ATOM 1958

An illustrated summary of the Fourth Annual Report of the

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

1st April 1957 to 31st March 1958

Price 1s. 6d. net

More Power from the Atom

In the commercial power stations now being built in Britain, one ton of uranium should do the work of 10,000 tons of coal. Sir John Cockcroft has forecast that we may eventually—some years hence—expect to make a ton of the metal do the work of 1,000,000 tons of coal.

During 1957–8 appraisal of a variety of possible reactors has made it possible for the Authority to discern the lines along which advances are most likely to be made during the next 20 years. Knowledge is growing so rapidly, however, that no firm long-term programme could or should be formulated.

During the 1960's a primary objective will be to realise the full potentialities of the GAS-COOLED GRAPHITE-MODERATED REACTOR. Experience with Calder Hall and the advances in design of the commercial nuclear power stations of the Calder Hall type show that this successful system is capable of still further development.

After 1965 new power stations should benefit from information yielded by the ADVANCED GAS-COOLED REACTOR. (Work on this reactor is beginning in 1958. It should be in operation by 1961.)

For the late 1960's a possible alternative is a GAS-COOLED HEAVY-WATER-MODERATED REACTOR. The engineering aspects of such a reactor are being studied.

By the 1970's work on a FAST-BREEDER REACTOR system may have reached a stage at which commercial power stations of this type can be built.

Another possibility for the 1970's is the HIGH-TEMPERATURE GAS-COOLED REACTOR. A large-scale experiment for the study of this system is being built at Winfrith Heath in Dorset. (It should be in operation during 1959.)

Research with ZETA and other apparatus on the control of THERMONUCLEAR REACTIONS has made good progress. But it is impossible yet to forecast when a contribution to power supplies from this source can be expected.

CALDER HALL: The Starting Point

The 'parent' of Britain's first 'family' of commercial nuclear power stations is Calder Hall.

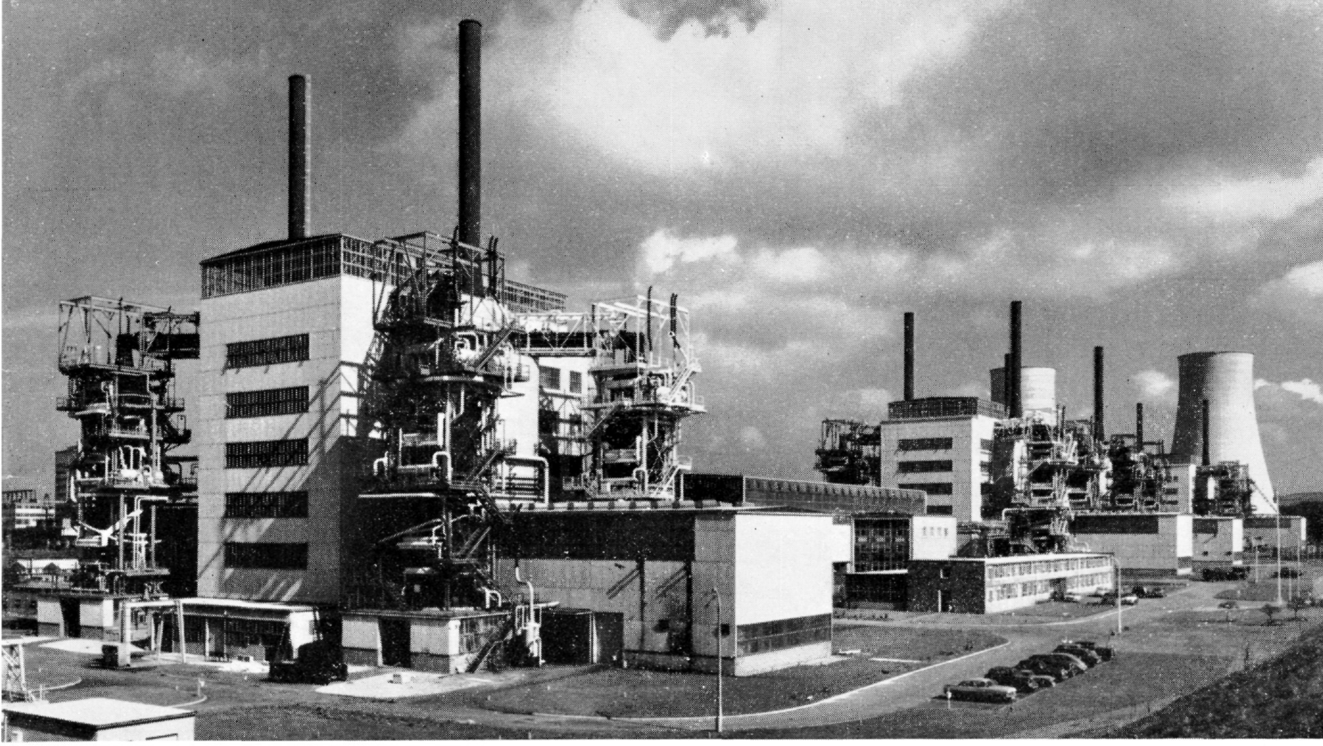
There will eventually be four graphite-moderated gas-cooled reactors at Calder Hall. Two of them were generating electricity during the period between April 1957 and March 1958. In that time they supplied 438,797,000 units of electricity to the national grid. The third reactor went into operation in March 1958 and construction of the fourth was virtually complete.

Technical adjustments to the first reactor (in August 1957) raised its heat output from 180 megawatts to 200 megawatts with a consequent increase in its power output from 42 to 45 megawatts.

No. 2 Reactor operated at the designed power of 42 megawatts from April 1957.

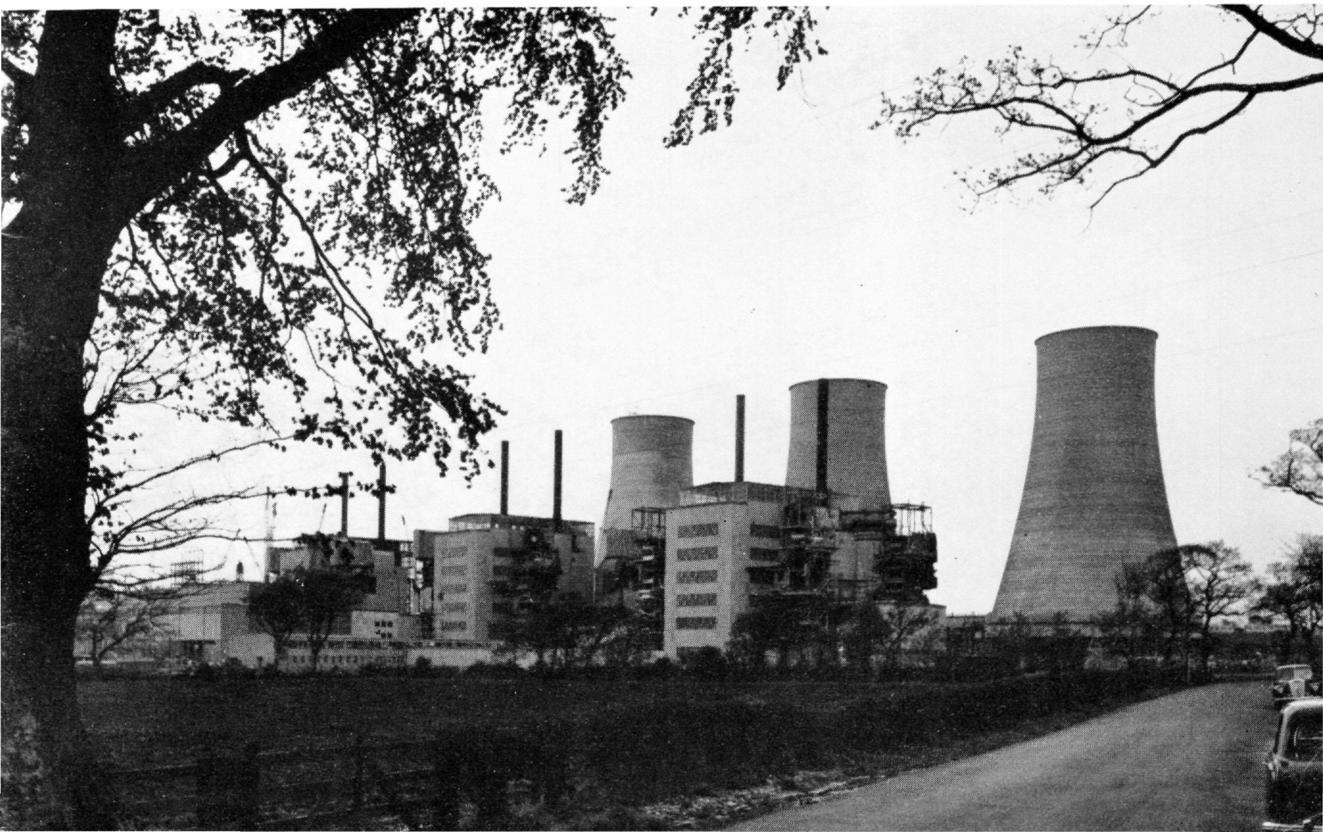
Four more reactors, exactly like those at Calder Hall, are being built at Chapel Cross in Dumfriesshire. By April 1958 the first reactor was reaching the final stages of its mechanical and electrical installations. Work was well advanced on the second reactor and proceeding on the third and fourth.

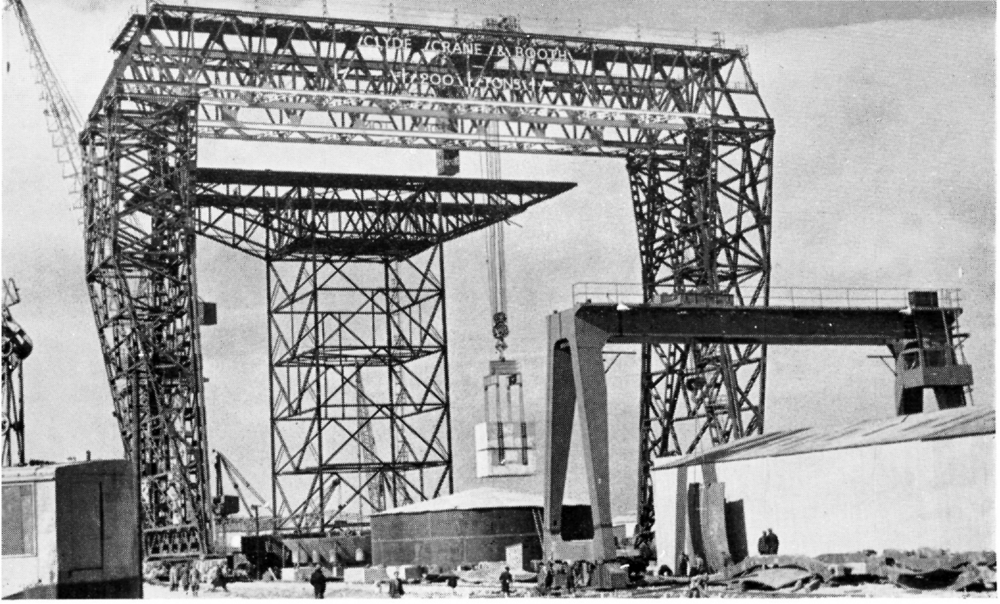
All eight of these reactors are being or will be operated by the United Kingdom Atomic Energy Authority.



