UNITED KINGDOM ATOMIC ENERGY AUTHORITY

SECOND ANNUAL REPORT

1955–56

LONDON
HER MAJESTY'S STATIONERY OFFICE
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ATOMIC ENERGY AUTHORITY

SECOND ANNUAL REPORT

For the Period
1st April 1955—31st March 1956

Presented to Parliament in pursuance of Section 3 (5) of the Atomic Energy Authority Act, 1954

Ordered by The House of Commons *to be Printed*
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HER MAJESTY'S STATIONERY OFFICE
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United Kingdom Atomic Energy Authority,
St. Giles Court,
London, W.C.2.
12th June, 1956

MY LORD,

I have the honour to submit, in accordance with Section 3 (5) of the Atomic Energy Authority Act, 1954, the second Annual Report of the United Kingdom Atomic Energy Authority. This Report covers the period from 1st April, 1955 to 31st March, 1956.

I have the honour to be, my Lord,
Your Lordship's obedient Servant,

Chairman.

The Most Hon. The Marquess of Salisbury, K.G.,
Lord President of the Council,
Privy Council Office,
Whitehall, S.W.1.

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CHAPTER I

INTRODUCTION

1. The dominant feature of the year ended 31st March, 1956, has been the great increase of interest and activity, both in this country and overseas, in the development of nuclear energy as a source of power for peaceful purposes.

2. This has not entailed any reduction in the Atomic Energy Authority's activities on the defence side. The nuclear weapons programme, and particularly the development of thermo-nuclear weapons, continues to have high priority; in fact, during the year, the rate of increase of staff has been higher in the Weapons Group than in the other parts of the Authority. Weapon development is, however, a continuing programme; in this field the year differed in degree, not in kind, from previous ones. But on the civil side, the increase in activity of industry in the U.K. and of Governments and industry overseas constituted a new feature of national and international affairs. A year ago, nuclear power appeared, for most countries, to be a possibility in the remote and indefinite future; now, it is a matter not of conjecture but of dates and of comparative costs.

3. Increasing interest in the civil applications of nuclear power has coincided with a considerable advance in the removal of security restrictions from nuclear energy information. Only a comparatively small part of the information relevant to nuclear power development is still subject to such restrictions. The success of the Geneva Conference on the Peaceful Uses of Atomic Energy (described in Chapter XII) was due to this combination of the growth of interest on the one hand and the removal of security restrictions on the other.

4. The measure of overseas interest in the British nuclear energy programme and of the Authority's overseas contacts is indicated by the fact that visits were paid to the Authority's establishments during the year by representatives of 36 countries.* During the Geneva Conference the Authority organized a one-day visit to Harwell for representatives of all the countries taking part in the Conference, air transport being provided to and from Geneva. In addition, there was a considerable flow of foreign visitors throughout the year, particularly to Harwell and Calder Hall. Representatives of the Authority visited atomic energy projects in a number of foreign countries. Several visits were paid to the U.S.A., in implementation of the

* The 36 countries were:

Australia	Finland	Japan	Spain
Austria	France	New Zealand	Sweden
Belgium	Germany	Northern Rhodesia	Switzerland
Brazil	Greece	Norway	Thailand
Canada	Holland	Pakistan	Turkey
Chile	India	Portugal	U.S.A.
Czechoslovakia	Iraq	Russia	Uruguay
Denmark	Irish Republic	South Africa	Venezuela
Egypt	Italy	Southern Rhodesia	Yugoslavia

Civil Bi-lateral Agreement concluded in June, 1955. In November a party of eight, led by Dr. B. F. J. Schonland, Deputy Director of the Atomic Energy Research Establishment, paid a six day visit to Russia.

5. The Prime Minister visited Harwell and Aldermaston in September, 1955. H.R.H. the Duke of Edinburgh visited the establishments of the Industrial Group in November, 1955; H.R.H. Princess Margaret visited the Radiochemical Centre at Amersham in December. In January it was announced that H.M. the Queen will open Calder Hall on 17th October, 1956.

6. During the year under review the industrial teams mentioned in the last Report (paragraph 82) continued the design work directed to construction of the first nuclear power stations. This work is described in more detail in Chapter V. Many more British firms started to build up their own atomic energy teams to study reactor development or the use in production processes of radioisotopes and irradiation sources supplied by the Authority. In February 1956 Associated Electrical Industries Ltd. announced their intention to construct the first privately-owned research reactor in the United Kingdom.

7. The increasing impact of atomic energy on the engineering life of the country was demonstrated by the formation in May, 1955, of the British Nuclear Energy Conference. The Conference was formed by the Institutions of Civil, Mechanical, Electrical and Chemical Engineers and the Institute of Physics. Its object is to provide a common ground for scientists and engineers to discuss developments in the technology of nuclear energy. The first Chairman is Sir Christopher Hinton, and the Board consists of three representatives from each of the constituent bodies. The Conference, which held its first symposium in November, 1955, arranges for the presentation of papers dealing with nuclear energy subjects, and publishes a Journal containing records of the papers, discussions, symposia and conferences conducted by the Board.

CHAPTER II

GENERAL DEVELOPMENTS

Authority Membership

8. In October, 1955, the Lord President of the Council appointed Mr. W. Strath, C.B., a Third Secretary in the Treasury, to be a full-time Member of the Authority. Mr. Strath is largely concerned with the Authority's relations with industry and with overseas atomic energy organisations, and with raw material procurement. At the same time, Sir Rowland Smith, Chairman of the Ford Motor Co., and Mr. C. F. Kearton, a Director of Courtaulds Ltd., were appointed as part-time Members. This brought the membership of the Authority up to the limit of 10, other than the Chairman, laid down in the Atomic Energy Authority Act, 1954. The Members of the Authority are listed at Appendix I.

Capital Facilities

9. Construction of new capital facilities continued at almost all the Authority's establishments during the year. New laboratories were completed at Aldermaston. At Harwell the two research reactors DIDO and LIDO (the Swimming Pool reactor) made good progress. Work proceeded on considerable extensions to the gaseous diffusion plant at Capenhurst, and at Springfields preparations were made for the introduction of new chemical

processes. The construction of the prototype nuclear power reactor at Calder Hall kept pace with the programme. At Dounreay erection of the protecting sphere for the fast breeder reactor was well under way. A large new office block was completed at Risley.

10. Three new sites were taken over by the Authority during the year—Chapel Cross, Grove Airfield and Bracknell.

11. In June, 1955, it was announced that six more atomic reactors of the Calder Hall type, designed to produce fissile material for military purposes as well as electricity, were to be built. As is described in Chapter IV two are to be sited at Calder Hall itself, and the remaining four at Chapel Cross, near Annan.

12. At Grove Airfield, near Wantage, new laboratories for the Technological Irradiation Group are projected, and it is proposed at a later date to transfer the Isotope School there from Harwell.

13. Harwell has now almost reached the maximum size compatible with efficiency of management and the avoidance of unreasonable pressure on the facilities of the surrounding country-side. But the needs of research and development continue to demand more scientific staff and more working space. Grove Airfield will provide some slight relief. In addition, under arrangements made with the Bracknell Development Corporation, a satellite workshop and design office at Bracknell started operating in January, 1956. It is building up to a strength of about 100. A small electronics unit is to be located nearby. These measures will not, however, solve the main problem ; and at the close of the financial year, the Authority were examining possible new sites with a view to setting up a further major research establishment, to which new research and development projects could be directed.

Staff

14. The continuously expanding programme throughout the Authority's establishments requires a considerable expansion of staff. During the year, the Authority's non-industrial staff increased by 30 per cent., the industrial staff by 13·6 per cent. The total staff at 31st March, 1956, numbered nearly 24,000.

The Authority's senior staff at 31st March, 1956, are listed at Appendix II.

Finance

15. An Estimate of the Authority's expenditure in 1955–56 was presented to Parliament on the 17th February, 1955, and showed £50,562,000 as the net sum required. As the year progressed it became plain that more money would be required to implement the Government's decisions to develop thermo-nuclear weapons, to carry out a nuclear power programme and to increase the output of plutonium (see paragraph 52 below). Additional requirements for Salaries, Wages, etc., Stores, Materials and Services, and Capital Works were offset by savings on the original estimates for Other Current Expenditure, Capital Assistance and Loans. After adjustment for the savings, the net additional expenditure was £3,550,000, which sum was approved by Parliament as a Supplementary Estimate on the 15th March, 1956.

16. The actual expenditure for the financial year 1955–56 will be included in the Appropriation Account of the Office of the Lord President (Atomic Energy). This, after examination by the Comptroller and Auditor General, will be presented to Parliament and published.

17. On the 15th February, 1956, an Estimate of the Authority's expenditure in 1956–57 was presented to Parliament. This showed £68,242,000 as the net sum required.

Accounts

18. Besides the cash accounting required for purposes of Parliamentary control, commercial accounting records are necessary to provide information for management and to facilitate the preparation of commercial accounts in the form directed by the Treasury under Section 4 (3) of the Atomic Energy Authority Act, 1954. Although a commercial system of accounting had been in operation for some years at some of the establishments taken over by the Authority, accounting at other establishments had previously been aligned primarily to Vote accounting. The Authority therefore faced a major task in establishing commercial accounting systems throughout the organisation. An essential pre-requisite was the preparation of a statement of assets and liabilities taken over by the Authority at 1st August, 1954, under Section 2 (1) of the Atomic Energy Authority Act, 1954. Where commercial accounting already existed the recorded written-down values of assets were adopted. At the establishments which had previously operated Government accounting systems, information as to written-down values was not available and it was decided to proceed on the basis of an " as found " inventory valued at cost or estimated cost at the time of construction or acquisition less depreciation for the period for which the individual items had been used.

19. A Balance Sheet as at the 31st March, 1955, has been submitted to the Comptroller and Auditor General and will in due course be presented to Parliament.* (The Operating Account is withheld from publication in the interests of national security.) There has not yet been sufficient time for a critical review of the information assembled in preparing this first Balance Sheet and the Authority recognise that it is not of the high order of accuracy which they would desire. Some adjustment of the figures will be necessary in succeeding years.

Conferences

20. At Appendix IV are listed the principal Conferences held at Harwell during the year.

CHAPTER III

MATERIALS

21. Uranium, which is the necessary starting point of both military and civil atomic energy programmes, has throughout the year attracted more attention than almost any other metal. The main reason for this has been the spate of new discoveries, most of them on the North American Continent. These discoveries have been so extensive that they have removed the danger of a worldwide shortage. The Authority have continued planning ahead to match their growing requirements with greater production, particularly from Commonwealth sources. But as the world supply position grows easier, more attention has to be paid to the relative cost of production from new deposits: there is no question of paying almost any price for uranium. The forecast, made in September, 1954, by the Director of the Raw Materials Division of the United States Atomic Energy Commission, that the acceptable price for

* Ordered by the House of Commons to be printed on 16th May, 1956 and now on sale at Her Majesty's Stationery Office (price 6d.). The Balance Sheet, together with the Authority's foreword, is reproduced at Appendix III.

uranium contained in a high-grade concentrate might become about $10 (71s. sterling) per lb., has already received some confirmation.

Combined Development Agency Contracts

22. For their current uranium imports the Authority have continued to depend on contracts placed by the Combined Development Agency on behalf of the Authority and the United States Atomic Energy Commission. The following developments concerning Agency contracts should be mentioned:

(a) *Australia.* The first shipments of concentrates have been received from the mines at Rum Jungle and at Radium Hill. A plant erected at Port Pirie on the Spencer Gulf to treat Radium Hill output has been built with capital provided by the Agency and was officially opened in November, 1955, by the South Australian Government.

