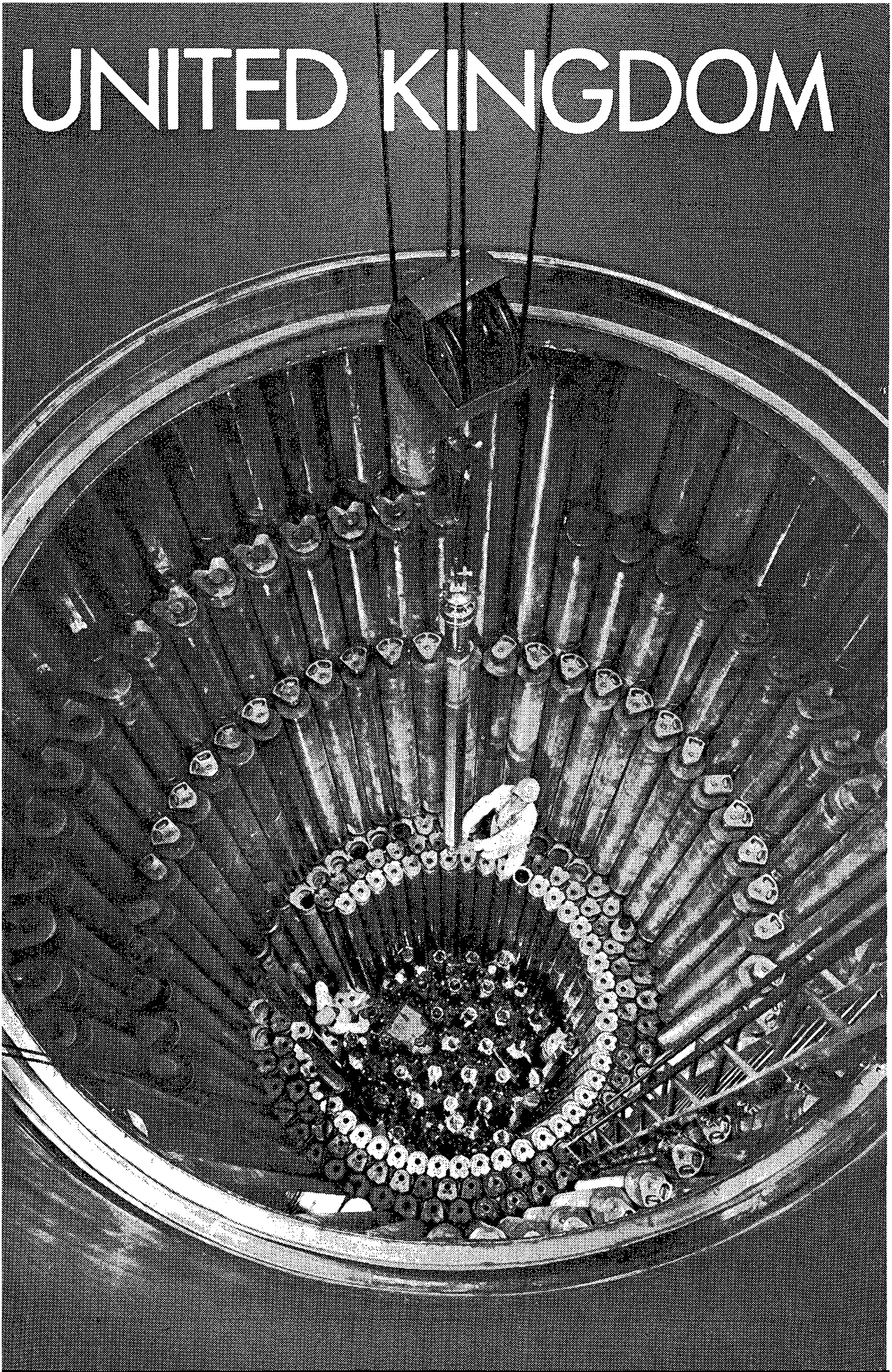
UNITED KINGDOM



A SURVEY OF NUCLEAR POWER IN THE UNITED KINGDOM

by Sir John Hill

"There is an increasing awareness to-day that the provisions of a source of energy which is cheap, clean and assured is essential to ensure steady controlled economic growth, with resources to spare to combat pollution. It is my belief that the generation of electricity from nuclear power is the source of energy most likely to fulfil this requirement. I hope to demonstrate this by looking not only at likely trends in the next twenty years, but also at the lessons to be learned from the United Kingdom's extensive experience in the nuclear field.

