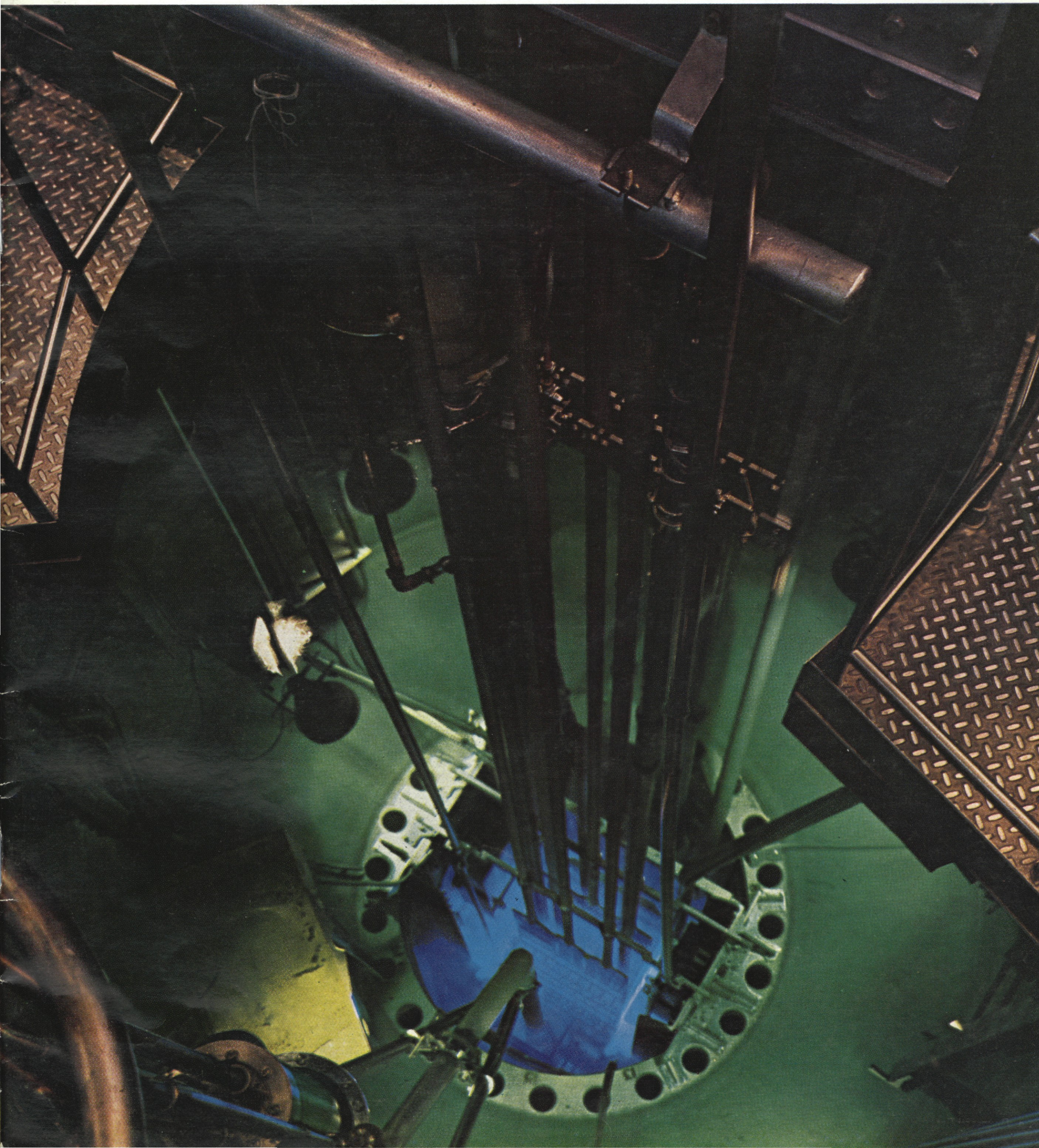
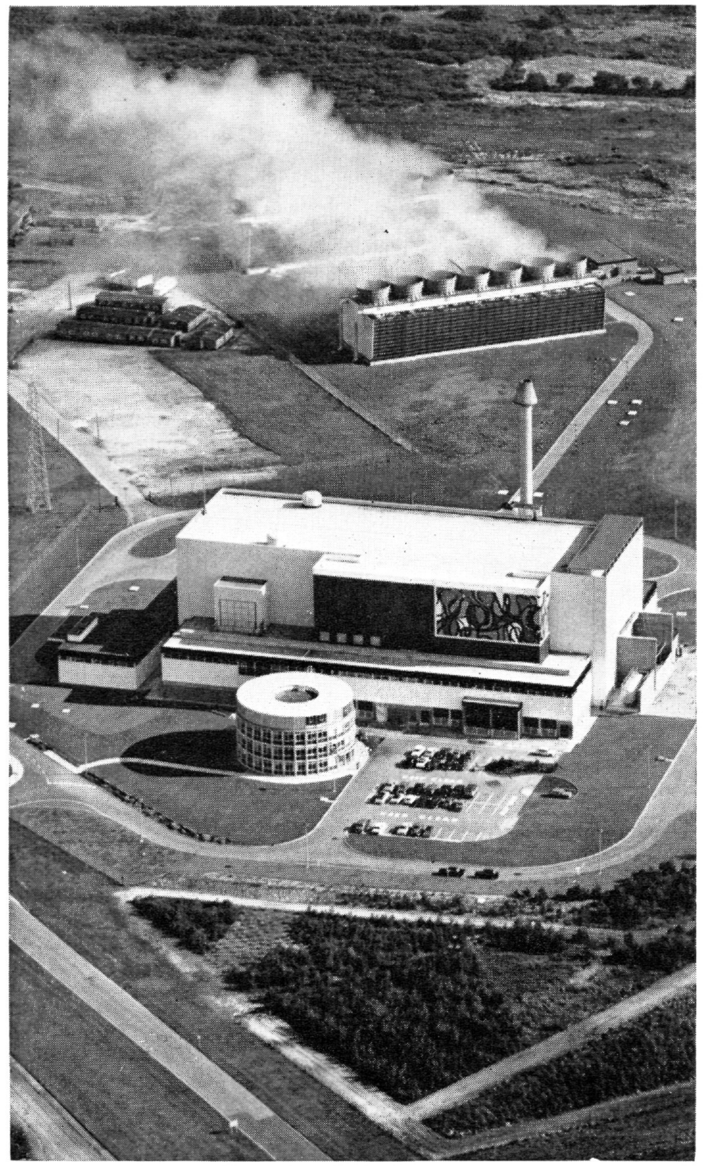
Atom 69

An illustrated summary of the fifteenth annual report of the United Kingdom Atomic Energy Authority from 1st April 1968 to 31st March 1969



The Authority 1968-1969



The Steam Generating Heavy Water Reactor, Winfrith

By the end of the year under review, the first steps in the planned reorganisation of the nuclear power industry had been accomplished.

The recommendations of the Select Committee on Science and Technology on the United Kingdom nuclear reactor programme and the decisions of the Minister of Technology (announced in the House of Commons on 17th July, 1968) were printed in the Authority's annual report for 1967/68.

In accordance with these decisions, the Minister asked the Industrial Reorganisation Corporation "to assist in the creation of two design and construction organisations to be established in place of the three commerical firms and the design teams working within the Atomic Energy Authority."

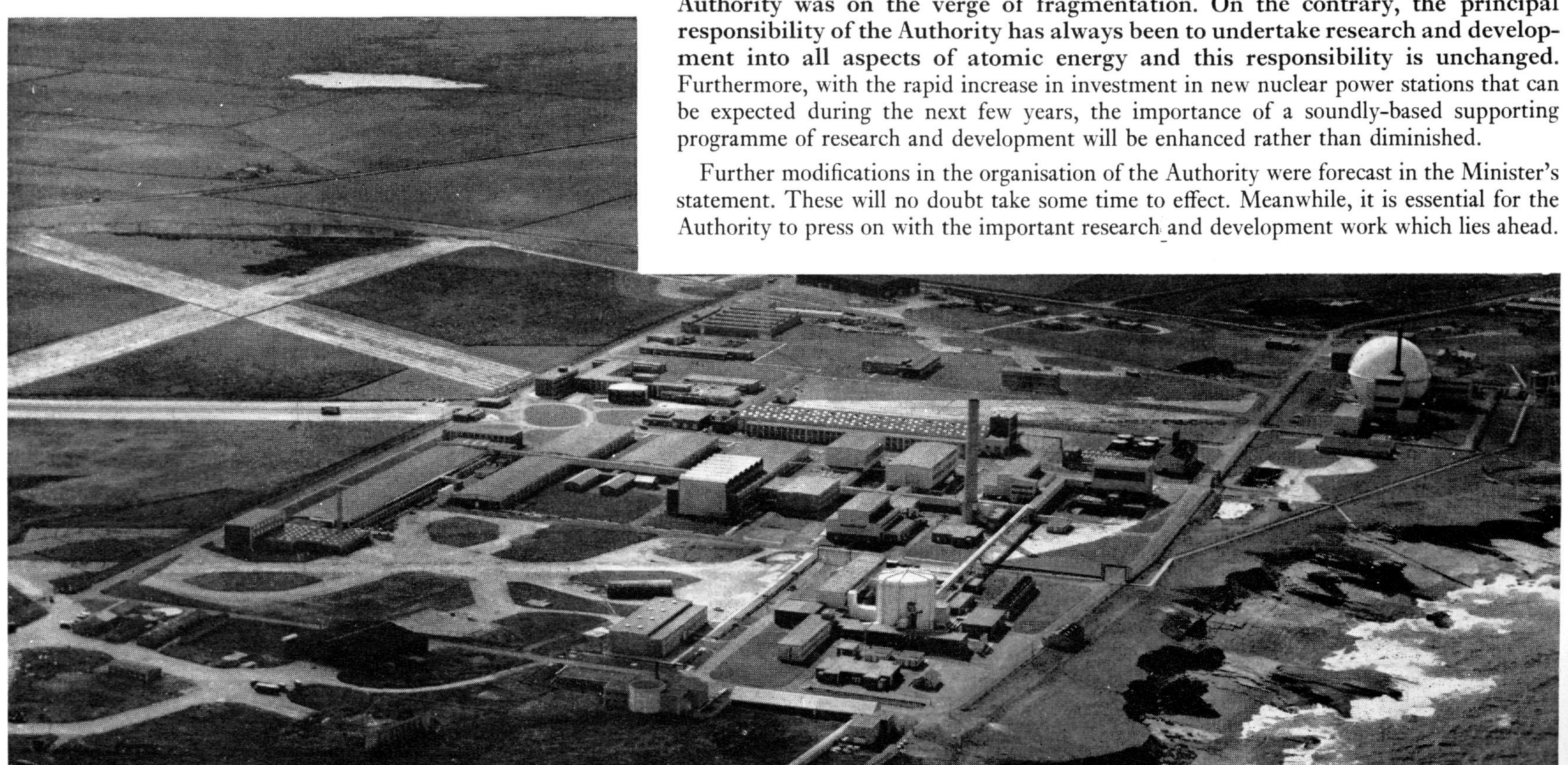
Two such companies—British Nuclear Design & Construction Ltd. (B.N.D.C.) and The Nuclear Power Group (T.N.P.G.)—have now been established. The Authority have a 20 per cent. shareholding in each company and are represented on its board. In pursuance of the Ministry's policy that the design and the later development stages of nuclear reactors should now be the responsibility of the two new companies rather than of the Authority, T.N.P.G. have been given contracts for managing the completion of the Dounreay prototype fast reactor (P.F.R.) and for certain development work on the fast reactor system. Some 40 members of the Authority's design and engineering staff have accepted offers of employment with the company; and the Authority, in order to secure continuity of effort on fast reactor work, have seconded a further 100 officers to serve temporarily with T.N.P.G. on work covered by the two contracts.

Early in 1969, the Authority initiated discussions for the conclusion of licensing agreements with the two new companies (when established) covering all the reactor systems developed by the Authority, both thermal and fast. It is intended that these agreements should supersede the existing agreements which are confined to gas-cooled reactors.

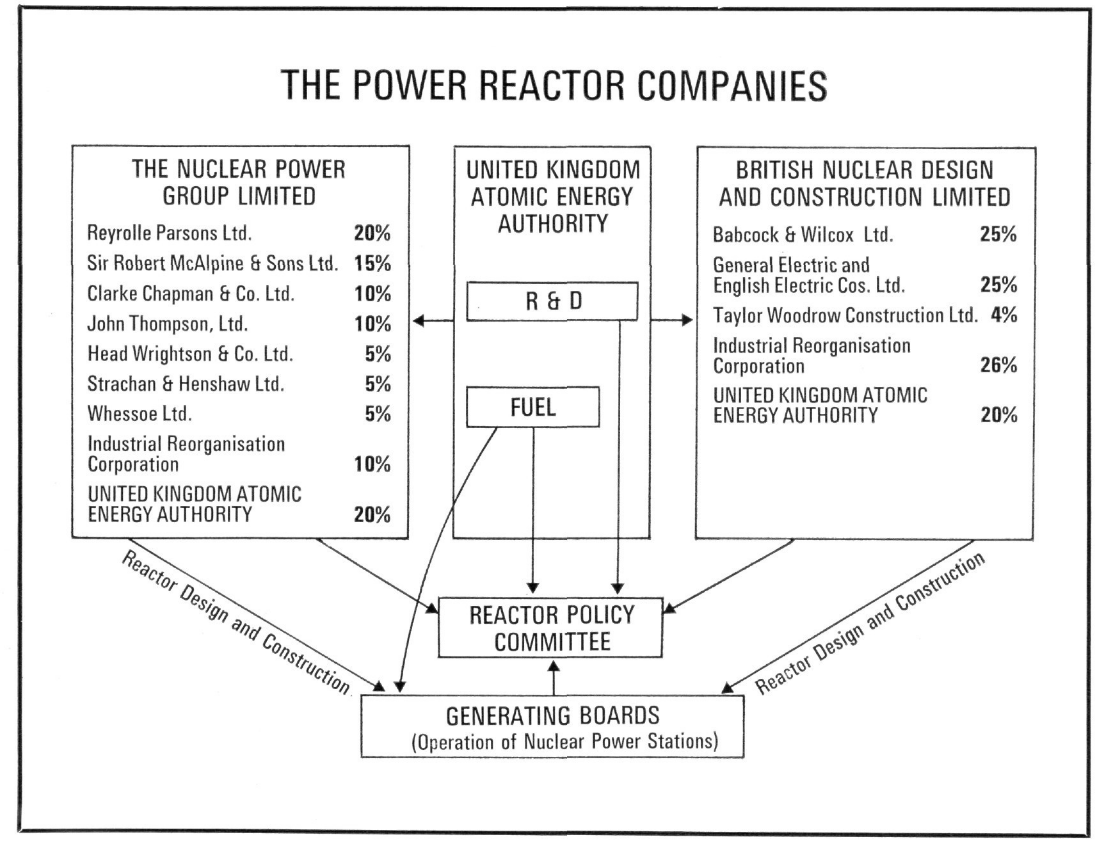
The Minister's statement of July, 1968 envisaged the transfer of the Authority's fuel business to a publicly-owned company under the Companies Acts. This transfer of part of the Authority's functions will require legislation, and discussions concerning the form of the legislation were in progress at the year's end.

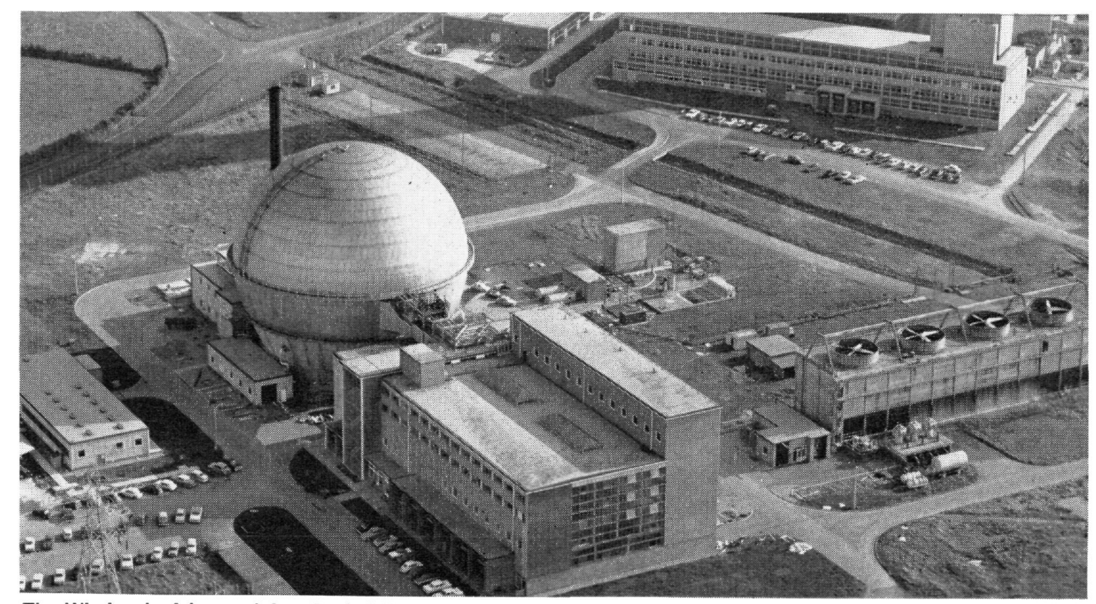
Of the Authority's civil research and development expenditure, by far the larger part (currently over £40 million per annum) is in aid of reactor development and there seems no possibility that the design and construction companies could accept responsibility for any substantial part of this work in the short term. It is clearly in the general interest that major facilities now provided by the Authority—e.g. the fast reactor at Dounreay (D.F.R.), the Prototype Advanced Gas-cooled Reactor (A.G.R.) at Windscale, the Steam Generating Heavy Water Reactor (S.G.H.W.R.) at Winfrith, the Materials Testing Reactors at Harwell—should continue to be operated in the interests of both companies; it would be impracticable for each company to duplicate them. **Various statements which have been made concerning reorganisation seem to have created the impression that the Authority was on the verge of fragmentation. On the contrary, the principal responsibility of the Authority has always been to undertake research and development into all aspects of atomic energy and this responsibility is unchanged.** Furthermore, with the rapid increase in investment in new nuclear power stations that can be expected during the next few years, the importance of a soundly-based supporting programme of research and development will be enhanced rather than diminished.

