reconstituted and strengthened with more academic members in 1980, after a government decision that the next nuclear station to be built would be a PWR, if safety requirements could be met. The whole study was reviewed, using the latest evidence on materials properties. The work included a fracture assessment of the pressure vessel of a generic four-loop PWR of modern design, reviewing and comparing different methods of fracture analysis. The final Report, published in 1982, ended with 57 ‘essential’ recommendations and listed a further 26 topics that should be pursued to improve understanding (15). Sir Alan Cottrell accepted the general conclusion that a PWR pressure vessel subject to all these conditions would have a high integrity and reliability in service and welcomed particularly the emphasis given in the Report to the need for rigorous ultrasonic inspection, backed by independent validation of the techniques used. This recommendation was later implemented in the arrangements made for the non-destructive testing of the Sizewell PWR. The general influence of the Study Group has since been extended by the formation of a Technical Advisory Group, currently chaired by Sir Peter Hirsch, F.R.S., which provides a peer review body on structural integrity issues (TAGSI) across all nuclear plant in the UK.

Walter Marshall also played a vigorous part in the debates about the safety of the nuclear fuel cycle that took place in the 1970s. These debates were initiated by worries about the safety of fast reactors—then the major project of the UKAEA—and of the dangers of the theft or diversion of plutonium 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, as in the Sixth Report of the Royal Commission on Environmental Pollution in 1976. Most significantly, official opinion in the USA turned against reprocessing nuclear fuel and even against the worldwide growth of nuclear power. President 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 co-chairman with a Japanese delegate, of Working Group 4 of INFCE, dealing with reprocessing, plutonium handling and recycling.

Marshall made his own personal position very clear in a series of lectures, during and after the conclusion of INFCE in early 1980. He was convinced that an increasing nuclear power programme was essential—‘a moral imperative’—to meet the energy requirements of an expanding world population. To achieve this, a gradual change to fast reactors and an efficient, closed fuel cycle would be necessary. He thought that the fears that had been expressed about fast reactors had been 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 USA, fearing that the stores could become plutonium sources of increasing accessibility which would be a target for diversion or theft (13).

Marshall’s alternative vision was 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 (12). Marshall recognized that such an international regime could be realized only if many governments saw the advantages and were willing to support it. In any case, it could be only one item in an international regime aimed at preventing the proliferation of nuclear weapons—a broader objective than the control of plutonium, and essentially a political objective, which might be assisted, but not solved, by technical means. Much depended on the political leadership of the USA, and Marshall gave several lectures in the USA to explain his views (11).

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 UK. Marshall was thanked for his contribution by the Department of Energy. Since the early 1980s, however, the economics of fast reactors have seemed less favourable. Marshall could not offer funds for fast reactor development when he moved to the CEGB, and government support has also been withdrawn. More countries have turned to recycling plutonium in thermal reactors—as Marshall predicted would happen.

Years of technical management

Walter Marshall's life changed dramatically when, in 1983, Mr Nigel Lawson, Energy Secretary, summoned him to say: 'The Prime Minister and I have decided that in the national interest you should be the next Chairman of the CEGB'. Privatization of the electricity industry was not an issue at this stage. The big 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. But a paramount factor, Lawson made it plain privately, was that Marshall was seen by the Government as 'Mr Nuclear'. It was the start of some of the happiest years of Marshall's life.

His abilities as an inspirational manager and natural leader who 'made things happen' 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 to one of the authors: 'I think if Walter had stayed any longer, he would have taken over this laboratory'.

The task that brought him to ministerial attention as a potential chairman of the CEGB was one thrust upon him as the new Chairman of UKAEA in 1981. Britain's nuclear design and construction industry was in disarray. This was most evident in attempts to get ready for public inquiry a design for a 'British PWR'. The CEGB and the nuclear companies asked the Energy Secretary for Marshall to lead a Task Force to sort out an agreed design. For 18 months Marshall led this Task Force, which settled the design for Sizewell B, seen as Britain's lead PWR station. This design had to meet Britain's nuclear safety requirements, founded on gas-cooled reactors, without compromising the integrity of the Westinghouse nuclear steam supply system (NSSS) required for the PWR. Marshall demonstrated well that he could lead a divided and quarrelsome industry (14).

