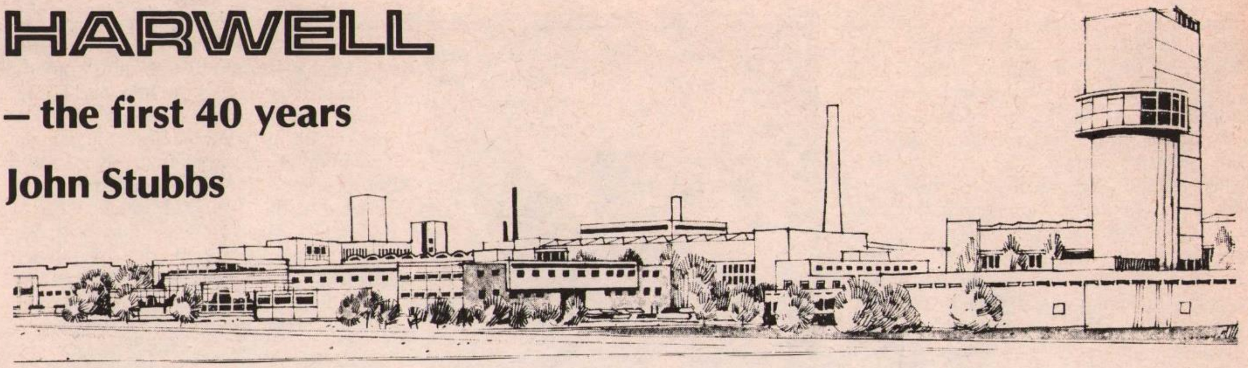
HARWELL

– the first 40 years

John Stubbs



The participation of British scientists in second world war atomic energy projects has been well documented. One group joined the Manhattan project in the USA, which resulted in the world's first atomic bomb tested in New Mexico on 16 July 1945, whilst another group was led by Halban and Kowarski, who had escaped from France to England in June 1940 bringing with them the world's entire stock of heavy water. This team was primarily interested in civil nuclear power applications, and they started work at the Cavendish Laboratory on a nuclear reactor moderated by heavy water. In 1943 the work was integrated into a joint Anglo-Canadian project at Montreal University; Professor (later Sir) John Cockcroft took over as Director in March 1944.

Britain's own long-term development of atomic energy had been considered by the government as early as the spring of 1944, and Prime Minister Churchill discussed it with President Roosevelt at the Yalta conference in February 1945. The war-time British Tube Alloys Technical Committee had recommended an 'experimental establishment', having a low-energy graphite pile and a van de Graaff generator, and undertaking nuclear physics research and work on the design and construction of specialised research equipment. By the spring of 1945 the desired features of the proposed new organisation were beginning to evolve, with particularly a minimum of red tape and flexibility in the flow of staff between the establishment and universities. In July 1945, John Cockcroft was invited to become the first Director of the new establishment; he was promised 'the utmost measure of freedom in control' and asked to devise an organisation which would ensure the vigorous development of atomic energy.

The next step was to search for a suitable site and it soon became clear that the only practicable proposition was an airfield with engineering workshops, roads, water supply, houses etc, and especially with hangars to house large nuclear machines. Various RAF stations near Cambridge and Oxford were examined before a final choice was made. In the House of Commons on 29 October 1945, Prime Minister Attlee announced, 'The government have decided to set up a research and experimental establishment covering all aspects of the use of atomic energy. Accommodation is being provided for the establishment at Harwell airfield near Didcot' . . . 'The Tube Alloys Directorate will become part of the Ministry of Supply'. The RAF moved out in December and the Atomic Energy Research Establishment, Harwell, came into existence on 1 January 1946.

This article reviews how its original aims were achieved and charts the metamorphosis of a single-mission government laboratory into one of the world's best known contract research and development organisations.