The United Kingdom has indeed been involved in the development of power from the atom from the very beginning. Many of the early scientific discoveries were made at Cambridge University. During the Second World War, British scientists collaborated closely with their American and Canadian colleagues and immediately after the war the British Government established an atomic energy project within the U.K. The first British reactors, GLEEP and BEPO, were built at Harwell, GLEEP becoming operational over 25 years ago on August 15th 1947. The possibility of using the heat from a nuclear reactor to replace the boiler in a conventional electricity generating station was realised at an equally early date and, at a conference held at Harwell in September 1950, it was decided that the idea was a feasible one, and a design team was established. It is almost 20 years ago that the British Government authorised the construction of a duel-purpose power and plutonium producing reactor at Calder Hall. The reactor, the first of eight of the same design, all of which are still operating, was the world's first regular power producing nuclear reactor and first fed power (about 35 MW) to the national grid on 17th October 1956.

It was over then years ago that the first of a number of nuclear power stations, based on the Calder Hall design and experience, began to operate. This programme of Magnox nuclear power stations, set out in Government policy papers in 1955 and 1960, was completed with the coming on-load of the 1180 MW(E) station at Wylfa in 1971, bringing the installed capacity of the nine nuclear stations to some 5000 MW(E). A second nuclear power programme initiated in 1964 involved the construction of five Advanced Gas-cooled Reactor stations, each of two reactors, representing an additional installed capacity of 6200 MW(E): all five stations should be completed by 1976.

Looking ahead

"In looking ahead twenty years, what lessons can be drawn from our experience of the past twenty years?

Perhaps the most important lesson is not to over-estimate the speed at which development can take place in an industrial context. Many problems take a long time to become apparent and some take even longer to overcome. The concept of having four or five separate design and construction organisations in a country the size of the United Kingdom was clearly wrong. It resulted in too many different designs, too many teething troubles, and more delays in construction and increases in building costs than were necessary.

However, the performance and reliability of these stations has been very satisfactory and, in spite of some setbacks, substantial benefits have been obtained from our early development of nuclear power. The Magnox stations are easy to operate, safe and very dependable — facts emphasised by the high load factors achieved. This feature of high availability is reflected in production costs. Figures issued earlier this year for electricity generated during 1971

The prototype fast reactor, Dounreay, Scotland,
showing the core tank from above with a dummy fuel sub-assembly being lowered into position.

showed nuclear stations in first and second place in the table of low production costs. Other Magnox stations have base load generating costs comparable with contemporary coal-fired stations away from the coalfield.

The Advanced Gas-cooled Reactors now under construction have, like most large power stations round the world, experienced delays in construction, but with their higher temperatures and improved fuel, hold out the promise of generating costs competitive with those of the best contemporary fossil-fired stations.

The British reactor construction industry has undoubtedly suffered from its fragmentation and the resulting uneven load placed on individual companies by the variations in the reactor ordering programme. The British nuclear fuel industry has similarly been affected by fluctuating demand but, because of the continuing demand for replacement fuel and the steps taken to secure overseas business and develop international collaborative arrangements, to a much lesser extent. Nuclear fuel services, formerly the responsibility of the Atomic Energy Authority's Production Group and now of British Nuclear Fuels Limited, have built up to an annual business of £55M., on which a trading profit of £7½M. was earned in 1971/72, and the wide experience gained over many years and the substantial improvements made in the manufacturing plants give good prospects for the future.