But in so doing inevitably he made himself the prime target of groups opposed to nuclear energy. He met criticism with a disconcerting mixture of jolly good humour and abrupt dismissal. When a group called SCRAM—the Scottish Committee for Resisting the Atomic Menace—published a postcard featuring a sketch of a PWR with Marshall's features drawn on the containment dome, he considered it to be 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 Britain's 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 for themselves; especially the tricky business of accommodating British safety requirements. Marshall also promised his guests a meeting with the Energy Secretary. The visit coincided with rumours of a Cabinet reshuffle in which Mr David Howell, Energy Secretary, would be replaced by Mr Nigel Lawson. Anticipating the change, Marshall sent a note to the Prime Minister's office to register how important it was to the PWR programme that his guests should meet the Energy Secretary. As a result, the American engineers found themselves at 10 Downing Street meeting not only Lawson, the new Energy Secretary, but also the Prime Minister, Margaret Thatcher. The 30-minute interview began with the Prime Minister stating that she understood the critical issue was detecting cracks only an inch long in the pressure vessel. Finally, the Americans were convinced Britain was serious about the PWR.

The long coalminers strike, in 1985–86 was an unscheduled interruption to Marshall's tenure at the CEGB. As he saw it, the electricity supply industry had a professional obligation to keep the lights burning, regardless of the miners' arguments. He did not take sides publicly. Nuclear energy was not an issue during the strike, since the CEGB ran its reactors at base load and there was no extra power available from that source.

In what Marshall called a personal footnote to a book by CEGB executives about its management of the miners' attempt to deprive them of their principal fuel (Ledger & Sallis 1995), he recounts how at his first board meeting in mid-1982 he asked about plans to combat a strike, and was not satisfied with the answers. He called for a 'simple, straightforward statement of policy'. His director of operations responded with a £70 million plan to build coal stocks to unprecedented levels, to prepare power stations against siege picketing, and to burn oil in both oil- and coal-fired stations (18).

The strike began in March 1984, and two days later he met his executive directors to decide what the utility's response should be. It was a difficult decision, for they could not ask for government advice lest this give the dispute a political flavour and alienate its own workforce. The decision his board had to take was whether to burn the coal stocks it had accumulated and paid for, or burn oil. If it burned coal and the strike outlasted stocks, the miners would win. On the other hand, if they burned oil and the strike proved short-lived it would have to pay a big extra fuel bill. 'I decided to burn oil … a unilateral decision taken in view of the legal responsibility of the CEGB "to maintain a secure electricity supply to England and Wales"'.

The next three months were miserable, Marshall records. Then colleagues in the industry and Whitehall began to talk of the wisdom of burning oil. As winter approached there was need to keep the Prime Minister informed. The Energy Secretary—by then Peter Walker—arranged for them both to see her. They promised her they would keep the lights on. 'Of course I did not actually know that we could, but it was quite clear that the Prime Minister's role in this dispute was to sit quietly at No. 10 as an observer. It was not a role that Mrs Thatcher liked, but with some reluctance she agreed. Walker and I therefore hold the unique record of giving her unwelcome advice—and surviving' (17).

The strike lasted a year and the CEGB ran up a £2 billion oil bill, underwritten by the Government. For keeping the lights on, Marshall was rewarded with a peerage that elevated him to Lord Marshall of Goring—the Thames-side town where he lived for most of his career.

Marshall also had a flair for public relations that was not characteristic of the industry he led. Shortly after he became Chairman, anti-nuclear critics charged that the CEGB's spent-fuel shipping casks would not survive a serious transportation accident. Marshall agreed to a dramatic public demonstration of a cask's integrity. A full-size, albeit 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.