Figure 1 Sir John Cockcroft, OM, FRS, Director 1946–59

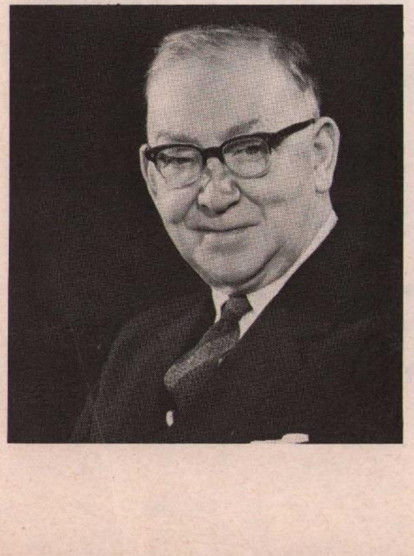
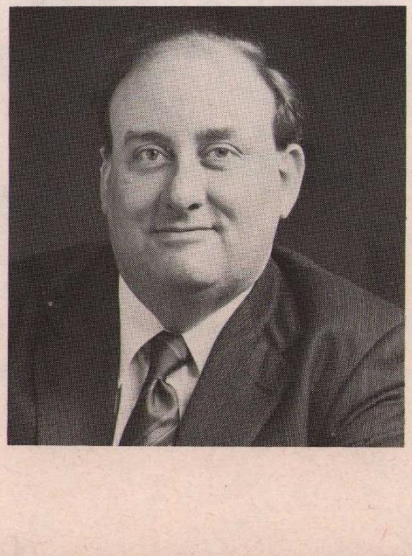


Figure 2 Lord Marshall, FRS, Director 1968–75



The early years

The objective of the Montreal group had been to design and build a heavy water moderated nuclear reactor using uranium and heavy water supplied by the Americans. The Anglo-Canadian team first designed a zero-energy experimental pile (ZEEP) and then moved on to the much larger NRX reactor. Both were built at Chalk River, on the south bank of the Ottawa river, 130 miles west of Ottawa: ZEEP became operational in September 1945 and NRX in July 1947. Towards the end of 1944, a Graphite group had been formed at Montreal to prepare general arrangement drawings for an experimental graphite pile. A 'Future systems group' was examining the employment of thermal reactor systems in producing electrical power and/or plutonium.

This and other work enabled the new Atomic Energy Research Establishment at Harwell to get off to a flying start in January 1946. While conversion and construction of buildings was getting under way, staff from the Manhattan and Montreal teams returned to the UK and some took up appointments at the new organisation. They were joined by scientists from the Telecommunications Research Establishment at Malvern and others from university teams at Oxford, Cambridge, Birmingham and Liverpool which had worked for the Tube Alloys Directorate.

By August 1947 a graphite low-energy experimental pile (GLEEP) was in operation (the first in Europe) and it is still running 38 years later. The centre of the site was soon dominated by a 200 foot chimney which was to carry skywards the six tonnes of cooling air per minute from the 6 MW (thermal) research reactor, BEPO. Commissioned in July 1948, this became the work-horse of the nuclear research programme for 21 years, as well as a large-scale producer of isotopes for medicine and industry. Waste heat from the reactor was used to heat nearby buildings in the first nuclear-powered district heating scheme.

Other facilities constructed in the late 1940s were a 5 MV electrostatic accelerator and a 180 MeV synchrocyclotron. These machines, besides GLEEP and BEPO, were housed in former aircraft hangars and another hangar contained the main engineering workshops. One of the first custom-built facilities was the Radiochemistry Laboratory, designed by the Montreal team and with many innovations based on their early experience.

With this array of machines and facilities, the scientists were soon tackling a wide range of atomic energy projects, from particle physics to the functioning of major reactors. Cockcroft's view was that some 50% of Harwell's effort should be self-initiated research and the remainder should support reactor technology and fuel production/reprocessing which was being carried out elsewhere in the UK. A university-type approach, coupled with the appeal of involvement in developing a new energy source, attracted many high quality staff and by 1953 the number of qualified scientists and engineers had reached 800.

Experience with the BEPO research reactor led to a collaborative study with the (then) British Electric Authority and a number of major industrial firms, which resulted in a proposal to build a graphite-moderated power reactor cooled by carbon dioxide. The government authorised the building of a prototype power station of this type at Calder Hall in Cumbria, and the world's first industrial-scale production of electricity from a nuclear reactor began in October 1956, when HM The Queen connected the output from Calder Hall to the National Grid.

By 1954 the atomic energy programme was growing rapidly and the government decided to separate the work from the Civil Service. Subsequently, a public corporation, the United Kingdom Atomic Energy Authority (UKAEA), was set up to take over responsibility for Harwell and the Directorate of Atomic Energy Production (based at Risley) from the Ministry of Supply.

Consolidation

The feasibility of nuclear power having been established, a programme was announced in 1955 for building 12 stations with a total capacity of 1500 to 2000 MWe over a period of ten years. Following the Suez crisis of 1956, this programme was expanded to 5000 MWe. Harwell's involvement with these Magnox reactors (so-called because the uranium metal fuel was clad in a magnesium alloy) has, over the years, covered metallurgical work and fuel radiation damage studies, as well as a detailed investigation of the chemical reactions between the carbon dioxide coolant and the graphite moderator. This has helped to extend the design life-time of these reactors from 20 to 30 years and Magnox power stations have been the backbone of nuclear electricity generation in the UK.