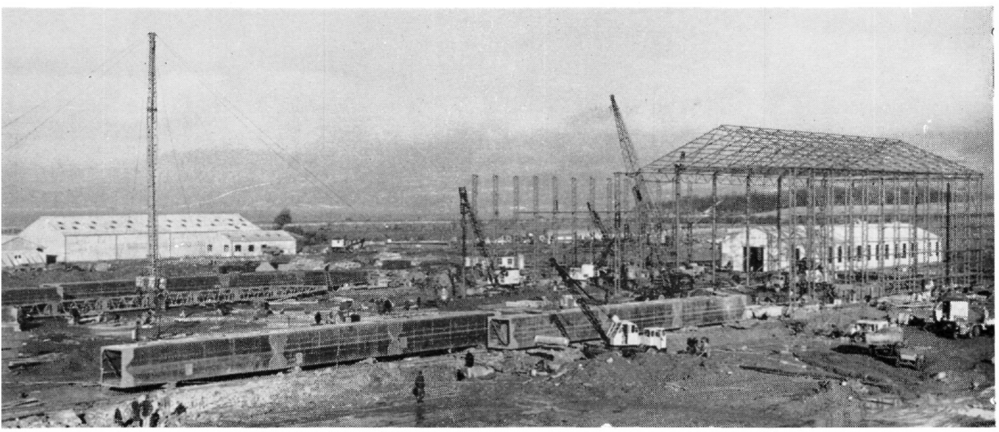
Calder Hall, showing 'A' and 'B' stations, the latter nearing completion.

Chapel Cross, near Annan, Scotland, with the first reactor almost completed.

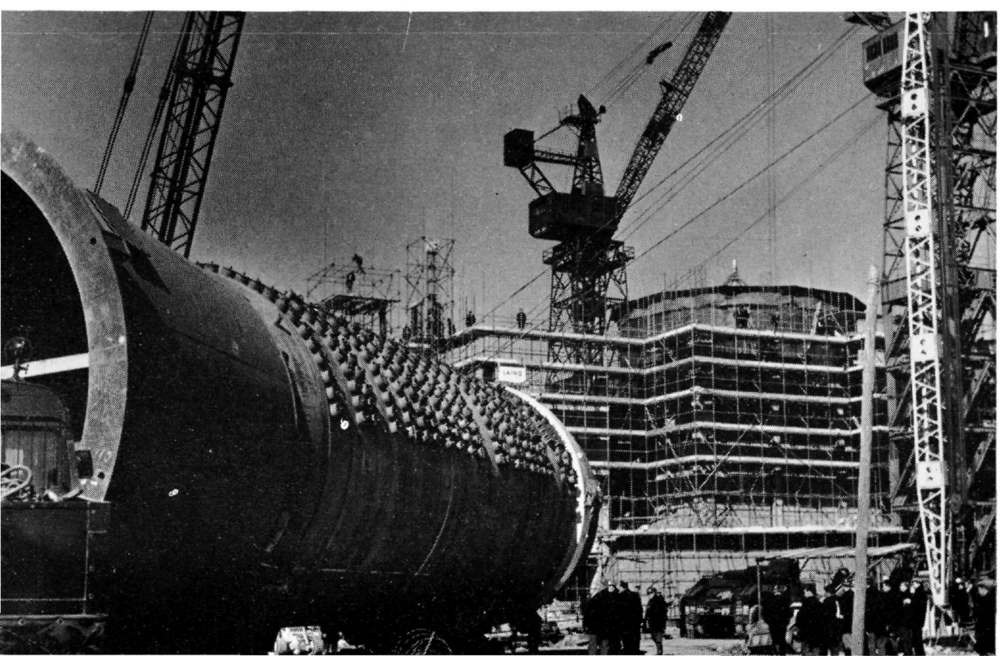




Work in progress on the site of Bradwell nuclear power station, Essex, under construction by the Nuclear Power Plant Co. Ltd.



Hunterston nuclear power station, under construction by the G.E.C.-Simon Carves Atomic Energy Group.



The site of Berkeley nuclear power station, Gloucestershire, now being built by A.E.I.-John Thompson Nuclear Energy Co. Ltd. In the background is reactor No. 1 in course of construction.

Progress of the Power Programme

The construction by industry of four nuclear power stations (developments of the Calder Hall type) is under way. Three of these are being built for the Central Electricity Generating Board and one for the South of Scotland Electricity Board.*

It is clear that these stations will be of substantially greater capacity than was assumed when Her Majesty's Government published the *Programme of Nuclear Power* in February 1955.

At that time it was envisaged that the first commercial stations would be of 100–150 megawatt capacities. The designed capacities of the first four stations will, in fact, be as follows:—

Berkeley, Gloucestershire ...	275 MW.
Bradwell, Essex	300 MW.
Hinkley Point, Somerset ...	500 MW.
Hunterston, Scotland ...	320 MW.

The original intention (in 1955) was to provide 1,500–2,000 megawatts of nuclear generating capacity by 1965. In April 1957 it was decided to raise the 1965 target to 5,000–6,000 megawatts, but in October of that year—as part of the Government's review of capital expenditure—it was decided to extend this first phase of the programme to the end of 1966. In other words, three times the original ten-year programme is now to be carried out in eleven years.

A substantial amount of the United Kingdom Atomic Energy Authority's research and development effort is devoted to work directly in aid of the civil nuclear power programme.

For example, although the behaviour of the Calder Hall fuel elements† has been exceptionally favourable, work is going on to increase reliability still further. Another object is to cheapen the manufacturing process.

Trials are being carried out in the Calder Hall reactors to study the effects of the higher 'burn up' of nuclear fuel demanded by the commercial power reactors. So far, these have been made with modified Calder Hall fuel elements, but prototypes of the commercial power reactor fuel elements will also be tested at Calder Hall.

Samples of steel have also been put inside the Calder Hall reactors to see how they behave under irradiation. Irradiation can have an adverse effect on steel and the object of the research is to develop new steels with an increased capacity to withstand it.

* It is also planned to build a nuclear power station of 400–500 megawatts capacity at Trawsfynydd, a lakeside site in North Wales. It is hoped to operate this station in association with a pumped storage hydro-electric plant. The latter—the largest in the world—is under construction some five miles north of the Trawsfynydd site.

† A 'fuel element' is the form in which fuel is inserted into a nuclear reactor. In the case of Calder Hall type reactors it is a cylindrical rod of uranium sealed into a container or 'can' of magnesium alloy. In other types of reactor it can take other forms.

Construction work at Hinkley Point nuclear power station, Somerset, under construction by English Electric-Babcock & Wilcox-Taylor Woodrow Atomic Power Group.

NUCLEAR POWER:

A primary objective of the Authority during the 1960's will be to realise the maximum development potentialities of the gas-cooled graphite-moderated reactor. Experience in the operation of the Calder Hall reactors and the advances marked by the designs of successive commercial power stations have shown that this successful system is capable of still further development.

Development of this type of reactor is being carried on by industry but the use of nuclear fuel in the form of uranium rods in magnesium cans imposes definite limits on the temperature at which this type of reactor can operate.

Advanced Gas-Cooled Reactor (A.G.R.)

Higher temperatures are needed to obtain a further large increase in efficiency.

To achieve these a new kind of 'fuel element' is needed. The higher temperatures can be achieved by replacing the uranium metal rod with a 'ceramic compound' (e.g. uranium oxide—a powder—heated and compressed) and replacing magnesium as the canning material with some other metal, such as beryllium.

This represents such a major change in design that it is considered desirable to develop the new technologies involved by building a prototype reactor.

Planning of this project began in September 1957. It is proposed to site the reactor at one of the Authority's existing establishments and work is expected to start in the third quarter of 1958. The reactor should be in operation by mid-1961.

The present intention is to use beryllium-clad uranium oxide as fuel but the reactor will be designed in such a way that alternative forms of fuel can be tested on a large scale.

The objective in the design, construction and operation of a carbon dioxide-cooled graphite-moderated reactor experiment operating at a temperature intermediate between the improved Calder Hall type of reactor (like those now being built for the nuclear power programme) and the high-temperature gas-cooled reactor system (see below).

Information from the A.G.R. prototype will become available for use in the design of commercial power stations within a few years and those commissioned after 1965 should benefit by it.

This reactor system might, in a scaled-down version, be suitable for merchant ship propulsion.

Gas-Cooled Heavy-Water-Moderated Reactor

Like any other reactor system, the advanced gas-cooled reactor will present many new design and development problems.

It would be imprudent to base a future programme entirely on the assumption that all the desired improvements will in fact be realised at an economic cost.

Accordingly the Authority have continued to study other reactor systems which might be employed in commercial power stations by the mid-1960's, should progress along the 'Calder Hall route' be less rapid than expected.

The best alternative system may well be a gas-cooled reactor using heavy water instead of graphite as a 'moderator' (a moderator is a substance used to facilitate a chain reaction by slowing down the neutrons which are given off when the nucleus of an atom is split). This conclusion has been reached in the course of studies for small land-based power stations and for ship propulsion.

Fast-Breeder Reactor

The Calder Hall type of reactor produces not only electricity but plutonium, a very rich nuclear fuel. One way of using plutonium produced in the commercial power stations will be to use it as fuel in a 'fast-breeder reactor'. Such a reactor is nearing completion at Dounreay in Scotland. It is called a 'breeder' because, apart from producing heat for conversion into electricity, it should 'breed' more nuclear fuel than it consumes.

By the 1970's work on a fast-breeder system may have reached a stage at which commercial power stations of this type can be built.

All the civil engineering work and major mechanical construction in the fast-breeder reactor building at Dounreay was completed by March 1958. The steel sphere, 135 feet in diameter, had been successfully pressure-tested.

The scheduled date for this reactor to come into operation was April 1958, but this was postponed for several months in view of a recommendation by the

1965—1980?

Fleck Committee on the Organisation of the Industrial Group. The Fleck Committee recommended that the staffing of existing production facilities should be strengthened, if necessary at the cost of concentrating the Authority's future development programme on fewer projects.

As the fast reactor is a relatively long-term project its priority is lower than those more immediately concerned with the nuclear power programme.

High-Temperature Gas-Cooled Reactor

Another system for possible use in the 1970's is the high-temperature gas-cooled reactor.

This project has several possible variants. Either graphite or beryllia could be used as moderator and there is also a choice of gases for cooling.

This reactor would be suitable for operation with a uranium-233/thorium fuel cycle (i.e. uranium-233 producing heat *and* transmuting thorium into a fresh supply of uranium-233 fuel).