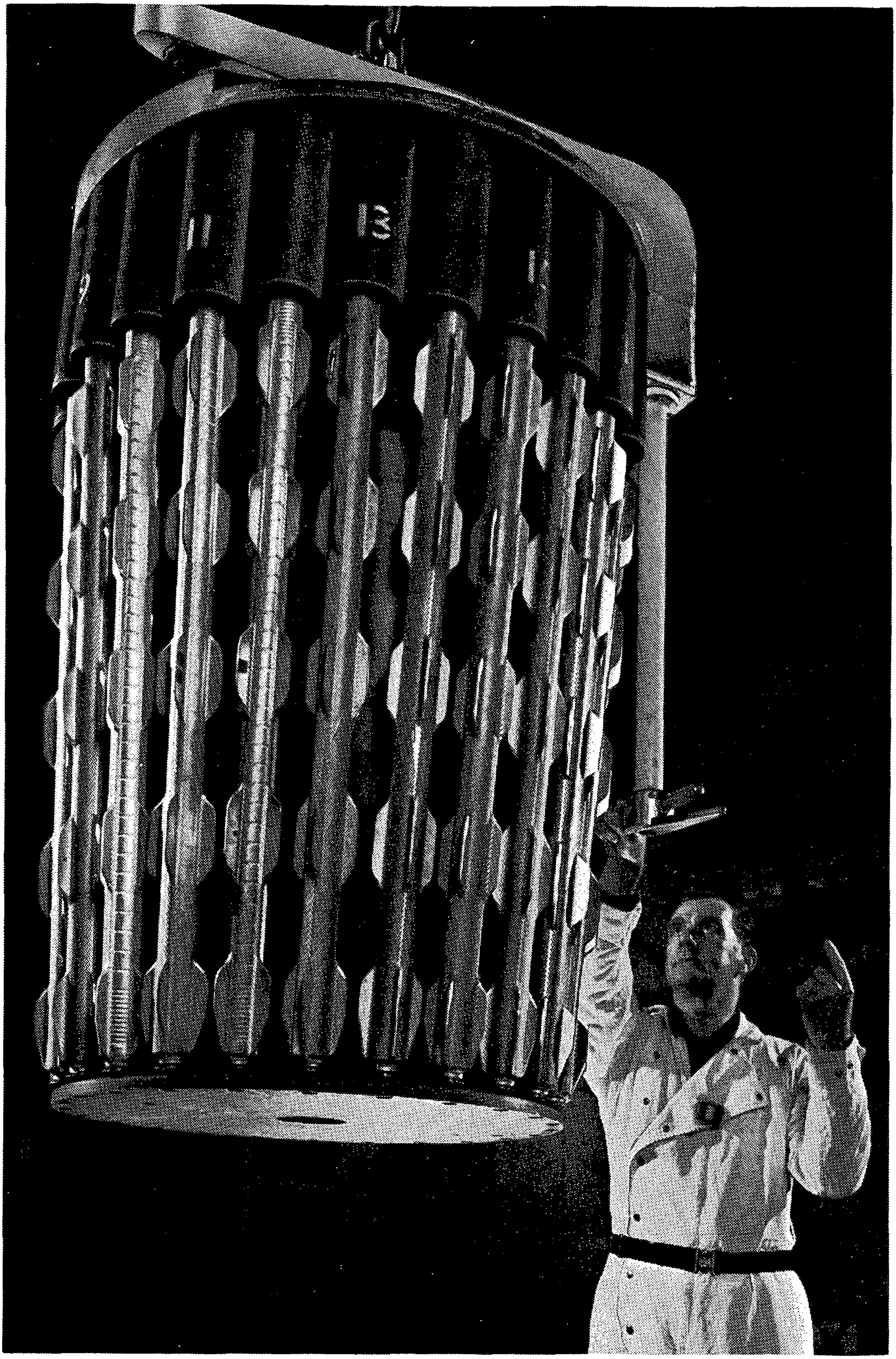
As we have learnt from past experience, the forecasting of electricity demand over a period as long as twenty years is always a difficult and uncertain task, especially at a time when the rate of increase in electricity consumption in the U.K. has been unusually low. However, it seems probable that the growth rate in electricity consumption will return in due course to the higher levels achieved in the past. Bearing this in mind, it seems likely that electricity consumption in the U.K. may well treble over the next twenty years. To meet such a demand would require a corresponding increase in total generating capacity from the present figure of about 62 GW.