Another success was scored soon after the coal strike ended in 1986, when 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 get the perceived hazards of radioactive waste into better perspective. His address became known as 'the garden lecture' and was subsequently given by him throughout Britain. It involved bringing samples of nuclear waste, suitably contained, into the hall, within a few metres of his audience, and using a very audible signal from a Geiger counter to dramatize their presence. An enthusiastic gardener himself, he showed how a garden always contains substantial quantities of radioactive materials. In his words, 'we are surrounded by radioactivity, and most of us are hardly conscious of the fact' (16).

Marshall's consummate skill at putting across complex technical matters in simple terms, and often with very appropriate wit and humour, became greatly appreciated at all levels, from the schoolchildren who received his first garden lecture so enthusiastically, to the Prime Minister. Where he had problems with boardroom colleagues at the CEGB was in recognizing that it was basically a coal-fuelled generating company, and long would remain so, no matter how successful he proved in converting it to a nuclear utility. The immense magnitude of the nuclear problems took centre stage in his mind; not only problems in launching the PWR but also problems with seriously underperforming gas-cooled reactors which were expensive and were compromising the nuclear image.

In 1981, the year before he joined the CEGB and as Chairman of the UKAEA, 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 see they had enough time to think about problems beyond today and this week. Another important task of management, he urged, was to avoid anonymity. Big organizations so easily became remote and impersonal. To some senior managers the task came more naturally than to others, but whether they liked it or not it was a task they had to do. Marshall's boundless enthusiasm and energy left no one in doubt that it came naturally to him, and that this forceful personality revelled in being seen as the leader.

A senior civil servant who had been closely associated with Marshall's career from the time when he was appointed Chief Scientist to the Department of Energy in 1974 recalls, 'the aura of a man who knew his worth and who could demand his own terms on such matters as living and travelling arrangements'. He wanted a car he could use as a travelling office for his frequent journeys between Harwell and Whitehall. He used Harwell, which he knew intimately, as a technical resource in strengthening the Department of Energy.

Where Marshall proved less robust as a manager was when, in 1977, he was abruptly sacked by Mr Anthony Wedgwood Benn, Secretary for Energy. Relations between them had grown increasingly strained through Marshall's enthusiasm for nuclear power and Mr Benn's growing suspicion of the nuclear industry. Benn's action was against the advice of his most senior officials. Marshall, clearly very shocked by the first major setback of his career, returned disconsolately to the UKAEA, where he had retained his position as Deputy-Chairman.

The Chernobyl explosion

On 27 April 1986, a Soviet-designed RBMK reactor exploded at Chernobyl in the Ukraine, releasing radioactivity that was to spread worldwide. Speaking to nuclear industry executives and MPs on 1 May, Marshall said the reactor had unsatisfactory safety characteristics, which ensured that the design could never be licenced in Britain. He called it a unique design with no counterpart in the West. Britain had no bilateral exchange agreement on nuclear accidents with the USSR of the kind it had with many other countries. By the end of May, Marshall was acknowledging that the accident had badly shaken public confidence in nuclear power and cast gloom over all nuclear activities.

Marshall 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 colour film of the burning reactor core, Dr Valery Legasov, leading the large Soviet delegation, spoke of a 'tremendous psychological mistake on the part of the designers of this reactor'. He admitted several crucial design weaknesses. 'He's laying it all out', said an astonished Marshall. 'He's admitting faults in the design, in training, in Soviet safety philosophy' (Fishlock 1986).

Legasov also sought help from the West. Marshall accepted that what had occurred was a nuclear excursion. He was to play 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. He was later to liken the basic design flaw to a car with a design fault that required the driver to give constant attention to his brakes when driving below 20 miles per hour, to prevent the car from surging to 100 miles per hour if, for example, the fan belt should break.