Further modifications in the organisation of the Authority were forecast in the Minister's statement. These will no doubt take some time to effect. Meanwhile, it is essential for the Authority to press on with the important research and development work which lies ahead.

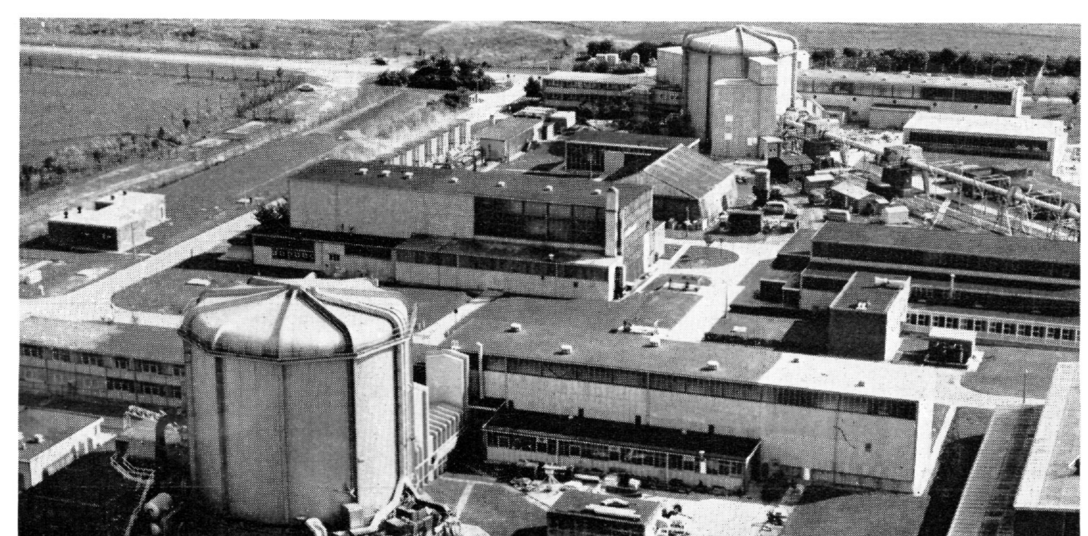


Dounreay Fast Reactor





The Windscale Advanced Gas-Cooled Reactor



PLUTO and DIDO Reactors, Harwell

UKAEA Reactors

1 **GLEEP**	*Harwell*	Routine testing of the quality of graphite and uranium. Research with oscillator. Biological irradiations.
2 **LIDO**	*Harwell*	Thermal reactor studies including shielding and neutron spectra measurements.
3 **DIDO**	*Harwell*	Studies of nuclear reactor materials. Isotope production. Neutron and solid state physics. Radiation chemistry.
4 **PLUTO**	*Harwell*	Studies of nuclear reactor materials. Isotope production. Neutron and solid state physics. Radiation chemistry.
5 **FAST REACTOR (D.F.R.)**	*Dounreay*	Fast neutron irradiation testing of advanced fuels, structural materials, etc. Development of fast reactor technology.
6 **ZENITH**	*Winfrith*	Reactor physics investigations for advanced graphite-moderated reactors.
7 **HERALD**	*Aldermaston*	Studies in neutron physics, radiochemistry and nuclear reactor materials.
8 **HORACE**	*Aldermaston*	To obtain basic nuclear information for HERALD.
9 **VERA**	*Aldermaston*	Experimental studies of fast reactor systems.
10 **NESTOR**	*Winfrith*	Source of neutrons for sub-critical assemblies.
11 **DIMPLE**	*Winfrith*	Testing of a wide range of lattices.
12 **HERO**	*Windscale*	Reactor physics studies for the advanced gas-cooled reactor system.
13 **DAPHNE**	*Harwell*	To simulate DIDO or PLUTO; to provide basic physics information in support of these reactors.
14 **ZEBRA**	*Winfrith*	Reactor physics studies of the P.F.R. and other large fast reactors.
15 **HECTOR**	*Winfrith*	Oscillator reactor reactivity measurements on materials and fuel elements.
16 **JUNO**	*Winfrith*	Testing of a wide range of liquid-moderated lattices.
17 **VIPER**	*Aldermaston*	Pulsed reactor. Experimental studies of the effects of intense, transient bursts of neutrons and gamma radiation.
18 **ADVANCED GAS-COOLED REACTOR (A.G.R.)**	*Windscale*	To study the advanced gas-cooled power reactor system and to test fuel elements for commercial A.G.R.s.
19 **STEAM-GENERATING HEAVY-WATER REACTOR (S.G.H.W.R.)**	*Winfrith*	To obtain experience with the S.G.H.W.R. concept and to test fuel for commercial S.G.H.W.R.s.
20 **PROTO-TYPE FAST REACTOR (P.F.R.) (under construction)**	*Dounreay*	To obtain the information necessary for the design of high power, commercial fast reactors.
21 **CALDER HALL (Four reactors)**	*Calderbridge*	Power and plutonium production; process steam supplied to Windscale site services.
22 **CHAPEL-CROSS (Four reactors)**	*Annan*	Power and plutonium production; experimental work in aid of the U.K. power programme.

THE AUTHORITY'S main programmes have been well maintained during the year under review. The Authority continued to meet the requirements placed upon them by the Ministry of Defence and pursued their programme of research into detection of nuclear explosions. The Trading Fund had another good year. Seven of the eight Calder and Chapelcross reactors operated at high load factor; the blocked fuel channel in Chapelcross No. 2 reactor was cleared and the necessary measures to bring the reactor back to power were set in hand. The Windscale A.G.R. continued to perform satisfactorily, as did the S.G.H.W. reactor at Winfrith, apart from fuel troubles due to early malfunctioning of the water purification plant. The Dounreay Fast Reactor (D.F.R.) was restored to power operation on 22nd June, 1968, after the sodium leak had been remedied. Construction of the P.F.R. continued; though it was necessary to set back the completion date by about 12 months because of difficulty which had been experienced in fabrication of the radiation shield roof.

In May, 1968, the Authority announced their intention to close down two research reactors, B.E.P.O. at Harwell and the Materials Testing Reactor at Dounreay. This decision, reached as a result of a review designed to ensure the most efficient use of the Authority's materials testing facilities, will reduce annual operating costs by £¾ million. B.E.P.O., the second oldest of the Authority's reactors—it had been in operation since 1948—was finally shut down on 13th December, 1968; D.M.T.R. was closed on 12th May, 1969.

In June, 1968, the Radiochemical Centre, Amersham formed a joint company with G. D. Searle & Co. (Inc.), one of the leading manufacturers of pharmaceuticals in the United States, to market Radiochemical Centre products in North and South America.

Satisfactory results of the Authority's gas centrifuge development programme led the Authority, early in the year under review, to conclude that in European conditions the gas centrifuge would probably be the most economical method of uranium enrichment. Accordingly, if development continues satisfactorily, further expansion of U.K. enrichment capacity necessary to fuel the UO_2-fuelled nuclear power stations will be provided by the centrifuge route. Centrifuge development has already been carried on in Germany and Holland, and negotiations were begun between the three Governments towards the end of 1968 with a view to establishing joint enterprises for the construction and operation of centrifuge enrichment plants.

Two developments concerning the nuclear power programme should be noted. First, **the Central Electricity Generating Board (C.E.G.B.) have now increased the assumed life of A.G.R. power stations from 20 to 25 years in the light of satisfactory experience of the Windscale A.G.R.** Second, whereas the capital costs of the earliest magnox stations were some three times higher than those of their fossil fuel equivalents, the difference between the Hinkley 'B' A.G.R. and the coal-fired Drax is narrowed to some 25 per cent. When account is taken of the very much cheaper fuelling costs, this establishes a decisive cost advantage for nuclear power.

NUCLEAR COSTS

In the House of Commons in March, 1969, the Minister of Power gave the following cost estimates for electricity generation, revised as a result of the CEGB decision that the assumed life of an AGR station should be increased from 20 to 25 years (compared with 30 years for a coal-fired station):

Station	Base Load Generating Cost (d. per unit)	Year of Commissioning
Nuclear		
Dungeness 'B'	0.56	1972
Hinkley Point 'B'	0.52	1972
Coal-Fired		
Ratcliffe	0.55	1968
Cottam	0.60	1969
Drax	0.61 *	1971
Oil-Fired		
Pembroke (with tax)	0.59	1970
Pembroke (without tax)	0.48	1970

(**On the assumption that the whole 3,960 MW station is completed.*)

The estimates for 1969/70 under the Atomic Energy Vote total £27·9 million nett (£94·79 million gross) and show a reduction of £2·3 million. The Authority's cash expenditure in 1968/69 on the civil research and development programme was £48 million and 2,380 qualified scientists and engineers were engaged on this work at the end of the year. In addition, 265 qualified staff were employed on other nuclear and non-nuclear work on repayment.

The Authority's sales, primarily of nuclear fuel services, electricity and radioisotopes totalled £41·7 million with a net surplus of £1·5 million. All the electricity sales and the larger part of the fuel services sales were to the U.K. electricity generating boards; overseas fuel service sales totalled £1·9 million, and outstanding export contracts totalled £19 million at the year's end. Sales of radioisotopes from the Radiochemical Centre increased by ten per cent. to £3·15 million of which 57 per cent. were overseas.

The first priority of the Authority's reactor programme is to ensure the satisfactory operation of the Mk. II commercial gas-cooled reactors (A.G.R.'s) now under construction. The scope for further development of the gas-cooled system is being exploited by improvements to the fuel for the Mk. II reactors under construction and to be ordered. The S.G.H.W.R. is being pursued as a complementary system for home and overseas markets with particular emphasis on the intermediate output stations (about 450 MW(E)). Designs for commercial fast reactors are being studied, since they are expected to give the lowest generating costs, though the rate of installation is likely to be limited for a time in the late 1980s by the availability of plutonium from thermal reactors. Improvements to thermal reactors are also being considered. The considerable experience of gas-cooled reactors is being exploited further by development of a Mk. III gas-cooled reactor, using low-enriched coated particle fuel and helium coolant, exploiting the new technology evolving from the Dragon project.

During the year the C.E.G.B. signed a letter of intent for the 1250 MW(E) A.G.R. power station at Hartlepool. This brings the total capacity of Mk. II gas-cooled reactor stations ordered under the second nuclear power programme to about 5,000 MW(E). It was previously estimated that capacity totalling about 8,000 MW(E) of these stations might be in commission by 1975, but electricity peak demand has been growing rather more slowly than expected and the Government have indicated in "The Task Ahead" that the growth of nuclear power is also likely to be slower.

The nuclear fusion research programme at Culham Laboratory continues to be organised and implemented with the advantage of a full exchange of information among the principal world laboratories engaged in this field. Overall plasma confinement times continued to increase and show promise that the confinement needed for a fusion reactor can be realised.

The Chairman of the Authority, Dr. J. M. Hill, and the Director of Culham Laboratory, Dr. R. S. Pease, gave further evidence on the nuclear fusion programme to the Select Committee on Science and Technology on 28th November, 1968, and the Chairman reaffirmed the Authority's intention to maintain a viable fusion and plasma physics programme.

The effort devoted by the Authority to applied research and development with industrial objectives outside the nuclear power field is steadily increasing. Some of the work is classified as applied nuclear R. & D.; the remainder is classified as non-nuclear R. & D. In both cases the objectives are to achieve national benefit, either economic or social. These benefits are assessed by the Programmes Analysis Unit (P.A.U.) or by the Authority's Economics and Programming Branch.

The Authority continued their programme of research and development into matters not connected with atomic energy. During the year, five additional Requirements were issued by the Minister of Technology under Section 4 of the Science and Technology Act, 1965: quality control; water renovation by reverse osmosis; high temperature chemical technology; electrotechnology; and marine technology. Extensions to existing programmes of research into hydrostatic extrusion and the improved utilisation of steels were under consideration at the year's end.

The effort devoted to these activities continued to increase as follows:

			(qualified scientists and engineers)
1965/66	42	man/years	
1966/67	81	,,	,,
1967/68	175	,,	,,
1968/69	264	,,	,,

A further increase is expected in 1969/70.

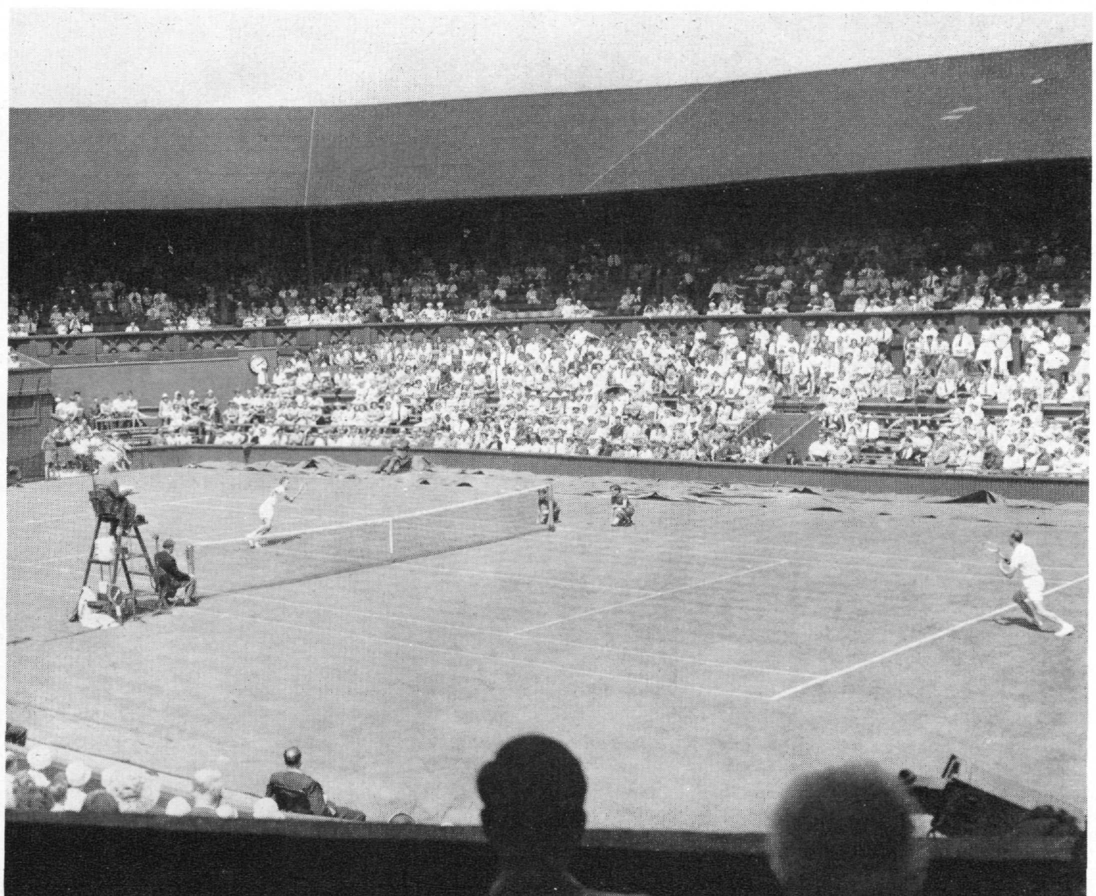
The Authority's R. & D. programme on nuclear reactors and in the applied nuclear and non-nuclear fields are supported by underlying research in the relevant scientific disciplines. All these research and development programmes require the support of special major facilities such as research reactors, computers, particle accelerators, mass spectrometers, electromagnetic separators, as well as radiochemical laboratories and post-irradiation examination cells for handling and studying highly radioactive materials.

The reduction in the Authority's expenditure on reactor research and development consequent on the achievement of economic nuclear power necessitated a re-assessment and reduction of the underlying research and a change in emphasis in many of the programmes. This re-assessment has now been completed, taking into consideration not only the long term needs of the reactor programme and other applied programmes, but also the need to maintain a strong and coherent scientific base from which the country can exploit the new scientific and technical opportunities that arise in the nuclear field. At the end of the year, approximately 290 qualified scientists and engineers were deployed on underlying research.

The principal aims of this programme are to study the properties of materials used in the Authority's programmes, and to devise and explore new processes and techniques which may have application in research or production.

The major research facilities (e.g. reactors, accelerators, mass spectrometers, electromagnetic isotope separators) also provide the means of studying and developing new ideas and applications such as the uses of radioisotopes and radiation sources.

Notable progress has been made in physical and chemical studies of all the types of nuclear reactions of importance in reactor technology.