Most electricity in the United Kingdom is currently generated from fossil fuel plants but nuclear stations are now contributing over 10% of the total. This balance is expected to change radically over the next twenty years as the growing demand for energy exerts pressures on the world's resources of economically exploitable oil and gas. The advances already achieved and in prospect for nuclear power make this the most economic way of meeting the bulk of the world's growing demands for electricity. It seems quite possible, for example, that economic factors will, by about 1980, suggest that between two-thirds and three-quarters of the new generating capacity ordered in the U.K. should be nuclear. On this basis, and if the rate of growth of electricity demand reverts to more normal levels, we might expect a total nuclear installed capacity of some 80 GW in twenty years' time, roughly equal at that time to the amount of fossil-fired plant also in operation.

Looking to this longer term, attention is concentrated in the U.K. as elsewhere on the sodium-cooled fast breeder reactor. This is not to deny the importance in the shorter term of reaching correct decisions on the development and installation of thermal reactors. This is a matter to which we in the U.K. are currently devoting particular attention, not least in view of the need to reach decisions consistent with our longer term objectives of international collaboration and early exploitation of the fast reactor.

A study is being undertaken on possible improvements to the Advanced Gas-cooled Reactor to assess the prospects for further development and improvement of this reactor system. The High Temperature Reactor (H.T.R.) is also on the scene as a further development in gas-cooled reactors. The international "Dragon" reactor at Winfrith has provided valuable experience in this field and the scope for international collaborative development is being further explored. We are also studying various types of water reactors, both the B.W.R. and P.W.R. and also the pressure tube version of the B.W.R. – the steam generating heavy water reactor. Our 100 MW(E) prototype at Winfrith has performed very well over the last four years and is a

Her Majesty Queen Elizabeth of England on October 17, 1956, opening the world's first full sized atomic power station at Calder Hall.



Herringbone type fuel elements being loaded into a fuel basket on the charge floor at Calder Hall.

particularly versatile reactor type. It is therefore difficult to forecast the precise nature of the developments over the next few years.