(b) *Belgian Congo.* Following the negotiation of a new inter-Governmental Agreement in November, 1955, a further extension of contract for the supply of uranium ore and concentrates from the Shinkolobwe mine is being negotiated between Union Minière du Haut-Katanga and the Agency. Meanwhile the flow of uranium concentrates from this source has continued as expected.

(c) *South Africa.* The output of uranium concentrates from the Transvaal and Orange Free State mines continues to grow. During the year ending 31st March, 1956, additional mines have been brought within the Agency's programme and the Authority have agreed to make further capital investments in treatment plants. During the year the Authority entered into loan agreements with 5 gold-uranium producers. This brought the total number of such agreements to 27.

U.K. Contracts

23. The following steps were taken during the year to secure the additional imports which will be needed in the future. As will be seen they have included the signature of the first contracts for delivery of uranium direct to the U.K. as distinct from contracts for supplies through the Combined Development Agency.

(a) *Australia*

(i) *Queensland*

In March, 1956, the Authority signed a contract with Mary Kathleen Uranium Ltd., a member of the Rio Tinto Group of Companies, under which the Authority are to buy for a number of years uranium concentrates to be produced in the Mary Kathleen mine in north-west Queensland. The Authority have undertaken to lend up to £5 million sterling of the capital required to bring the mine into production; the balance is to be found by Rio Tinto. The mine is situated some 500 miles from the coast at Townsville and about 40 miles from Mount Isa. The project will involve the building of a new town which will house up to 1,000 people. The Government of the State of Queensland have welcomed the project, which will make extensive use of Queensland services and which will in turn make an important contribution to the development of the area.

(ii) *Northern Territory*

The Authority have entered into a commitment in regard to the deposits of the South Alligator region of the Northern Territory of

Australia. This is an area in which interesting mineralisation has been discovered but in which the uranium deposits found have not so far justified the erection of a treatment plant. After discussion with the Commonwealth Government, the Authority have undertaken to buy a considerable tonnage of uranium concentrates if and when produced from this region, at a minimum guaranteed price. The Authority's offer is open until 31st December, 1957, and it is the hope of the Commonwealth Government and of the Authority that the confidence generated by the offer will be sufficient to encourage exploration to prove whether or not substantial ore bodies do exist there.

(b) *Central African Federation*

The Authority have taken steps during the year to foster an interest in uranium prospecting in the Central African Federation, which is geologically promising but in which no rich strike has yet been made. The contract with the Rhokana Corporation for the output of the small uranium orebody in the Nkana copper mine in Northern Rhodesia (referred to in last year's Annual Report) was signed in July, 1955. In December, 1955, the Authority, in conjunction with the Geological Survey and Museum, opened an office in Salisbury, Southern Rhodesia, to advise and encourage local Geological Survey organisations and prospectors.

Technical Developments

24. *Geological Electronic Instrumentation.* The efficiency of uranium prospecting depends on the efficiency and sensitivity of the electronic instruments used. In collaboration with the Geological Survey, with mining houses, individual prospectors and the electronics industry, the Electronics Division at Harwell continues to develop prospecting and other geological electronic instruments of the most advanced types. Its products include portable geiger and scintillation counters for prospectors, air-borne and car-borne survey equipment, and instruments for use in mines and in treatment plants. Close liaison is maintained with the Scientific Instrument Manufacturers Association. The desirability of developing and manufacturing instruments that will appeal to world-wide export markets is borne constantly in mind.

25. *Chemical Methods of Extraction.* Once uranium has been found and mined, the ore, which contains probably only a fraction of one per cent of uranium, has to be treated so as to provide a chemical concentrate with a minimum of 50 per cent uranium as the feed material for the Authority's chemical and metallurgical plant at Springfields. The physical methods used in the initial upgrading are not peculiar to uranium, but some of the subsequent chemical methods used have had to be specially developed. All information relating to current techniques for the extraction of uranium from its ores was freed from security restrictions in August, 1955. This has enabled an account to be published of the ion exchange process, by which methods originally developed for the softening of water were applied to the extraction of uranium from low grade ores. Had this application, which first came into prominence in 1950, not been developed, much the greater part of the present uranium programme would not have been possible except at a vastly increased cost. Papers will shortly be published showing the great part played in this development of ion exchange by the Radiochemical Group of the Chemical Research Laboratory of the Department of Scientific and Industrial Research.

Thorium and Beryl

26. The role of thorium as an atomic fuel lies in the future, and the Authority's purchases of thoria continued to be relatively small. The Authority continued to import small quantities of beryl from Australia.

Graphite

27. By the terms of their agreement with the Central Electricity Authority, the Atomic Energy Authority are required to make arrangements in advance, where necessary, to secure the satisfactory supply of special materials. Reactor graphite is an important example. The nuclear power programme contemplates the extensive use of reactors designed to use graphite as a moderator, and the large quantities needed would far outstrip the present capacity for producing graphite of the high quality and purity required in a nuclear reactor. Arrangements have been made during the year to create additional capacity for production in the United Kingdom.

28. A research group at Harwell is investigating the problems of producing special grades of graphite for future reactors.

Heavy Water

29. The plan, mentioned in paragraph 51 of last year's Report, to combine a heavy water distillation plant with an electricity generating station in New Zealand, has been abandoned because of a substantial increase in the estimate of capital cost. The figure of £2 million originally estimated was found to be less than half the probable cost. On the basis of the revised estimate the scheme would have been uneconomic. Fortunately, no difficulty is expected in obtaining from elsewhere all the heavy water likely to be required. Supplies are on order from both U.S.A. and Norway.

Uranium Production and Fabrication

30. The production of uranium metal has been increased to meet the requirements of Calder Hall and to maintain supplies to the existing reactors. Increased quantities of uranium hexafluoride have been produced for the gaseous diffusion plant. Economies in operation and plant modifications have reduced unit costs and increased the capacity of the plant.

31. In addition to virgin material brought into the uranium production plant at Springfields during the year, a large accumulation of slags and other materials produced in the uranium purification process have been treated for the recovery of their uranium content. Uranium depleted in the 235 isotope through irradiation has, following treatment in the Windscale chemical separation plant, been converted to the hexafluoride for re-enrichment in the gaseous diffusion plant at Capenhurst.

32. It has been decided that the first stage in the modernisation of the uranium extraction plant should be to change from calcium to magnesium as the means of reducing uranium tetrafluoride to metallic uranium. This will lead to a big saving in raw material costs. Construction of temporary facilities to cover the period until the new integrated plant is built is almost complete and production in them will start within a few months.

33. The aim of development work on other sections of the process is to introduce continuous operation in place of batch working. This work is well advanced and construction is about to start. In the new plant, the opportunity will be taken to exclude the operators wherever possible from contact with uranium.

34. The manufacture of fuel elements to meet the needs of BEPO and of the Windscale piles has continued. Special cartridges have been made for isotope production. Significant improvements have been made in cartridge manufacturing techniques and the service life of the cartridges has thus been increased. New equipment has been installed and brought into operation to make cartridges for the Calder Hall reactors. The greater length of these cartridges and the additional strength needed to enable them to be stacked in vertical channels are two factors which have raised manufacturing problems. These are being overcome. Half of the initial charge for the first reactor had already been completed by the end of the year under review.

Production of Fissile Material

35. During the year further sections of the gaseous diffusion plant at Capenhurst have been commissioned, thus allowing greater quantities of material to be enriched to various extents. Enriched uranium has been produced to meet the programme of military supplies, to fuel the fast reactor which is being constructed at Dounreay, and to provide material for experimental purposes at Harwell.

36. To meet additional demands for separation capacity, it has been decided to extend the facilities at Capenhurst.

37. The plutonium-producing piles at Windscale have continued to work satisfactorily and it has been found possible to achieve a further increase in their output. The most noteworthy achievement of the period has been the steady progress in the development of maintenance techniques for use inside the pile shield. The piles were designed and built on the assumption that access would be impossible once they had been in operation, and the success which has been achieved offers two advantages for the future. First, it suggests that the life of an existing reactor may be extended if it is threatened by mechanical breakdown; and, second, it gives greater freedom to designers of future reactors. It is now practicable to include items of limited life, and these can be replaced if they break down or wear out. This eases what had been a severe limitation on design and on the choice of equipment.

38. Much of the development has been based on the use of periscopes and television cameras to examine parts of the interior of the piles where the activity level is too high to permit entry even under shut-down conditions. In conjunction with this, maintenance techniques have been developed. Staff have succeeded in designing tools, ranging from hammers to welding torches, which, in spite of the small size of the access holes, can be inserted and then operated inside. Lining plates which had become distorted by the action of the cooling air stream have been straightened and welded in position; they are now as secure as when they were originally installed.

39. On one occasion it was found necessary to repair equipment at the foot of the discharge face. To do this it was decided to try to enter the pile vault and carry out the maintenance direct. Access was possible through the water duct which connects the pile and the cooling pond, and which is used for removing the irradiated cartridges on trolleys. With the pile shut down, the duct was almost completely emptied of water and a radiation survey carried out. From the results of this an estimate was made of the amount of shielding needed to reduce the radiation level sufficiently to enable a man to work for a limited period at the point where the repair was needed. After careful consideration of alternatives, it was decided to build a steel "umbrella" which could be hung above the working spot and would absorb a large fraction of the radiation. Because of space limitations in the water

duct, this shield had to be made in sections and assembled inside the duct. The whole of the operation, which was carefully rehearsed before starting, was carried through with complete success. The work was arranged in relays, so that the greatest individual dose received was less than the six weeks' limit—an amount too small to have ill effects and compensated for by ensuring that the worker was not exposed to further radiation for six weeks.

40. The separation plants for dealing with the irradiated cartridges from the Windscale piles have continued to operate satisfactorily. More details of the primary separation plant have been published. After the cartridges leave the pile they are stored for some months in a cooling pond to allow some of their activity to decay. (During the extremely cold weather in February the heat generated by the activity was sufficient to prevent any ice formation on the pond.) The aluminium can is then removed from the cartridge while it is still under a sufficient depth of water to provide adequate protection for the operators against radiation. The uranium rods are transported in lead-lined containers to the top of the primary separation plant; the containers are opened, again under several feet of water; and the rods are fed to a dissolver in which they are dissolved in strong nitric acid. The solution then passes through a solvent extraction process in which the acid solution and an organic solvent (dibutyl carbitol) flow in opposite directions through tall stainless-steel columns. In the first of these the plutonium and uranium pass into the solvent and nearly all the fission products are left in the acid, which then passes through a treatment plant to storage. In further columns the plutonium and uranium are separated from each other and a further removal of the remaining fission products takes place in the plutonium and uranium purification plants. The solutions leaving the primary separation plant are aqueous and the solvent is re-used, being purified as necessary in a separate plant. The uranium solution is returned to Springfields for conversion to hexafluoride, so that the uranium, which has lost a proportion of its content of 235 isotope, can be enriched again by passing it through the gaseous diffusion plant.

41. The amount of plutonium produced as a result of irradiation in the piles is much less than one part in a thousand of the uranium in which it is formed, and therefore high efficiencies are essential in the chemical plants to avoid losing what would be regarded in any normal process as an unimportant impurity.

42. Although they are not concerned directly with the production of fissile material it is appropriate to refer here to the Dounreay chemical plants for the fabrication of fuel elements and for their processing after irradiation. These fuel elements, for DIDO, PLUTO and the fast reactor, will contain a much higher proportion of fissile material than those handled at Springfields and Windscale, and criticality problems arise which need careful attention at the design stage. The recovery processes for the DIDO and PLUTO elements have been determined and construction, both of these plants and of the fuel element fabrication plants, has started.