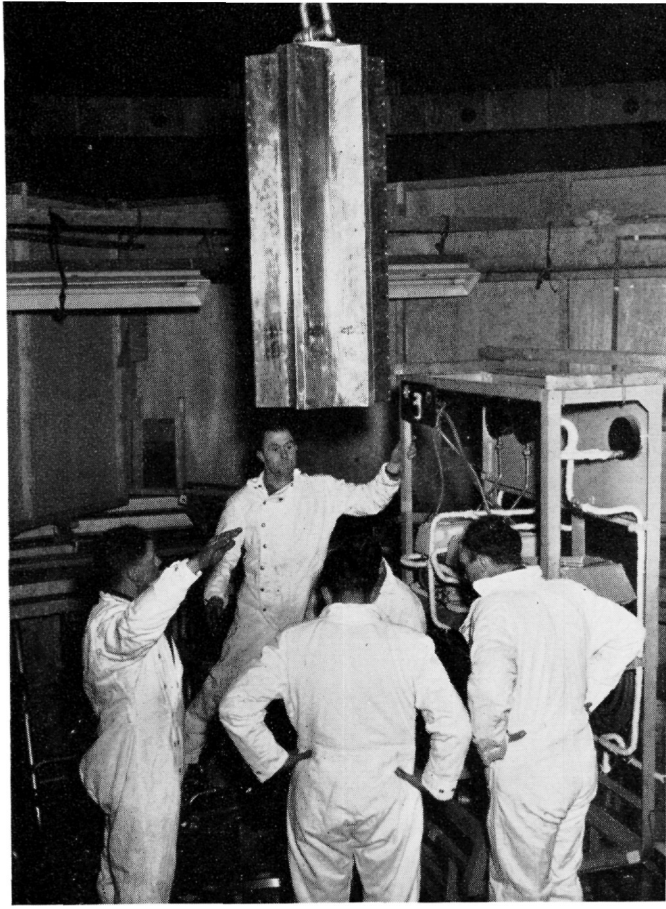
Because the principles involved in the new system depart radically from those of previous designs, it will be necessary to test them in a reactor experiment before building a prototype power-producing reactor.

The research programme at Harwell for this reactor involves the placing of fuel samples in the reactors BEPO and DIDO; the study of the behaviour of fuel, moderator and coolant gas at various temperatures in the reactor PLUTO.

To study the neutron-physics of the system a high-temperature zero-energy system is being built at Winfrith Heath in Dorset. This should be in operation by the summer of 1959. The core of this assembly may be raised to a temperature of 800°–900° C. by circulating electrically heated nitrogen through it.

Merchant Ship Propulsion

An Admiralty Committee, on which the Authority are represented, has been set up to determine a reactor system which would show a prospect of



Above: A section of the inner core of the fast reactor at Dounreay is lowered into position.
Below: Examining irradiated metal samples in the high-activity handling building, A.E.R.E., Harwell, as part of research on future reactors.

being both efficient *and economic* for marine propulsion.

One conclusion from their studies is that a scaled-down version of the present Calder Hall type of reactor would not be suitable for marine propulsion except in very large vessels.

Not enough is yet known of this type of reactor for it to be prudent to proceed direct to its installation in a ship and experience of the prototype advanced gas-cooled reactor will be used to provide information for a propulsion reactor.

Other systems being studied for this purpose are a gas-cooled heavy-water-moderated reactor, a pressurised water system, and an organic-liquid-moderated system.

Export Reactors

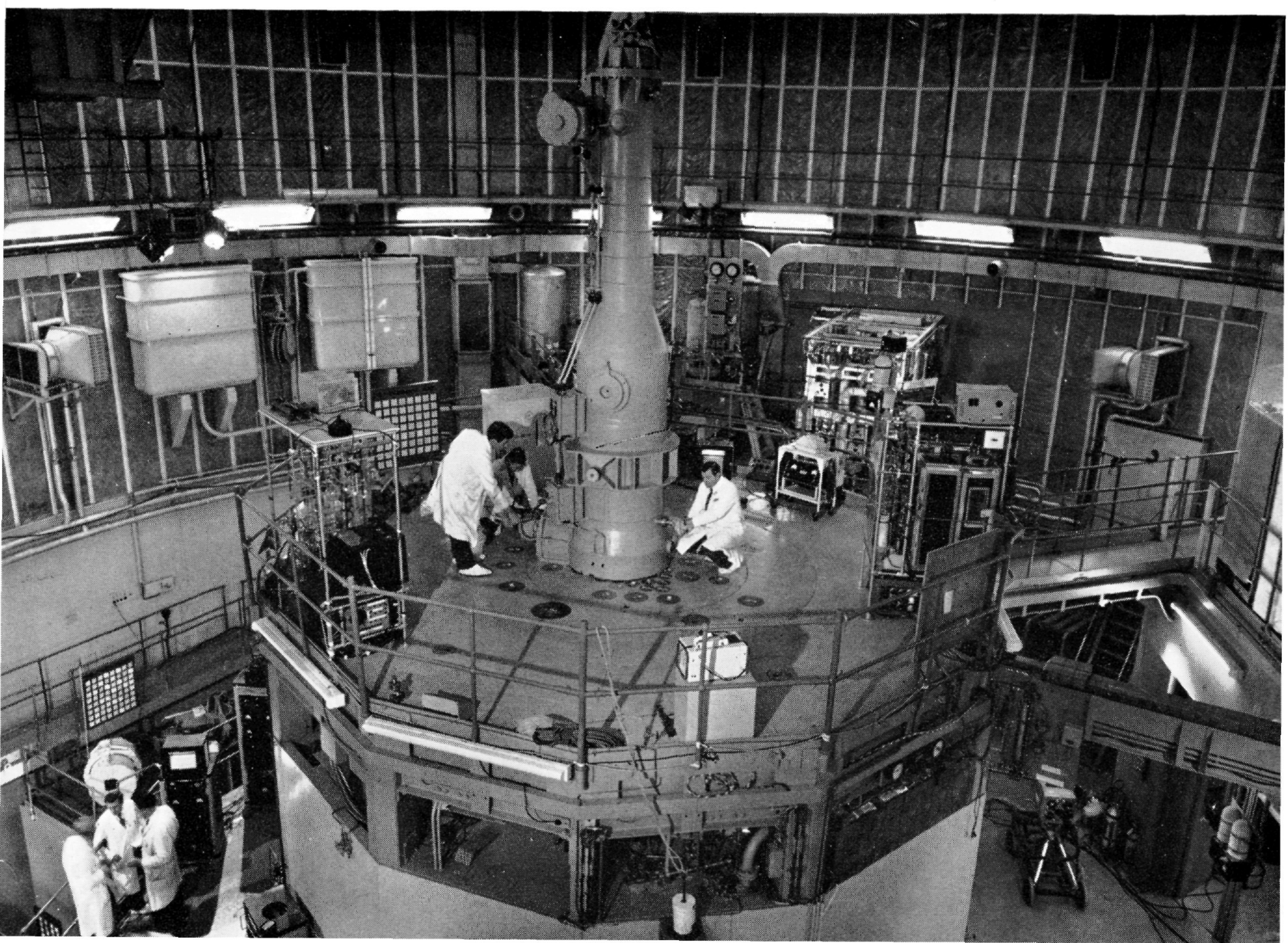
Because of the large electrical output of the reactors being built by British industry in the United Kingdom, the main overseas markets are likely to be initially in the larger industrial countries.

Research Reactors

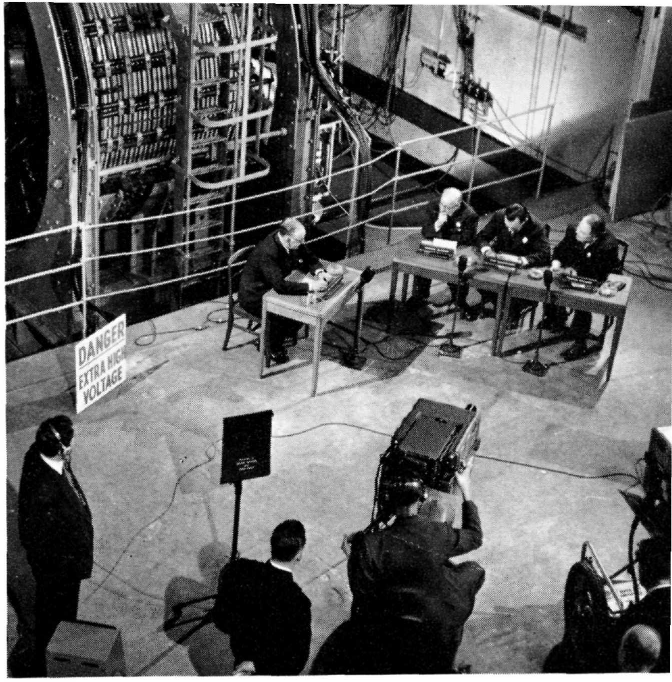
Mention has been made above of the research reactors BEPO, DIDO and PLUTO. These and other reactors (a full list is given on page 23) play an important part in the study of fuels and other materials needed for the construction and operation of commercial power reactors.

PLUTO came into operation in October 1957. A reactor practically identical with PLUTO—known as D.M.T.R. or Dounreay Materials Testing Reactor—is now operating at Dounreay. NEPTUNE, designed to study the physics of water-moderated reactors, came into operation at Harwell in November 1957. A light-water-moderated research reactor, HERALD, is being constructed at Aldermaston.

The DIDO research reactor at Harwell.



Is a FUSION REACTOR possible?



ZETA. Sir John Cockcroft talks to U.S. and British journalists during a television programme.

All the power reactors or possible power reactors which have been described so far—including Calder Hall and the developments from it—are based on the fission (or splitting) of heavy atoms, such as those of uranium.

Another possible way of obtaining energy for electricity generation is by the fusion (or joining) of light atoms such as those of hydrogen.

It must, however, be fusion of a special kind.

For fusion to take place at all very fast moving atoms of deuterium (or heavy hydrogen) must collide with other deuterium atoms. But they may be speeded up in different ways.

A proportion of the atoms may be speeded up in one direction by electrical means. If one of these fast deuterium atoms collides with another stationary atom, fusion can take place. This is rather like a moving car hitting a parked car.

Or *all* the deuterium atoms may be speeded up by heating the gas to very high temperatures. The collision in this case is like that between *two* moving cars. This is 'thermonuclear fusion', i.e. the fusion of atoms speeded up by heat.

Although both kinds of fusion release the same amount of energy, only if 'thermonuclear fusion' is taking place can one be confident that further increases in temperature will cause the rapid increase in the rate of fusion that will be required to release useful amounts of energy.

The temperatures which the scientists are trying to achieve are many times those which occur at the centre of the sun (15 million degrees centigrade).

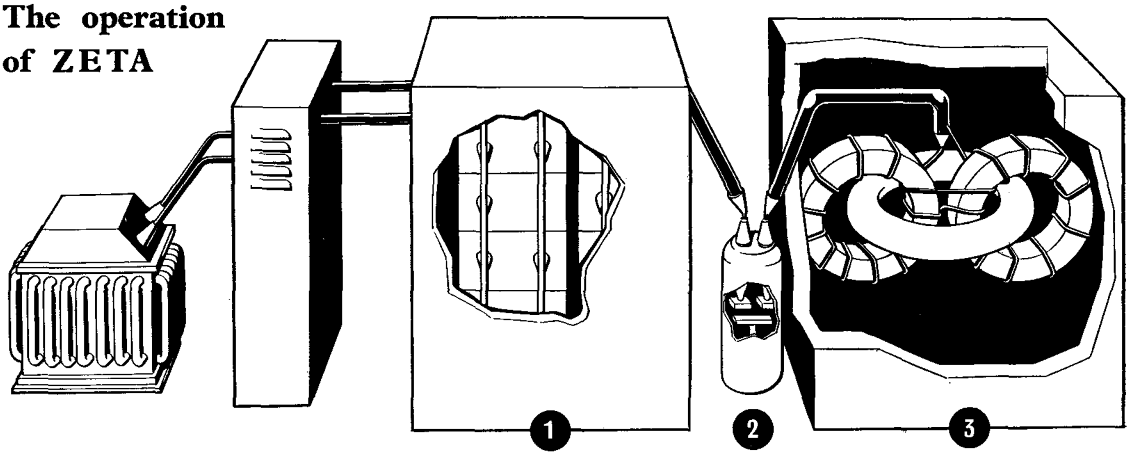
The first step on the way to this goal is to devise a method by which deuterium, in the form of a gas, can be raised to high temperatures and kept at those temperatures for an appreciable time inside a containing vessel.