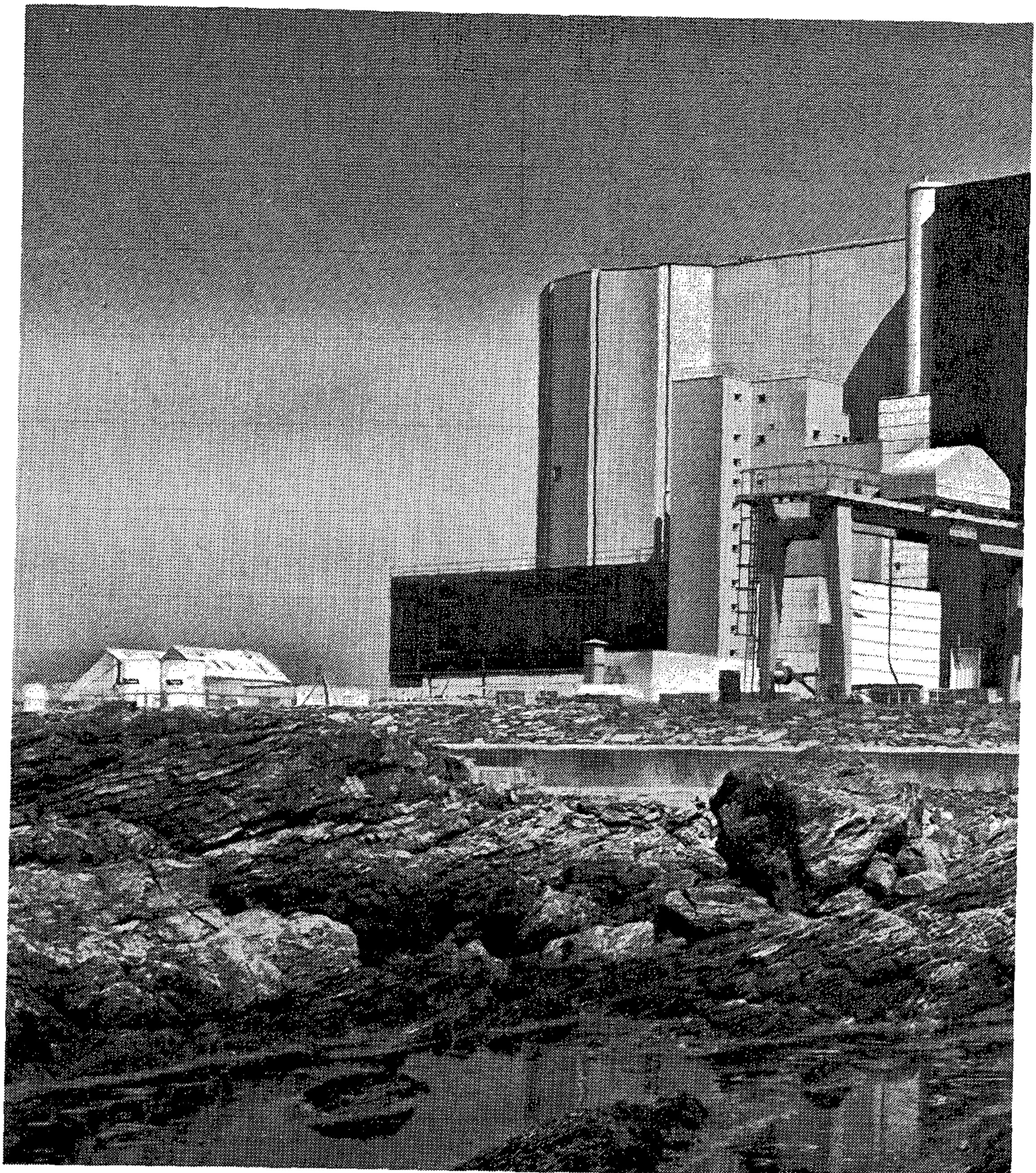
Fast reactor

"But let us turn again to the fast reactor as the system most likely to be of major importance in the long run. Our interest in this system has been a long one. It is indeed now some twenty years since the first U.K. zero energy fast reactor was built at Harwell. This was ZEPHYR, fuelled with plutonium, which demonstrated the feasibility of breeding and the potentiality of the system. Not long after ZEPHYR was built, the decision was taken to build an experimental fast reactor at Dounreay, in the North of Scotland. This Dounreay Fast Reactor, the world's first fast reactor supplying electricity for general public use, began operations in November 1959 and has operated at its full design power of 60 MW(H) since 1963. Its main function has been to provide operating experience of a liquid-metal cooled fast reactor, and as an invaluable materials – and primarily fuel – testing facility; during its ten years operation about a thousand nuclear experiments have been carried out, including a number for overseas customers, and over 430 million kWh of electricity have been generated. Experience with the Dounreay Fast Reactor was very encouraging and in 1966, also at Dounreay, work began on the 250 MW(E) Prototype Fast Reactor (P.F.R.). Work is now well advanced and P.F.R. will start its commissioning programme early in 1973. Allowing sufficient time for testing and establishing operating experience we would hope that the Central Electricity Generating Borad would be able to place their first order for a large, probably 1300 MW(E). Commercial Fast Reactor (C.F.R.) in 1976 for completion by 1980-81. The fuel for the P.F.R. is currently being fabricated by B.N.F.L. at their Windscale factory, thereby giving the company valuable experience in the preparation and fabrication of plutonium bearing fuel.

"By comparison with the rate at which U.K. gas-cooled reactor technology has been exploited for the commercial production of electricity, the rate of exploitation of the fast reactor may appear slow: the decisions to build Calder Hall and the Dounreay experimental fast reactor were made within about a year of each other. The change of pace reflects, however, both the difference in technologies involved and the more systematic approach we have evolved since those early days. However, in spite of our much more cautions approach, the encouraging results of our development programme on the fast reactor have convinced the Government, the electricity authorities, as well as ourselves in the Atomic Energy Authority, of the need to develop the fast reactor as rapidly as sensible evolution permits be able to supply the bulk of the country's base load electrical requirements in the future. By the mid-1980s fast reactors may well make up the major part of nuclear plant orders and within twenty years the fast reactor should be contributing significantly towards satisfying electricity demands in the United Kingdom. On a world basis, I believe, the fast reactor programme will reasonably soon ease pressures on uranium supplies and carry one stage further the freeing of electricity from the economic limitations arising from dependence on fossil fuels.