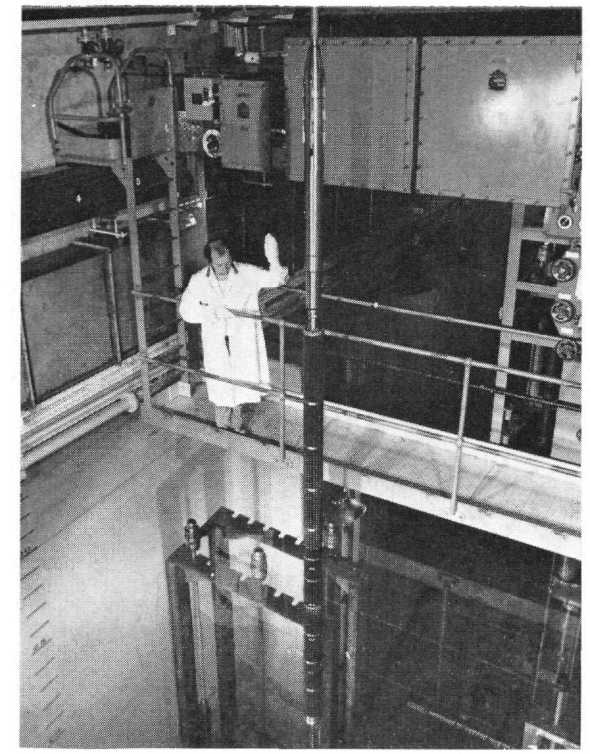


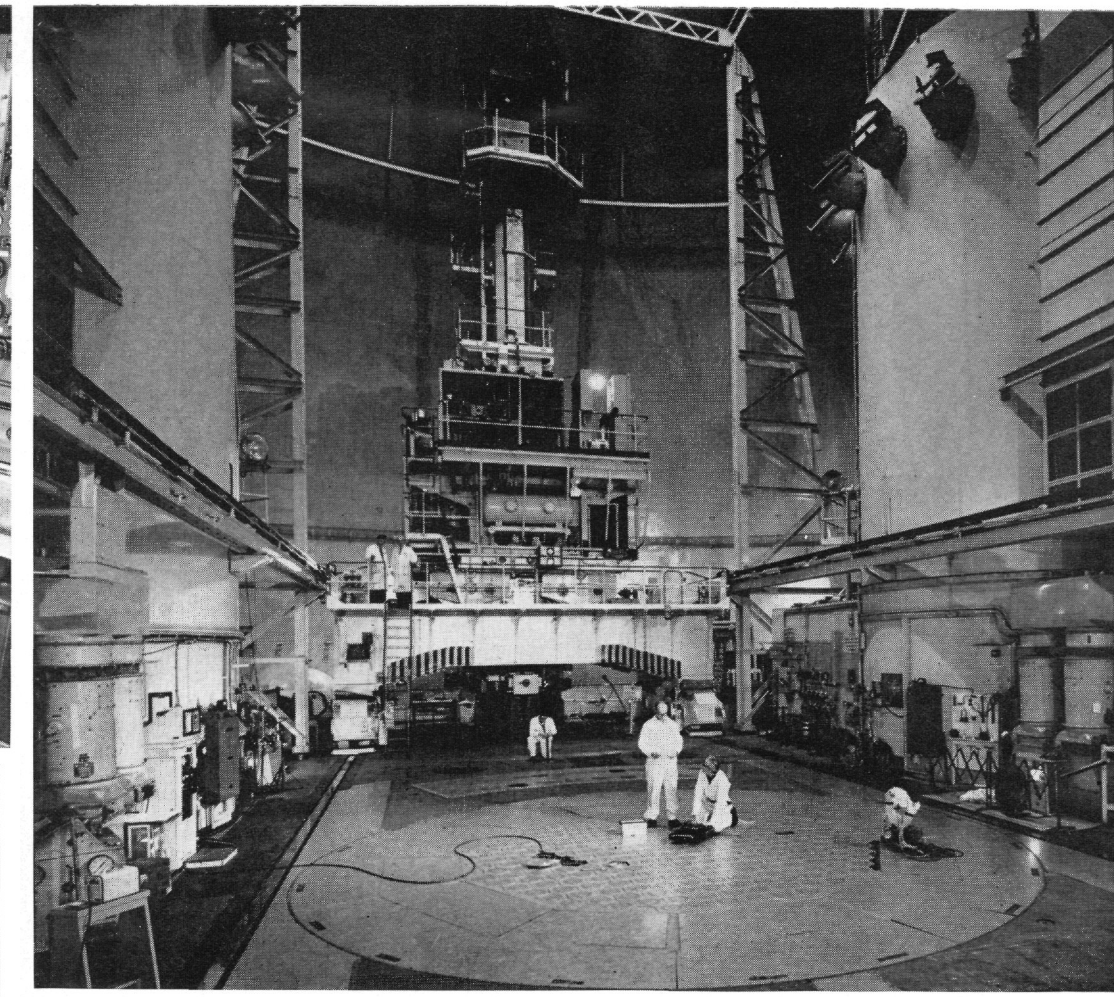
FUEL RECORD The quantity of reactor fuel produced at the Springfields factory of the Production Group in 1968/69 was the highest ever achieved. The compactness of nuclear fuel can be judged from the fact that, although this output will provide energy equivalent to 30 million tons of coal, the whole of it could be accommodated in a stack eighteen inches high over an area no bigger than a tennis court.

POWER

The Authority's reactor development programme has, as its first priority, the completion of work necessary to ensure the completely satisfactory operation of the commercial Mk. II gas-cooled reactors (A.G.R.'s), 5,000 MW(E) of which are at present under construction for the electricity generating boards. The advent of these fully economic reactors offers the prospect of very substantial economic benefits and much larger nuclear power installation programmes in the future. Development policy is increasingly being directed towards the opportunities and problems which this larger programme will create.

A major technical and economic review undertaken by the Authority during the year indicates a pattern in which the introduction of further improved thermal reactors will increase the economic advantage of nuclear over fossil fuelled stations, even at reduced load factors. With nuclear stations comprising the majority of new power plant installations in the future, the thermal reactor stations will be followed by the phased introduction of sodium-cooled fast reactors which in turn will generate electricity at even lower cost.





Above: The Windscale A.G.R. which has produced over 1,000,000 kWh of electricity in six years.
Above left: A fuel element being lowered into the fuel-handling pond of the Winfrith S.G.H.W.R.
Left below: June, 1969. Work in progress on the reactor jacket of the P.F.R. at Dounreay.

GAS-COOLED REACTORS

The Mk. I gas-cooled reactors (the Magnox stations) already incorporated in the electricity boards' networks have proved reliable to date and have been operated at high cumulative load factors.

The Authority's gas-cooled reactor development programme continued in support of Dungeness 'B' and the later stations of the second nuclear power programme. The aim of the work has been to endorse the design of the fuel. The final manufacturing details of the first fuel charge for Dungeness 'B' have been defined and fabrication of the fuel has started.

The Windscale A.G.R. has operated satisfactorily throughout the year; the availability over the past six years since commissioning is about 84 per cent. and more than half of the fuel charge in the reactor is test fuel for the commercial stations. Fuel pins similar to those for the commercial stations have been irradiated beyond the target peak burn-up expected in the commercial reactors.

The performance of features of the fuel design chosen for Dungeness 'B' has been tested by extensive irradiation in the Windscale A.G.R. The performance of the fuel under a range of conditions is now being investigated to guide the operational fuel management in the Dungeness 'B' reactor.

Attention is now being directed to the longer term objective of defining fuel pin materials able to endure the station load following conditions which the electricity generating boards expect will be relevant to the late 1970s.

An important reason for pursuing gas-cooled reactor development is the scope for continuing improvements. The electricity boards, the consortia and the Authority continued their studies of reactor designs based on graphite-coated fuel particles of uranium dioxide. The studies have confirmed the economic advantage of these reactors. Economic considerations led to the choice of the homogeneous type of reactor using low enriched coated particle fuel in graphite tubes cooled by helium. Taking account of the need to ensure early exploitation, the development is being concentrated on a single fuel design. The development programme to support a commercial reactor based on this concept is being worked out in detail and work has started on the most immediate aspects.

Irradiation of coated particle fuel for helium-cooled Mk. III reactors has centred largely on the Dragon reactor in association with the Dragon Project.

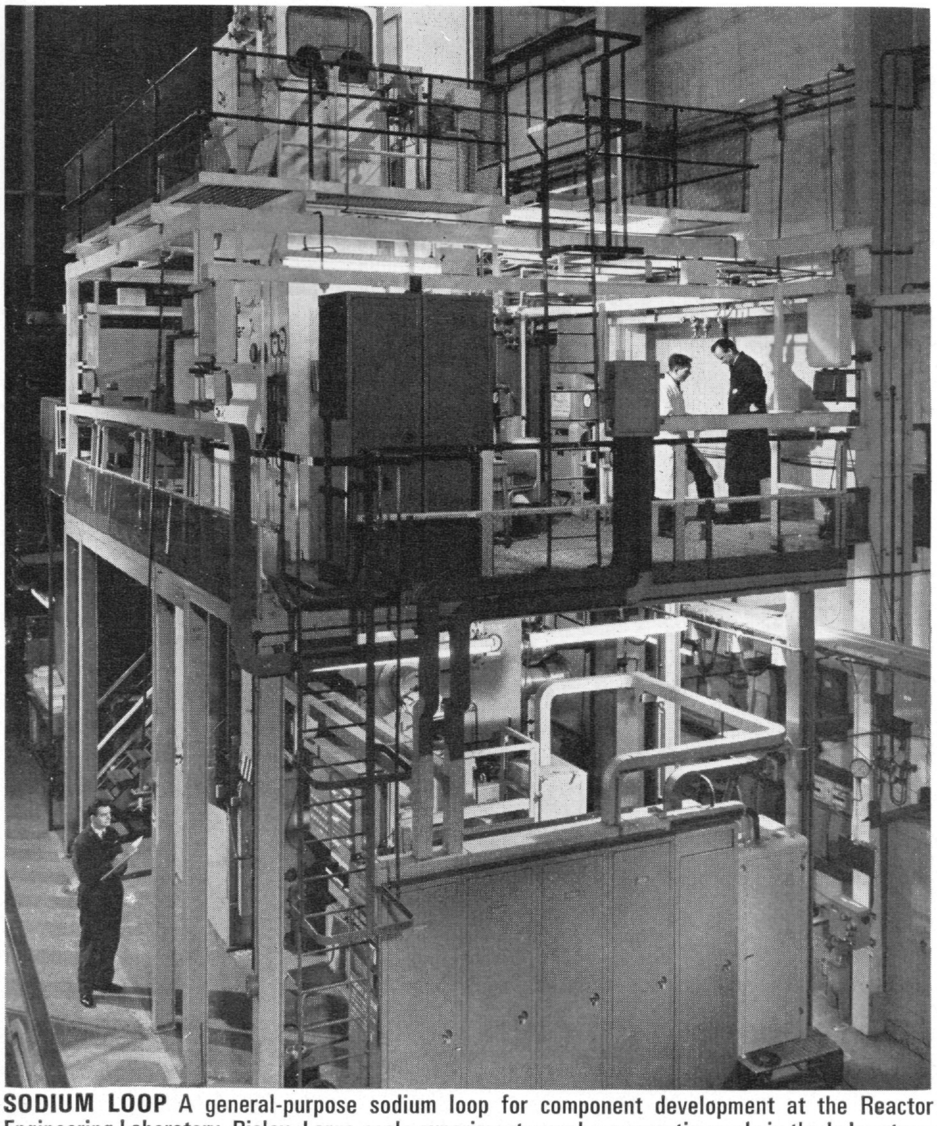
The Authority's study of the application of gas turbine driven generators was extended to include their application to helium-cooled reactors.

SGHWR

The Steam Generating Heavy Water Reactor (S.G.H.W.R.) is an alternative thermal reactor system with attractive operational features offering economic benefits comparable to gas-cooled reactors.

Since the station reached full power at the end of January, 1968, more than 470 million kW/h of electricity have been generated at a load factor of 45 per cent. and a station availability of 51 per cent. to the end of March, 1969. The loss of operating time was a consequence of incorrect functioning of the water

SODIUM FLOWMETER The Authority's extensive R. & D. experience on sodium cooling has been deployed to develop instrumentation for P.F.R. (whose coolant will be 1,000 tons of sodium). Above: "Saddle coil" flowmeter for measuring sodium flow in large diameter pipe.



SODIUM LOOP A general-purpose sodium loop for component development at the Reactor Engineering Laboratory, Risley. Large-scale experiments can be run continuously in the Laboratory, which includes a complete engineering design office.

purification plant during the first few months of reactor operation.

The malfunctioning of the purification plant resulted in solids being deposited on the fuel elements which led to overheating and failure of the fuel element cladding.

Apart from the consequences of incorrect control of the primary water purity, which has been rectified, the reactor has performed very well. The operating characteristics were found to be very close to prediction and control of the plant was straight-forward. The physics and fuel cycle performance are also close to predictions. Examination of fuel withdrawn from the reactor confirms that, apart from the damage caused by the solid deposits, the details of the fuel design are satisfactory.

The designs of commercial reactors (450 MW(E) compared with 100 MW(E) of the Winfrith S.G.H.W.R.) exploit rather more highly rated fuel than is presently being irradiated in the majority of the S.G.H.W.R. channels. Some fuel channels were operated at ratings appropriate to the commercial reactors from the start of operation of the S.G.H.W.R. at Winfrith, and arrangements are being made to increase the number of these channels.

FAST BREEDER REACTORS

At 31st March, 1969 the buildings for the 250 MW(E) Prototype Fast Reactor at Dounreay were all weathertight and plant was being erected and installed. The reactor vault had been completed and the leak jacket, which is the outermost vessel and about 40 ft. in diameter, had been lowered into it. The reactor tank, which will sit just inside the leak jacket, had also been fabricated at site and these two vessels will finally be welded to the biological shield roof.

Trouble was experienced in welding the biological shield roof and it had not yet been delivered to Dounreay; construction of P.F.R. has been delayed by about a year. The roof is of conventional engineering structure and the troubles which have been encountered are not connected with fast reactor aspects.

The design and performance parameters selected for the first fuel charge of the P.F.R. have been confirmed by further laboratory and irradiation experiments. Information arising during the year indicates that the conservative target for P.F.R. performance should be achievable.

Work has continued on a series of designs for the larger generating stations that will follow the P.F.R. Reactors giving electrical outputs of both 625 and 1250 MW were studied. These designs follow closely on the lines of the P.F.R. but contain some novel features intended both to reduce the cost and increase the reliability of the reactors. On the basis of the study, a development programme for reactor components is being drawn up to meet the requirements of reliability and cost for commercial reactors.

From April to June, 1968 the Dounreay Fast Reactor was recommissioned after the successful repair of the primary circuit liquid metal leak which caused the reactor to be shut down in mid-1967. After a period of proving trials at full power (60 MW(H)) the programme of irradiation of fuel and reactor materials was recommenced in August, 1968. Improved detectors to monitor the reactor for local boiling of the liquid metal coolant in the event of a fuel element failure or coolant channel blockage were installed and tested. This type of equipment is very sensitive and will probably become standard equipment of future liquid metal-cooled fast reactors to give immediate detection of coolant flow restriction.

The European Nuclear Energy Agency has sponsored the assessment of fast reactors with alternative coolants to sodium. The two study groups set up in which the Authority participated concluded that gas-cooled systems had considerably greater development prospects than steam-cooled systems, particularly if direct cycle gas-turbine systems can be successfully engineered. The analysis of gas-cooled systems covered designs with either metal clad or coated-particle fuel. The possibility of an international collaborative development programme on the gas-cooled system is under consideration.

SHIPS

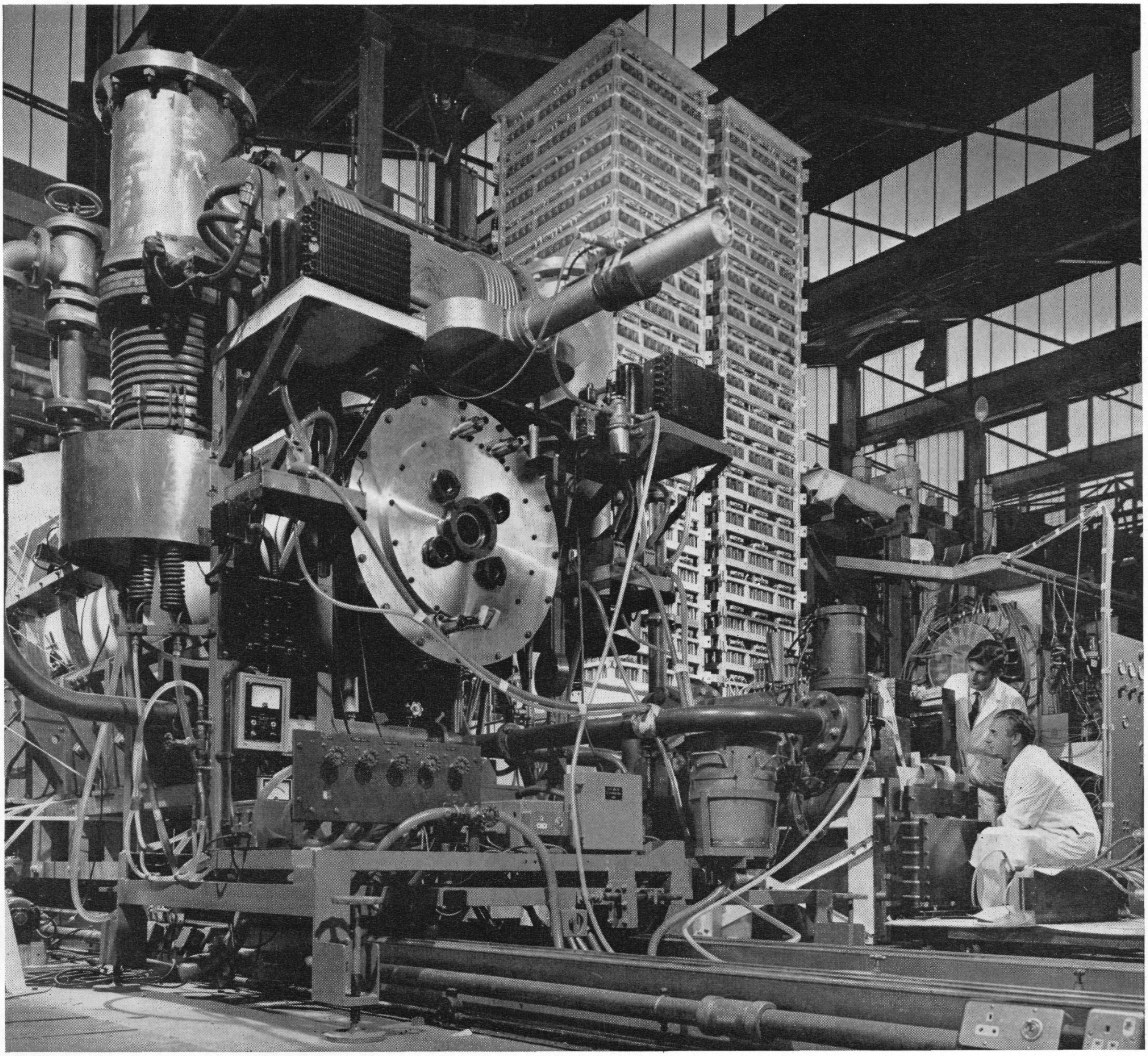
A small amount of work has continued throughout the year in support of the nuclear container ship study by Vickers' Shipbuilding Group. Detailed specifications for a 40,000 s.h.p. burnable poison pressurised water reactor (B.P.W.R.) suitable for a container ship are not complete. The Authority can make no further contribution unless, on a fresh assessment of the economics of nuclear propulsion, the shipping industry and the Government determine a nuclear marine policy from which a firm marine reactor design and construction requirement can emerge.