The second step is to raise the deuterium to such a temperature that clear evidence of a thermonuclear reaction can be obtained. It is calculated that this temperature must be some millions of degrees centigrade. It is obviously essential that the hot gas must be kept away from the walls of the vessel in which it is contained. Otherwise heat would be lost and the walls of the vessel damaged.

The third step is to raise the temperature still further and for such a period of time that as much energy is created by fusion as is lost by radiation from the hot gas. This is usually called the 'break-even' point. It is calculated that the required temperature for this will be 300 million degrees if one uses deuterium and 50 million degrees if one uses a mixture of deuterium and tritium (another form of hydrogen). Theory indicates that these temperatures must be held for periods of about one second.

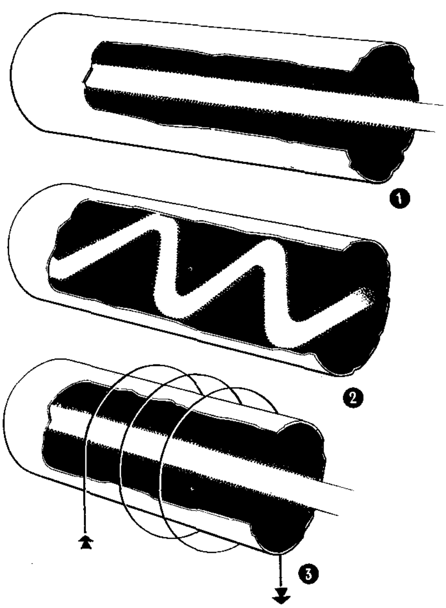
The fourth step is to carry the process beyond the

The operation of ZETA



1. *Condenser bank charges up to* 25 *Kv in* 10 *seconds, storing* 500,000 *joules energy;* 2. *Switch closes;* 3. *Condenser bank discharges its energy into transformer primary.*

Principal difficulty: the 'wriggle': 1. *Ideal case: current straight down axis;* 2. *Actual case: current wriggles violently;* 3. *Solution: stabilisation by axial magnetic field.*



'break even' point to a stage where there is a net gain of power. In other words, the energy obtained from fusion must be greater than the electrical energy put in to trigger off and maintain the process.

The fifth step is to build an economic electrical power station based on these results.

Investigations so far at the Atomic Energy Research Establishment, Harwell, the Atomic Weapons Research Establishment, Aldermaston, and Associated Electrical Industries Ltd., Aldermaston, have been concerned only with Steps 1 and 2.

One way of achieving the high temperatures desired is to pass a large electric current through the deuterium gas. This current sets up a discharge in the gas (something like that in a neon sign) and produces an intense magnetic field round the column of hot gas. This magnetic field 'pinches' the gas so that it moves inwards away from the walls of the vessel in which it is contained.

One form of apparatus used in this work is a 'torus', i.e. a ring-shaped tube like the inner tube of a motor tyre.

Early torus experiments at Harwell showed that when the hot gas was pinched it tended to 'wriggle' and touch the walls of the tube. For several years this problem was studied and results obtained by 1954 showed that, whilst the gas still 'wriggled', very high temperatures could be obtained by using high electrical currents and metal tubes of large diameter.

In 1954 design began of a large apparatus which subsequently became known as ZETA (Zero

Energy Thermonuclear Assembly). This was intended to reach currents of 100,000 ampères and it was believed that temperatures could be attained just sufficient to give rise to detectable thermonuclear reactions. By mid-1956 the use of magnetic coils wrapped round the outside of the tube appeared to offer a promising method of counteracting the 'wriggle' and Zeta was modified to incorporate this improvement.

The overall width of the Zeta torus is just over four yards and its tube has a diameter of just over one yard.

Zeta began operation in August 1957 and has worked more successfully than was expected. Current pulses up to 230,000 ampères have been passed through the gas for periods up to five-thousandths of a second and ion temperatures of from 1,000,000 to 5,000,000 degrees centigrade have been indicated (by measurements with an apparatus called a spectroscope) for periods up to three-thousandths of a second.

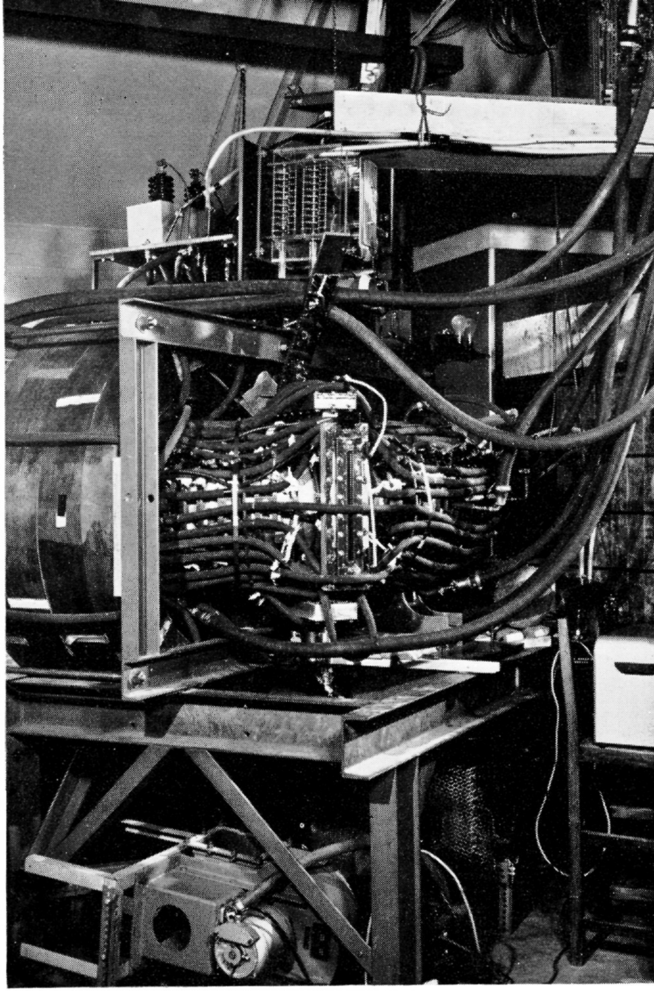
At a discharge current of 200,000 ampères, the hot gas emitted about four million neutrons per pulse. Neutrons are present in the nucleus of an atom and their emission indicated that fusion was taking place. But was it 'thermonuclear fusion'? Was it a head-on collision between two moving cars or merely a moving car hitting a stationary car?

When the work on Zeta was made public on 24th January 1958 the official announcement said this: 'The source of the observed neutrons has not yet been definitely established. There are good reasons to think that they come from thermonuclear reactions, but they could also come from other reactions such as collision of deuterons with the walls of the vessel, or from bombardment of stationary ions by deuterons accelerated by internal electric fields produced in some forms of unstable discharge.'

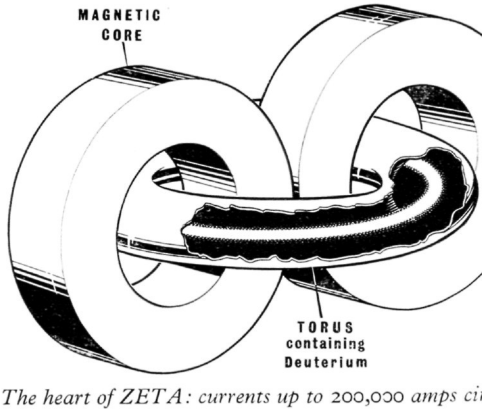
Tests made since then have definitely established that the neutrons come from collisions between deuterium atoms in the body of the gas and not from impacts with deuterium absorbed on the tube walls.

But the tests have also shown that the great majority of the neutrons are produced by accelerated deuterium atoms fusing with stationary deuterium atoms (moving car hitting stationary car).

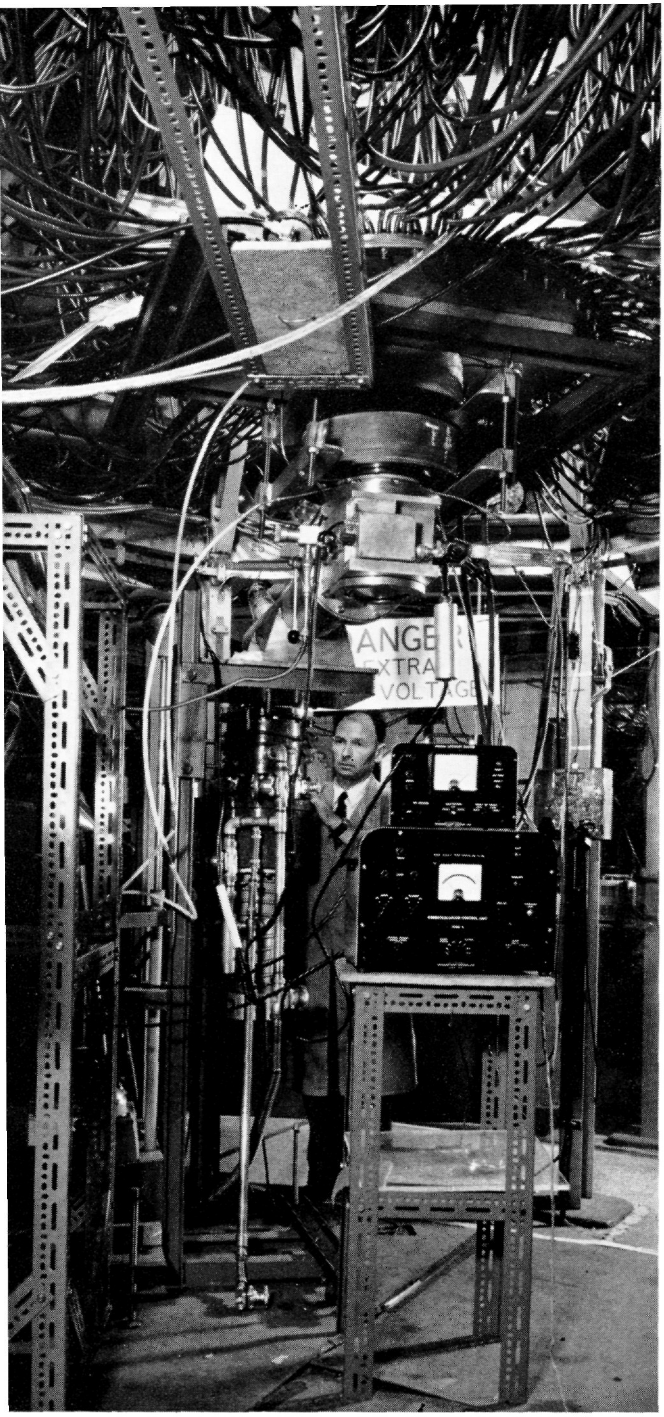
Owing to the large number of neutrons arising



Sceptre III, the small torus or electrical discharge chamber, used in hydrogen fusion experiments at the A.E.I. Research Establishment at Aldermaston Court.