Fusion

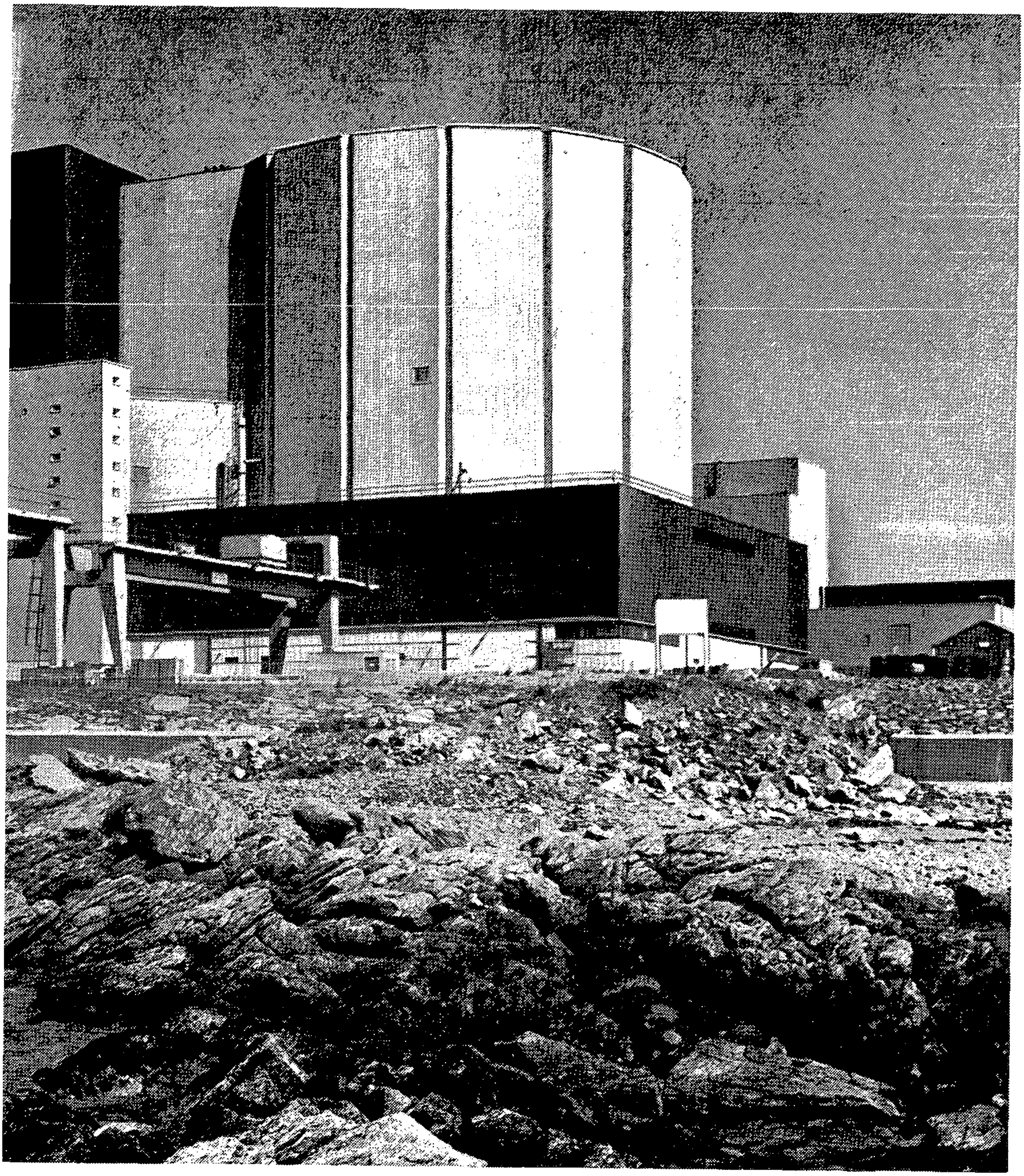
"One further prospective source of nuclear power remains to be examined: fusion. Work in this area is, of course, still very much at the stage of assessing scientific and technological feasibility, although all those involved feel sure that it will be possible to build a controlled thermonuclear reactor eventually. International co-operation has greatly assisted progress in the fusion field during the past decade. It is most desirable that this collaboration should be continued in the future. The development of fusion to the commercial and industrial phase will be very expensive. However, given such a united effort, and a sufficient level of financial support, it seems reasonable to predict that within about twenty years the design of a



Wylfa Nuclear Power Station, Angelsey, North Wales, built by British Nuclear Design and

prototype, power-producing fusion reactor could be under way. This would lead in due course to the construction of large fusion reactors offering a source of energy based upon the potentially vast fuel reserves of deuterium and lithium.