FUSION

The aim of the Authority's programme on controlled nuclear fusion is to find means of releasing in a controlled fashion the energy stored in the nuclei of the light elements. At present, the work is mainly at the stage of establishing the scientific principles which must be the basis of future practical systems. In particular, the controlled fusion reactions can take place only in matter raised to a very high temperature, where it forms what is called a high temperature plasma. The research has to establish the physics of high temperature plasma and, in particular, the means by which plasma may be confined—that is, isolated and thermally insulated from the ambient surroundings which would otherwise cool and destroy it. Magnetic fields of practicable strength can in principle provide the means of confining plasma. The key subject of present-day fusion research is to establish whether or not the planned confinement needed for controlled fusion reactions can indeed be achieved by means of magnetic fields.

During the year, the Third World Conference on Controlled Nuclear Fusion and Plasma Physics, held by the International Atomic Energy Agency at Novosibirsk, U.S.S.R. in August, 1968, provided a major opportunity for assessing the world-wide progress of this research. The new results of both theoretical and experimental studies presented there show that excellent progress is being made, both in advancing the densities, temperatures and confinement times of magnetically confined plasmas, and in the understanding which is essential in order to extrapolate from present-day experiments to the envisaged controlled fusion reactors of the future. There are now good expectations that the necessary confinement of high temperature plasma can be achieved. Such confinement has, however, still to be demonstrated beyond doubt; and there are important problems of matching the principles established to the practical requirements of envisaged fusion reactors and formidable technological problems to be studied. The Authority programme, which is conducted at the Culham Laboratory, continues to make a major contribution to this world-wide progress.

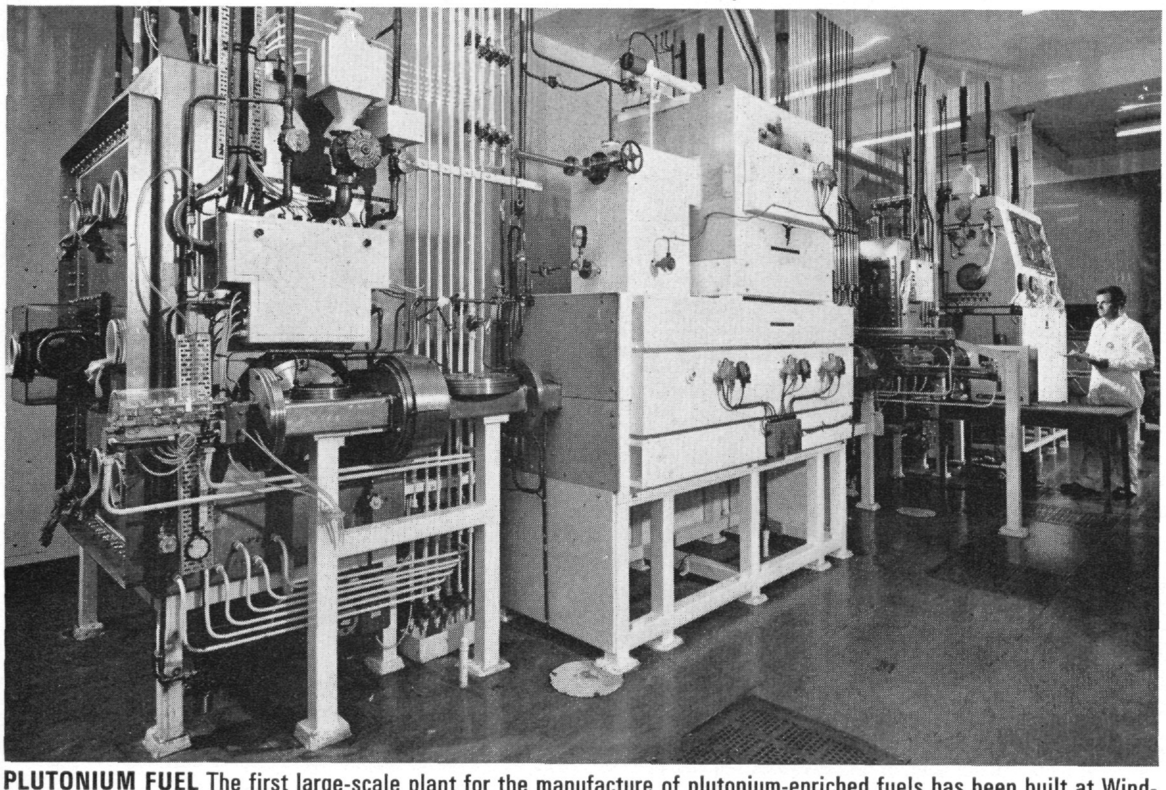
In evidence to the Select Committee on Science and Technology in November, 1968, the Chairman of the Authority reaffirmed the Authority's intention to maintain a viable fusion and plasma physics programme.



MTSE II Magnetic Trap Stability Experiment II, one of the two magnetic mirror machine experiments at the Culham Laboratory. An international conference on "Nuclear Fusion Reactors" was held at Culham by the British Nuclear Energy Society from 17th to 19th September.

Fuel

HEAD-END PLANT A new head-end plant for the primary treatment of irradiated oxide fuel is now in operation at the Windscale reprocessing plant, which has a capacity of over 2,500 tonnes a year.



PLUTONIUM FUEL The first large-scale plant for the manufacture of plutonium-enriched fuels has been built at Windscale. It is extensively automated and remotely controlled and plant operation is based on fully continuous processing equipment.

The major feature of Production Group operations in 1968/69 was the introduction of new facilities at Springfields, Capenhurst and Windscale for the fuel cycle services for advanced thermal reactor systems, and at Windscale and Springfields to meet the fuel requirements for the Prototype Fast Reactor now being constructed at Dounreay.

The total quantity of magnox fuel produced at Springfields in 1968/69 was equivalent to nearly 30 million tons of coal. This type of fuel, which included the bulk of the initial charges for the Wylfa reactors, was supplied to a total of 26 reactors in the U.K. and two overseas, at Latina in Italy and Tokai-mura in Japan.

The main feature of operations at Springfields was the commissioning and start up of a new plant to manufacture uranium oxide fuel for Dungeness 'B', the first advanced gas-cooled reactor being constructed for the C.E.G.B. Replacement and experimental oxide fuel was manufactured for the Authority's prototype reactors, the A.G.R. at Windscale and the S.G.H.W. reactor at Winfrith, as well as enriched uranium oxide powder for export. Further extension of capacity for enriched oxide fuel manufacture is planned for 1971.

The new uranium hexafluoride plant, designed on the fluidised bed principle, was successfully started in May, 1968. The Authority have already obtained substantial export business for conversion of uranium ore concentrate to uranium hexafluoride for toll enrichment.

Installation of plant for the manufacture of breeder fuel for the prototype fast reactor is nearly complete.

The section of the Capenhurst diffusion plant which was shut down in 1962 on completion of defence requirements and recommissioned last year as a low enrichment facility for reactor fuel continued to operate satisfactorily. However, difficulties were experienced in the commissioning of the first of the modified larger process units. This set-back is not serious and it is expected that the final date for completion of the project will be as originally planned, and enriched uranium requirements for the U.K. programme met.

Development continued during the year, both on a large separation unit, working on the diffusion principle, and on the gas centrifuge process, with a view to meeting the further expansion of separation capacity which will be needed in the 1970s. However, as the year progressed, the prospects of successful development of the centrifuge process increased and more effort was devoted to it. Similar work in Europe led to the agreement, reached in November, 1968, between Ministers of the Dutch, Federal German and U.K. Governments to explore the possibility of collaboration. Studies of the commercial and financial implications of such collaboration have since been carried out, with a view to establishing joint enterprises for construction and operation of centrifuge enrichment plants.

There was a marked increase in the rate of delivery to the Windscale reprocessing plant of irradiated magnox fuel from U.K. civil stations; it was dealt with successfully. Uranium throughput of the reprocessing plant rose by 30 per cent. and plutonium throughput by 55 per cent. A second cave-type decanning machine for stripping the magnox cans from the irradiated uranium metal fuel was brought into operation. The performance of these machines represents a major advance over the old pond-type decanning system and has been a key factor in the achievement of increased throughput. After some years of difficulty with decanning, operations have now become routine, and the maintenance required has been much reduced.

Commissioning of the new head end plant for pre-treatment of irradiated oxide fuel continued. Successful trials were carried out with simulated advanced gas-cooled and water reactor fuels. During March, the first consignment of zirconium-clad oxide fuel from the Garigliano reactor in Italy was received in accordance with the terms of a reprocessing contract with Ente Nazionale per l'Energia Elettrica. It is proposed to bring the plant into operation in 1969/70 using Windscale A.G.R. fuel and to follow this with the reprocessing of Garigliano fuel.

Plant for the production of mixed plutonium/uranium oxide powder and its pelletting, canning and assembly was still under construction; it will provide the initial charge for the P.F.R. at Dounreay. Commissioning of some parts of the plant has started.

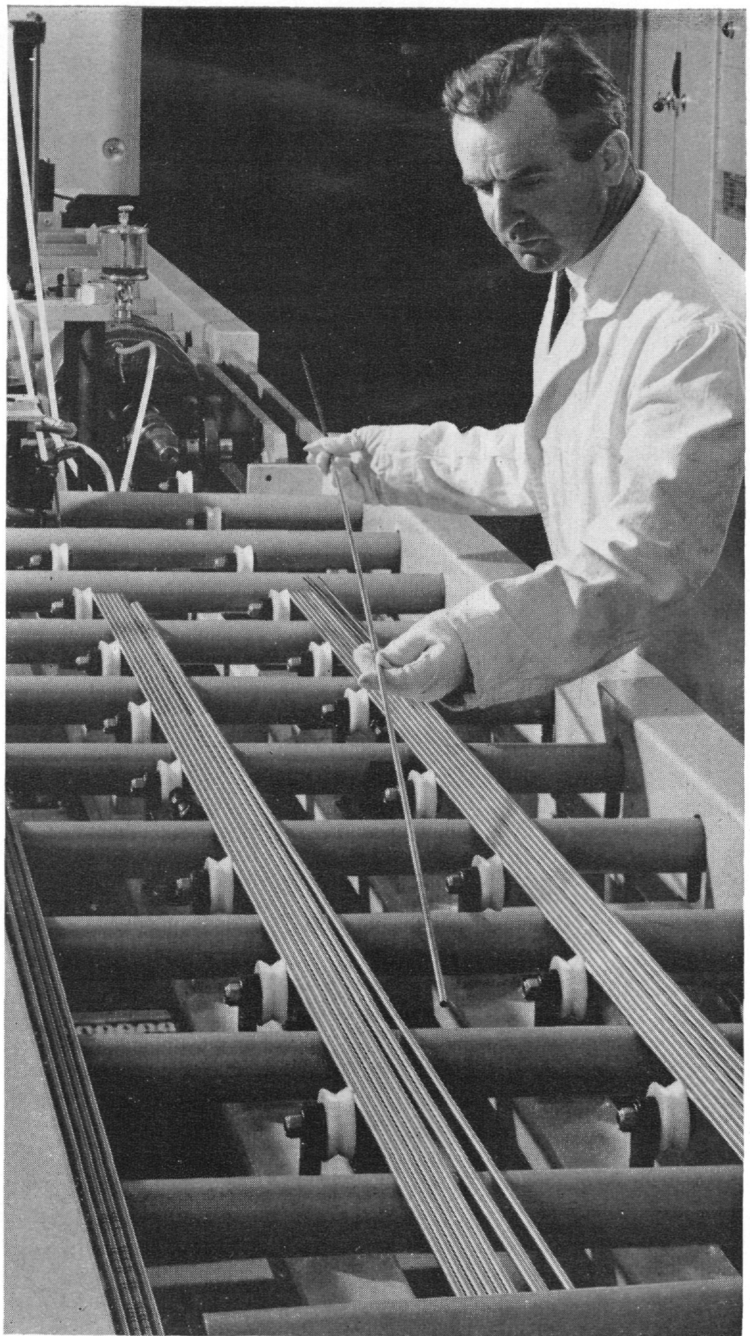
More development effort was devoted to the design of transport flasks for moving irradiated fuel, to improve pay load and accommodate the more highly rated fuel from enriched uranium reactors. Improved flasks are now in service. A second ocean-going vessel, the M.V. *Leven Fisher*, was chartered and at the end of the year was being fitted out in Barrow-in-Furness prior to joining her sister ship the *Stream Fisher* in transporting irradiated fuel from overseas reactors for reprocessing in this country.

Routine production continued of concentric tube type fuel elements for the Authority's materials testing reactors (M.T.R.'s) and German and Danish M.T.R.'s. Dip-brazed box type elements were supplied to Authority and University research reactors in the U.K. and to HIFAR in Australia. The annual throughput is about 700 elements of all types.

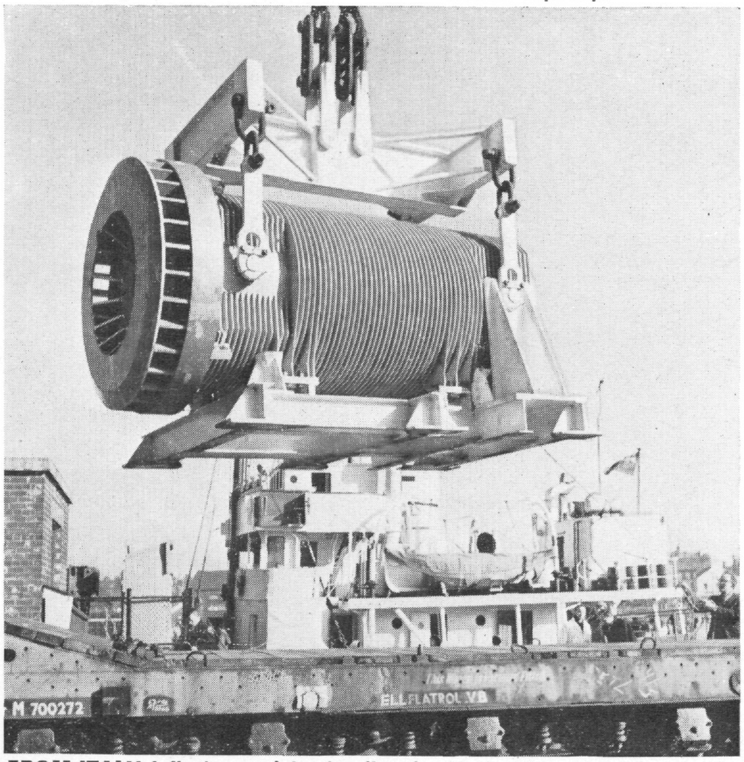
Reprocessing of spent M.T.R. fuel elements from domestic and overseas reactors continued in the highly-enriched uranium reprocessing plant. Eighty-five kg. of enriched uranium from these sources was reprocessed during the year including Danish and German material.

Reactor No. 2 at Chapelcross remained shut down following the melt-out on 11th May, 1967, of experimental fuel in one channel. The other three reactors at Chapelcross and all four at Calder continued to operate satisfactorily. High load factors were again maintained in 1968/69. During the S.S.E.B. peak loads last winter, Chapelcross provided 151 MW(E) to the grid from the three reactors available, which is higher than the original design output of the station based upon four reactors.

Development and test work on fuel and reactor materials in support of the A.G.R. programme continued in the Windscale A.G.R. The reactor has now operated for more than 6 years and has exported over 1,000 million. kWh of electricity. Some of the original fuel pins are still under irradiation in the reactor and have reached a maximum burn-up of 29,000 MWD/t, whilst experimental fuel of a type similar to that designed for the commercial stations has reached a burn-up of 24,000 MWD/t.



P.F.R. Swaging and cropping fuel pins for the Prototype Fast Reactor before they are loaded with fissile fuel. The Windscale plant is being used initially for P.F.R. fuel, but will have additional capacity.



FROM ITALY A flask containing irradiated oxide fuel from the water reactor at Garigliano, Italy, being unloaded from M.V. "Stream Fisher" at Barrow-in-Furness en route for the Windscale reprocessing plant.

FUEL

PRODUCTION GROUP EXPORTS

The value of export sales completed during the year was £1·9 million and the total of new export contracts signed and letters of intent received was £11·4 million. At the end of the year, outstanding export business covered either by long or short term contracts was about £19 million.

During the year, new contracts for fuel business were won with the following countries:

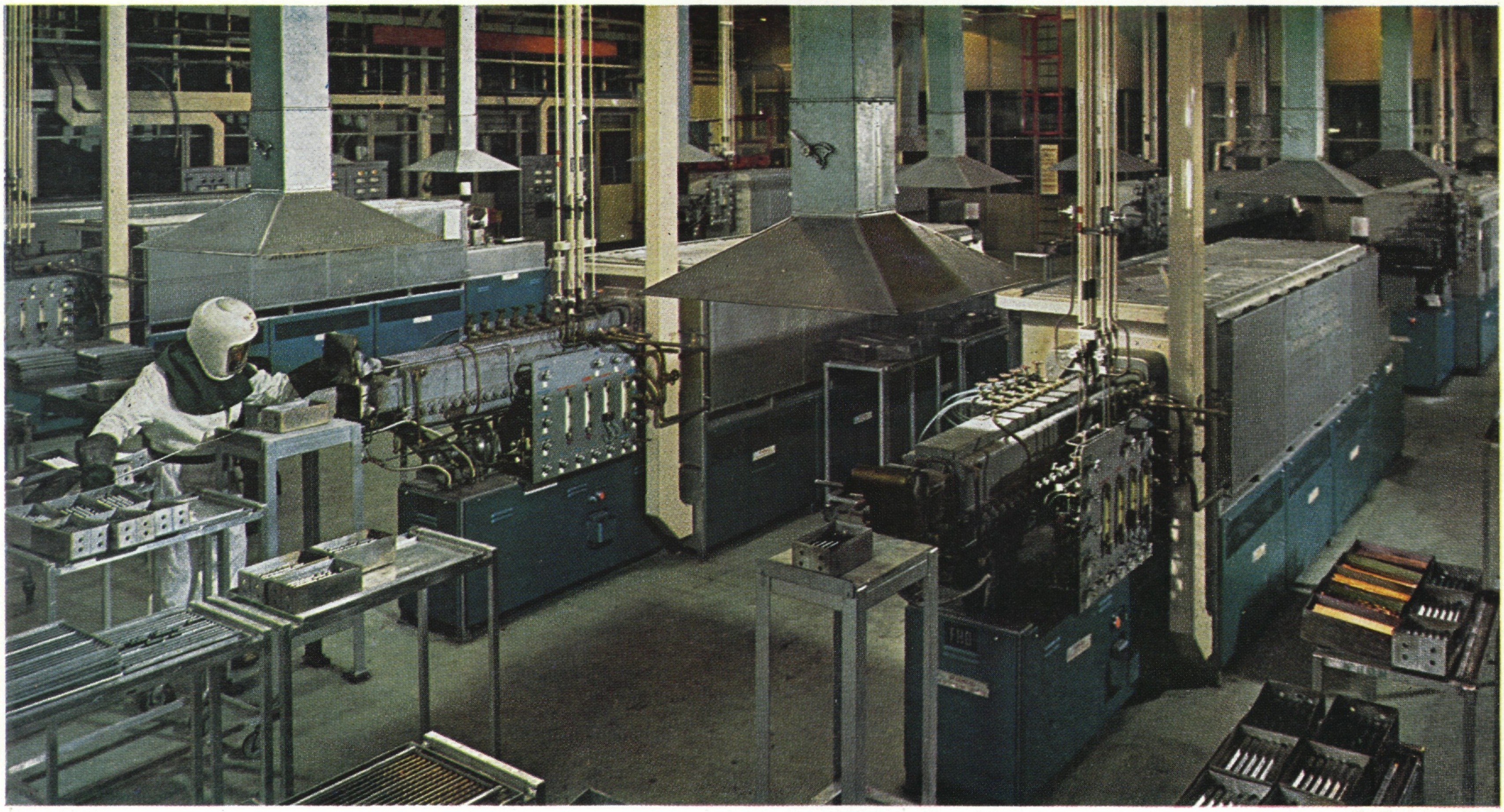
Argentine
Australia
Belgium
Brazil
Canada
France
Holland
Italy
Japan
Rumania
South Africa
Spain
Sweden
Switzerland
U.S.A.
West Germany

Of particular significance were those new contracts or letters of intent obtained in three fields representing the first orders for new types of commercial business. These were:

(*a*) Supply of replacement fuel for the foreign-designed, and previously foreign-fuelled, water reactor at Dodewaard in Holland.
(*b*) Reprocessing of irradiated oxide fuel from the water reactors at Garigliano (Italy), Beznau (Switzerland) and Whiteshall (Canada) with responsibility for arranging all aspects of fuel transport.
(*c*) A contract with Allgemeine Elektricitats-Gesellschaft (A.E.G.) (Germany) for conversion of uranium ore concentrate to uranium hexafluoride for toll enrichment in the U.S.A.