The heart of ZETA: currents up to 200,000 amps circulate in a closed torus.



A 45,000 joule condenser assembly used in fusion experiments at the Atomic Weapons Research Establishment, Aldermaston.

from this mechanism it has not yet been possible to identify the smaller number which are to be expected from a true thermonuclear fusion process.

Work is now going on to prepare for a more powerful machine, ZETA II. The necessary information for this will be obtained by increasing the current in Zeta, devising new methods of measurement and new instruments.

Work on controlled thermonuclear reactions has also been proceeding at the Atomic Weapons Research Establishment, Aldermaston. Here the apparatus has consisted of straight tubes (in contrast to the Zeta torus) and an approach known as 'shock heating' has been used. Electrical circuits have been designed to give very high rates of rise in the discharge current and values exceeding a million million ampères a second have been measured.

Two pieces of equipment have been used and both have produced neutrons from discharges in deuterium. Studies of neutrons from the first and smaller apparatus have been difficult because of the limited yield of 100,000 neutrons per pulse. The second and larger apparatus is already able to yield 10,000,000 neutrons per pulse and with this it should be possible to achieve a better understanding of the heating processes.

Further work in this field is being carried out at the laboratory of Associated Electrical Industries Ltd. at Aldermaston Court, in close collaboration with Harwell and under contract to the Authority. With an apparatus known as Sceptre III, about one-third the size of Zeta, ion temperatures of up to four million degrees centigrade were obtained for times about a quarter of the duration of those in Zeta. The number of neutrons per pulse was about 100,000. Plans are being made for a modification of this apparatus with which it is hoped to attain much higher temperatures.

The significance of controlled thermonuclear research to the 'man in the street' is that heavy hydrogen can be extracted from ordinary water. This means that if it is eventually possible to construct a fusion power-station operating on heavy hydrogen, mankind will possess—in the oceans of the world—a virtually inexhaustible source of fuel.

But although research in this field has made good progress, the prospects of commercial exploitation are necessarily long-term, so long-term that it is impossible yet to suggest when a contribution to power supplies from this source can be expected.

THE AUTHORITY AND INDUSTRY

Each of the four groups of industrial firms* formed in 1954 to design and construct nuclear power stations is now engaged on one of the commercial stations being built for the electricity boards (see 'Progress of the Power Programme').

The Authority collaborate with these groups of firms (usually referred to as 'consortia') and also act as consultants to the electricity boards in connection with the nuclear power programme. In addition, collaborative programmes of development work relating to the gas-cooled graphite-moderated reactor are formulated by a committee on which the four consortia and the Authority are represented.

Staff from the fifth consortium—Atomic Power Constructions Ltd.—have received training in the Authority's Industrial Group.

A new industrial partnership, Hawker Siddeley-John Brown Nuclear Constructions Ltd., was formed in the summer of 1957. The new company declared their intention of studying the nuclear propulsion of merchant ships.

Industry has participated in the work on controlled thermonuclear reactions. The principal contractors for the construction of ZETA were Metropolitan-Vickers Electrical Company Ltd. (who also collaborated in the design), British Insulated Callender Cables Ltd., and Telcon Ltd. Research work in this field is also being carried out by Associated Electrical Industries Ltd.'s research laboratory under contract with the Authority.

The Authority normally have a number of scientists and engineers from industry working on attachment to various of the Authority's research, development and design projects. This promotes a valuable interchange of ideas between the Authority and industry; access to the Authority's facilities enables staff from industry to acquire experience not obtainable elsewhere; and such staff provide a useful reinforcement of the Authority's own technical resources. At 31st March 1958 more than one hundred scientists and engineers from British industry were attached to the Authority's establishments.

During the year under review discussions were held with the British Chemical Plant Manufacturers' Association with a view to enabling member firms to have scientists and engineers from their staff trained by the Authority's Industrial Group in the design of chemical plant for the treatment of radioactive materials. This will enable the firms concerned to compete in various overseas markets for this type of plant.

The Authority are necessarily concerned in the export of power-producing and research reactors, as the Authority are at present the sole producers of fuel elements in the United Kingdom. However, the primary responsibility for export promotion rests with the industrial consortia.

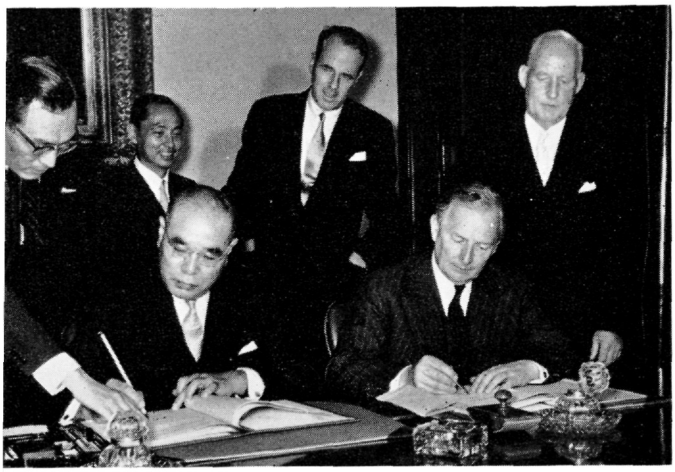
It was announced in November 1957 that the Italian firm Agip Nucleare had issued a letter of intent to the Nuclear Power Plant Co. Ltd. envisaging the negotiation of a contract for the construction in Italy of a gas-cooled nuclear power plant of 200 megawatts to British design. It was contemplated that the Nuclear Power Plant Co. Ltd. and Agip Nucleare would work together in designing and constructing the plant and that a substantial proportion of the nuclear part of the station would be supplied from the United Kingdom. The letter of intent was confirmed by a formal agreement in May 1958.

Head Wrightson Processes Ltd. secured two orders for DIDO-type research reactors, one from the Danish Atomic Energy Commission and another from the German Land Government of North Rhine-Westphalia.

The Harwell Reactor School has extended its scope considerably during the past year. During the year 378 British and 120 overseas students attended courses; the total numbers from the formation of the school to 31st March 1958 have been 765 British and 204 overseas students. Six courses have been held at the Calder Operations School, three for British students and three mainly for overseas students. Thirty-two British and 41 overseas students attended. A one-week course for overseas industrialists was also held.

* The original groups are: The G.E.C.–Simon Carves Atomic Energy Group; The Nuclear Power Plant Co. Ltd.; The English Electric–Babcock & Wilcox–Taylor Woodrow Atomic Power Group; A.E.I.–John Thompson Nuclear Energy Co. Ltd. Later a fifth group was formed by the association of Atomic Power Constructions Ltd. and Nuclear Civil Contractors.

Above: Sir William Cook, C.B., Member for Engineering and Production, U.K.A.E.A., talks with Dr. Balke, Minister for Atomic Energy, Western Germany, at the 1958 Hanover Trade Fair.



Above: The Rt. Hon. Selwyn Lloyd, Foreign Secretary, and Dr. Katsumi Ohno, Japanese Ambassador in London, sign the agreement between the two Governments for co-operation in the peaceful uses of atomic energy concluded in June 1958.

Relations with

The great intensification of interest in the technical and economic aspects of nuclear power, and an increasing realisation of the magnitude of the problems, such as those of health and safety, associated with its successful exploitation, have led to an unceasing demand upon the Authority for information and assistance.

International Organisations

At the Second United Nations Conference on the Peaceful Uses of Atomic Energy which will open at Geneva on 1st September 1958 the British delegation will be led by Sir John Cockcroft who will be a Vice-President of the Conference. The United Kingdom team will present about 200 papers.

The Authority are represented by Sir John Cockcroft on the United Nations Scientific Advisory Committee on the Peaceful Uses of Atomic Energy. Authority staff have acted as advisers on the work of the U.N. Committee on the effects of Atomic Radiation. The Authority maintain close touch with the activities of the International Atomic Energy Agency and Dr. Seligman of the Atomic Energy Research Establishment has been seconded to the Agency as Deputy Director General for Research and Isotopes.

The European Nuclear Energy Agency—established by OEEC—receives consultant services from the Authority on a wide range of matters including training and health and safety.

The Nuclear Training Centre in Baghdad—established under the ægis of the Baghdad Pact—has now been in operation for a year, under the direction of a member of the Authority's staff.

Members of the Authority's staff took an active part in the proceedings of the first meeting, in August 1957, of the Technical Committee on Nuclear Energy of the International Standards Organisation.

Other international organisations with whose activities the Authority has been associated during the period include, the World Health Organisation, the International Labour Office, the European

Left: Students from Japan and Germany at the Calder Operations School, at which engineers from all over the world obtain practical experience in reactor operation. The school adjoins Calder Hall.

Other Countries

Atomic Energy Society, the International Commission for Radiological Protection and the European Organisation for Nuclear Research (CERN).

THE COMMONWEALTH. Good working relations, informal but close and business-like, have been maintained between the Authority and equivalent organisations in Australia, Canada, India, Pakistan and South Africa, and with interested bodies in other Commonwealth countries.

Events deserving to be singled out for special mention are the conclusion in July 1957 of an agreement for co-operation between the Authority and the South African Atomic Energy Board and the coming into operation in January 1958 of the Australian Atomic Energy Commission's HIFAR materials testing reactor. This is a replica of the DIDO reactor at Harwell and uses enriched fuel elements supplied by the Authority.

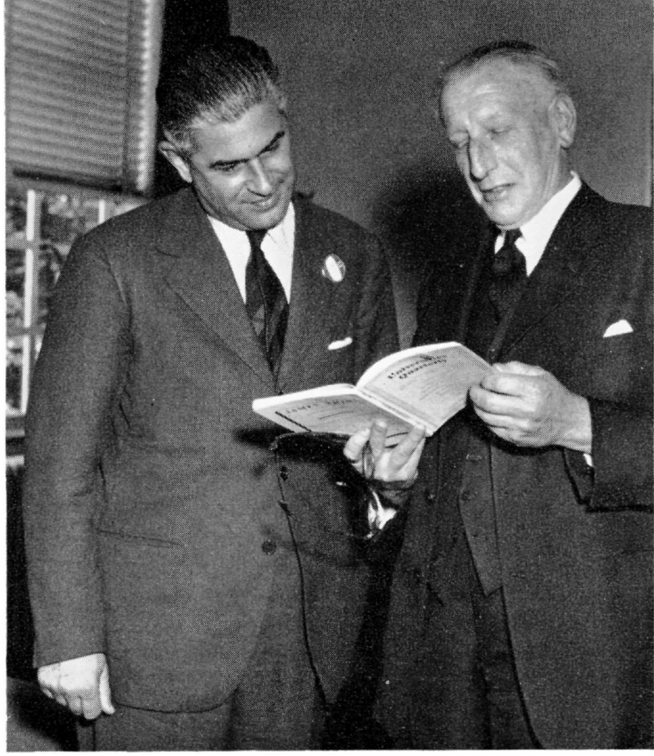
THE UNITED STATES. The Authority's relationship with the U.S. Atomic Energy Commission is close, cordial and continuous. Exchanges of information on various topics, including the technology of the gas-cooled graphite-moderated reactor system, controlled nuclear fusion and submarine propulsion reactors, have taken place.