Between 1953 and 1959 the number of staff at Harwell doubled, and several different reactor systems were being investigated. Work on ceramic fuels (UO_2) permitted the use of higher fuel temperatures, and led in turn to the advanced gas-cooled reactor (AGR); five AGR stations are now in operation in the UK and another two are under construction. When seeking an alternative

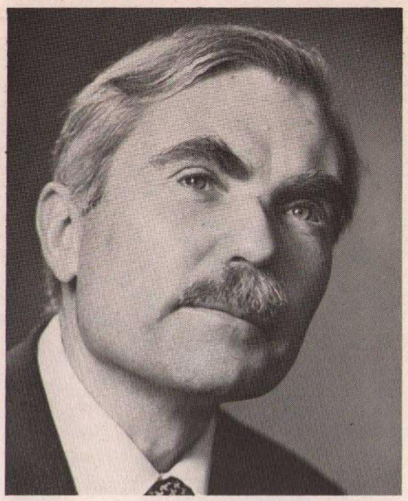


Figure 3 Dr Lewis Roberts, CBE, FRS, Director since 1975

to graphite as a moderator, the chemistry of water reactors came under scrutiny and led to the construction, at Winfrith, of a steam-generating heavy water reactor (SGHWR) which has been producing 92 MW of electricity for the National Grid since 1967. Fast reactor systems research led to construction of a prototype fast reactor (PFR) at Dounreay in Scotland. In addition to this, there were teams working on high-energy physics and on fusion (ZETA).

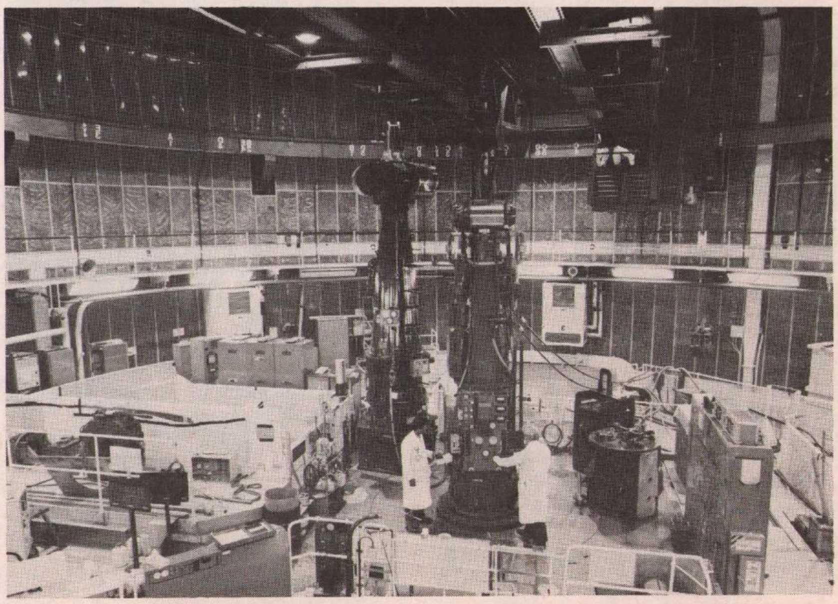
In 1957 all fundamental atomic particle research at Harwell was hived off to the newly created National Institute for Research in Nuclear Science (at nearby Chilton) and this organisation has since become the Rutherford Appleton Laboratory. In 1959 the Atomic Energy Establishment at Winfrith in Dorset was set up, taking many reactor physics staff; at first this was an outpost of Harwell, but it subsequently became a separate management unit. In 1960 fusion research moved seven miles away to the Culham Laboratory, which has seen exciting new developments, particularly as host to the JET Joint Undertaking. Also in 1960 a specialist laboratory was set up at Wantage for research and development into industrial uses of radioisotopes, including radiation sterialisation. This led to the launch of a new company, ISOTRON, providing a gamma irradiation service. By 1965 the number of qualified scientists and engineers at Harwell had reached 1370 an after 20 years the laboratory was about to enter a new phase.

Diversification

The development of commercially viable nuclear power had required an exceptionally wide range of technical innovation, extending well beyond the reactor itself to more conventional plant and also to related problems such as waste management, environmental safety and systems reliability. Hence Harwell built up a variety of advanced technology and multi-disciplinary skills, enabling it to take advantage of the Labour government's 1965 Science and Technology Act. This empowered the new Minister of Technology to authorise programmes of agreed non-nuclear work in government laboratories and in the UKAEA. Harwell, under the directorship of Dr Walter (now Lord) Marshall, took up the new challenge with great vigour and enthusiasm.