A contract was obtained for the supply of 180 kg. plutonium to BelgoNucléaire, and a letter of intent was received for 200 kg. for Germany.

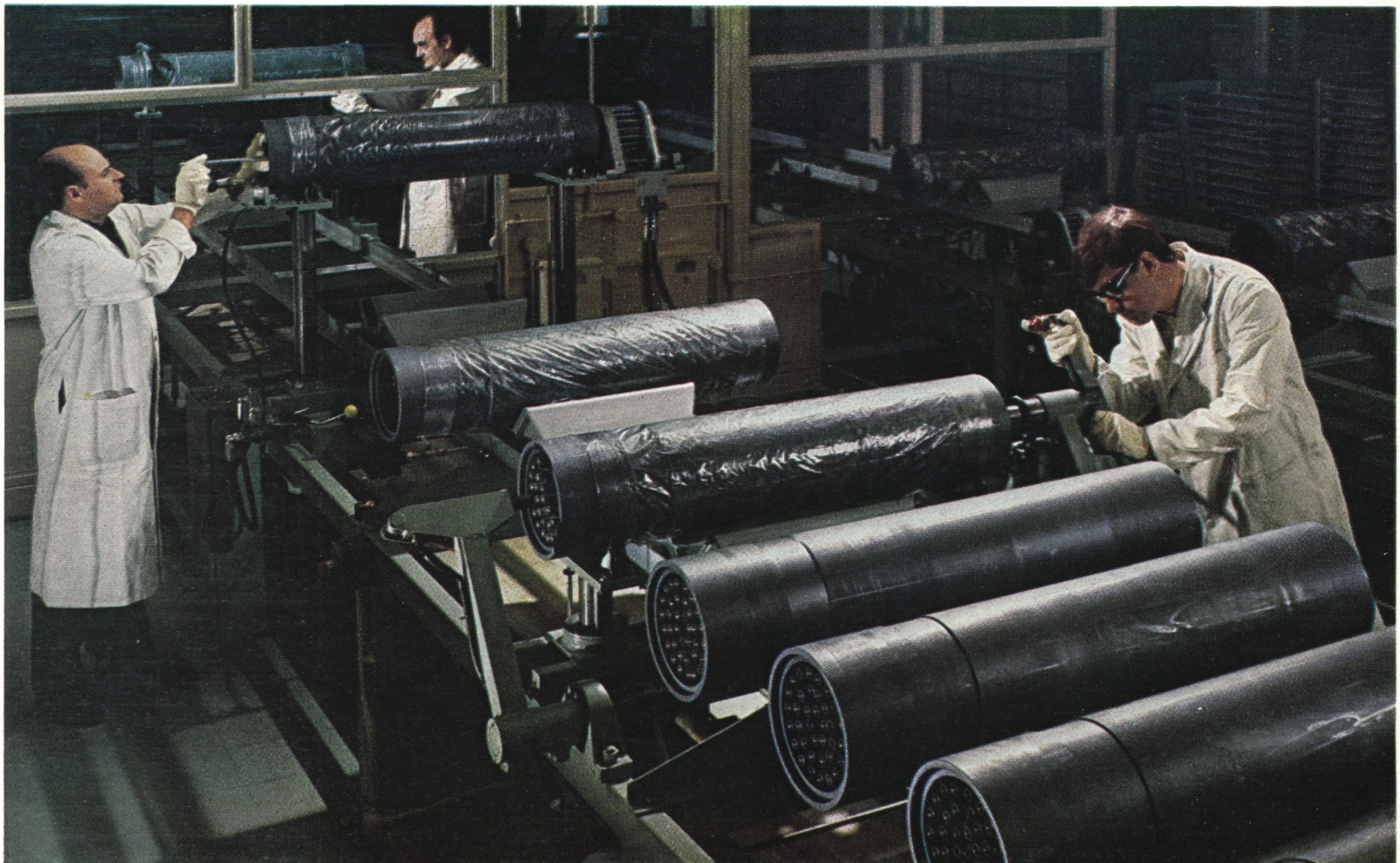
Combustibili Nucleari, the joint company formed last year in Italy with Società Minerali Radioattivi Energia Nucleare, has obtained its first order for fabrication of magnox fuel for the Latina reactor. Construction of the new plant for the company at Rotondella, in southern Italy, is on schedule and commissioning started in May, 1969.



FUEL

C.A.G.R.—PELLETS (above) The furnace area of the Commercial A.G.R. oxide pellet plant at Springfields. At the Springfields Works uranium ores and concentrates are converted into metal or oxide. For A.G.R. the oxide is made into pellets.

C.A.G.R.—ASSEMBLY The photograph below shows the final assembly of C.A.G.R. fuel elements at Springfields. The oxide pellets are inserted into stainless steel tubes to form fuel "pins" and a cluster of 36 of these forms a complete fuel element.



Royal Visit

H.M. the Queen and H.R.H. the Prince Philip visited the Atomic Energy Establishment, Winfrith, during their tour of Dorset on 11th July.

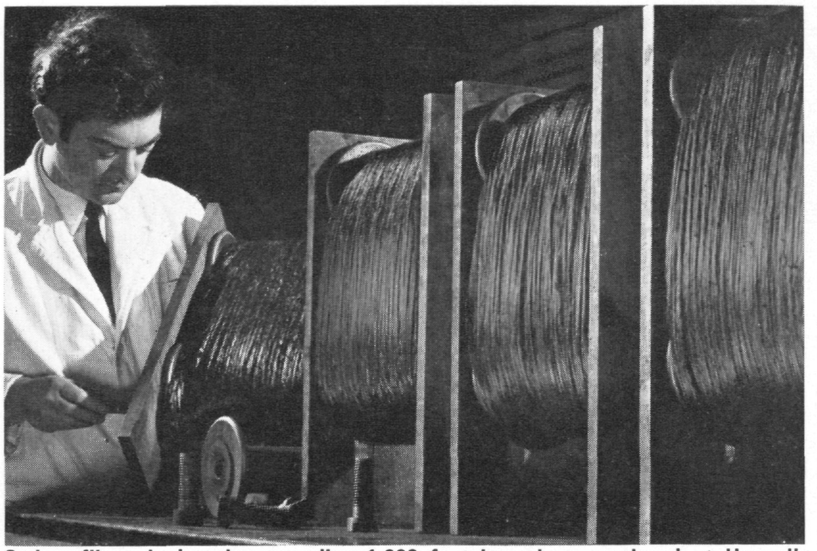
The Chairman of the Authority, Sir John Hill, is presented to Her Majesty by the Rt. Hon. Anthony Wedgwood Benn. Lady Hill and Mr. Donald Fry, Director of Winfrith, are on the right.

The Queen and Prince Philip walking towards the Staff Restaurant where the Royal party were entertained to lunch.

Among the Winfrith staff presented to the Queen were (left to right): Mr. B. R. Gill; Mr. B. W. Fisher; and Mr. D. M. Burden.

Members of the Winfrith catering staff wave goodbye to the Queen and Prince Philip as they drive away from the site at the end of their visit.

Industrial



Carbon fibres in lengths exceeding 1,000 feet have been produced at Harwell. Continuous lengths after final batch heat treatment are shown above.

CARBON FIBRES

Harwell is participating in a joint development and exploitation programme on carbon fibres with the Royal Aircraft Establishment, Farnborough, and the National Research and Development Corporation. Carbon fibres in lengths exceeding 1,000 ft. were produced by a continuous process in the experimental graphite plant at Harwell to develop applications of carbon fibres and to supplement other U.K. production. In particular, about 50 lbs. of this material was supplied to an industrial producer for test marketing in Britain and the United States.

Research and development on the production technology of carbon fibres provided the data and parameters for the design of large-scale plants to produce relatively cheap material. Unit costs are scale-dependent. It is now believed that carbon fibres in large tonnage quantities could be produced for less than £5 per lb.

Carbon fibres can be dispersed in various matrices to yield materials four times as strong as steel with a quarter the weight. Much industrial interest has been aroused and help is being given to industry in the engineering design of components incorporating such fibres.

Despite the commercial nature of much of the work, some details were published; two papers which were presented at conferences in the U.S.A. aroused considerable interest. The work was also exhibited at two Royal Society soirees.

CONVEYOR BELT MEASUREMENTS

The present trend towards automation has led to a need for accurate measurement of quantities of bulk materials (such as iron ore, sinter, coal and fertiliser) transported on conveyor belts. Radioisotope techniques based on gamma-ray attenuation and scatter have several advantages over other methods. The optimum design parameters which give least effect from variations in the distribution and type of material on the belt were established and a prototype on-line system is to be constructed in collaboration with Nuclear Enterprises Ltd.

LOW POWER GENERATORS

The Authority's RIPPLE programme to develop isotope-powered electrical generators for use in remote locations is approaching a successful conclusion. Five prototype generators are undergoing evaluation trials; three of these are powering off-shore marine lights, one feeds an aircraft navigational beacon in the outer Hebrides and one is being evaluated by the U.S. Navy. All perform exactly according to design predictions; the longest in service was installed early in 1967. A generator system was developed which can be used for the assembly of generators of any power between 8 and 64 watts (electric); the programme will conclude with the fuelling of a 25 watt version during 1969. An encapsulation plant for strontium-90 titanate in nearly complete. This will give the Authority the capability of producing strontium-90 heat sources suitable for isotope-powered electrical generators of a wide size range.

The Authority are devoting increased effort to the exploitation of their expertise and facilities in the interests of technology in British industry generally—not merely in the nuclear industry.

In some cases the work is carried out as a requirement from the Minister of Technology under Section 4 of the Science and Technology Act (which enables the Authority to undertake non-nuclear work).

In others it falls within the provisions of the Atomic Energy Acts and is classified as applied nuclear research and development.

In either case the objective is the same: the production of a national benefit, economic or social.

Much of this work is undertaken for industrial firms or other organisations on commercial terms which are negotiated to suit individual circumstances.

In 1968/69 the Minister required the Authority to undertake research into five additional matters:

- Quality control
- Water renovation by reverse osmosis
- High temperature chemical technology
- Electrotechnology
- Marine technology

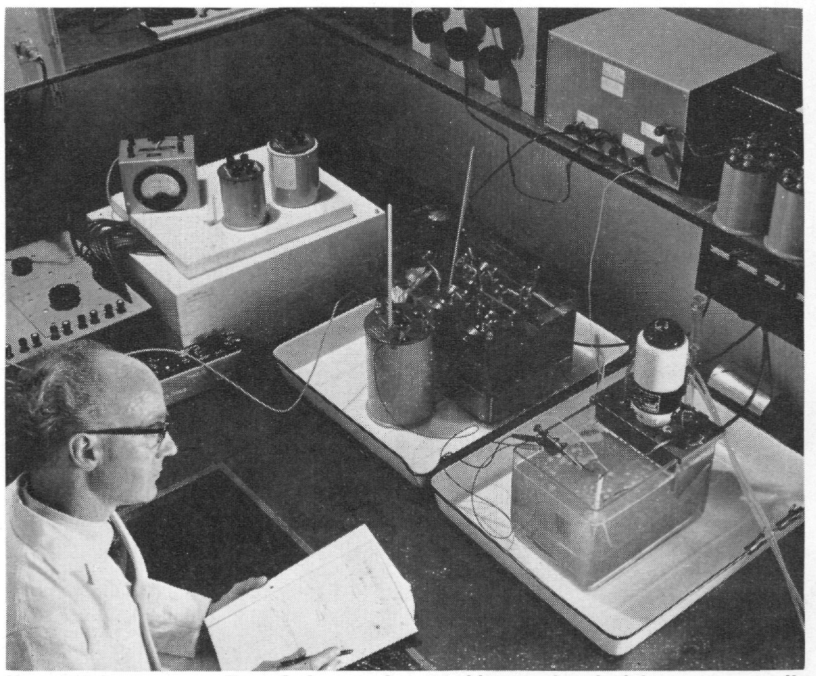
At the end of the year extensions were under consideration to the existing programmes on hydrostatic extrusion and the improved utilisation of steels.

A number of substantial new contracts for non-nuclear research at Aldermaston were commissioned by Government departments; in particular the Ministry of Technology authorised extensions to the Aldermaston Project for the Application of Computers to Engineering (APACE).

MATERIALS

The Materials Technology Bureau, Harwell, was set up in 1967 to make the Authority's experience in materials problems more widely available to industry. During the year some 50 investigations were conducted for various firms and over 160 enquiries from individual organisations were answered. The services offered were described to over 230 visitors, who were shown facilities available for experimental investigations on new materials and products. There was a continuing demand for literature and references on more recent developments in the materials fabrication field.

INSTRUMENT TEST LABORATORY



Harwell Instrument Test Laboratories provide an electrical instruments calibration service for industry. Certificates are issued stating the degree of accuracy obtained and defining errors.

technology

COMPUTERS

During the year 526 engineers enrolled for 49 training courses with the Aldermaston Project for the Application of Computers to Engineering at Blacknest. This represents over a 60 per cent. increase of activity and attendance. Heavy demands developed for providing computer software for use with numerically controlled machine tools: APACE has become a focal point for this work in aid of the machine tool and user industries. A growing range of engineering management programs is available on Aldermaston computers for industrial use. Electronic design services started in Autumn 1968 and are now well established. Major programs are available for immediate use by industry and a magnetic tape library of transistor model data is being set up at the request of the Ministry of Technology.

Work continued at Harwell in applying computer optimisation techniques to industrial problems, including scheduling for railway track renewal, a metal rolling mill, paper making machines, a fleet of ships, pipe layout for hot water distribution in district heating, and the arrangement of shapes for cutting out sheet material.

A contract from the Ministry of Technology added Group Technology to the range of production control subjects offered to industry by APACE. A training centre at Blacknest and various demonstration centres at company premises are being set up. Work also started on Ministry contract for an experimental study of the adaptive control of machine tools.

CAMAC

Agreement has been reached with other major nuclear laboratories in Europe on a common standard for instrumentation used to connect experiments to computers for real-time data processing and control. This standard, known now as CAMAC (formerly IANUS), is formally specified and is rapidly earning wide acceptance in Europe and to some extent in the U.S.A. The Authority's 7000 Series range of equipment conforms to this standard, and two licensed companies (EKCO Electronics Ltd. and Nuclear Enterprises Ltd.) are working jointly with Harwell to develop equipment in this format for manufacture and sale in the wide markets opened up by the agreement.

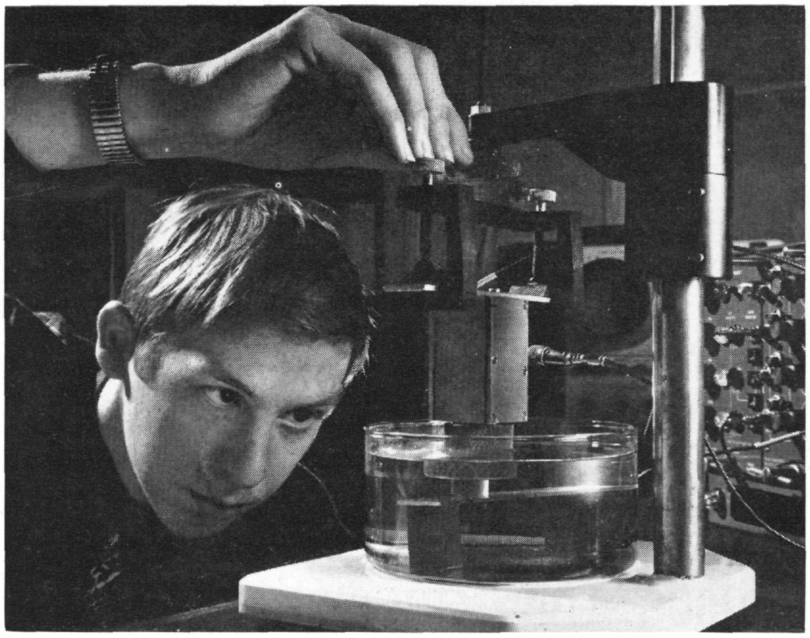
Hitherto, the lack of a widely accepted and technically advanced signal data processing standard has tended to cause individual nuclear laboratories to set their own standards or adopt the standards used by particular manufacturers. The new agreement thus offers the prospect of greatly increased international markets for nuclear data processing equipment.