Thorium and U233

43. The production of thorium, the source material for uranium 233, has continued on a small scale at a factory operated by an industrial firm as agents for the Authority. Meanwhile consideration has been given to methods of adapting the process to larger scale production.

44. Chemical processes have been developed at Harwell for the complete separation of the fissile uranium 233, fertile thorium and the radioactive

fission products from neutron-irradiated thorium. These processes have been operated on a small pilot plant scale, thus confirming the plant flowsheets. Sufficient uranium 233 has been produced for many of the nuclear characteristics of this material to be investigated.

CHAPTER IV

REACTORS UNDER CONSTRUCTION

Calder Hall

45. Progress on the construction of the prototype nuclear power station at Calder Hall has continued throughout the period in accordance with the programme. The pressure vessel and the octagonal concrete shield of the first reactor were completed at the beginning of the year ; the reactor could then be compared to a ship at the time of launching. Throughout the year the " fitting out " has gone ahead, and at the end was so nearly complete that mechanical operating tests had started. Early in 1956, therefore, progress had reached a stage when it was possible to decide that by October, 1956, the station should be operating with sufficient reliability to supply electricity to the Central Electricity Authority's distribution system. This supply will be inaugurated by H.M. The Queen at a ceremony on 17th October.

46. One of the most intricate installation jobs was the building up, from many thousands of carefully machined graphite bricks, of the elaborate moderator structure with its vertical channels in which the fuel elements and control rods will be housed. Because of the paramount importance of cleanliness everyone entering the reactor vessel during this period had to pass through a changing room and make a complete change of clothing. When the graphite was in place, measuring and detection equipment had to be installed.

47. The same scrupulous attention to cleanliness was necessary in installing the tubes in the heat exchangers, for any dirt deposited there might be carried by the cooling gas stream into the reactor. The banks of tubes, covered with millions of studs to improve the heat transfer, were shot-blasted on site to remove every trace of rust and then packed in boxes for transfer to the heat exchangers. The same changing procedure was adopted for people entering the exchangers as for the pressure vessel, so that the tubes should be completely clean. To minimise the risk of water leaking into the coolant circuits the heat exchangers were so designed that all welds made on the tubes after erection were outside the vessel.

48. In addition to the work on the reactor core and heat exchangers, a large amount of ancillary equipment had to be installed, including the blowers, the standby diesel generators, the fuel charging and discharging machines and the control room equipment.

49. The second reactor has progressed in line with the first but is programmed six months later. At the end of the period the graphite structure was complete, the four heat exchangers were in position, and the installation of the tubes in the exchangers was nearing completion.

50. During the twelve months ending December, 1955, eight heat exchangers, weighing about 200 tons each, were successively lifted into position, the same lifting tackle being moved between each lift.

51. The generating equipment to be installed consists of four 23MW turbo-alternator sets, two for each reactor. At the end of the period, the first

of these was complete, whilst erection of the second was well advanced. One cooling tower, and the concrete structure of the second, had been completed; installation of the internal pack was going ahead. The associated mains and pump house were ready for service.

Increased Military Programme

52. In June, 1955, it was decided that increased supplies of military plutonium were required. Careful consideration was given to finding a way of producing them which would cause the minimum interference both with the development of the civil programme of nuclear power stations and with the pioneering activities in the reactor field of the Industrial Group of the Authority. To save time it was decided to build three new units of the Calder Hall type, each consisting of two reactors and the necessary ancillary equipment for generating electricity.

53. One of these units is sited alongside the first Calder Hall unit but a new location was needed for the other two. Any reactor site must satisfy certain conditions (see Chapter V), but in this case there were additional requirements. The irradiated fuel was to be processed at Windscale, and therefore it was desirable that the site should be within reasonable distance, not more than 100 miles away. Also, because the programme was urgent, it was desirable that the land should already be in Government possession. The choice finally fell on a disused airfield at Chapel Cross, near Annan, in Dumfriesshire and preliminary work started there in August, 1955. To assist further the Authority's staff in meeting this unexpected demand, it was decided to employ Messrs. Merz and McLellan as consulting engineers for the power plant layout, services and civil engineering and as construction agents for the whole Chapel Cross project.

54. The existence of services, office and storage accommodation, and equipment at Calder Hall enabled work on the second unit there to be started quickly and to make rapid progress. By the end of the period the biological shield of the third reactor was partially constructed and the foundations of the fourth were well in hand. The excavation for the turbine hall was complete and concrete work was proceeding.

55. At Chapel Cross, the first task was to recondition the airfield offices and accommodation for staff and workers. After that, in spite of adverse weather conditions, excavation went ahead on the first two reactor sites. The foundation concrete for No. 1 reactor had reached ground level by the end of the period. The construction labour force has built up to 600 and will increase over the next year to a peak figure of 2,000.

Fast Breeder Reactor

56. The most conspicuous progress on the fast breeder reactor at Dounreay, construction of which had just started at the beginning of the period, has been the completion of the lower half of the protecting sphere, which, at the end of the period, formed a bowl, 70 feet high and 140 feet across. The next stage is the construction, inside it, of the concrete vault, 80 feet in diameter, which will contain the reactor core, the breeding blanket and reflector which surround the core. Outside these will be the primary heat exchangers. The floor of the vault was complete and the steel-work for the walls had been erected by March 1956. When this work is finished the upper half of the sphere will be erected.

57. The reactor coolant, an alloy of sodium and potassium, must be kept from contact with the boiler water from which steam will be produced to drive the turbines. An intermediate circuit was therefore introduced. This also contained sodium-potassium alloy. The intermediate circuit connects

the primary exchangers inside the vault with secondary exchangers where the heat is given up in generating steam. The secondary exchangers will be outside the safety sphere. Fabrication of the primary heat exchangers and of the reactor vessel has proceeded according to programme.

58. Sea water will be used for condenser cooling, thereby avoiding the need for cooling towers. The construction of the pumphouse and seawater channels has involved considerable excavation and the blasting away of a rock barrier. This was practically complete and the laying of concrete had started at the end of the period.

Materials Testing Reactors

59. During the year, construction of the 10 MW heavy water cooled and moderated thermal reactor, DIDO, at Harwell reached an advanced stage. The main building block was nearing completion and the installation of the reactor heavy water circuit and the control and instrumentation equipment was well under way. There has been considerable difficulty in meeting completion dates of the various items. This has been due to the generally overloaded capacity of sub-contractors, and because of it an effort on progress and inspection much larger than originally estimated has had to be made. Nevertheless it is hoped to bring this reactor into operation towards the end of July, 1956, and to work up to full power by Christmas.

60. The research programme associated with this reactor has been defined and work has started on the design and manufacture of special experimental equipment and devices for the production of radioisotopes. The reactor will also be used for a limited amount of engineering loop work. By early 1957 a high pressure water loop and a high temperature gas loop will be installed for detailed investigation into possible reactor systems using these coolants.

61. The foundations and the main structure of the Harwell PLUTO, a 10 MW heavy water high flux reactor, were complete at the end of the period and the reactor tank had just been installed. PLUTO should be complete by September, 1957, and available for use early in 1958. Work had commenced on the design and construction of the first of the engineering loops that will be installed in this reactor to try out the technology of advanced reactor systems.

62. In order to increase the Authority's facilities for the testing of reactor materials under conditions of radiation, it has been decided to build a duplicate of PLUTO at Dounreay. Work has started on the reactor building and the plinth and support frame for the tank were completed during the year. Construction has also begun of the associated pump house and cooling tower.

Shielding Reactor

63. The Harwell swimming pool reactor designed for research and development related to the problem of shielding has been named LIDO, and construction is progressing satisfactorily. It is hoped to bring this reactor up to criticality in August or September, 1956. The programme of experimental work to be carried out with this facility is being planned and the necessary experimental equipment being ordered.

CHAPTER V

THE NUCLEAR POWER PROGRAMME

Industrial Activity

64. During the year great progress has been made on the collaboration scheme with the four groups of industrial firms which is the starting point for the national nuclear power programme. At the beginning of the period, the senior members of the teams had attended courses at the A.E.R.E. Reactor School. There followed a comprehensive and detailed course of instruction in the establishments of the Industrial Group. Those taking part in this course were able to see the operation of the Authority's reactor installations, to examine the construction work in progress at Calder Hall and to participate in discussions in the design offices and development laboratories. Following this, a second course, in which there was rather more specialisation, was arranged for the benefit of the section leaders of the design teams.

65. As the first commitment of the four groups is to submit tenders to the Central Electricity Authority in October, 1956, for the first two power stations, they were clearly obliged to base their reactor design on that of Calder Hall. Accordingly, while the training already described was still proceeding, the whole range of technical reports dealing with Calder Hall which had been prepared inside the Atomic Energy Authority during the course of the project was carefully examined to establish their usefulness to the design teams. A comprehensive selection was made from them and supplied to each team together with a specially-written commentary. In the same way a collection of drawings was provided to assist in building up background knowledge.

66. With a nucleus of trained staff, the four groups then turned their attention for a time to the setting up of design organisations. When this had been achieved they quickly started preliminary design work. During this period, although competing against each other for orders worth several million pounds, the four groups have been willing to meet regularly for the discussion of design problems and the exchange of information. A committee to coordinate major policy on design matters—the Nuclear Power Collaboration Committee—was set up with representatives from the four groups and the Authority. It meets every two months under the chairmanship of the Director of Engineering of the Industrial Group. It has been attended since its inception by members of the Central Electricity Authority and, more recently, by representatives from the South of Scotland Electricity Board. The range of technical problems arising out of the design work for these power stations is so great that the committee has set up working parties to deal with specific aspects. These also meet regularly and report back to the main committee. They deal with such questions as the choice of special reactor materials and their behaviour in operation, the design and development of fuel elements, heat transfer problems, reactor physics and reactor operation. These specialised meetings form an effective way of placing the experience of the Authority's staff at the disposal of this new industry.

67. To cater for the varied forms of collaboration which have been described, the Industrial Group has maintained an organisation which provides a consultant service and liaison between the teams and the appropriate section of the Authority on any specific problem.

68. At the same time as the industrial firms were setting up their design teams the Central Electricity Authority formed a Nuclear Power Branch

under its own Chief Engineer, who accepted an invitation to take part in the schemes for training and for the supply of documentary information. Initially, the Atomic Energy Authority organisation which dealt with the design teams provided the service for the C.E.A.; but it was felt inappropriate to continue this to the stage when tenders were submitted and C.E.A. would require assistance in their technical appraisal of the reactors. Early in 1956, therefore, a separate organisation was formed, under the control of the Operations Branch of the Industrial Group, to advise and assist the electricity undertakings and their consulting engineers. In this way, relations with the sellers' and buyers' sides have been divorced as far as is practicable in a situation where the Atomic Energy Authority is the only source of assistance to both.

69. Whilst the outcome of this industrial activity cannot properly be assessed until the tenders have been examined, the efforts of the design teams give every promise that the first power stations in the nuclear power programme will fully satisfy the conditions laid down in the White Paper and will represent a substantial technological advance on the Calder Hall prototypes.