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 programme 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. He rejected Treasury criticism of CEGB investment plans as too ambitious and too expensive as 'the kind of thing the Treasury always says'.

In February 1988, the Government published its White Paper on the future shape of the electricity supply industry. The CEGB was to be split into two generating companies, with a third to own the transmission grid. Marshall's efforts to persuade government that it should be kept whole because it had been conceived and designed as a single, integral system which could be destabilized by fragmentation had been unsuccessful. Political imperatives had prevailed. Marshall was disappointed but phlegmatic: he saw the decision to break up the utility as a purely political decision and not a criticism of the CEGB. 'I can accept that', he said. He was later appointed Chairman-Designate of National Power, the larger of the two generators and the one which was to run the nuclear reactors.

But in 1989, the Government made three basic decisions relating to the reactors that were to change the situation profoundly. One of them effectively eliminated the task for which Marshall had been recruited in 1983. The first decision, in July, was to withdraw the ageing Magnox reactors from privatization plans, on grounds that it was unrealistic to expect private investors to shoulder the high shut-down costs for plants then seen as relatively near the end of their economic life. The second decision, in November, was to abandon the PWR programme, in light of the financial criteria by which the City of London was weighing electricity investment. Sizewell B, the lead PWR, 2.5 years under construction, was to be completed but not replicated as replacements for Magnox reactors. The private sector simply refused to accept the economic case for a series of PWRs on its investment terms, and anyway wanted government to underwrite all financial risks.

The third decision was simply a consequence of the other two: namely, that there was little point in privatizing the advanced gas-cooled reactors when Magnox and the PWR would remain in the public sector. The Government invited John Collier, a long-time close associate and friend of Marshall, to head a new public-sector organization to run the CEGB reactors. John Wakeham (Lord Wakeham), announcing Marshall's resignation to Parliament in December, stressed that Marshall was in no way to blame for the difficulties that had led to those decisions.

Marshall's last act as Chairman was to sign the delayed CEGB accounts for the year, which provide some of the evidence underpinning the nuclear decisions. Provisions for the future nuclear liabilities had increased substantially, partly at least because of the protracted efforts the CEGB had made with its supplier, British Nuclear Fuels, to quantify the inherent uncertainties and hence the true costs of nuclear generation. Its estimates included a doubling of previous figures for the cost of decommissioning a Magnox station, for example, and a doubling of the costs of spent fuel reprocessing. The net result of the increased nuclear cost estimates for the year was to cut by two-thirds the CEGB's earlier estimate of profits for 1988–89, from £956 million to only £355 million.

In a valedictory address to the British Nuclear Energy Society, Marshall observed wryly: 'When at long last we embark upon an appropriate technology we are compelled to abandon it because of the nature of the privatization process which forces short-term commercial judgments on a project whose value is primarily long-term and strategic'. The CEGB had assumed an 8 per cent cost of capital over a 40-year life for its PWR programme. The banks wished to recover their capital in 20 or even in 10 years, he said (17).

The entrepreneurial years

Several senior commercial friends rallied to the support of the deposed Chairman. Sir Richard Giordano, Chairman of British Oxygen and a non-executive CEGB member, helped sort out Marshall's financial terms with a Treasury that was disposed to be miserly. Bill Lee, President of the US electricity company Duke Power, proposed that Marshall should become Executive-Chairman of a new international nuclear organization called the World Association of Nuclear Operators (WANO) that the two of them had helped to found in the aftermath of Chernobyl. The salary offered was larger than his CEGB salary. Having spent his life to the age of 57 in the public sector, Marshall embarked on a new phase, that of entrepreneur.