OTHER COUNTRIES. In a year in which the Authority had dealings of one kind or another with some forty overseas countries, it is difficult to select particular events for comment. The most notable trend was the further intensification by governments and power undertakings in many countries of their study of the technical and economic aspects of nuclear power. The Authority have done their best to facilitate these investigations.

A notable event during the year was the exchange of letters of intent between a British and Italian firm for the erection of the first nuclear power station overseas to British design. The Authority were retained by the Italian firm as consultants on certain aspects of the project. The Authority will also be directly concerned at a later stage as suppliers of fuel for the station.

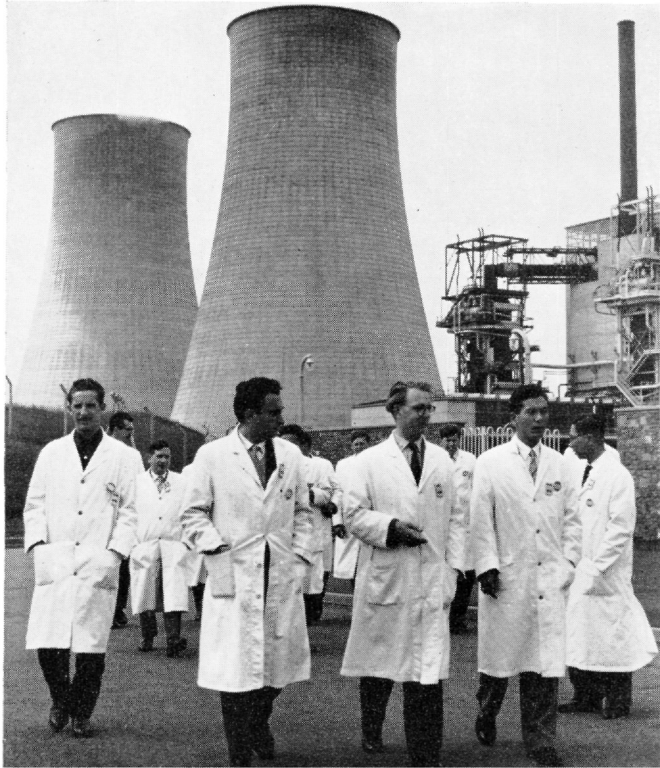
Another Italian project with which the Authority have been concerned is that known as 'Project

Continued on page 23

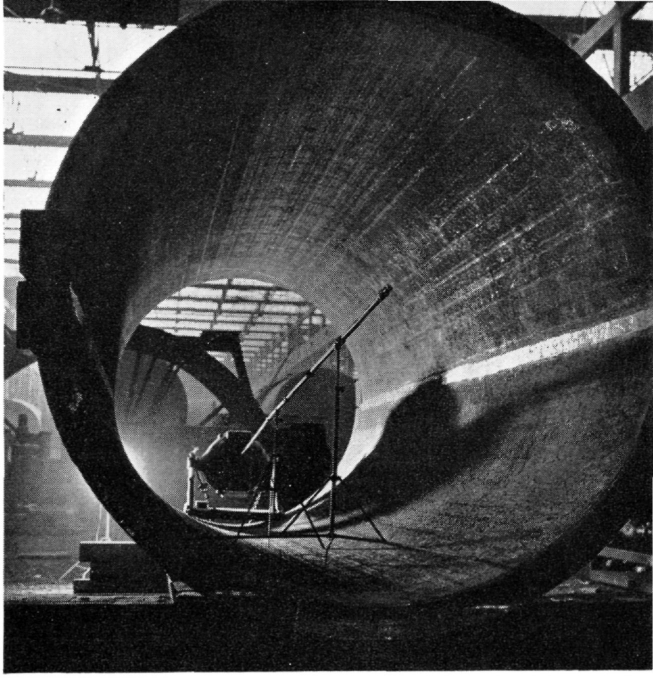


Prof. Felice Ippolito, Member and Secretary General of the Italian National Committee for Nuclear Research, talks with Dr. B. F. J. Schonland, Director, during a visit to A.E.R.E., Harwell.

Students from overseas at Calder Operations School leave Calder Hall Power Station.



ISOTOPES AND IRRADIATION



Using a radioisotope (contained in the axial tube) as a source of gamma rays to radiograph a joint. Photo: G. A. Harvey, Ltd., Greenwich.

Valuable by-products of nuclear reactors are 'radioisotopes', radioactive substances which have many hundreds of uses in medicine, industry, agriculture and research.

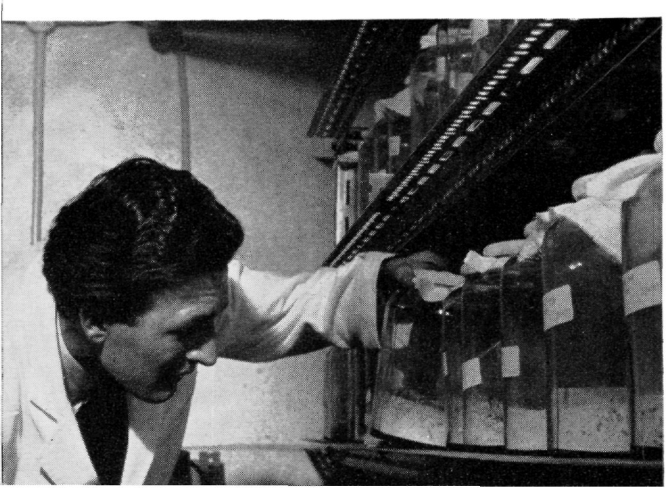
The Authority's sales of radioisotopes continued to increase during the year, reaching a total value of £650,000, of which £150,000 was from the Isotope Division at Harwell and £500,000 from the Radiochemical Centre at Amersham. This total represents an increase of more than 20 per cent. over last year's total. The proportion exported was 60 per cent.

New applications of radioisotopes continue to be evolved, particularly for industrial use.

It has, for example, been possible to determine by their use the size and position of leaks in a system of pipes in an underground coal gasification plant. They have also been used to test the flow-rate of the Big Spring in the Severn Tunnel; to measure the efficiency of industrial filters; and to study the properties of certain magnesium alloys.

Gauges for measuring the thickness of sheets of material have been in commercial use for some time and a new thickness gauge for research on paper has been developed recently. Particles from a radioactive source pass through the paper and fall on a strip of photographic film. Measurements of the blackening of the film will indicate microscopic changes in the density of the paper. A camera has been devised which enables the measurement to be made simply.

A scientist at A.E.R.E., Harwell, examines flour mill moths which are used as test insects in research into irradiation as a means of pest control.



In another application, using a different method, thicknesses of chromium plating have been measured down to as little as a few millionths of an inch.

Specially complex substances of value in biological research—including cancer research—are produced at the Radiochemical Centre, Amersham. The use of these 'labelled compounds', as they are called, for the study of weedkillers, pesticides and fertilisers is also becoming widespread. For such purposes, during the year 1957–8, the Centre synthesised over 500 compounds containing twenty different isotopes. Amersham handles some 20,000 consignments a year and has transactions with 50 countries.

The amount of radioactivity used in the applications described above is tiny, but the Authority also produce large radiation sources for medical or industrial purposes. Several units of about 1,000 curies of caesium-137 (equivalent to 1,000 grammes of radium) have been supplied to hospitals in Britain and a 1,300 unit is being shipped to a hospital in Toronto, Canada. Ten 100 curie sources of Cobalt-60 have been sent to five overseas countries.

The use of large radiation sources for industrial and research purposes is studied in the Wantage Radiation Laboratory at Grove.

By January 1958 scientists from ten industrial firms were using the installations at Grove for research into processes of industrial interest.

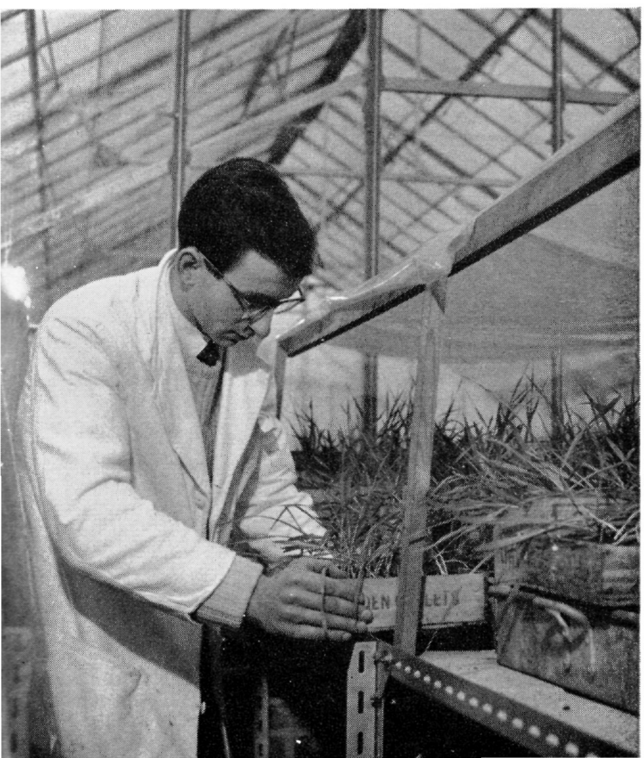
The initial work has been to investigate methods of producing synthetic substances, such as plastics, at lower temperatures and pressures than are normally possible.

A particular process which is being studied is concerned with synthetic fibres like nylon, rayon and terylene. One difficulty with these is that, because they are good electrical insulators, they collect static charges and therefore attract dust which causes the soiling of fabrics made from them. The fibres may be coated with a conducting film to prevent the formation of this static charge, but ordinary methods of doing this result in a coating which tends to wash off with laundering. At Wantage a suitable coating has been grafted experimentally to the material of the fibre, which cannot be removed by ordinary treatment.

Another important group of applications is concerned with preventing the deterioration of food in store. The damage done by insects to stored products is enormous; estimates of the annual loss of harvested cereals vary from 5 per cent. to 50 per cent. in various parts of the world. Grain weevils are the principal pests and work at Wantage has established a means of treating grain which will reduce the life of these insects to a few days and prevent their having progeny. Present evidence suggests that the quality of the grain is not impaired. Weevils from all over the world are being tested at Wantage to determine how sensitive they are to radiation.

The Isotope School at Harwell increased the scope of its activities during the year 1957–8.

Selecting seedlings grown from irradiated barley seed. As a result of this treatment, new strains with greater disease-resistance or other improved qualities can be developed.



Determination of the rate of flow of blood from wrist to wrist of a patient at the Royal Marsden Hospital. An isotope is injected in one wrist and the counter is placed over the other.