Selection of Sites for Nuclear Power Stations

70. The advent of nuclear power has permitted a new freedom and also imposed new limitations upon the choice of power station sites. All the usual requirements for the site of an orthodox station remain with the exception of large scale facilities for the transport of fuel and for the disposal of ash, but there is added the limitation imposed by the precautions necessary having regard to the radioactivity which accumulates inside the reactor. The type of reactor which is planned for the first power stations is, as has been explained above, based on those in course of erection at Calder Hall, which are of inherently safe design. As it uses dilute fuel, a nuclear explosion is impossible in any circumstances; and it is difficult to conceive of any circumstances which would cause the release of any appreciable fraction of the radioactivity. However, it is recognised that there is at present only a relatively short experience of the working of nuclear reactors, and that, even though the design is inherently safe, it must be demonstrated, over a period of years, that the nuclear power stations are not dangerous in operation. Accordingly, the first stations will be built away from heavily built-up areas.

71. The Atomic Energy Authority have set up a panel of their own specialists together with representatives of the electricity undertakings to consider the problems of reactor siting. This panel has studied the sites proposed by C.E.A. for the first two stations at Berkeley, Gloucestershire, and Bradwell, Essex. In the light of the recommendations of the panel, the Authority have advised the C.E.A. that in the Authority's opinion these sites are appropriate to the type of reactor to be built there. The panel has also examined proposals by the South of Scotland Electricity Board for sites for a third station.

CHAPTER VI

RESEARCH AND DEVELOPMENT

(*a*) The Reactor Research Programme

72. The Authority's reactor research programme provides for the three successive stages of the country's nuclear power programme.

Stage One

73. A substantial amount of research and development work is still being done on the graphite-moderated gas-cooled reactors being designed by industry for the C.E.A. For example, a study of the reactions between the CO_2 coolant and graphite at the temperatures envisaged for the C.E.A. reactors is being carried out in a testing "loop" (or circuit) in BEPO; research on improved canning materials for the fuel elements is being carried out with the objective of enabling higher temperatures to be achieved in future designs; development of improved fuel elements and studies of radiation damage continue.

Stage Two

74. Feasibility studies and research and development work are being carried out on the pressurised water reactor and the sodium-graphite reactor. These reactors would provide higher heat ratings than gas cooled reactors, but would require enriched fuel.

(1) *Pressurised Water Reactor*

75. A number of loops have been built to study the corrosion of carbon steels and stainless steels under the conditions likely to be experienced in pressurised water reactors. One of these loops was being installed in the N.R.X. Canadian reactor at the end of the period under review. Another has been operating in BEPO for some time and a further loop will be installed in DIDO.

76. Fuel element specimens using highly alloyed uranium and the more corrosion-resistant uranium oxide have been made and are being investigated for irradiation damage. Zirconium alloys have been developed for canning the fuel elements. Development work is also being carried out on aluminium alloys for sheathing the fuel elements. If successful, this would reduce their cost greatly below the cost of elements using Zircalloy.

77. The use of organic liquids such as diphenyl and terphenyl as an alternative to the water moderator and coolant is being investigated. Their stability under irradiation looks promising. If such liquids could be used the system pressure would be much lower and corrosion problems might be less severe. Another method of reducing the pressure is to use a boiling water system, and this alternative also has been studied.

(2) *Sodium Graphite Reactor*

78. Reactor physics and metallurgical and engineering investigations are being carried out on the alternative reactor using graphite as a moderator and liquid sodium as a coolant. This system would have the advantage of enabling higher temperatures and therefore higher thermodynamic efficiencies to be attained. The pressure of the system would also be lower than that of the pressurised water reactor system.

79. In this reactor the liquid sodium coolant must be prevented from penetrating the graphite. One method of achieving this is to can the graphite blocks in hafnium-free zirconium sheet. This requires study of the compatibility of liquid sodium with zirconium. Another method would be to seal the fine pores in the graphite.

80. The physics of this reactor is being investigated to determine the degree of uranium enrichment required and the overall economics of the fuel cycle. A zero energy system is being constructed.

81. If these studies show one of these reactors to be more economically favourable than Stage One reactors, the Authority expect that design work on a prototype will be started by the end of 1956. Present information suggests that the choice will probably fall on the sodium graphite system. This prototype will be additional to the twelve stations planned for operation by 1965 in the White Paper Programme.

Stage Three

82. One major objective of Stage Three is to attain a much higher fuel utilisation by the achievement of breeding. Four reactor systems are being investigated for this stage, in addition to the organic system mentioned in para. 77

(i) Fast reactor system.

(ii) Homogeneous aqueous reactor system.

(iii) Liquid metal fuelled reactor system.

(iv) High temperature gas cooled reactor system.

(i) *Fast Reactor System*

83. The Zero energy fast reactor, ZEPHYR, was in operation throughout the year. The experimental programme centred mainly around the investigation of breeding characteristics of the plutonium-uranium system and the determination of the nuclear properties of many materials in fast reactors. The best data available for the neutron economy in ZEPHYR indicated that a breeding ratio of about 2 was obtained in the ideal conditions of a small uncooled system, that is, the reactor produced about twice as much fuel as it consumed.

84. The energy distributions of the neutrons in various regions of ZEPHYR were also studied and a large amount of systematic information on the neutron cross-sections of most of the natural elements and many separated isotopes has been accumulated. "Delayed neutron" emission from the fissile isotopes and from U238 and Th232 in fast fission was studied and the results related to the kinetic behaviour of ZEPHYR.

85. During the year, ZEUS, the zero energy version of the Dounreay fast reactor, was constructed. It came into operation on the 22nd December, 1955. Work is now in progress on this new system to obtain preliminary information relating to the final design and operation of the Dounreay reactor.

(ii) *Aqueous Homogeneous Reactor System*

86. The objective of the Aqueous Homogeneous Reactor is to achieve breeding in the U233-Thorium system, and by this means to achieve very low fuel costs.

87. Research and development work on the system has continued both at Harwell and under contract with the chemical industry. Chemical work on the effects of irradiation on the stability and corrosiveness of uranium solutions at high temperatures and pressure is now well advanced, and chemical engineering studies have been made into methods for the continuous removal of fission products from these solutions. A programme has been started of work in high pressure pumped loops, one of which will go in BEPO and the other in the new reactor PLUTO.

88. Zero energy critical assemblies (known as ZETR) have been made with both fissile isotopes of uranium (U233 and U235) in order to check nuclear physical calculations of critical size, flux distributions and temperature coefficients.

89. An assessment has been made of a power reactor generating about 100 MW of electricity to bring out the outstanding problems for which design data should be obtained through a reactor experiment.

90. Small scale investigations have been continued into fused salts which will dissolve uranium compounds and which might be used as fuel in very high temperature homogeneous reactors. Some promising systems are now being studied in detail and with special regard to corrosion and radiation stability.

(iii) *Liquid Metal Fuelled Reactor System*

91. An alternative to the Aqueous Homogeneous Reactor as a thermal breeder is a reactor using a graphite moderator and a fuel consisting of enriched uranium dissolved in a liquid metal. Such a reactor would have the fuel processing advantages of an aqueous homogeneous reactor combined with a relatively high output temperature. High pressures in the coolant circuit, which are necessary in aqueous systems because of the high pressure of the fluids, would be avoided. Reactor engineering studies in the past year have shown that the best system for the thermal reactor is likely to use a fuel consisting of a solution of U235 in bismuth. The reactor core would be surrounded by a "blanket" of a thorium-bismuth compound suspended in bismuth as a slurry. In this way neutrons which would otherwise escape from the core may be captured in the fertile material thorium to produce fresh supplies of the fissile material U233. Metallurgical studies are in progress on the handling and purification of bismuth and its alloys, and on the selection of corrosion-resistant containers. A loop in which bismuth can be circulated has been put into BEPO, and it is planned to put a further loop into PLUTO to simulate circulation in a power reactor.

(iv) *High Temperature Gas Cooled Reactor System*

92. The achievement of very high outlet temperatures (of the order of 750° C) would greatly increase the thermal efficiency of a reactor system, and would make possible the use of gas turbines as a means of extracting the energy from the system. To achieve these temperatures, gas-cooling would be necessary. The feasibility of such a system is being studied.

93. It is probable that one or two of the Stage Three reactors will be chosen in 1957–58 to proceed to a reactor experiment. This would consist of a relatively low power reactor which would be designed to test the general technology of the system and to allow attention to be paid to its possible application to the development of medium power output nuclear power stations. Such stations, in the region of 10 MW output, would be more suitable for export to many countries than the larger stations of the type being developed for the Electricity Authorities in the United Kingdom.

(b) **Reactor Technology**

Shielding studies

94. With the advent of nuclear power stations and mobile reactors, attention is being focussed on the need to design shields of minimum cost and size. During the past year the properties of different kinds of concretes have been studied, and cost estimates have been made of various combinations of materials as reactor shields. A small reactor (LIDO) has been under construction during the year for shielding studies. (See para. 63 above.)

Nuclear Data

95. In the period under review the considerable programme of work in compiling the necessary nuclear data for the power programme has been completed. A compilation of the data presented at the conference at Geneva has been made, and the best available values of the fundamental constants required have been deduced. Studies have been made of the variation of the number of neutrons released in fission as a function of incident neutron energy; an accurate absolute method of calibration of neutron sources has been devised; and the energy spectrum to be expected in the moderator of water reactors has been measured.

Gas Bearings

96. Liquids and gases to be used as reactor coolants have to be handled without contamination by lubricants or inward leakage from the surroundings. These surroundings may combine high temperature, corrosiveness and radioactivity. It has therefore been necessary to develop several unorthodox types of pump. Among these are the now familiar electromagnetic pumps. Pumps for gases have been developed using the gas itself as the bearing lubricant in bearings of the hydrodynamic type; such a pump, for example, is now being used to circulate carbon dioxide gas at fairly high temperature and pressure through BEPO in an experimental circuit. Gas bearings are also being employed in mechanical pumps for handling liquids which are not well suited to the electromagnetic or submerged bearing types and which present special difficulties with respect to the use of shaft seals.

Preparation of the raw materials

97. In the last report the initiation of the chloride extraction method, which uses cheap materials and simple processes for the extraction of thorium, uranium and beryllium, was described. This work has been developed and it appears that the process may compete, both technically and economically, with current large-scale methods: a pilot plant is being built to test the process on a larger scale.

Uranium

98. The physical properties of uranium are now well understood, and work has been concentrated on methods of producing better materials for reactor use. Uranium has been alloyed with a wide range of metals to produce a material in which the grains are small and randomly orientated in order to reduce the phenomena of "wrinkling", expansion, etc., which occur under irradiation. Irradiation studies have shown the advantages of such alloys and present work is directed to choosing the best production methods. An interesting example of the apparatus developed in this work is a television camera for remote viewing of irradiated samples. This also enables several operators to carry out an inspection simultaneously, and the screen may be photographed much more easily than the image in a conventional optical system.

Plutonium

99. During the year the metallurgy of plutonium has been developed towards the more extensive use of plutonium-bearing fuels in the power programme. This metal has to be handled by special remote handling techniques to avoid the toxicity hazard. The physical properties of the material are being determined with greater precision so that the calculations can be made on a firmer basis. The results also increase fundamental

understanding of the new group of metals produced artificially under irradiation. Techniques are being developed to alloy plutonium with other metals and to fabricate it into shapes required by the reactor programme.

Beryllium and beryllium oxide

100. Both beryllium and beryllia are now being made in Britain on a pilot plant scale. A new and simple technique has been developed to produce pure beryllium powder from the raw products; the powder can then be used for fabrication of the necessary shapes required in reactor work by powder metallurgical techniques. A method has been worked out to produce a homogeneous mixture of beryllium and fissile material which avoids the porosity in the normal sintering method. A useful development is the production of uranium fuel elements clad with beryllium by a sheath forging technique using beryllium powder, thus avoiding the difficulty of welding this material but producing a gas-tight envelope with very good heat transfer properties. Beryllium oxide shapes are now being fabricated by a hot pressing method which gives an enhanced bulk density of value in reactor moderators.