WANO was the industry's response to the Chernobyl explosion. At its inauguration in Moscow in 1989, Marshall, as Non-Executive Chairman, had warned its 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 group pressure; the kind of pressure that ensures no club member can risk being accused of failing to comply with the spirit of WANO. To kindle this spirit he spent much of the early 1990s visiting member companies worldwide, accompanied by his wife, Ann. He estimated that in 1994, the year the new Russian republics were created, he was away from home on WANO business 60 per cent of the time.

Marshall believed that WANO helped to give new status to the engineers who operate and manage nuclear stations in the former Comecon countries. Operators got the blame officially for Chernobyl (although an international study published in 1992 found the engineers and scientists who designed the stricken reactor equally guilty). WANO preached that nuclear operation was a professional discipline and reactor operators were a community of highly trained professionals, as aware of peer group pressures as, say, accountants or scientists. Marshall also helped persuade the big state-owned research and engineering institutes which hitherto had dominated the international nuclear scene that they themselves had no place in WANO, and that in future they must share power and influence with operators (Fishlock 1996).

Marshall also 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 as railway and aircraft accidents continue to happen—a catastrophe like Chernobyl could not possibly happen in the West. When Marshall relinquished his position as WANO's Executive Chairman in 1993, it 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 1990, a young underwriter at Lloyd's of London insurance market set up a syndicate specializing exclusively in insuring nuclear risks—the first ever. Michael Dawson recognized that he needed two things to succeed: considerable expertise in assessing nuclear risk and credibility in the City (he was only 29). He phoned Marshall and immediately won his attention. Marshall became adviser to the new venture, and friend and mentor of the ambitious young underwriter. In 1995, Dawson floated his venture on the London Stock Exchange, with Marshall—now a Lloyd's Name—as Chairman. From a market capitalization that year of £30 million, Cox Insurance Holdings grew to £400 million over the next three years.

In 1992, Mr Shiochiro Kobayashi, Chairman of Kansai Electric Power Company, a leading Japanese nuclear generator, made another personal approach to Marshall for help in setting up a new technical venture aimed at reinforcing public confidence in the inherent safeness of nuclear power. He sought an independent adviser of international standing. That year Marshall was appointed adviser to the new Institute of Nuclear Safety System Inc. headed by Professor Nobuaki Kumagai. The appointment took him to Japan several times a year. In 1997, the Institute dedicated the Marshall Conference Room. It has also named an eddy current flaw detector the Marshall Probe.

Walter Marshall was a person of considerable and unforgettable presence, and of many parts, a polymath and much more. Even his tortured accent was unique, forged he said by consorting mostly with emigré 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. Marshall 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 he was a popular and entertaining speaker. When it was discussed in the late 1980s that a book might be written about Walter Marshall, his first response was: 'I would want you to start with a long talk with Ann'. Ann Shepperd, who came from the same village, married Marshall when he took his first job and they remained together for 41 years, living beside the river at Goring from the mid-1960s. Bridleway House became famous for parties memorable for Ann's grace and elegance and Walter's boisterous good humour. Despite a crippling workload throughout his career he remained a family man to the end with a penchant for DIY and the garden. 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.

Honours and prizes

1964	Fellow of the Institute of Physics.
	Maxwell Medal, Institute of Physics.
1971	Fellow of the Royal Society.
1973	C.B.E.
1975	Glazebrook Medal, Institute of Physics.
1977	Foreign Associate, National Academy of Engineering, USA.
1977	Honorary D.Sc., Salford University.
1979	Fellow of the Royal Swedish Academy of Engineering Sciences.
1982	Knighthood.
	Honorary D.Sc., City University.
1983	Honorary Fellow of St Hugh's College, Oxford.
1984	Freeman, City of London.
	Honorary D.Sc., Birmingham University.
1985	Life peer.
	Henry de Wolf Smythe Nuclear Statesman Award, USA.
1987	Honorary Fellow of the Welding Institute.
1991	International Award, Canadian Nuclear Association.

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The frontispiece photograph, taken in June 1973, is reproduced with the kind permission of the Godfrey Argent Studio.

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