When establishing Harwell's wider programmes it was decided that they must relate to the special needs of UK industry, be firmly based on the laboratory's existing technology and, most importantly, that customers be found who would pay the full commercial cost of the work (plus a modest profit). At first, the going was hard. Many industrialists were eager to discuss technical problems but expected the research to be done free of charge. The situation improved when the Ministry of Technology issued

Figure 4 Inside the Materials Testing Reactor, PLUTO, which celebrated its Silver jubilee on 28 October 1982



'programme letters' authorising generic work in new industrial areas, sometimes with the help of industrial funding. By 1967 contracts were beginning to come in, and several new business centres had been established, including the Non-destructive Testing Centre, through which the UKAEA's considerable experience of many inspection techniques is channelled to industry, the Ceramics Centre, for exploiting broad materials' expertise, and the Heat Transfer and Fluid Flow Service (HTFS), a sponsored research programme on many industrially important aspects of heat transfer. All these have continued to flourish and expand.

At the same time, the commercial exploitation of Harwell's nuclear technology intensified, based on its wide nuclear science and engineering expertise and on the laboratory's major nuclear plant (reactors, accelerators and remote handling facilities). Business with the UK nuclear industry grew rapidly, and a number of major contracts for overseas customers were won against international competition.

The requirements of a growing contract research organisation were very different from that of a single-mission government-funded laboratory, however. Scientists had to develop an understanding of the way industry works, the R and D market had to be studied carefully, potential customers informed of Harwell's new role, contracts negotiated and intellectual property rights safeguarded. By the early 1970s industry was becoming aware of the advantages of 'buying in' research and Harwell had learned how to do contract R and D. Business built up steadily in many areas, such as nuclear fuels, radioactive waste management and nuclear instrumentation, as well as in nondestructive testing, new engineering materials, atmospheric pollution, corrosion, car exhaust catalysts, offshore technology, wear measurement, combustion, heat transfer, separation processes, biotechnology analysis and information retrieval.

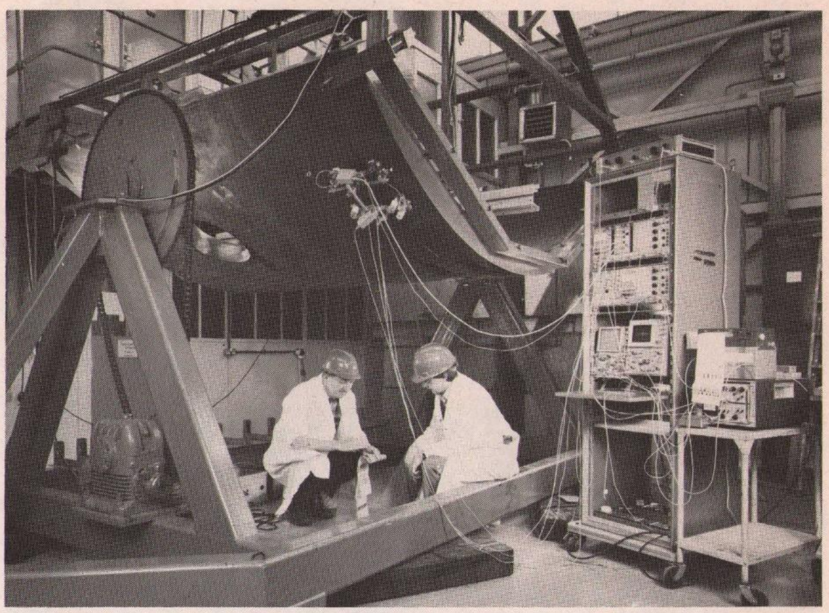


Figure 5 An inspection crawler moving over the under surface of a large pressure vessel forging. The crawler was designed at the National NDT Centre