HEALTH AND SAFETY

It is the policy of the Authority that all operations should be carried out with a minimum of exposure to radiation. To ensure that there shall be no harmful effects, maximum permissible levels of exposure, which have been approved by the Medical Research Council or the International Commission on Radiological Protection, are applied rigorously.

Waste disposal

Some radioactive waste material has to be stored permanently, but some—in the form of very dilute solutions—can safely be discharged into rivers or the sea, sometimes after preliminary purification. In the latter case detailed studies of possible biological effects are made. At Windscale and Dounreay these include measurements of radioactivity in fish, seaweed and sea bed, shore sand, and detailed studies of tidal movements and currents and their effects in diluting the activity. The results of this work are studied by the appropriate Government Departments. All establishments are regularly visited by representatives of the various Ministries, who inspect the records of the discharge of gaseous liquid and solid wastes.

Normal Industrial Safety

In addition to the hazards which may arise from the special nature of the Authority's work, there are the ordinary hazards which may occur in any big industrial undertaking. The lost time frequency rates for the year were 0.86 per 100,000 man hours for the Industrial Group, 0.43 for the Research Group and 0.67 for the Weapons Group.

These figures compare with the average frequency rate of 1.73 in 1956 for all the industries which supply this information to the Factories Inspectorate.

The Windscale Accident

On 10th October 1957, a fire occurred in No. 1 Reactor at the Authority's Windscale plant, and by the evening of that day some 150 of the fuel-element channels were affected. The fire occurred during an operation known as a 'Wigner release'. i.e. the release of energy stored in the graphite moderator. The fire was put out by the afternoon of 12th October.

Measurements taken in the countryside surrounding the site showed that there was escaping radioactivity, largely iodine-131; and further, that while there was no danger to health from breathing the air or from eating anything growing in the affected area, there was a possible hazard to infants from drinking milk which had become contaminated. Steps were then taken to restrict the sale of milk over an area of 200 square miles surrounding the plant. Radioactive iodine, which was the only isotope causing concern, has a short half life (i.e. the time taken for the radioactivity to decay to half its initial value); it was therefore confidently expected that the iodine in milk would fall steadily to a safe value. This indeed was the case and the milk restrictions were lifted progressively and finally removed on 23rd November 1957.

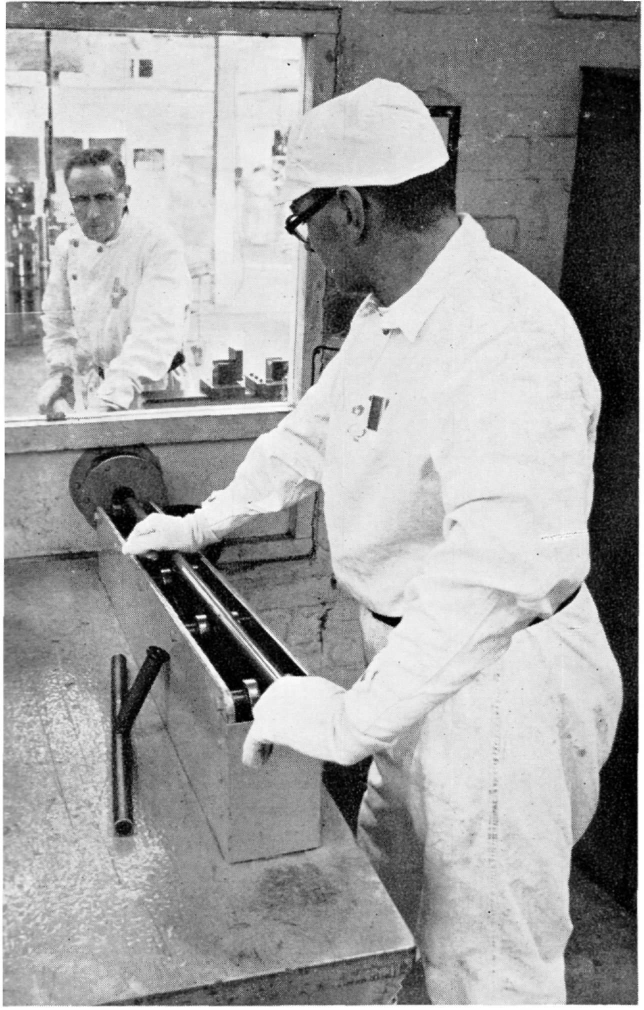
The Medical Research Council, after examining the various possibilities, reported that it was in the highest degree unlikely that any harm was done to the health of anybody, whether a worker in the Windscale plant or a member of the general public, as a result of the accident.

At the suggestion of the Authority the Prime Minister set up a Committee under the Chairmanship of Sir Alexander Fleck to review the organisation within the Authority as a whole for the control of health and safety.

Important recommendations in the Fleck Report concerned the training of the specialist health and safety staff who will be required in increasing numbers as the applications of atomic energy become more widespread. Detailed schemes to give effect to these recommendations are being prepared in consultation with the Government Departments concerned.

FUEL FOR REACTORS

The Authority's requirements for uranium have been somewhat reduced by the slowing down of the United Kingdom's nuclear power programme, and the Authority are not proposing for the present to make any additional commitments for the purchase of uranium, but have, however, continued to encourage prospecting and the development of reserves for the future.



The fuel element production line at Springfields. To prevent uranium contamination of the outside of fuel elements, no uranium is handled or allowed uncovered in the canning section of the line.

South Africa continued to supply much the greater part of the Authority's imports of uranium concentrates during the year. There are now 29 approved uranium producers and 17 treatment plants in South Africa. Supplies come also from the Belgian Congo, Rum Jungle and Radium Hill (Australia).

Between April 1962 and March 1963 the Authority will purchase uranium concentrates to the value of about $105 million from the Canadian Government's selling agency. Negotiations are continuing for further purchases from Canada during the period 1963–6.

In Australia, the Mary Kathleen Mine in Queensland will come into production during 1958. The capital costs have proved to be greater than expected and the Authority agreed to increase their loan to the Company from £5m. to £6m. The first uranium concentrates were received from the ore treatment plant at Nkana in the Central African Federation.

The Authority's office in Salisbury, Southern Rhodesia, continued to be mainly occupied in giving technical advice to prospectors throughout the Federation of Rhodesia and Nyasaland. An office was opened by the Authority at Dodoma in Tanganyika in April 1957, to serve the East African territories. Plans were made for searches for minerals in Swaziland and British Guiana. Discussions were held during the year about the assessment of reserves in parts of South Island, New Zealand.

The Geological Survey of Great Britain (Atomic Energy Division) undertook on the Authority's behalf reconnaissances in Sierra Leone, British Guiana, Jamaica, Bechuanaland, New Zealand and Southern Rhodesia. At home, a 1,000 square mile airborne geophysical survey was carried out in South-West Cornwall, and towards the close of the year test drilling operations were begun.

Discussions were held with the Bureau des Recherches Minieres of the French Commissariat a l'Energie Atomique in the course of which the Authority's and the Commissariat's prospecting programmes were reviewed.

During the year purchases of beryl were increased, and a contract placed for a small tonnage of beryllium metal for the fuel elements of the advanced gas-cooled reactor. Helium, which is of potential interest as a heat transfer medium in the high-temperature gas-cooled reactor, was reported to be present in unusually high concentrations at a site in Tanganyika and drilling was begun.

During the year the Authority entered into an agreement with the Colonial Development Corporation under which the advice of the Corporation's Mining Division is made available to the Authority on mining engineering problems. A similar arrangement was entered into with the Directorate of Oversea Surveys for advice on Geophysical Surveys and general prospecting problems in overseas territories.

ORGANISATION OF THE AUTHORITY

THE PRIME MINISTER

THE ATOMIC ENERGY OFFICE

SIR EDWIN PLOWDEN, K.C.B., K.B.E.
Chairman of
THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

PART-TIME MEMBERS
SIR IVAN STEDEFORD, K.B.E.
MR. C. F. KEARTON, O.B.E.
SIR W. ROWLAND SMITH
SIR JAMES CHADWICK, F.R.S.
RT. HON. LORD CITRINE, P.C., K.B.E.

SIR JOHN COCKCROFT
K.C.B., C.B.E., F.R.S.
Member for Scientific Research

SIR WILLIAM PENNEY
K.B.E., F.R.S.
Member for Weapons Research and Development

SIR DONALD PERROTT
K.B.E.
Member for Finance and Administration

MR. W. STRATH
C.B.
Member for External Relations and Commercial Policy

SIR WILLIAM COOK
C.B.
Member for Engineering and Production

Secretary
MR. D. E. H. PEIRSON

INDUSTRIAL GROUP
SIR LEONARD OWEN
C.B.E.
Managing Director

RESEARCH GROUP
DR. B. F. J. SCHONLAND
C.B.E., F.R.S.
Director

WEAPONS GROUP
SIR WILLIAM PENNEY
K.B.E., F.R.S.

Early in 1958 steps were taken to free Members of the Authority from executive control of one of the Authority's establishments, in order to allow them to devote more time to their other responsibilities. Thus Sir John Cockcroft, who since the setting up of the Authority has been Member for Scientific Research as well as Director of the Atomic Energy Research Establishment, was succeeded in the latter post by Dr. B. F. J. Schonland. Sir William Penney, however, remains Director of the Atomic Weapons Research Establishment pending the appointment of a new Director.

U.K.A.E.A. ESTABLISHMENTS

UNITED KINGDOM ATOMIC ENERGY AUTHORITY,
11 Charles II Street, London, S.W.1.
Telephone: Whitehall 6262.

U.K.A.E.A. RESEARCH GROUP,
Atomic Energy Research Establishment,
Harwell, Didcot, Berks.
Telephone: Abingdon 1220.

U.K.A.E.A. INDUSTRIAL GROUP,
Industrial Group Headquarters,
Risley, Warrington, Lancs.
Telephone: Warrington 31244.

U.K.A.E.A. WEAPONS GROUP,
Atomic Weapons Research Establishment,
Aldermaston, Berks.
Telephone: Reading 0060.

THE RADIOCHEMICAL CENTRE,
White Lion Road, Amersham, Bucks.
Telephone: Little Chalfont 2278.

ATOMIC ENERGY AUTHORITY FACTORY,
Western Road, Binfield,
Bracknell, Berks.
Telephone: Bracknell 1078.

U.K.A.E.A. RESEARCH GROUP (WANTAGE),
Wantage Radiation Laboratory,
Grove, Wantage, Berks.
Telephone: Wantage 458.

U.K.A.E.A. RESEARCH GROUP (WOOLWICH),
Woolwich Outstation,
Building C.37, Royal Arsenal,
Woolwich, London, S.E.18.
Telephone: Woolwich 2044.

U.K.A.E.A. RESEARCH GROUP (CHATHAM),
Chatham Outstation,
H.M. Gun Wharf, Chatham, Kent.
Telephone: Chatham 4201.

PUBLICATIONS

Details of publications on nuclear energy and allied subjects can be obtained from Public Relations Branch, U.K.A.E.A., 11 Charles II Street, London, S.W.1.

The following libraries are depositories for U.K.A.E.A. documents:

Science Museum Library, South Kensington, London, S.W.7.

Central Library, Surrey Street, Sheffield, 1.

Central Library, Ratcliffe Place, Birmingham, 1.

The Mitchell Library, North Street, Glasgow, 3.