However, returning to the more immediate subject of the fission process, the disposal of radioactive waste is going to require a substantial effort in view of the number of nuclear power stations under construction and envisaged. Highly active liquid wastes have been stored with complete safety for over fifteen years in the U.K. and elsewhere, and a number of processes



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are under investigation to reduce the problem in the long term. These include recycling, volume reduction, and, in particular, putting the waste into a solid form thereby making it easier to handle and considerably reducing the possibility of accidental release to the environment. As for other hazards, a great deal of attention is already devoted to safety standards.

In conclusion, nuclear power in 1990 should be not only cheap but clean. It will provide the large amounts of energy required in a way acceptable to the environment. It will do this at a time when fossil fuels, particularly oil and gas, will be increasingly scarce and expensive."

AN IAEA SERVICE:

FILM LENDING LIBRARY

Four new films have been received in the past two months, to add to the IAEA's extensive film lending library.

During the year, the library sent out more than a thousand films. They are available on free loan for educational, non-commercial, non-profit showings only.

The library, housed in the Agency's headquarters in Vienna, has 800 copies of films in many languages, which can be ordered from a catalogue appearing annually.

The following proved the most popular in 1972:
Basic Principles of Power Reactors (IAEA-150), Principles of Thermal, Fast and Breeder Reactors (IAEA-235), The Nuclear Challenge (IAEA-403), "A" is for Atom (IAEA-466), A Nuclear Explosion puts out a Gas Well Blaze (IAEA-508) and Underground Nuclear Explosion Excavates Artificial Lakes (IAEA-509).

Details of the new films, which will not appear in the catalogue until its 1973 printing, are:

IAEA-552 YOUR PLACE IN THE NUCLEAR AGE

USA. English, 26 Minutes, Colour, 1969

Gives the student a picture of the professional environment in which he would be working if he chose a career in nuclear science or engineering. The employment areas cover basic and applied research in commercial nuclear industries, in colleges and universities, and in contractor's laboratories of Atomic Energy Commissions.

IAEA-553 SPIRES/BALLOTS REPORT

USA. English, 15 Minutes, Colour, 1970

Describes in a non-technical manner how computers are being used to control the growing mass of library materials and the rapidly increasing costs of manual processing systems. Project SPIRES (Stanford Public Information Retrieval System) and Project BALLOTS (Bibliographic Automation of Large Library Operations Using a Time-Sharing System) are significant because they show promise of revolutionizing library use.

IAEA-554 A SUPERCONDUCTING MAGNET FOR FUSION RESEARCH

USA. English, 22 Minutes, Colour, 1971

Describes the general concept of the Baseball II neutral beam injection experiment, the winding and installations of the 13 ton superconducting magnet system, and the initial testing of the new fusion research facility at the Lawrence Livermore Laboratory of the University of California. This huge liquid helium-cooled magnet operates at cryogenic temperatures and is capable of containing dense gases whose temperature reaches 300 000 000 degrees centigrade.

IAEA-555 TRANSPORTATION OF RADIOACTIVE MATERIALS
PART II. ACCIDENTS

USA. English, 34½ minutes, B/W, 1965

With liberal use of charts, pictures, actual packages, and off-screen film footage, transportation accidents involving radioactive materials are discussed. It is shown that only a small proportion of shipments of radioactive materials present real danger in the event of accident. Included are problems related to radioactive material becoming airborne in an accident, the degree of hazard, radioactive contamination, precautions to be taken and the availability of radiological assistance.

Postage and handling charges are not made if the films can be forwarded by the Missions of Member States. All other requests will be charged a postage and handling fee of $10 per film. Return postage, shipment by airfreight, has to be paid by the borrower.

Both the Catalogue and films can be obtained from:

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