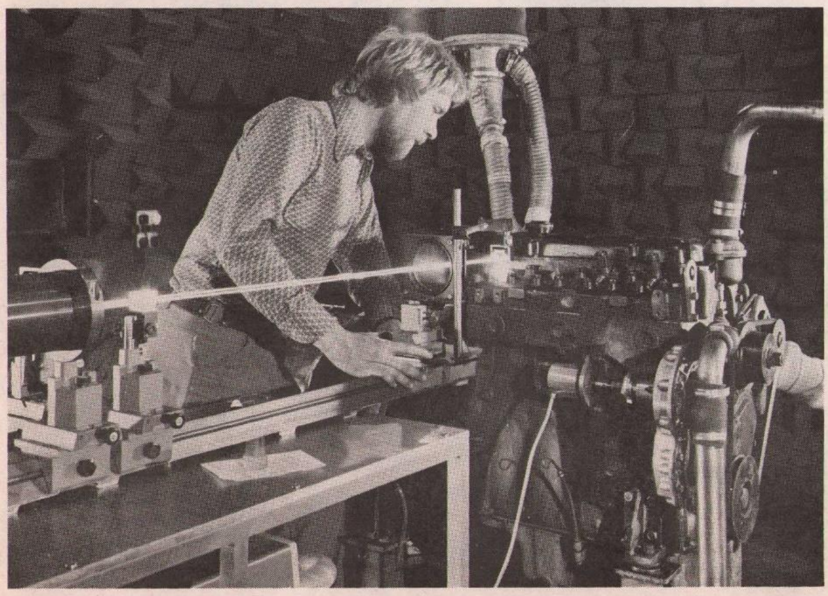
Wider horizons

Early 1974 marked the formation of the Department of Energy, with responsibility for the nation's electricity, coal, gas and petroleum policy, and for the UKAEA. The Department set up an Energy Technology Support Unit at Harwell to assess research needs in non-nuclear forms of energy. In the past decade, ETSU has coordinated an exciting UK research programme on renewable energy sources – wave, wind, solar, tidal, geothermal etc – and its latest report appeared recently. ETSU has also been responsible for coordinating the Department's energy efficiency (conservation) programme and has had particular success with the Demonstration Projects scheme. Here a particular industrial firm collaborates on a relevant energy-saving investment, the results of which are measured and brought to the attention of other firms. It has been shown that whereas renewable energy sources could make a small contribution to our energy requirements in the longer term, energy efficiency can make greater contributions within a few years.

Today rather less than half of Harwell's professional staff are employed on Atomic Energy Vote funded work directly related to the UK nuclear power programme. Government funding for specific programmes (both nuclear and non-nuclear) also comes from the Departments of Energy, the Environment, and Trade and Industry (Requirements Boards). Since 1983, the CEGB has been funding some of the nuclear power programme, and British Nuclear Fuels has been a major customer for research into fuel fabrication, reprocessing and waste disposal since it was set up in 1971. Harwell's PLUTO and DIDO reactors are the main producers of radioisotopes for Amersham International (formerly the Radiochemical Centre and 'hived off' from the UKAEA in 1971).

The scope of the non-nuclear programme is too great to cover in this article but two points deserve a mention. First, with the increasing cost of scientific research, many industrial organisations are forming 'clubs' for the joint funding of programmes. There are over 20 such clubs at Harwell. For example, the HTFS now has 160 members and the newly-formed Offshore Inspection R and D club has 15 members; other clubs cover such areas as gas sensors, mining

Figure 6 Adjusting the beam-steering optics on the Harwell laser–Doppler anemometer system, set up to measure gas motion in the cylinder of a motored engine



instrumentation, metal matrix composites, thermography and separation processes. Secondly, the maintenance of a broad underlying research programme is important to the continuing success of the laboratory and its commercial operations. For example, one of the important developments in ultrasonics in recent years has been the 'time of flight' technique for the detection of flaws in metals. Developed at Harwell from a supporting research programme, this has now become important in testing pressure vessel materials for the pressurised water reactor which the CEGB proposes to build, and it is also being adapted for the inspection of offshore structures.

At present, some 1200 contracts are negotiated each year with customers in the UK and overseas, and Harwell's contract research income outside the Atomic Energy Vote is now around £1m each week.

The future

In 1984 the Department of Energy carried out a review of the UKAEA, which by then had been in existence for 30 years. The recommendations, discussed and approved at senior level in government, were that the UKAEA should continue as a unit and not be privatised. It was envisaged that substantial government funding would continue, but that there would be further moves towards a commercial basis for all operations. From 1 April 1986, the whole of the UKAEA will operate as a Trading Fund – broadly equivalent to a limited company but with the Treasury as the sole shareholder. Financial targets will be set, and the UKAEA will be expected to provide a return to the taxpayer on the assets it employs, and to make profits. The UKAEA's plans, and the changes in its financial and organisational framework needed for the Trading Fund, are virtually complete. Harwell will continue as a major influence in nuclear research and in other work directly funded by the government, but the Trading Fund will provide further opportunities for the laboratory to develop its role as an international multi-disciplinary contract R and D organisation.

Over the past 40 years an RAF airfield has been transformed initially into an internationally known atomic research laboratory, which later broadened its research role for industry and government to become one of the world's largest contract R and D organisations. Harwell has achieved a unique position in its interaction with business, universities and government. John Cockcroft would have been well pleased ■

Further reading

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F J Stubbs is Head of the Public Relations Group, Harwell Laboratory