Although the CAMAC system is designed primarily to meet computer-based measurement and control requirements in the nuclear field it is also likely to be of value in many other measurement and control situations, especially those which involve the use of a controlling computer.

* Nuclear Enterprises announced in August that they had received orders worth $180,000 from the U.S.A. for units in the CAMAC system.

ELECTROHYDRAULIC CRUSHING

Quartz before and after it has been crushed in a Harwell rig by a shock-wave whose intensity approaches that of a chemical explosive.



Setting up a 100 MHz cadmium sulphide ultrasonic transducer to obtain reflections from a thin metal sheet at the Non-Destructive Testing Centre, Harwell.

NON-DESTRUCTIVE TESTING

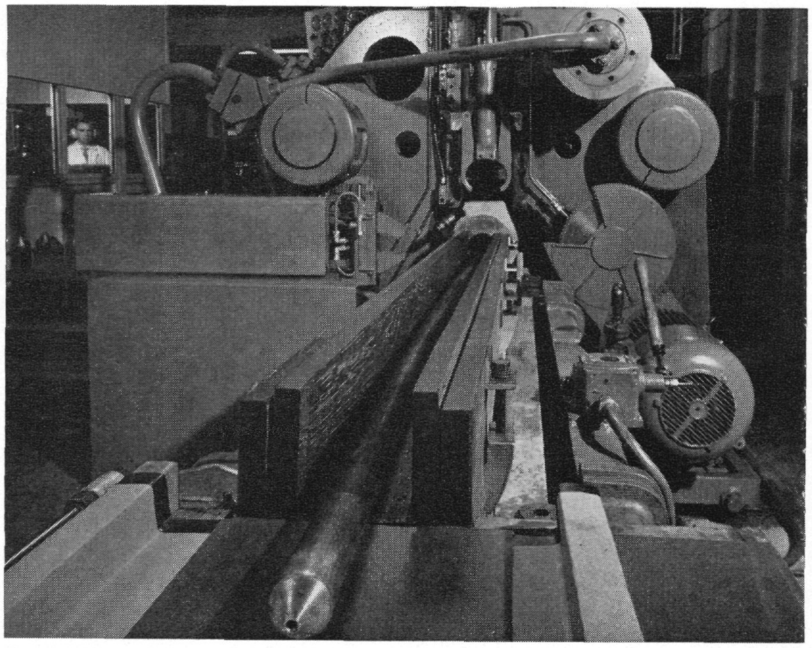
Industry is showing a widening interest in the services offered by the Harwell Non-Destructive Testing Centre. Twelve contracts were negotiated with industrial firms for confidential laboratory work to evaluate specific problems or develop instrumentation for specialised systems. More than 400 enquiries were dealt with by the N.D.T. Information Service, and advice on inspection problems was given to over 100 industrial firms. A monthly current awareness bulletin, NDT-Info, is prepared and distributed as a jointly-managed enterprise between the Centre, Iliffe Science and Technology Publications Ltd., and the Non-Destructive Testing Society of Great Britain. The Centre organised the annual N.D.T. Appreciation Course for Industry and participated in N.D.T. exhibitions at Leeds and Warwick.

The Centre's programme of background research in non-destructive testing included automated processing of inspection data, high definition radiography, magnetic flaw detection and the development of modular circuitry to increase the range and application of ultrasonic flaw detection. Research into non-destructive methods of monitoring the properties of carbon fibre composites resulted in a new model for the elastic behaviour of carbon fibres and in experimental methods for measuring fibre/matrix adhesion. These non-nuclear activities are closely linked to the development of new inspection methods for reactor components.

CHEMICAL PLANT

The High Temperature Chemical Technology project, approved in August, 1968, involves collaboration by Harwell with industry in exploiting the Authority's expertise in the design of chemical plant and the study of chemical reactions at high temperatures. A number of commercial agreements were established with industrial firms. High temperature research at Harwell involves diverse techniques, such as the use of fluidised, vibrated and stirred beds in solid-solid and solid-gas reactions, the use of molten salts as reaction media and the application of powder metallurgy in novel ways. At Aldermaston, the gel precipitation technique is being developed to produce metal oxides as the first stage in a process for the preparation of ferrous and non-ferrous metal powders and alloys. The second stage, involving the reduction of oxide gel to metal powder, is under study at Harwell.

Sintering of powders in controlled atmospheres, originally applied to ceramic fuel fabrication, is being developed as a method of fabricating very fine metal powders into strong high-density components. Other examples are studies of reactions between molten metals and slags, and the development of techniques for the on-line control of high temperature processes.



The 1,600 ton hydrostatic extrusion press at the Reactor Fuel Element Laboratory, Springfields, can develop fluid pressures up to 200 tons per square inch for experimental purposes.

HYDROSTATIC EXTRUSION

The 1600 tons hydrostatic extrusion machine at Springfields was used both for the continuing development of the possible techniques and for hire to industrial organisations both in the U.K. and overseas for investigation into their own forming problems. Techniques were developed and used for the extrusion of complex sections, tubes and multi-strand products. Warm extrusions using pre-heated billets were successfully demonstrated at temperatures up to 300°C. The materials extruded by the industrial users included eighteen aluminium alloys, several high strength steel alloys, stainless steels and copper.

A new concept of extrusion using a rotating tool assembly is being investigated. This device, termed hydrospin, which should make possible extremely high extrusion ratios and hence very long products at easily attainable pressures will be developed jointly with the semi-continuous extrusion machine recently installed.

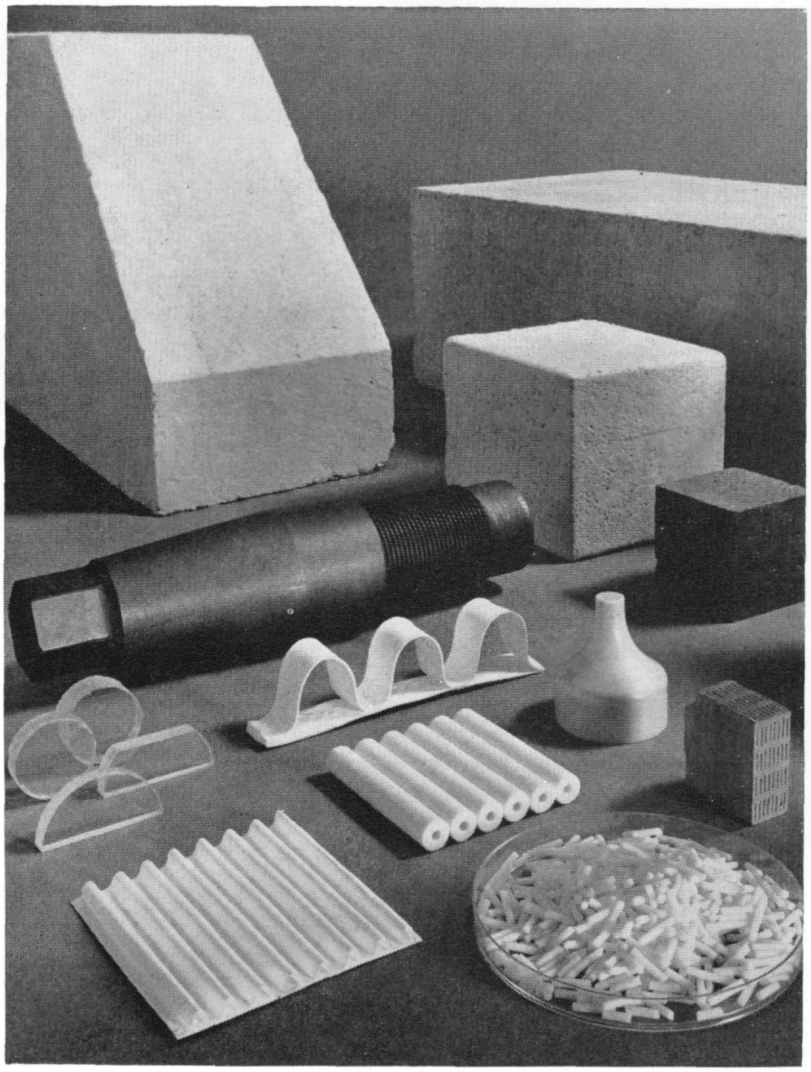
The P.A.U. carried out a national survey of hydrostatic extrusion which indicated that the technique offered considerable economic advantage justifying a substantial development programme. The Ministry of Technology, recognising the Reactor Fuel Laboratory (R.F.L.) at Springfields, as the main centre for long product extrusions and the development on the 1600 tons machine of processes such as hydrospin and hydrostatic drawing, approved an extension of the Authority's R. & D. programme in April, 1969.

PROSPECTING AND MINING

A major user of uranium, the U.K. has an economic incentive to facilitate the discovery of new reserves of uranium and to assist in the development of improved ore processing methods. Harwell is collaborating with the Institute of Geological Sciences in research and development to establish new and improved methods of prospecting for uranium and to develop uranium detecting instruments. The design of a sensitive, lightweight, gamma-ray scintillometer for field use was licensed to Elliott Automation Ltd. and this instrument is now being purchased by many of those engaged in the search for uranium. Particular attention is being paid to methods of inferring the presence of deep-lying uranium deposits, which have little surface manifestation and consequently are hard to discover.

In mineral exploration, and in several aspects of mining operation control, there are advantages in direct measurement of mineral concentration in short bore-holes less than 100 ft. deep instead of the more costly and time consuming alternative of core analysis. A prototype X-ray fluorescence bore-hole probe was developed and arrangements were made to produce the equipment commercially under license.

Examination continued of the possibilities of economic extraction of uranium from the sea. Improvements were made in various aspects of the manufacture and performance of an absorber. A pilot unit with the capacity to process about one million gallons of seawater per week is under construction at the Portland testing station; this will give experience in problems encountered in the scaling-up from laboratory experiments.



Components made at the Ceramics Centre, Harwell. The programme of the Centre is guided by an advisory committee on which British industry is represented.

CERAMICS

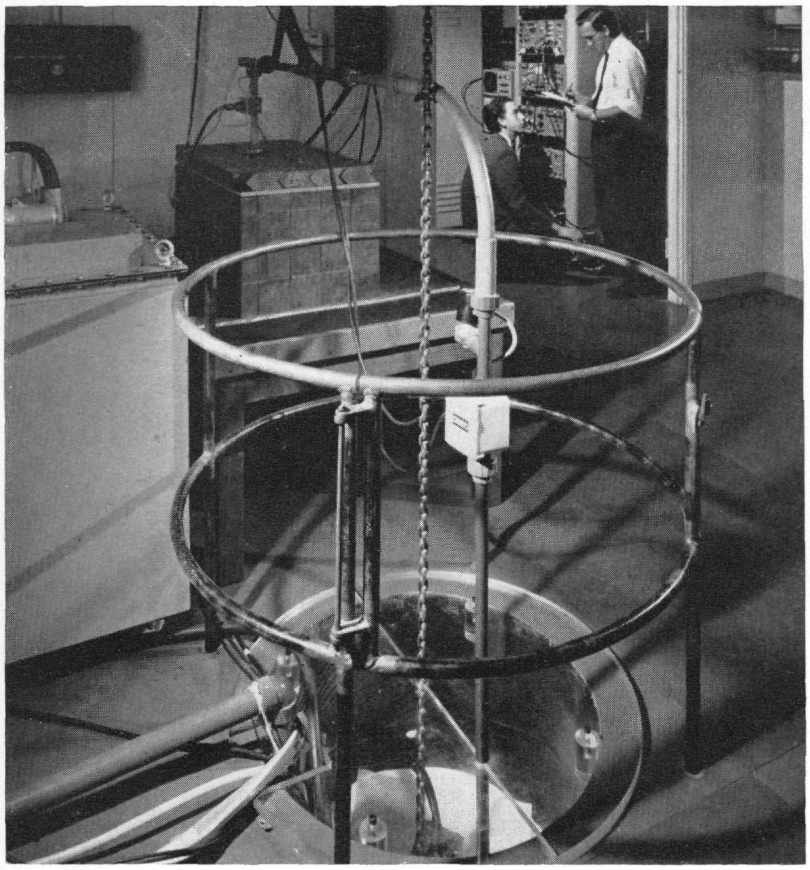
The programme of the Ceramics Centre, Harwell, covers a wide range of research into ceramics and their applications aimed at the needs of British industry. The Centre is guided by an advisory committee including representatives of industry and research associations. The number of projects involving industrial collaboration is increasing.

Agreements were established with the following firms:

- British Lighting Industries Ltd. (a subsidiary of Thorn Electrical Industries Ltd.)
- Cochran & Co., Annan, Ltd.
- General Refractories Group Ltd.
- Imperial Chemical Industries Ltd.
- Murex Ltd., Rainham (B.O.C. Chemicals & Metallurgical Division)
- Pickford, Holland & Co. Ltd.
- Rolls Royce Ltd.
- Smith Industries Ltd.
- The Metal Box Co. Ltd.
- Thomas Marshall & Co. (Loxley) Ltd.
- Thorium Ltd.
- United Glass Ltd.

These programmes now account for over half the work of the Centre. All the agreements reached during the past year involve either full repayment or sharing of the Authority's costs, usually with a royalty on any successful products arising from the work. The technological emphasis of the work is on new fabrication or processing methods and the development of composite materials.

The Centre also collaborated with the Scientific Instrument Research Association on glass polishing, using ion beams. Following a collaborative engineering development with Cambridge Vacuum Engineering Co. Ltd., the Company began to market a 600 watt welding machine using a glow discharge device as a source of electrons. Experiments on the crushing of brittle solids by means of underwater sparks were aided by a 4 kW machine developed and made at Aldermaston which operated satisfactorily for several months. As a result, a prototype fine crusher capable of handling up to 100 kg/hr is now available for industrial trials.



The Elliott sealed tube neutron generator of the Analytical R. & D. Unit at Harwell is for fast neutron activation analysis. Silicon in aluminium can be measured in 1–2 minutes.

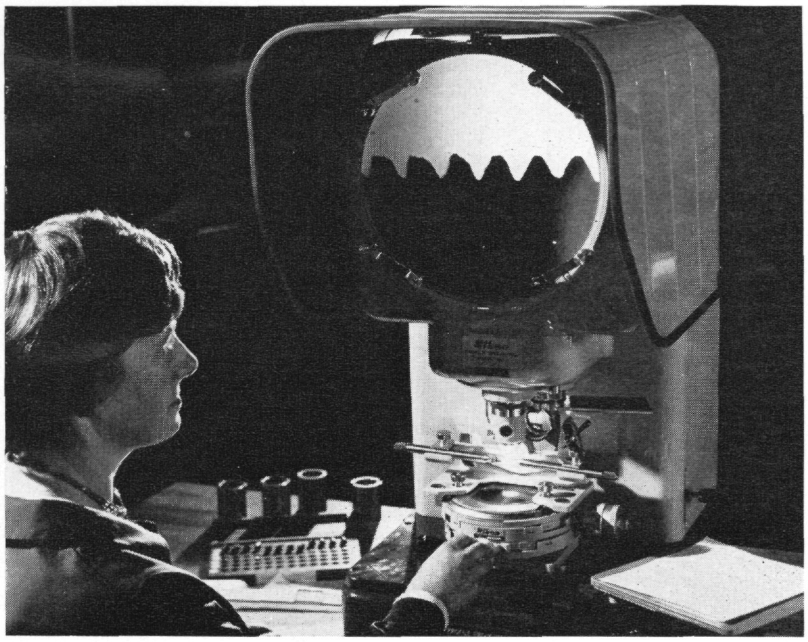
ANALYTICAL R & D

The Analytical Research and Development Unit, Harwell, which was approved by the Minister of Technology on 8th April, 1968, undertakes research on industrial problems concerned with the identification, measurement and control of impurities in materials. The Unit also provides industry with access to a wide range of analytical facilities. About 100 enquiries, R. & D. problems, and requests for analytical measurements were received in the first half-year of operation. Of the commercial quotations issued by the Unit, 30 were accepted.

There is a continuing and increasing high demand from industry for the Wantage activation analysis service introduced in 1965; this service is complementary to the Analytical Research and Development Unit and the Physico-Chemical Measurements Unit operated by the Authority under non-nuclear requirements from the Ministry of Technology. Automated radiochemical separation systems are being developed so that more high sensitivity analyses can be accepted, and a new neutron generator system is being installed to provide a rapid service for the analysis of oxygen in metals.

MECHANICAL STANDARDS LABORATORY

HARWELL MECHANICAL STANDARDS LABORATORY is part of the British Calibration Service, set up to test measuring instruments against approved national standards. Photograph shows calibration of a ring gauge at the Laboratory.



A profile projector being used to inspect metal wear at the National Centre for Tribology, Risley. Tribology is the science of lubrication and wear.

TRIBOLOGY

During its first year of operation the Tribology Centre at Risley dealt with over 200 enquiries from industrial firms and concluded 30 commercial agreements. A wide variety of firms approached the Centre for advice; all sizes of firms from the very small to large national companies were represented, and the technologies ranged from food manufacturing to heavy engineering. Many enquiries were satisfied by a relatively quick assessment of the problem using existing knowledge; others resulted in development programmes costing several thousand pounds.

The Centre works closely with the University of Salford and other universities and colleges of technology. Arrangements were made to exchange information regularly with the Tribology Centres at Leeds and Swansea Universities. Centre staff contributed to lecture courses and a post-graduate course in tribology was held in April, 1969, sponsored by the Centre in association with the Universities of Liverpool, Manchester and Salford. The Centre published a "Bibliography of Authority Reports and Patents relevant to Tribology".

ELECTRON MICROSCOPE

The production of a one million volt electron microscope in Britain was strongly encouraged by the Ministry of Technology, and the design has been developed by the makers, G.E.C.-A.E.I. (Electronics) Ltd., after extensive consultation with the customers for the first three instruments (Harwell, the National Physical Laboratory and the Science Research Council). As a result of this co-operation between the manufacturer and users, the specification of this instrument is believed to be in advance of that of any other existing high voltage microscope. Harwell, where the first instrument will be installed later this year, played a major part in originating and testing many of the innovations. This microscope will be made available to university and industrial users on repayment.

WOOD PLASTICS

The use of plastics to improve the hardness and water resistance of wood has been increasing in recent years. A process involving the impregnation of wood with a plastic resin which is then polymerised *in situ* by the use of radiation, has considerable advantages.