Thorium

101. Thorium metal has a high melting point, consequently it is difficult to select crucible materials and avoid contamination if the normal methods of fabricating bars or other shapes by casting are used. A technique has been developed which avoids the fire and health hazards consequent on using this material at high temperature. In this process, thorium powder is inserted in a rubber tube sealed at each end; the tube is then subjected to high pressures in a hydraulic press and a bar produced by cold pressing. The bar may then be sintered to increase the bulk density and can be swaged to the desired diameter without the need for machining.

102. The metal efficiency of this process (i.e. the amount of metal extracted from a given input) is very high (about 98 per cent). Tubes and plates may also be produced in this way, and the process can be used in mass-production methods.

Aluminium Alloys

103. The use of conventional aluminium alloys in water-cooled reactor systems is difficult because of high corrosion rates at the temperature employed. A new class of alloys of aluminium with iron, nickel silicon or titanium (Aereal alloys) is being developed. These are resistant to corrosion in water at high temperature and pressure.

Fuel element casting and canning

104. Solid fuel elements for a nuclear reactor must be enclosed in a gas-tight can to prevent escape of the highly-active materials produced in fission. It is difficult to manufacture a can which is tight enough to allow good heat transfer to the cooling media. One method has been described above; another recent development is a cold hydrostatic pressure technique similar to that used in manufacture of cold-pressed thorium bars. This avoids the complication of pressing at high temperature, and gives a better bond between the fissile material and the can. Satisfactory bonding between uranium rods and zirconium cans has been achieved both by extruding both together, and also by casting the uranium direct into the can, using the latter as a mould. Chromium-plated precision moulds have been developed which allow use of cast uranium rods without further machining. Fabrication of enriched uranium elements clad in aluminium for the

DIDO class reactors has proceeded satisfactorily. Elements using uranium oxide in aluminium are being developed for use with low enrichment uranium.

105. In addition to the work at Harwell, the Research and Development Branch of the Industrial Group is carrying out an extended series of investigations on the metallurgy of fuel materials and studies of the properties of canning materials of interest to current reactor projects. Amongst the more basic work is creep testing of uranium and its alloys to study the behaviour in service of various compositions and treatments. On some of the metals which may be used for sheathing fuel, such as niobium and vanadium, it was necessary to start by developing methods of producing the metal in a ductile form, suitable for forming to the required shape, and then, having produced these, to examine their physical properties under temperature conditions similar to those in a reactor. The properties of importance include creep strength, thermal conductivity and compatibility with uranium and sodium.

106. Besides this basic work, a considerable effort has been devoted to testing prototype fuel elements for the Calder Hall and fast reactors. Some of these fuel elements have been irradiated in the Windscale piles to study the effects of actual pile conditions, and to determine the importance of minor defects in the cartridges. At the same time, methods have been developed of using cartridges which have certain manufacturing defects.

Liquid Sodium Technology

107. The work on liquid metals reported in the previous report has been continued and extended. Large scale circuits have been constructed and operated for thousands of hours. The development of pumps and instrumentation has continued. A study has been made of mass transfer of pipe materials from the hot sections of the circuit to the cooler parts. If unchecked, this could lead to blockage of the pipes. Other problems affecting construction which have been examined include methods of cleaning the circuits, valve design and means for removing oxides and entrapped gases from the liquid metal. Associated with this work has been a study of the design of heat exchangers suitable for use with these coolants.

Irradiation studies on fuel element materials

108. During the irradiation of fissile material considerable changes take place in its physical properties because of the formation of fission products within it. The economics of nuclear power depend on the frequency of fuel reprocessing and thus on the "burn-up" or total energy which is released in the fuel. For the past year the irradiation work on fuels has centred on the problems of obtaining a burn-up of about 3,000 megawatt-days per ton of fuel (3,000 MWD/T). Even at 1,000 MWD/T, density measurement and microscopic examination show that at high temperatures there is appreciable swelling of uranium metal due to the internal pressure of the gaseous fission products.

109. This problem is being attacked in two ways. On the one hand, experiments are in progress to determine the effects of irradiation and to improve our understanding of the fundamental causes; on the other hand, alloying, external restraint and dispersion of the fuel in other media are being investigated in an attempt to suppress the effects of irradiation. The design and manufacture of facilities for irradiating these fuels and examining them subsequently is absorbing a substantial effort.

(c) Processing of Irradiated Fuels

110. The treatment of irradiated uranium by dissolution in acid followed by extraction with organic solvents continues to be a successful method for the separation of plutonium and the recovery of uranium for re-use on the industrial scale. During the year further experience of this processing method has been gained on the pilot plant for the extraction of the fissile material uraninum 233 from irradiated thorium. There have also been developments, both in the type of plant and in the solvents and chemical processes employed, to make the solvent extraction method suitable for the more immediate aims such as the treatment of irradiated fuels from DIDO and other similar reactors.

111. Advanced types of power reactor, such as the fast breeder, light water moderated, and homogeneous systems, impose new problems and requirements in the processing of irradiated fuels. The cost of processing will constitute an appreciable part of the total cost of nuclear power, and this cost could be reduced if the fuel, with its valuable fissile material, were treated by some simpler means than solvent extraction and the fissile material made ready for re-use in a shorter period of time. One method, which is under development for metallic fuels, consists of a high temperature melting process.

(d) The production of a controlled thermonuclear reactor

112. Since 1948, the Atomic Energy Authority and its predecessors have supported a programme of research into the possibilities of obtaining economic power from controlled thermonuclear reactions. The occurrence of abundant fuel such as deuterium and lithium is a strong incentive to achieve this objective.

113. The nuclear fuel must be brought to a temperature in the region of 100 million degrees centigrade to make a fusion reactor possible. Energy is given up by the hot gas in three ways :—

(*a*) Conduction to the surrounding medium.

(*b*) Radiation (similar to that from the sun).

(*c*) By nuclear reactions.

114. The energy release by nuclear reaction must be greater than (*a*) and (*b*) to make an efficient reactor. Whilst it is possible to initiate nuclear reaction at much lower temperatures, it is not yet certain that a pure fusion reactor can be built which yields more useful power than it consumes. Two main problems must be solved, namely—to bring a mixture of the light elements to the very high temperature mentioned above, and to maintain this temperature long enough for the energy released in nuclear fusion to be greater than that required to heat the fuel. Methods of heating the atoms of the reacting elements, under conditions which provide good thermal insulation from the walls of the surrounding vessel, are being explored.

115. The fuel would be a mixture of the two heavy isotopes of hydrogen, deuterium and tritium. Although tritium is not a naturally-occuring element it could be made by the absorbtion in a lithium blanket of the neutrons produced by the deuterium-tritium reaction.

116. Many methods of heating a gas under conditions of good thermal insulation have been tested under laboratory conditions. Extremely high temperatures have been measured in these experiments. The Authority's work is still in the laboratory stage and many problems have to be solved before a practicable fusion reactor will be possible.

117. Universities and industry have helped the Authority on many aspects of this work. The assistance of specialists has been required in many branches of the natural sciences including ionised gases, hydro magnetics, shockwaves and astrophysics.

(*e*) 6–7 GeV accelerator

118. Design studies have been initiated on machines to accelerate beams of protons to very high energies. Such machines are complicated and costly but are urgently needed to enable physicists of the Authority and the British Universities to participate in research on the frontiers of nuclear physics.

119. For the immediate future, attention is being concentrated upon a new type of proton synchrotron accelerator for an energy of 6,000–7,000 million volts (6–7 GeV) with the object of producing about 100 times the intensity of the present American machines and of a new machine nearly completed in the U.S.S.R. The particles will be accelerated in the gap of a ring-shaped magnet of about 5,000 tons weight and about 120 feet diameter, and will have to be given a preliminary acceleration to 5 or 10 million volts in a subsidiary machine. It is planned to use new methods of focussing the particles in order to effect a saving in the total weight of steel and to enable the high intensity to be obtained.

CHAPTER VII

HEALTH AND SAFETY

120. The Medical, Health Physics and Safety Sections in the Authority's establishments are responsible for advising the Operational Groups on both the operational and design aspects of health and safety. These Sections are in close touch with the plant designers. Common standards are maintained by regular meetings of the Project Health Committee, which is also attended by medical and biological consultants, who can comment on the health and safety record and advise on matters of policy.

121. Besides providing a normal casualty service, the main task of the Medical Departments is medical supervision. This is carried out by pre-employment medical examination of all the Authority's employees and by routine re-examination at intervals of from 1–5 years. A total of 15,000 such examinations was made during the year under review. Routine chest X-rays are carried out annually on all employees. Haematological examinations have also been made regularly on employees exposed to radiation but their value as a routine method of control is now being re-examined. Records are kept of the causes of sickness absence and of death amongst the Authority's employees: these both show a completely normal pattern.

Safety of Employees

122. The need to take unusual precautions against radioactivity helps to keep employees safety-conscious. This, coupled with the careful design of plant and equipment, has resulted in a low incidence of industrial accidents. The lost-time frequency rates for the year ending September, 1955, were 1·01 per 100,000 man-hours for the Industrial Group, 0·42 for the Weapons Group and 0·95 for the Research Group. These figures compare well with those for the chemical industry; in fact, employment in the Authority is safer than in most comparable industries. In particular, the dangers of radioactivity are well controlled, so that the chance of an employee being

injured from this cause is exceedingly small. In the period under review there has been no case of occupational toxicity illness or death; nor has there been a single fatal accident.

123. The basis of the precautions against radioactivity is the recommendation of the International Commission on Radiological Protection of a permissible weekly dose of 0·3 rad/week. This is measured by the use of individual dosimeters. The employees are protected from the hazards of handling radioactive materials in three ways: first by the careful design and engineering of plant and processes; second by monitoring the radiation and radioactive dust levels in the factories and laboratories; and, third, by biological monitoring to detect inhalation or ingestion of radioactive materials. The results of these monitoring procedures show that no employee was regularly exposed at levels exceeding the I.C.R.P. recommendations. There has been no case of serious amounts of radioactive material being retained in the body. The average gamma-ray dose, taken over all employees of the Authority, is less than 0·5 rads per year and only 29 out of over 7,000 exposed employees in the year 1955 received more than half of the cumulative annual exposure corresponding to the I.C.R.P. recommended weekly permissible dose.

124. In order to obtain a measure of their genetic significance, the doses received by employees have been carefully studied. To do this, the total dose received by employees is averaged over the whole population of the United Kingdom (using a weighted averaging procedure). The result shows that the so-called "genetic dose" to the population from this cause is less than 1/10 of one per cent of that from natural sources of radiation. The detailed figures were supplied to the Medical Research Council's Committee on Medical Aspects of Nuclear Radiation.

Waste Disposal

125. Besides the occupational health problems, the Authority pay considerable attention to the problems of waste disposal. Part of the waste material has to be stored permanently, but some of it is in the form of very dilute solutions and these can safely be discharged into rivers or the sea, sometimes after preliminary purification. Whenever substantial quantities of radioactive wastes are dispersed into the environment, detailed studies are made of all the possible complications. At Windscale, these studies have lasted many years and have included measurements of the radioactivity in fish, seaweed, sea bed and shore sand. Similar measurements have been made at Dounreay, during experimental discharge of waste, to establish criteria of safety for use when the chemical plant comes into operation. The results of such work are considered by the appropriate Government Departments when they are issuing the statutory authorisations under Section 5 (4) of the Atomic Energy Authority Act, 1954, which permit the Authority to dispose of its waste materials.