Central Library, William Brown Street, Liverpool, 3.

Central Library, St. Peter's Square, Manchester, 2.

Central Library, New Bridge Street, Newcastle-upon-Tyne, 1.

Central Library, High Street, Acton, London, W.3.

Central Library, Albion Street, Kingston-upon-Hull.

A SHORT LIST OF FILMS ON ATOMIC ENERGY

ATOMIC ACHIEVEMENT (First decade of British Atomic Energy work). Eastman colour Commentary 16/35 mm. 20 minutes (1956) C.O.I.*

CALDER HALL (Construction of the power station). Eastman colour Commentary 16/35 mm. 30 minutes (1955) C.O.I.*

CRITICALITY (Training in safety precautions for industrial workers in atomic energy factories). Eastman colour Commentary 16/35 mm. 22 minutes (1957) U.K.A.E.A. C.O.I.*

THE PRINCIPLES OF NUCLEAR FISSION. (The animated section of Criticality which explains the principles of nuclear fission). Eastman colour Commentary 16 mm. 10 minutes. Foundation Film Library, Brooklands House, Weybridge, Surrey.

GREAT DAY (Construction and Royal Opening of Calder Hall). Eastman colour Commentary 16/35 mm. 20 minutes (1956) C.O.I.* (Free).

HOW A THERMAL REACTOR WORKS (The animated section of Great Day showing how a thermal reactor works). Eastman colour Commentary 16 mm. 7 minutes (1956). Ace Distributors, Ltd., 14 Broadwick Street, Wardour Street, W.1.

THE CONSTRUCTION OF CALDER HALL. Black and White Commentary 16/35 mm. 40 minutes. Ace Distributors, Ltd.

HEAT EXCHANGERS AT CALDER HALL. Black and White Commentary 16/35 mm. 28 minutes. Ace Distributors, Ltd.

ENGINEERING AT CALDER HALL. Black and White Commentary 16/35 mm. 30 minutes. Ace Distributors, Ltd.

THE DOUNREAY SPHERE. Black and White Commentary 16/35 mm. 35 minutes. Ace Distributors, Ltd.

NEW TOOL FOR INDUSTRY (Typical radioisotope uses in industry). Black and White Commentary 16 mm. 20 minutes (1955) C.O.I.*

A full list of 145 films on atomic energy and related matters has been prepared by the Scientific Film Association. This list is given in the Scientific Film Review, Vol. 2, No. 4 (October 1956), which may be obtained from the Editorial Office, 164 Shaftesbury Avenue, London, W.C.2, at 3s. 6d.

* The Central Office of Information Film Library (Government Buildings, Bromyard Avenue, Acton, London, W.3) supplies those films marked C.O.I. on hire at a modest rental.

The Authority's Reactors, 31st March 1958

EXPERIMENTAL REACTORS AT HARWELL

Name	*Date of start-up*	*Peak neutron flux*	*Maximum heat output*	*Moderator*	*Coolant*	*Fuel*	*Purpose*
1. GLEEP	1947	$3{\cdot}7 \times 10^{10}$ thermal n/cm²/sec	100 kW	Graphite	Air	Natural uranium metal and oxide	Now routine graphite, uranium quality testing; research with oscillator; biological irradiations.
2. BEPO	1948	2×10^{12}	6 MW	Graphite	Air	Natural uranium	Isotope production and general radiation source.
3. DIMPLE	1954	about 10^{8}	100 Watts	Heavy water	None	Varies	Thermal reactor studies.
4. LIDO	1956	10^{12}	100 kW	Natural water	Natural water	Uranium 235	Thermal reactor, studies including shielding.
5. DIDO	1956	10^{14}	10MW	Heavy water	Heavy water	Uranium 235	Isotope production, neutron physics, radiation chemistry, nuclear reactor material studies.
6. NERO	1957	about 10^{8}	Less than 100 watts	Graphite	None	Slightly enriched uranium	Investigations for advanced graphite-moderated reactors.
7. PLUTO	1957	10^{14}	10 MW	Heavy water	Heavy water	Uranium 235	Studies on nuclear reactor materials, isotope production.
8. NEPTUNE*	1957	about 10^{8}	Less than 100 watts	Light water	None	Enriched uranium	Studies by an Admiralty team at Harwell, in association with Authority staff, on water-moderated core designs, with specific reference to a pressurised water reactor for submarine propulsion. Rolls-Royce Limited are responsible for design and construction.
9. HAZEL	1958	about 10^{6}	Less than one watt	Heavy water	None	Uranyl fluoride (U^{235})	To obtain basic nuclear information on heavy-water-moderated, homogeneous systems.

EXPERIMENTAL REACTORS UNDER CONSTRUCTION

Name	*Location*	*Date of start-up*	*Peak neutron flux*	*Maximum heat output*	*Moderator*	*Coolant*	*Fuel*	*Purpose*
10. Fast Reactor, Dounreay	Dounreay, Caithness	1958	—	60 MW	None	Sodium potassium alloy	Enriched uranium or plutonium	Fast reactor breeding studies.
11. DMTR (Pluto type)	Dounreay, Caithness	1958	10^{14}	10 MW	Heavy water	Heavy water	Uranium 235	Studies on nuclear reactor materials.
12. HERALD	Aldermaston	1958	10^{14}	5 MW	Light water	Light water	Uranium 235	Neutron physics, radiochemical studies.
PLUTONIUM-PRODUCING EACTORS								
13/14. Windscale† (2 reactors)	Cumberland	1950	—	—	Graphite	Air	Natural uranium	Plutonium production.
PLUTONIUM/POWER-PRODUCING REACTORS IN PRODUCTION‡								
15/16. Calder 'A' (2 reactors)	Cumberland	1956	—	180 MW§ per reactor	Graphite	Carbon dioxide	Natural uranium	Plutonium and power production.
PLUTONIUM/POWER-PRODUCING REACTORS UNDER CONSTRUCTION‡								
17/18. Calder 'B' (2 reactors)	Cumberland	1958 (1st reactor)	—	180 MW§ per reactor	Graphite	Carbon dioxide	Natural uranium	Plutonium and power production.
19/22. Chapelcross (2 stations, 'A' and 'B' 4 reactors)	Annan, Dumfriesshire	1959 (3 reactors)	—	180 MW per reactor	Graphite	Carbon dioxide	Natural uranium	Plutonium and power production.

* Admiralty experimental reactor.
† One reactor damaged in the accident; the other reactor at presen tshut down.
‡ All power stations operated, or under construction for future operation by the Authority, are 'two reactor stations. These are Calder Hall 'A', Calder Hall 'B', Chapelcross 'A' and Chapelcross 'B'.
§ The total installed generating capacity of Calder Hall 'A' (two reactors) is 92 MW (electrical). The gross design output is 84 MW (electrical) and the net output of the station is about 70 MW. However, as stated in Chapter V, paragraph 6, Calder Hall 'A', No. 1 reactor, has been running at a maximum heat output of 200 MW providing a gross electrical output of 45 MW. The greater part of the output of the station is fed into the Central Electricity Generating Board grid. When both Calder Hall 'A' and 'B' (two reactors each) are in operation, the installed capacity will be 184 MW and the total output to the C.E.G.B. grid will be about 150 MW. The electrical output from Chapelcross 'A' and 'B' stations will be identical in all respects with Calder Hall 'A' and 'B'.

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EVENTS OF THE YEAR: 1st APRIL 1957 TO 31st MARCH 1958

During the year ended 31st March 1958, the Authority's principal tasks continued to be the fulfilment of defence commitments; research and development on the civil applications of nuclear energy; consultancy service to the electricity authorities and collaboration with industry in connection with the nuclear power programme.

The first British nuclear weapons in the megaton range were exploded on Christmas Island in May 1957.

At Harwell the zero-energy thermonuclear assembly ZETA started to operate on 12th August 1957.

The materials-testing reactor PLUTO became critical on 25th October 1957.

The zero-energy reactor NEPTUNE started working on 7th November 1957.

A successful Wigner energy release was carried out in the Harwell reactor BEPO in March 1958.

Harwell has brought into use a large installation for the remote handling of irradiated fuel elements.

The Marquess of Salisbury opened a new radiochemical laboratory and a new office building at the Radiochemical Centre, Amersham, in November 1957.

The third reactor at Calder Hall became critical on 12th March 1958.

The construction of the fast reactor and the materials-testing reactor at Dounreay made good progress.

A building labour force of 600 was on site by the end of the period at the new establishment to be known as the Atomic Energy Establishment, Winfrith, in Dorset. The initial programme for this establishment includes a high-temperature graphite-moderated zero-energy reactor to be commissioned in 1959.

A fire occurred in Windscale No. 1 Reactor on 10th October 1957. An escape of radioactivity led to restriction on the sale of milk over an area of 200 square miles. Following the accident measures of reorganisation, both technical and administrative, were recommended by Committees under the chairmanship of Sir Alexander Fleck.

At the end of the period the construction by industry of four commercial nuclear power stations for the electricity boards was under way. A fifth site was under consideration by the Minister of Power.

The Nuclear Power Programme now provides for 5,000–6,000 megawatts of nuclear generating capacity by the end of 1966.

The National Institute for Research in Nuclear Science have decided to establish their first laboratory, to be called the Rutherford High Energy Laboratory, on a site made available by the Authority adjacent to Harwell. The main research facility will be a 7 GeV proton synchrotron which the Authority began to build for the Institute during 1957–8 and which is due for completion at the end of 1961. The Authority propose to transfer a 50 MeV proton linear accelerator to the Institute in April 1959.

The most notable event in the international sphere was the inaugural meeting of the International Atomic Energy Agency in Vienna on 1st October 1957.

Bilateral agreements were concluded during the year between the United Kingdom and the Governments of South Africa, Norway, Sweden and Italy.

During the year, 24,711 people visited the Authority's establishments, many of them from overseas.

The Authority's staff increased from 27,290 to 30,341.

The death occurred on 4th January 1958, of Viscount Waverley, the report of whose Committee on 'The Future Organisation of the United Kingdom Atomic Energy Project' (November 1953) paved the way for the setting up of the Authority.

RELATIONS WITH OTHER COUNTRIES

(Continued from page 15)

ENSI'. This is sponsored by the Italian Government and has as its object the construction of a 150 megawatt nuclear power station to be financed in part by the International Bank. The Authority have given advice on the suitability of sites which were under consideration and a member of their staff has been appointed to serve on the international panel of experts which has been set up to review the tenders.

During the year there have been numerous consultations with the Japanese authorities on matters connected with the possible purchase of a United Kingdom type nuclear power station by Japan and in June 1958 the United Kingdom and Japanese Governments signed an agreement for co-operation in the peaceful uses of atomic energy. This agreement enables Japan to purchase from the United Kingdom power and research reactors together with the nuclear fuel for their operation.

Bilateral agreements were concluded during the period with Italy, Sweden and Norway; similar agreements are in existence with several other countries.

Front cover: ZETA, the zero-energy thermonuclear assembly at the Atomic Energy Research Establishment, Harwell.

Back cover: Dounreay, showing the fast-breeder reactor sphere.

Printed and Published for the United Kingdom Atomic Energy Authority by Her Majesty's Stationery Office, London, 1958

S.O. Code No. 88–2555*