Continuing industrial interest is being shown in the Wantage Research Laboratory service, inaugurated in February, 1968, for the plastic-impregnation and irradiation of timber and timber-based products. In the first 12 months of operation 30 orders were completed and wood was also processed on an experimental basis for 80 customers.

A second range of cutlery with wood-plastic handles was successfully test-marketed in the United Kingdom and an order placed to establish this production. Development work in collaboration with makers of industrial patterns and textile shuttles continued and attempts to interest manufacturers of musical instruments also met with an encouraging response.

The process was successfully extended to chipboard, laminates and veneers, and considerable interest was shown by the manufacturers of wood block flooring.

Water

The Authority programme on desalination continued with the further development of the commercially proven multi-stage flash distillation and electrodialysis processes in collaboration with the G. & J. Weir Water Division.

Work on the alternative processes of freezing and reverse osmosis (in collaboration with Simon Engineering Ltd. and Portal Holdings Ltd. respectively) reached the point of pilot plant operation.

The increasing success of British manufacturers in export markets was in line with predictions made by the Programme Analysis Unit prior to approval of the second phase of the programme.

The major effort on brine transfer devices is now concentrated at the Weir Westgarth seawater test facility at Troon. Data obtained from the three large stage geometry rigs at Troon are now being used in commercial designs. Work on the seawater corrosion of aluminium alloys was sufficiently encouraging for a large scale trial of aluminium condensers using a three stage M.S.F. rig at Troon. Considerable progress was made in resolving scale deposition problems. Improvements in the method of extracting incondensible gases were tested in the commercial 500,000 gal/day M.S.F. plant at Guernsey. The tests confirmed the design approach, and the improved system is now being incorporated in new commercial plant.

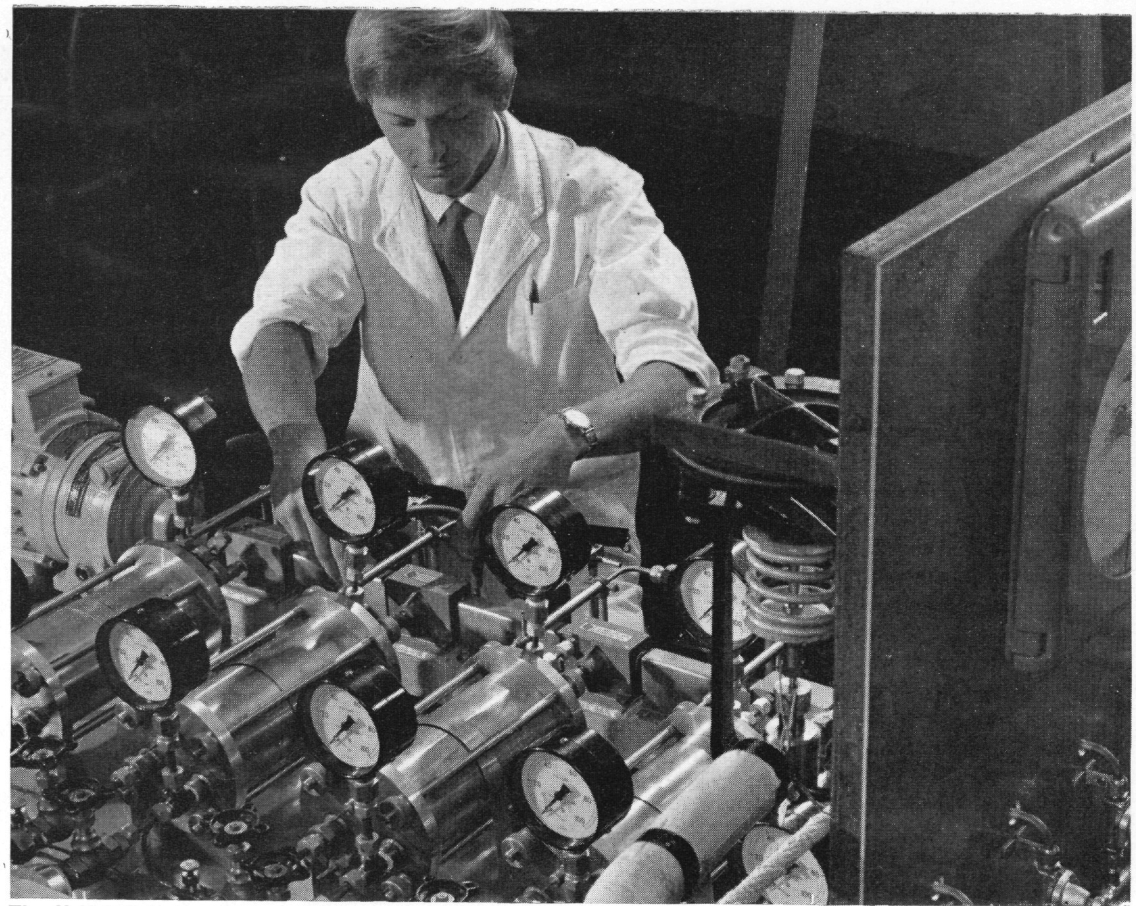
LARGEST IN THE WORLD

A notable export order, for a £890,000 electrodialysis plant to provide purer drinking water for the city of Benghazi, was won by William Boby Ltd. (of the Weir Group Water Division) in March, 1969. The plant will provide over 4,000,000 gallons of water a day and will be by far the largest electrodialysis unit in the world.

The 50,000 gallons a day electrodialysis pilot plant has continued to operate satisfactorily at Tendering Hundreds Water Board in Essex. Developments have been incorporated in the commercial plant now being built by William Boby Ltd. at Viesti in Italy and in the Benghazi plant.

A system analysis of alternative distillation processes undertaken by the Authority justified a programme of experimental work on multi-effect evaporation processes. Assessment studies of a range of distillation processes combined with vapour compression evaporators showed that significant savings over simple distillation processes might be achieved, in plants producing water only, in medium and high fuel cost areas; and that where power as well as water is needed, the combined system would allow the proportion of power and water to be adjusted, in contrast to distillation processes for which the proportion is virtually fixed.

The experimental equipment built by the Authority to study the immiscible refrigerant (butane) freezing process on a realistic scale (700 gal/day), provided new and important design information. Erection of a study plant (10,000 gal/day) was started by Simon Engineering (the Authority's collaborator) at Stockport; it will be used to study problems in designing major plant components on a larger scale and to gain practical experience in operating the process. Studies proceeded at Simon Engineering, in close collaboration with the Authority, to determine the competitiveness of the freezing process at various sizes.



The U.K.A.E.A. have responsibility on behalf of the Government for research and development into all methods of desalination. High-pressure apparatus at Harwell for studying scale prevention in sea-water evaporators.

In collaboration with Portal Holding Ltd., designs for industrial plant to desalt brackish water by reverse osmosis were developed. Prototype equipment is being evaluated in field trials.

POLLUTION

A joint programme by Harwell and the Water Pollution Research Laboratory established that significant reduction in the concentration of inorganic and organic contaminants in polluted water, particularly in sewage effluents, can be achieved by reverse osmosis; membranes satisfactorily withstood prolonged exposure to solutions of pollutants.

CONSERVATION

For a number of years, the Wantage Research Laboratory has investigated the use both of artificial tracers and natural tritium in field studies of water movements which are of especial importance

ELECTRODIALYSIS Advances developed in the 50,000 gallons-a-day pilot plant installed by William Boby & Co. Ltd., in Essex are being incorporated in the 4·2 million gallons-a-day plant they are building for Benghazi.

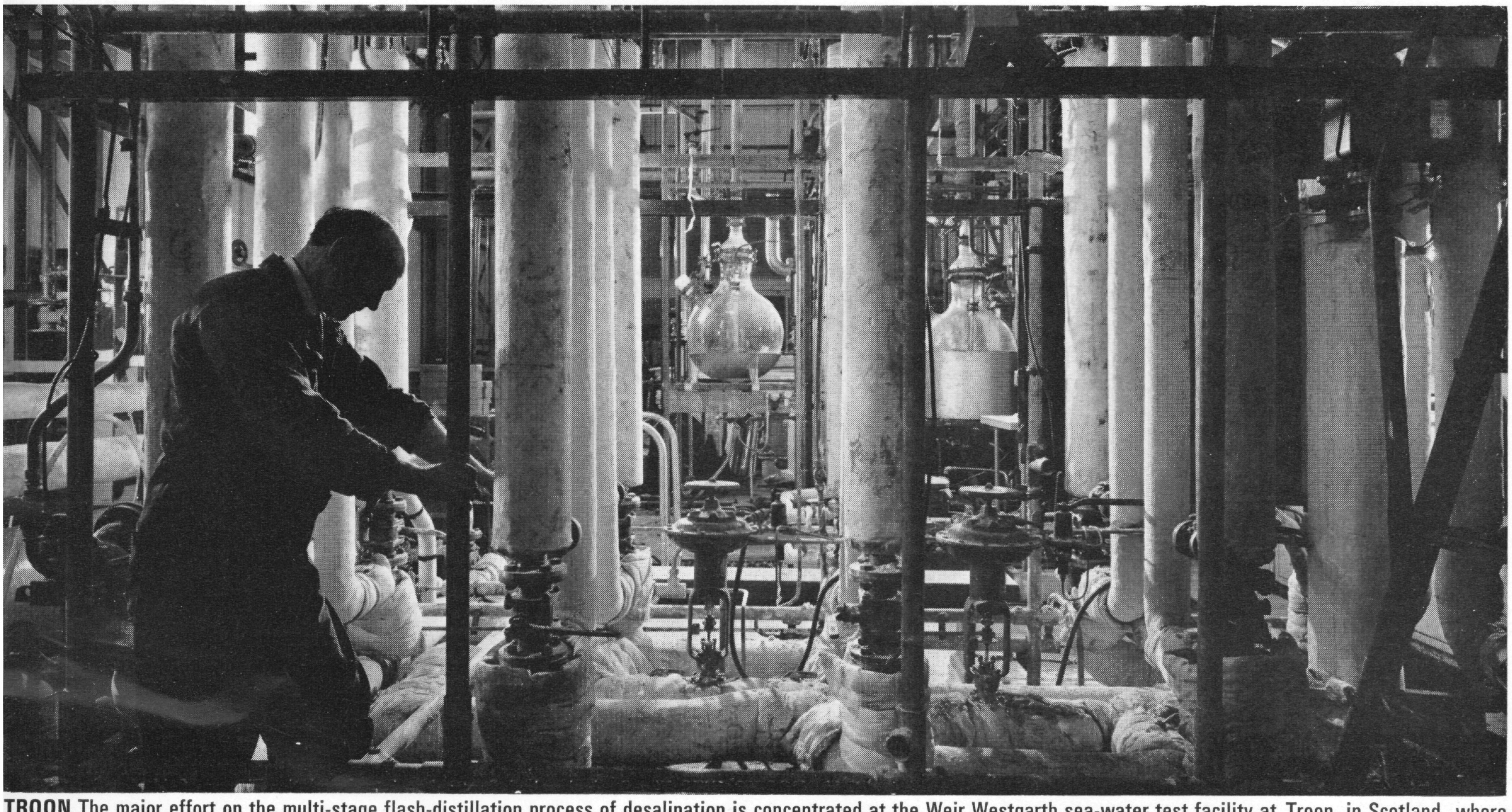
Ice crystal-brine separating column on the 10,000 gallons per day study plant for development of the secondary refrigerant (butane) freezing desalination process constructed at Simon Engineering Ltd.

in water conservation and supply, and for studies of catchment areas. This work is undertaken in close collaboration with the Natural Environmental Research Council and the Water Resources Board who jointly support financially the environmental tritium measurements. Recent results have thrown new light on the extent and mechanism of water penetration both into impervious media such as clay and porous media such as chalk. Measurement of natural carbon-14 in the bicarbonate content of ground waters was recently used to investigate the age of old ground waters.

RIVERS AND ESTUARIES

An accurate method of river flow measurement, using radioactive tracers, was further developed and applied to flows up to 600 cubic feet/second; it was also used to check the accuracy and reliability of chemical tracer methods of measuring flow.

Work continued on the use of radioactive tracers to measure sediment movements in the sea and in rivers. An evaluation by the Programmes Analysis Unit showed a considerable economic benefit resulting from reduced costs where the dredging practices had been altered as a result of radioactive tracer investigations. Preliminary results of a laboratory study on the quantitative application of tracers to silt movement indicate that finely ground glass can be size-matched to the silt to follow its movement accurately under estuarine conditions.



TROON The major effort on the multi-stage flash-distillation process of desalination is concentrated at the Weir Westgarth sea-water test facility at Troon, in Scotland, where large test rigs are operated in collaboration with the U.K.A.E.A. The apparatus shown in the photograph is a corrosion rig.

Medicine

Radioactive pharmaceutical products for use in medical diagnosis now constitute the most rapidly growing section of the business of the Radiochemical Centre, Amersham. Many leading pharmaceutical suppliers, particularly in the United States, are active in this field, and in order to compete successfully it is necessary not only to supply products of good quality, but also to package them attractively and in a form convenient for use. This has led to the introduction of diagnostic "kits" which contain not only the radioactive agent in a form ready for adminstration, but also all the other materials and components required for carrying out a test.

Sales of radioisotopes and other products from the Radiochemical Centre were £3·15 million, an increase of 10 per cent. over the previous year. Fifty-seven per cent. were exported. Other receipts totalled £110,000.

The smaller rate of increase of direct sales as compared with previous years (14 per cent. on average for the five years to 1967/68) was due mainly to revised trading arrangements in the United States. The decrease will be partly offset by the Authority's share of the profits of the Amersham/Searle Corporation (see below).

The number of consignments sent out by the Centre was 82,000, compared with 76,000 last year.

At the beginning of July, 1968, a new company was set up in the United States, jointly owned by the Authority and the established pharmaceutical firm of G. D. Searle. This company, known as the Amersham/Searle Corporation, is responsible for marketing all the Centre's products on an exclusive basis throughout North and South America. This new arrangement will greatly strengthen the Centre's competitive position in the important United States market.

A new general catalogue was published in February, 1969. This catalogue includes over 140 new products and there are many improvements in product specification and delivery. Twenty thousand copies have been distributed.

Further expansion of the research and development at Aldermaston in support of the Department of Health and Social Security (D.H.S.S.) took place during the year, mainly by broadening existing fields of activity. Several projects progressed sufficiently for discussions with industrial firms to take place in collaboration with D.H.S.S. and N.R.D.C. The projects included a novel infrared camera and gamma camera based on solid state detectors, both of which are used for medical diagnosis.

Investigations continued into ways of improving the *in vivo* life of cardiac pacemakers, and experimental models of a new cardiac pacemaker have been produced. An experimental isotope battery for powering implanted cardiac pacemakers has been developed successfully at Harwell in association with circuit development at Aldermaston.

A laser system incorporating a novel beam-steering device was assembled for experiments at the Royal College of Surgeons to test its effectiveness as a surgical tool.

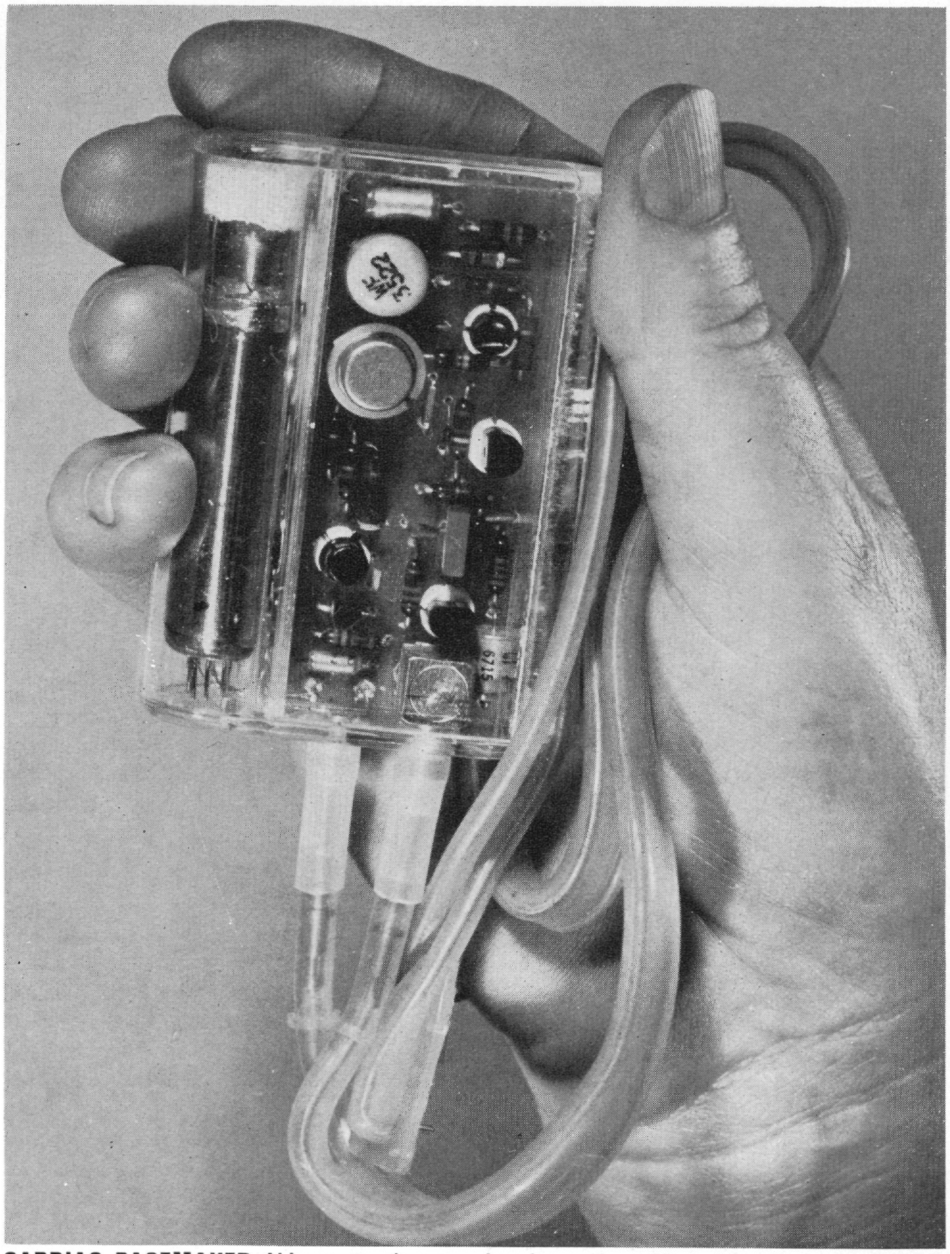
Investigations into factors causing corrosion in metal implants demonstrated the superiority of titanium and cobalt chrome alloy over stainless steel.