126. A great deal of work is being applied to the problems of waste disposal to ensure that members of the general public are fully protected from possible exposure to radioactive materials. The accumulation of over a decade's experience in the British project has resulted in the emergence of a balanced view of radiation protection. As further operating experience is gained and as more fundamental knowledge of radiobiology becomes available, the techniques of design and operation are being revised with the aim of improving the current standard of safety and, at the same time, of allowing the development of nuclear power and its by-products to go forward unimpeded.

CHAPTER VIII

ISOTOPES AND IRRADIATION PROGRAMME

127. Sales of radioactive isotopes by both the Radiochemical Centre and the Isotope Division of A.E.R.E. have grown steadily during the year. The total value of the products sold was about £483,000. All departments and all markets have shared in this increase in sales, which reflects the general trend towards a greater use of radioactive materials in industry, in research, and in medicine. Rather more than half of the total sales was exported. A summary of the various isotope consignments is given in the following table.

Isotope Consignments

(Year ending 31st March, 1956)

	From Harwell	From Amersham
To United Kingdom:		
Hospitals	1,803	6,423
Universities	515	715
Industry	1,294	390
Government Departments	323	271
Atomic Energy Authority Establishments	2,668	297
Others	—	71
U.K. Total	6,603	8,167
To Overseas:		
Commonwealth Countries	235	738
Other Countries	2,725	3,910
Overseas Total	2,960	4,648
GRAND TOTAL	9,563	12,815

These figures represent increases of 8·3 per cent and 28 per cent for Harwell and Amersham respectively.

Technological Irradiation Developments

128. The Authority's programme of reactor operation will result in a plentiful supply of radioactive by-products and the radiation emitted from these fission products has great potential use in industry. This potential is being actively explored by the Technological Irradiation Group of the Isotope Division, working in close collaboration with industry. Their investigations already cover a wide range of chemical, physical and biological applications. As mentioned in Chapter II, arrangements are in hand to move most of the Technological Irradiation Group and other sections of the Isotope Division to Grove Airfield, about nine miles from Harwell. At Harwell, the group will have facilities for using the spent fuel rods from DIDO and PLUTO before they are despatched for chemical processing and it is hoped that an irradiation source of more than a million curies will be achieved.

129. Chemical reactions initiated by radiation have been shown to proceed under a much wider range of conditions than hitherto considered possible. In many cases, the products are increased in value, as, for example, rubbers and plastics which can be treated by radiation to withstand higher temperatures.

130. The biological applications of irradiation in sterilization and mutation are being actively studied. Potatoes and onions have been successfully prevented from sprouting. Seeds of cereals and other crops have been dosed with gamma and neutron radiation to induce mutations. A number of agricultural institutions, including two in Italy, have sent seeds for treatment. While the total sterilization of food is not yet possible because of the failure to avoid changes in flavour, success has been achieved in the study of radiation pasteurization.

131. Work on the sterilization of drugs has shown that antibiotics which are normally destroyed by heat sterilization can be completely freed from bacteriological contamination by simple irradiation. The potency of the drug is not affected since virtually no rise in temperature takes place on irradiation.

Applications to Therapy and Radiography

132. Some 15,000 curies of cobalt 60 have been made and loaded into machines for cancer teletherapy and for industrial irradiation. A dozen British hospitals and several others in Europe are using cobalt for teletherapy. Production of caesium 137 at Windscale is now expected to start in the autumn of 1956, and plans are being made for use of this isotope in sources which are expected to replace the usual 200 kilovolt X-ray set for therapy. More requests are being received for samples which have to have carefully-scheduled irradiation because they are required with a predetermined level of activity. For example, gold grains for therapy are prepared which will have a specified activity at the time of their use in an operation.

133. The use of iridium sources for gamma radiography of welds, castings and pipes has increased. Supplies are sent to Australia, the Middle East and many European countries.

New Applications of Specific Isotopes

134. Many new applications of radioactive isotopes have been studied. The following three examples are given to illustrate the successes achieved.

135. Sewage pollution of beaches has been investigated by the introduction of ammonium phosphate containing radioactive phosphorus into a sewage pit before discharge into the sea off the south coast. The dispersion of the sewage was followed by immersed beta counters and the results compared with those obtained by adding harmless bacteria to the water at the same time as the phosphate and growing cultures from sea water samples. It was shown that a joint application of the two techniques was more satisfactory than more orthodox methods used at present.

136. Methods of using weak radioactive solutions to help detect leaks in water mains and oil pipelines, have also been devised. These have been used successfully in lines of lengths up to 20 miles and it is expected that this can be extended to 100 miles by suitable improvements in technique.

137. A new type of borehole logging has been developed in which a neutron source is lowered into a pipeline at about 1 foot distance from a scintillation counter. The gamma-rays detected by the counter will depend on the absorbing nuclides present in the strata and an analysis of the radiation will yield information on the nature of the strata.

Isotope School

138. There is a continuing demand for training in handling isotopes. During the year 167 students attended the normal four-week course in

the Isotope School and 104 attended special courses. One consequence of the training given in the school to students from industry is an increased use of the industrial advisory service.

CHAPTER IX

THE WEAPONS PROGRAMME

139. Throughout the year the Authority carried out their work for Her Majesty's Government, both as regards the research and development of nuclear and thermonuclear warheads and as regards the production of fissile material.

140. There were no major overseas weapon trials scheduled for the year, but active preparations were in progress for the third and fourth series of United Kingdom weapon tests to be carried out at Montebello and at the new Maralinga range respectively in 1956.

141. The Authority have decided that research into, and development of, nuclear reactors for future military application should be part of the responsibilities of the Weapons Group under the direction of Sir William Penney. This arrangement will not affect the submarine reactor, under development by the Admiralty.

CHAPTER X

THE AUTHORITY'S STAFF

Strength

142. The total number employed by the Authority increased from 19,859 on 1st April, 1955, to 23,973 on 31st March, 1956. Of these, the non-industrial staff rose from 8,302 to 10,795 and industrial employees from 11,557 to 13,178.

143. It will be seen from these figures that an expansion of nearly 21 per cent has been achieved during the year covered by this Report. The actual intake has been even greater, particularly in the non-industrial field: the net changes shown by the figures conceal not only normal wastage but also the abnormal wastage due to the release of seconded Civil Servants who did not wish to remain with the Authority. The acute shortage of scientists and technologists, which was referred to in the Authority's first Annual Report, remains a national problem: the expansion achieved by the Authority during the last year has therefore required a sustained and energetic recruitment campaign. As an indication of the effort involved, over 52,000 applications for non-industrial employment were received during the year; and over 12,000 candidates were interviewed.

Assimilation of Seconded Civil Servants

144. As was explained in the Authority's first Annual Report, offers of employment were issued to the Civil Servants whose work was taken over by the Authority.

145. The majority of offers to non-industrial staff remained open until February, 1956, by which time 88 per cent had been accepted. Three-quarters of the Civil Servants who decided against joining the Authority's staff had been released by 31st March, 1956. Arrangements have been made

with the appropriate Government Departments for the release of the remainder by 31st July, 1956, the date on which their period of secondment from the Civil Service expires. A number of the returning staff have been replaced by Civil Servants who have volunteered for service with the Authority.

146. In the case of the industrial employees seconded from the Department of Atomic Energy or taken over with their work from other Government Departments, 91 per cent accepted offers of employment with the Authority.

Recruitment

147. The intensive recruitment drive mentioned above has been reasonably successful for staff in the middle and lower ranges: but difficulty continues to be experienced, particularly in the engineering field, in filling the more senior posts. There has in general been an encouraging desire to enter the atomic energy field, and therefore a fair supply of candidates for senior posts ; but unfortunately only a small proportion were of the high standard required in this pioneering sphere. The growth of activity by private industry in nuclear power development has led to the loss of a small number of experienced staff to firms embarking on this work.

148. Recruitment of industrial labour, in spite of the difficulties due to full employment, has not been unsatisfactory, but there are still some unfilled vacancies.

Pay and Conditions of Service

149. As a body dependent on public funds, the Authority have a particular obligation to show due regard for economy while at the same time being fair to their staff and having regard to the competition (particularly for scientists and technologists) from industry.

150. In general, the Authority have continued to have regard to pay and conditions in the Civil Service. They have been concerned to provide flexibility in the matter of salaries and so to recognise special merit, experience and qualifications. Particularly in the difficult field of engineers, the Authority have given special attention to grading and remuneration of the higher posts. Nevertheless, the problem of filling the highest posts, in a period of rapid expansion of the Authority's responsibilities, remains.

151. Industrial employees have continued to be paid rates of wages similar to those paid in Government industrial establishments. At the end of the period under review negotiations were proceeding on the National Joint Industrial Council for the introduction of uniform wage rates and conditions of employment in the Authority's establishments.

Superannuation

152. During the year arrangements have been made to facilitate the exchange of staff with other organisations by providing inter-change arrangements with other similar contributory schemes. No arrangements have yet been made for superannuation benefits for industrial employees joining after Vesting Date. The question is under discussion on the National Joint Industrial Council.

Training

153. The Authority are considering what expansion should be made in their training facilities, particularly for scientific and technical staff, in the light of the White Paper on Technical Education (Command 9703).

154. During 1955 bursaries were again awarded to members of the staff for full-time University education. "Sandwich Courses", in which training in a Technical College alternates with periods of practical experience in the Authority's establishments, have been introduced experimentally. The scheme for post-graduate apprenticeship has been developed further and nine graduates were recruited to it in 1955. Meanwhile, the craft and student apprenticeship schemes have been continued and 357 and 69 apprentices respectively were in service with the Authority on 31st March, 1956. In addition, 5 apprentices were selected for full-time degree or diploma courses during the year.

Contributions to Technological education

155. The staff of the Authority have made important contributions to technological education in Universities, Polytechnics and other Technical Colleges by assisting with lecture courses in the nuclear sciences. Specialised lectures have also been given to learned societies, and senior staff played an active part in the work of the professional institutions, for example, through membership of appropriate committees.

Staff and Industrial relations

156. The United Kingdom Atomic Energy Authority Whitley Council for non-industrial staff has continued to operate during the year. Negotiations on pay and conditions of service, and joint studies on training and welfare questions, have proceeded in an atmosphere of mutual respect. Agreement has been reached on arbitration procedure, in accordance with the requirements of the Atomic Energy Authority Act, 1954.

157. The United Kingdom Atomic Energy Authority National Joint Industrial Council was formally established on 5th July, 1955, and regular meetings of the Council have been held. In addition, there have been numerous semi-official meetings at which a variety of subjects has been discussed. Local Joint Industrial Committees have continued to function satisfactorily.

Housing

158. As the Establishments continue to expand, the Authority have had to take further steps to supply suitable living conditions and amenities for their staff. Local Authorities, besides fulfilling their responsibilities for housing the Authority's locally recruited staff, have done their best to help in housing staff recruited from other areas. They have provided 1,100 houses for this latter purpose and hope to provide a further 300. Nevertheless the Authority have themselves had to continue with an extensive building programme during the year. On 1st April, 1955, they owned 2,750 houses. By 31st March, 1956, they owned 3,428 completed houses, while another 952 were under construction or planned.

Hostels

159. The remoteness of most of the Establishments makes it difficult to find suitable lodgings for unmarried staff. The expansion of the Authority's hostels, both in number and size, therefore continues. On 1st April, 1955, the Authority had hostel accommodation for 1,050 staff. During the year they took over a Government hostel at Aldermaston, which was already being used to accommodate Authority staff, and opened a hostel at Dounreay. By 31st March, 1956, the number of hostel places had risen to 1,272.

Schools

160. There has to be close co-operation between the Authority and the Local Education Authorities on the provision of educational facilities for

the children of the Authority's staff. Some of the problems mentioned in last year's report still recur and are being met as they arise.

161. This chapter would not be complete without a tribute to the enthusiasm and devotion to duty of the Authority's staff. The tasks of setting up a new organisation and of undertaking considerable additions to the atomic energy programme have placed heavy burdens of work and of responsibility on employees, both non-industrial and industrial, at all levels. The Authority wish to record their gratitude to their staff who have accepted these burdens efficiently and in a spirit of public service.

CHAPTER XI

RELATIONS WITH INDUSTRY

162. The year under review has witnessed a considerable increase in industrial activity in the atomic energy field. For a number of years, the United Kingdom atomic energy programme was exclusively a Government operation. The establishments were built to designs prepared in the Ministries of Supply and Works and, when built, were operated by Ministry of Supply staff. With the exception of development work carried out under extramural contract, the role of industry was confined to providing the materials, plant and equipment required for the new establishments. While some of these had to comply with unusual and exacting specifications, the majority were the normal stores required by large research and production organisations. The creation of the country's first atomic energy facilities therefore provided little opportunity to industry to acquire practical experience of the techniques of this new field.

163. This remained the situation until little more than a year ago. The growth of interest and activity on the part of industry can be dated from the formulation of the Government's nuclear power programme. It was from the start made clear that the Atomic Energy Authority would not construct nuclear power stations required by the electricity authorities, and a programme of training was instituted for staff from the four industrial teams referred to in the First Annual Report (para. 82). At the same time, interest in atomic power was quickened in a number of other countries, and British industry began to consider the possibility of exporting nuclear power stations or ancillary equipment. All these factors have occasioned a great increase in the independent activity of industrial firms in the atomic energy field during the last twelve or eighteen months.

Dissemination of Information

164. The history of atomic energy development in the United Kingdom brought about a situation in which the great bulk of the scientific and technical knowledge has been concentrated in the public service (first the Ministry of Supply, now the Atomic Energy Authority). It is imperative that this knowledge should be disseminated in order that industry may play its full part in exploiting the commercial applications of atomic energy. The Authority have devoted a great deal of effort to this, regarding it as one of their principal responsibilities at the present time. The several methods by which information is disseminated are described in the following paragraphs.

165. The Reactor School at Harwell has continued throughout the year to give training to staff from industrial firms on the construction and operation of nuclear reactors. The first course open to overseas students

was held in the Autumn of 1955; of the total of 49 students on that course, 21 were from overseas countries. Up to and including the first course in 1956, a total of 199 full-time and 100 part-time students have passed through the Reactor School. New buildings, which will increase the capacity of the School, will be completed by September, 1956, and plans are now being formulated to provide a variety of courses adapted to meet the needs of several types of students. It is hoped that industry will take full advantage of these expanded facilities by allowing sufficient men of high quality to attend the courses.

166. A monthly list of unclassified documents is now issued by the Authority. This includes the titles of reports publicly available and of articles in technical journals. Copies of this list can be obtained free of charge from the Atomic Energy Research Establishment, Harwell. Copies of the unclassified documents are supplied to the following "depository" libraries:—

The Science Museum Library, London.

Sheffield Central Library.

The Central Library, Birmingham.

The Mitchell Library, Glasgow.

The Central Library, Liverpool.

The Central Library, Manchester.

The Central Library, Newcastle.

Documents deposited in these libraries are freely available to the public, and the libraries have agreed to supply photostat copies at their usual rates on request. In addition, some of the documents are on sale through H.M. Stationery Office.

167. The United Kingdom, the U.S.A. and Canada follow the same "classification" procedure. Tripartite Declassification Conferences are held periodically with the object of removing secrecy restrictions from an increasingly wide area of atomic energy information. Following the adoption of the substantial relaxations recommended by the 1954 Conference, a careful review of thousands of reports has been necessary in order to determine whether, according to the new principles, secrecy can be removed in each individual case. This is a considerable task, which is being carried out by the Authority as rapidly as resources of scientific manpower will permit.

Access Agreements

168. Classified information, by definition, cannot be made freely available. It is clear, however, that firms working in the atomic energy field cannot be fully effective unless they have access to all the relevant information. The Authority are therefore prepared to enter into access agreements with individual firms on the following general lines:—

(*a*) The subject-matter to which access is given must be carefully defined, on the basis of a demonstrated "need to know". (The Authority could not enter into agreements giving general access to all the Authority's information, on an undefined basis.)

(*b*) The firm must observe the security precautions specified by the Authority.

(*c*) If the firm wishes to receive technological information of commercial value, the Authority should secure a reasonable return for the public money which has been spent in developing such information.

(*d*) If information provided under the agreement materially contributes to the making of a patentable invention in the atomic energy field, the patent shall belong to the Authority, subject to the grant of a royalty-free licence to the firm.

(*e*) The Authority hold themselves free to give the same information to any other firm or firms.

169. These conditions are intended to ensure that while firms have full access to information which they need, the following points are safeguarded :—

(i) That the Authority should secure some financial return for commercially valuable information or for the use of patents owned by the Authority.

(ii) That firms are not enabled to use the assistance afforded to them by the Authority to build up exclusive rights for themselves.

170. The Authority consider that they should secure a financial return for valuable information and patents, considering that these have been built up at very considerable expense to the taxpayer. They consider also that to allow particular firms at this early stage of development to acquire exclusive rights in particular basic reactor systems, developed largely at public cost and with the assistance of the Authority, would be unfair to industry as a whole. The various basic reactor systems under study are not likely to prove equally advantageous. Moreover, most firms are still in the stage of building up experience and facilities in nuclear technology ; the Authority are not yet able to select firms for particular development projects according to the normal criteria of competitive tender and proved experience. It would not, in the Authority's view, be right that, at the present stage, any particular firm should be given the opportunity, besides gaining useful experience, to acquire also exclusive rights in a basic reactor system which might prove to be of great value in a variety of applications. These rights should at the present stage be publicly owned. When firms have gained practical experience comparable to that which they already possess in other fields of technology, and when basic reactor systems become established, a different pattern of relationships will be appropriate.

171. Access may be by means of receiving classified reports, or by visits to the Authority's establishments, or—more rarely—by the attachment of staff on secondment from firms to the Authority's establishments for defined periods. Although the Authority are obliged to limit the facilities they can provide in this direction, over 100 scientists and engineers from British firms were attached to the Authority's establishments at the end of the financial year, under attachment agreements. These agreements have proved to be advantageous not only to the firms but also to the Authority, as attached staff have worked as members of the appropriate research teams and have in many cases made substantial contributions to the work of the Authority.

New Industrial Projects

172. In February, 1956, Associated Electrical Industries Ltd. announced their intention to construct a "swimming pool" research reactor at their Research Laboratory at Aldermaston Court. This will be the first privately owned reactor to be constructed in the United Kingdom, and illustrates the growth of industrial participation in the atomic energy field. The Company's siting and lay-out proposals are being examined by the Authority from the safety aspect. Enriched fuel elements for the reactor will be provided by the Authority on loan terms. It is understood that in addition to using the reactor for its own long-term research in physics and engineering and for the training of its own staff, the Company intend to make it available to

universities for graduate and post-graduate training in nuclear science and technology. The reactor design is unclassified.

173. Besides the groups of firms developing the Calder Hall type reactor, two new major groups have entered the nuclear field during the year. Vickers Ltd., Rolls Royce Ltd. and Foster Wheeler Ltd. have formed a new company, Vickers Nuclear Engineering Ltd., and are giving consideration to the application of nuclear energy marine propulsion. The Hawker-Siddeley Nuclear Power Co. Ltd., have taken as their initial study in the nuclear field, liquid metal fuelled reactor systems covering a wide range of applications.

174. The British Shipbuilding Research Association, by agreement with the Authority, have a team at Harwell studying the feasibility of reactor systems for marine propulsion.

Exports

175. The export of nuclear reactors, whether for research or for power production, will be the responsibility of industry and not of the Authority. It will, however, fall to the Authority to provide the necessary fuel elements. The Authority expect to be able to provide natural uranium fuel elements to match whatever volume of export business may be secured in the foreseeable future. Enriched fuel is in short supply, but part of the annual output of the Capenhurst diffusion plant has been set aside to provide fuel elements for export orders which may be placed with British industry for reactors requiring enriched fuel.

176. It is hardly to be expected that exports of nuclear reactors will reach a large volume over the next few years. There is already some demand from overseas countries for research reactors, but not of such magnitude as to affect significantly the total value of the engineering industry's annual exports. As to power reactors, it will be at least four or five years before electricity will be produced from nuclear energy in any country on a strictly commercial basis. The first nuclear reactors to be built for the electricity authorities in this country may be the first in the world to comply with this description. It is reasonable to expect that orders from overseas will follow, rather than precede, the achievement of nuclear power on a competitive basis in this country. The heavy electrical plant manufacturers are not, however, neglecting any opportunity to develop interest in foreign markets and the Authority, in conjunction with the Board of Trade, are in touch with the manufacturers on this subject.

Patents Policy

177. In the First Annual Report reference was made to the policy adopted by the Authority of granting non-exclusive licences to suitable United Kingdom recipients. Up to the present time 22 licences have been granted to United Kingdom firms to use Authority-owned inventions. In addition, three licences have been granted to United States firms, one licence to a firm in West Germany, and one licence to a firm in France. These 27 licences cover such varied fields as packings for exchange columns, thickness gauges, insulators, cold cathode valve circuits, timing devices, scintillation counters, electromagnetic pumps, trigger circuits, potentiometric recorders, and radioactive recorders. A considerable number of inventions having such general applications in industry are now available for exploitation. Information as to these inventions, and as to the terms on which the Authority are prepared to grant patent licences, may be obtained on application to the Patents Exploitation Officer, Patents Branch, United Kingdom Atomic Energy Authority, Bedford Chambers, Covent Garden, London, W.C.2.

CHAPTER XII

INTERNATIONAL RELATIONS

Geneva Conference

178. The steps taken during the past year to release from security restrictions virtually the whole of the basic information needed in a research and development programme for the peaceful applications of atomic energy have opened up a wide range of opportunities for the free flow of information between scientists of all countries. This flow of information has stimulated a remarkable increase in interest in nuclear energy in many countries. This was exemplified in the International Conference on the Peaceful Uses of Atomic Energy which took place in Geneva from 8th to 20th August, 1955. One of the largest scientific gatherings ever organised, the Conference was attended by 1,400 delegates and observers from 73 countries. More than a thousand papers were prepared for the Conference, of which 450 were read. The official British delegates were Sir John Cockcroft and Sir Christopher Hinton, Members of the Authority; Dr. J. F. Loutit, Medical Research Council and Agricultural Research Council; Sir George Thomson, Royal Society, representing Universities; and Dr. Willis Jackson, Metropolitan Vickers, representing British industry. The 123 advisers to the delegation included representatives of the Atomic Energy Authority Research and Industrial Groups, the Chemical Research Laboratory, the Medical and Agricultural Research Councils, the Department of Scientific and Industrial Research, the Ministry of Defence, the Ministry of Fuel and Power, the Institution of Civil Engineers, British Universities and a number of industrial concerns. The United Kingdom submitted 80 papers, of which 52 were read. In the words of Sir John Cockcroft ("Nature", 10th September, 1955), "The Conference has been more successful than we had dared to hope from such a large gathering. It has brought together East and West after a long period of separation in the physical sciences. It has been a meeting ground for innumerable friends from all parts of the world. It has enabled us to discuss how best we can help other countries, and has done a great deal to re-establish the normal pattern of communication in the scientific world."