Research is being conducted on classifying the waste products of metabolism and their removal by sorbent materials in a kidney machine, and on sorbent materials for removing metabolites directly from the blood, or from the rinsing fluid of a dialyser.

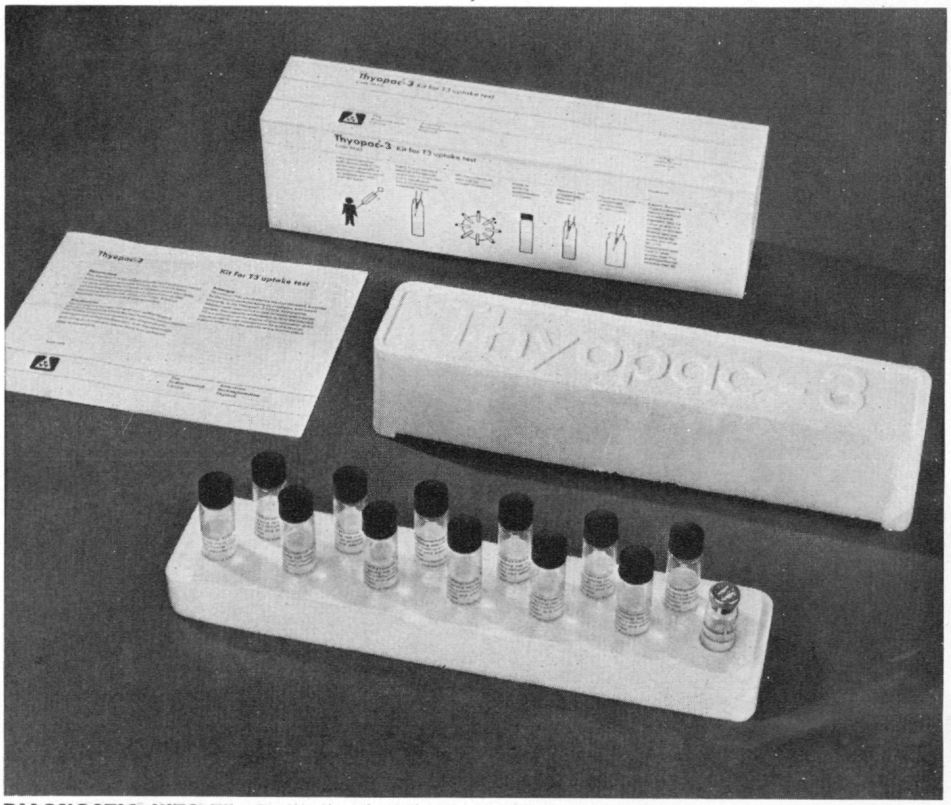
Experimental work is in progress at Harwell on the design and testing of an improved dialysis pack of greatly reduced size for an artificial kidney.

Work is proceeding on the application of modern inorganic material technology to dental cements of superior oral acid resistance, to dental porcelain of improved strength and to anterior fillings of extended life.

A significant part of the programme consists of the scientific and engineering assessment of commerical equipment such as kidney machines, echo-encephalographs and blood gas analysers.

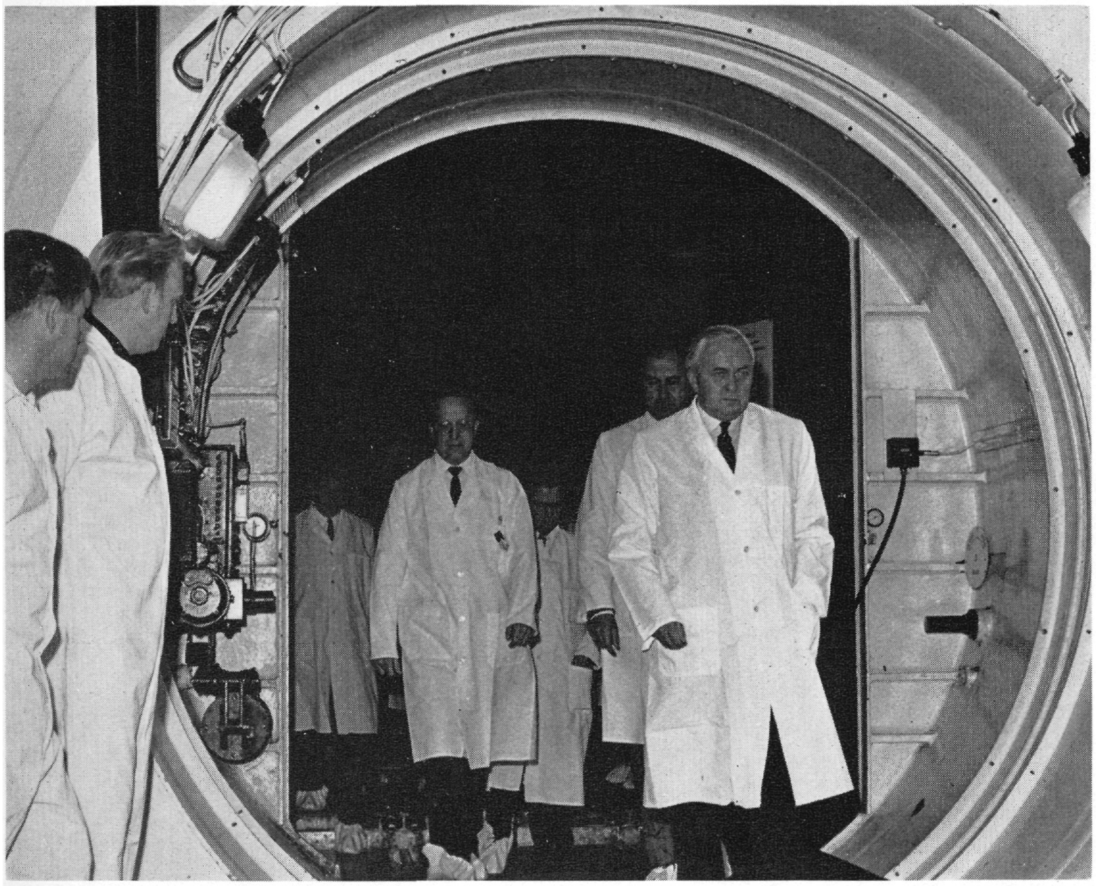


CARDIAC PACEMAKER Aldermaston have produced experimental models of a new cardiac pacemaker. Harwell, in association with Aldermaston, have developed an isotope battery to power the device. The design-life of the unit is 10 years which should reduce the frequency of replacement surgery.



DIAGNOSTIC KITS The Radiochemical Centre has introduced the Thyopac-3 kit for the "T3 test", which is an in vitro procedure for measuring the concentration of blood thyroid hormone. This provides information for the diagnosis and management of thyroid disorders.

Visits & Visitors

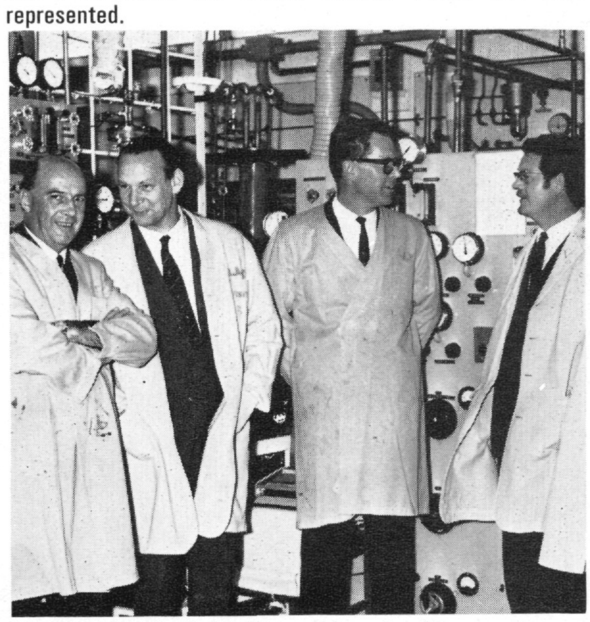


DOUNREAY The Prime Minister, the Rt. Hon. Harold Wilson, visited the Dounreay Experimental Reactor Establishment during a tour of the Scottish Highlands in July. He is shown passing through the air-lock of the Dounreay Fast Reactor sphere with Mr. Peter Mummery, Director of Dounreay, and Mr. F. J. Barclay, manager of the Dounreay Fast Reactor Group.

TO RUSSIA Five tons of apparatus from the Culham Laboratory were flown to Moscow in March, to be used by four Authority scientists in collaboration with Russian scientists in a fusion experiment at the Kurchatov Institute. The British team were: Dr. N. J. Peacock, Mr. M. J. Forrest, Mr. P. D. Wilcock and Dr. D. C. Robinson (who is spending a year at the Institute).

HERALD Mr. Peter Bray, of Fairey Engineering Ltd., signs a £600,000 contract for the sale of a HERALD reactor to Chile. In July, Fairey's sold a HERALD and five HELENS to Brazil. Both types are sold abroad by Fairey's under A.E.A. licence.

WASHINGTON The Chairman addressed the American Nuclear Society during an international conference in Washington last November. He is shown above (left) conducting the British Ambassador round the U.K.A.E.A. exhibit in "Atom Fair", at which the British Nuclear Forum was also represented.

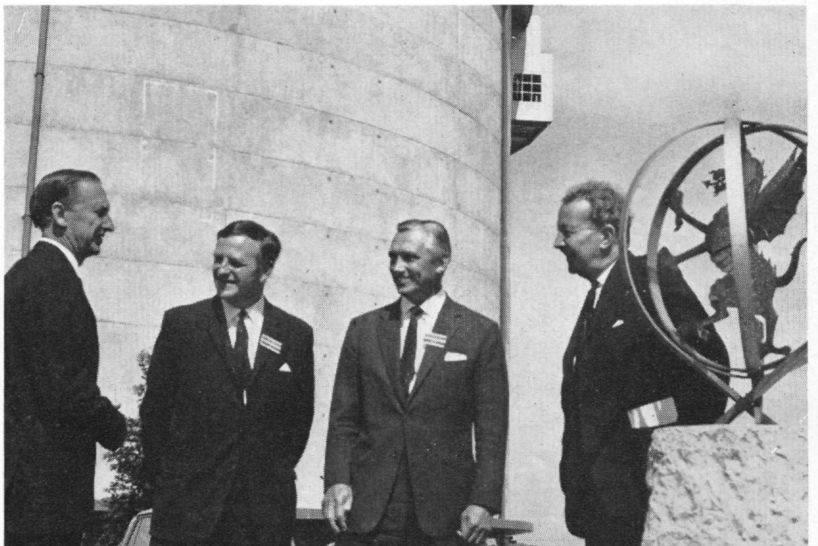


AUSTRALIA Mr. R. V. Moore, Managing Director, Reactor Group (first from left) and Mr. J. Moore, Chief Technologist, S.G.H.W.R. (right) on a visit to the Lucas Heights research establishment of the A.A.E.C. in May.

AUSTRALIA Sir Philip Baxter, Chairman of the Australian A.E.C., visited Winfrith in October, 1968. Above (left to right) are: Mr. K. F. Alder, A.A.E.C. Commissioner; Mr. D. R. Griffiths, Chief Engineer, A.A.E.C.; Sir Philip Baxter; Mr. D. Smith (Winfrith); and Mr. D. W. Fry, Director of Winfrith.

PROLONGATION In November, 1968, an agreement was signed at the Authority's headquarters prolonging the E.N.E.A. Dragon Project to 31st March, 1970. Above (left to right) are Professor Dr. U. W. Hochstrasser (Switzerland); Professor Dr. M. J. Higatsberger (Austria); and Mr. V. O. Eriksen (Norway).

ISOTOPES The Radiochemical Centre, Amersham, has formed a joint company with G. D. Searle & Co. (Inc.), of the U.S.A., to market their products in North and South America. British members of the Board are: Sir Charles Cunningham (U.K.A.E.A.); Dr. W. P. Grove (Amersham); and Mr. Lewis Barman (A.E.A. consultant).



DRAGON The tenth anniversary of the Dragon Project was celebrated by an international gathering at Winfrith on 25th June, 1969. In the photograph on the left are (left to right): Mr. Compton Rennie, first executive head of the Project; Mr. M. I. Michaels (Ministry of Technology); Mr. B. T. Price (Ministry of Transport); and Mr. D. E. H. Peirson (Secretary of the Authority). On the right (left to right) are: Dr. L. R. Shepherd (Chief Executive, DRAGON); Mr. A. Chinneck (Ministry of Technology); Sir John Hill (Chairman of the Authority); and Mr. J. W. P. Mallalieu (Minister of State, Ministry of Technology).

GERMANY A party of German industrialists visited Windscale, Winfrith and Dungeness (C.E.G.B.) in February. Above are: Professor H. Mandel, of the Rhein-Westphalia Electricity Authority (left); and Herr Helmut Wagner, of Farbwerke Hoechst.

NEW SOUTH WALES Mr. P. H. Morton, Minister for Local Government, New South Wales (second from left) hears an explanation of the R. & D. "back up" for S.G.H.W.R. from Mr. R. J. Symes, of Winfrith (right).

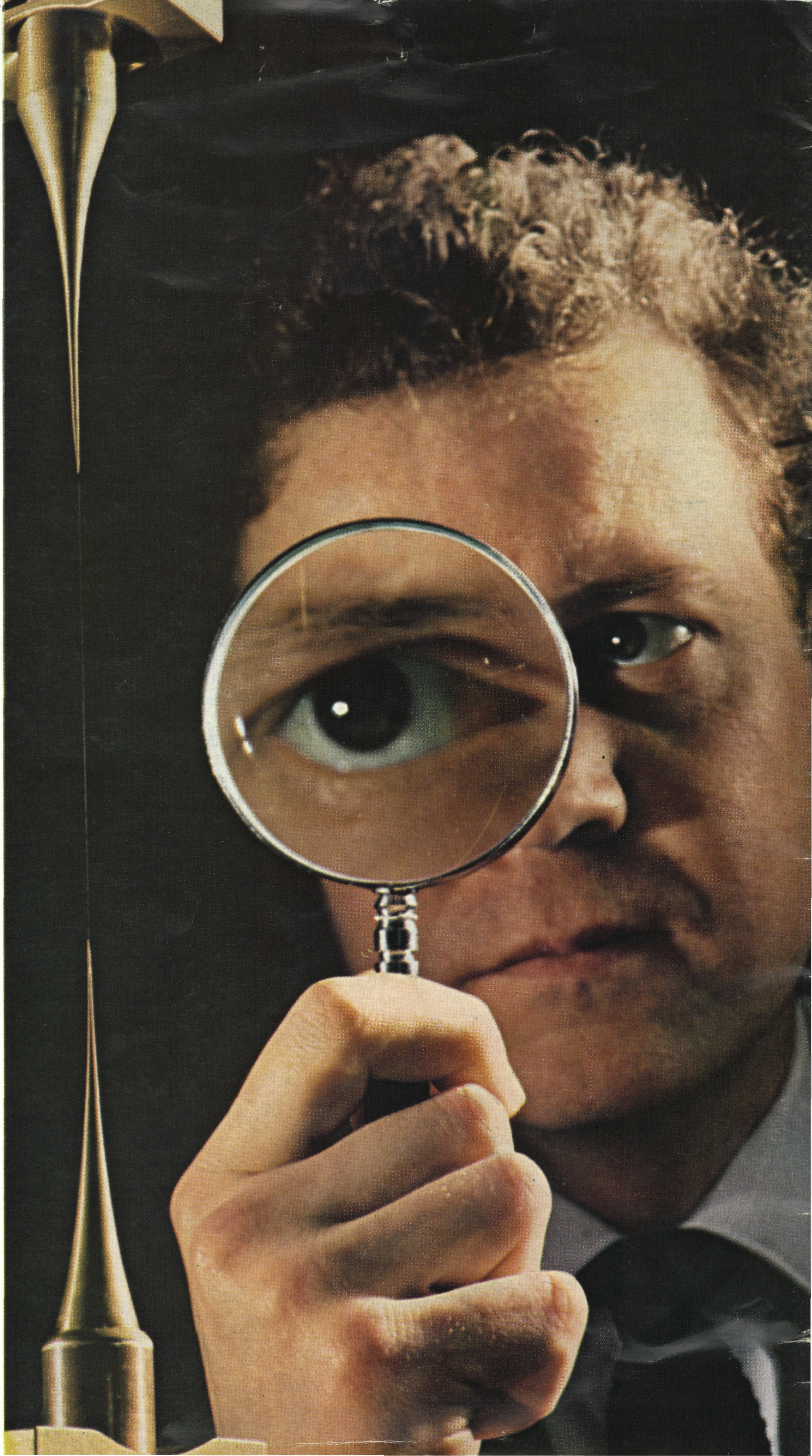
GREECE Mr. C. Kypraios, Greek Minister for Industry, with Dr. J. E. R. Holmes, Chief Physicist, during a visit to Winfrith in May. On the far right is Mr. N. Mitsos, vice-president of the Greek Federation of Industries.

JAPAN A party of engineers from the Electric Power Development Company of Japan toured British nuclear installations in May/June. In addition to visiting the Authority establishments at Windscale, Risley, Springfields and Winfrith and a number of firms in the British nuclear industry, they saw the nuclear power stations at Dungeness 'B', Hinkley 'B' and Oldbury. In the photograph above they are inspecting a model of the Winfrith S.G.H.W.R.

BRAZIL Mr. T. Tuohy, Managing Director of the Production Group, led the team which represented the Authority at the British Industrial Exhibition in Sao Paulo, Brazil, in March. He is seen on the right above with (left to right): Dr. Pedro B. Camargo, Director, Nuclear Engineering Division, Atomic Energy Institute, Sao Paulo; Dr. Mario P. Bhering, President, Eletrobras; and Sr. J. Aflalo Filho, Eletrobras.

Right: An instrument to measure the elasticity of carbon fibre—which is so thin that it can hardly be seen with the naked eye. (See page 14).

Front Cover: The HERALD research reactor at Aldermaston. HERALD-type reactors have been sold by Britain to Chile and Brazil. (See page 21).



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