179. Two exhibitions were presented concurrently with the Conference. The exhibition in the Palais des Nations was purely scientific, intended principally for members of the delegations. The second exhibition, in the Palais des Expositions, was designed for the general public as well as for delegates. The United Kingdom exhibits, which received great commendation, included seven models of nuclear reactors, as well as many other aspects of the British nuclear energy programme. The main burden of presentation was carried by the Authority, but valuable contributions were made by British industry.

180. In addition, a film showing the progress of construction at Calder Hall was exhibited at Geneva and aroused great interest: this film has since been in great demand both at home and abroad.

Overseas Commitments

181. Quickened international interest and activity have been responsible for a marked increase in the number of requests for information and for visits by overseas scientists to the Authority's establishments, and in the number of invitations to the Authority's scientists to visit other countries. This imposes a considerable load on the Authority's resources.

182. Similarly, the progress of co-operation under existing arrangements with the projects of Commonwealth and other countries, the making of new

formal and informal bilateral arrangements for co-operation, and the acceptance of further commitments towards international and regional plans and projects have during the year added greatly to the Authority's work. The Authority are faced with no easy task in accepting these overseas commitments, in addition to fulfilling their defence responsibilities and at the same time providing the amount and quality of effort demanded by the United Kingdom nuclear power programme.

183. Some limit to the number of overseas commitments which the Authority can undertake is therefore imposed by the amount of effort available. Further limits, particularly on visits to certain of the Authority's establishments and to some parts of all their establishments, have to be imposed because the defence work carried out by the Authority is not wholly separable from their civil work. This latter difficulty will to some extent be eased when the planned expansion of the Authority's training facilities for overseas students has been completed.

184. Subject only to these unavoidable limits the Authority have continued to co-operate with other countries under the arrangements listed in last year's Report, and a number of new bilateral arrangements for co-operation have been made, notably with the United States, India, Belgium, and the Netherlands. Agreements negotiated directly by the Authority usually contain provisions of a commercial or quasi-commercial character, and their texts therefore remain confidential. One of the principal aims of these arrangements for co-operation is to achieve some measure of co-ordination of scientific effort in order to ensure a genuinely reciprocal exchange of information of value to both parties.

185. The individual needs of some countries for materials, information of commercial value, or other services which the Authority are in a position to provide can often be met without formality on a straightforward commercial basis, and the Authority have during the year made a number of arrangements of this kind.

186. It has become increasingly clear that the key to the enjoyment of the fruits of atomic energy is the possession of a nucleus of adequately trained staff. The initial training of such staff is one of the principal ways in which countries with advanced atomic energy projects can assist others. The Authority's Isotope School at Harwell was fully international in character from the outset, and during the past year the Harwell Reactor School began to run courses open to students from all over the world. Reference has been made above to the steps which are being taken to expand the Authority's training facilities available to students from overseas.

The Commonwealth Countries

187. Co-operation with the projects of the Commonwealth countries grew greatly during the past year. Many discussions and exchanges took place between the Authority and the various Commonwealth atomic energy organisations.

Canada

Close contact was maintained with the Canadian project and the fourth annual Canadian-United Kingdom Technical Conference was held at Chalk River in October, 1955. The main fields of collaboration were the designs of light and heavy water reactors and homogeneous aqueous reactors ; and the fabrication, irradiation behaviour and subsequent processing of fuel elements. The Authority continued to use the facilities afforded in the NRX reactor at Chalk River for the investigation of some of their own technical problems.

Australia

Good progress was made towards the provision of the DIDO-type research reactor and of laboratory facilities needed for the Australian research and development programme. The Australian Commission's Chief Scientist was in residence at Harwell during the year to supervise the training of members of the Commission's scientific staff. The training of some of them had neared its completion by the end of the year. Arrangements are now being made for the Authority to supply a number of additional materials required by the Australian programme. Visits have also been paid to the Authority by scientists and others from several of the States.

India

The discussions referred to in the previous year's report were completed towards the end of 1955 and an agreement was reached between the Authority and the Indian Department of Atomic Energy providing for close co-operation and mutual assistance in the promotion and development of the peaceful applications of atomic energy. The agreement includes provision for the exchange of information and visits, for the supply by the Authority of fuel elements for a swimming pool type of research reactor at Bombay, and for assistance by the Authority in the design and construction of a high flux research reactor to be built at some later date.

Pakistan

Discussions were held with the head of the Pakistani atomic energy project, who also visited some of the Authority's establishments. It is expected that arrangements will shortly be made for a number of Pakistani students to attend the Authority's training courses. Pakistan will also be able to take advantage of the training facilities to be provided under Bagdad Pact arrangements.

South Africa

A fully representative mission visited the Authority's establishments in the summer of 1955 and discussed with the Authority the broad lines which an atomic energy development programme might follow when it became advantageous for South Africa to embark upon one, and the various ways in which assistance might be given by the Authority.

Other Countries

188. The Authority have continued to extend both formal and informal contacts with atomic energy organisations in other countries. A number of bodies in other countries charged with the task of setting up atomic energy projects for the first time or of drafting legislation and regulations have approached the Authority for information and advice.

United States

The United States Atomic Energy Act of 1954 permits the United States Government to enter into bilateral agreements for the exchange of information between the Atomic Energy Commission and similar authorities in other countries, and negotiations for the extended co-operation with the United Kingdom which the new Act permitted were completed in June, 1955, by the signing of an agreement* between Her Majesty's Government and the United States Government for co-operation on the civil uses of atomic energy. The agreement provides for the exchange between the Authority and the Commission of information on a wide range of subjects including

* Published by H.M.S.O. as Cmd. 9560 with slight amendment in Cmd. 9677.

the use of nuclear energy for the generation of electrical power. It safeguards the commercial interests of those industrial firms which are co-operating with the authorities in their respective countries in the development of nuclear power stations, and it makes possible direct exchanges between industrial firms in the two countries. Immediate advantage has been taken of the new opportunities for fruitful co-operation which this agreement has offered. Many useful visits and a great deal of valuable information have already been exchanged. Further visits and discussions are in early prospect. The resumption of co-operation on this scale with the highly-advanced United States project will be a continuing stimulus and has been warmly welcomed by the Authority's staff, many of whom worked as war-time colleagues with the staff now in the service of the Commission. Also in June, 1955, the two Governments concluded an agreement* for co-operation regarding atomic information for mutual defence purposes. Under this agreement, information will be made available which the supplying Government deems necessary to:

(*a*) the development of defence plans;

(*b*) the training of personnel in the employment of and defence against atomic weapons; and

(*c*) the evaluation of the capabilities of potential enemies in the employment of atomic weapons.

France

The Authority and the French Commissariat à l'Energie Atomique have continued to co-operate under the arrangements concluded early in 1955. Visits, information and materials have been exchanged. Arrangements have also been made for the supply of additional materials.

Israel

The Authority have made an agreement with the French Commissariat and with the Israeli Atomic Energy Commission associating the United Kingdom project with previously existing arrangements between France and Israel for co-operation in research and development work on methods of heavy water production.

Denmark

In the summer of 1955 the Authority signed an agreement with the Danish Atomic Energy Commission for co-operation in the peaceful applications of atomic energy. It provides for assistance in the design and supply of a research reactor and of fuel elements for it, and for the Danish research and development programme to be drawn up in such a way as to avoid duplication of effort and to ensure an exchange of information of mutual benefit. Visits and discussions to implement the agreement have taken place at frequent intervals and are continuing.

Belgium

In November, 1955, Her Majesty's Government signed an agreement† with the Belgian Government for co-operation in the peaceful uses of atomic energy. The Agreement follows closely an agreement concluded between the Belgian Government and the United States Atomic Energy Commission earlier in the same year and may be regarded as a development of the special relationship between Belgium, the United States of America and the United Kingdom, which has existed ever since the Second World War when arrangements were first made for the supply of uranium ore from the Belgian

* Published by H.M.S.O. as Cmd. 9555.
† Published by H.M.S.O. as Cmd. 9632.

Congo for the Allied war effort. The agreement, which is for a period of 10 years, provides *inter alia* for the exchange of information on the general progress and economics of power reactor programmes and of technological information required for the construction of specific reactors in Belgian territory. It also provides for the supply of source and research materials. Discussions have been held between the Authority and the Belgian authorities on ways and means of implementing the agreement in detail, and arrangements are being made for two Belgian engineers to work with and participate in the construction of the second of the first two reactors at Calder Hall.

The Netherlands

In March, 1956, the Authority signed an agreement with the Reactor Centrum Nederland for co-operation in the design and development of a particular type of experimental reactor and in the supply of materials. The agreement also provides for the transmission of information on gas-cooled graphite-moderated reactor systems to enable an assessment to be made by the Dutch authorities of their possibilities as economic sources of electrical power.

Spain

The President and Vice-President of the Spanish Atomic Energy Junta visited a number of the Authority's establishments and had preliminary discussions with the Authority on the ways in which the Authority and the Junta might usefully co-operate. These exchanges of view are continuing.

Other Countries

Discussions with a view to the conclusion of collaboration agreements have been held with representatives of atomic energy organisations in Norway, Sweden and Western Germany. Visits have also been paid to the Authority by the Prime Minister of Schleswig-Holstein, by representatives of the Federal German Inter-Parliamentary Committee on Natural Resources, and by a number of representatives of German industry. The municipality of Karlsruhe, which is to be the site of one of the German research reactors, sent a mission to visit Harwell and to discuss some of the problems connected with the siting of reactors. Fact-finding missions from Austria and Japan have visited the Authority. Interest has been shewn in the Authority's activities by many other countries, including the Argentine, Brazil, Jugoslavia and Portugal. Services have been performed on a commercial basis by the Authority for a number of countries, including Italy and Switzerland.

United Nations

International Atomic Energy Agency

189. Considerable progress has been made towards the establishment of the International Atomic Energy Agency which was first proposed in December, 1953, by President Eisenhower and is sponsored by the United Nations. A draft statute was circulated on 21st August, 1955, to all members of the United Nations and Specialised Agencies, who were asked to send their written comments to the United States Government, acting on behalf of the countries sponsoring the proposed Agency. Comments on the Agency were also made during the Tenth Session of the General Assembly. The Assembly agreed that twelve countries, the United Kingdom, the United States of America, Canada, France, Portugal, Belgium, Australia, South Africa, the U.S.S.R., India, Brazil and Czechoslovakia, should appoint representatives to consider the draft of 21st August, 1955, in the light of all comments received. This Negotiating Group met in Washington from 27th February to 18th April, 1956, and adopted a revised draft of the statute, which will

be submitted to a Preliminary Conference of interested members of the United Nations and Specialised Agencies to be held during the latter part of September in New York.

Radiation Hazards

190. The United Nations General Assembly resolved in 1955 to initiate world-wide investigation into the hazards arising from radioactivity and into methods of protection. A scientific committee was set up to give effect to that resolution and has begun its work. The Authority have given technical advice and have provided technical representatives both for the discussions and conferences held in connection with the proposed Agency and for the special committee on Radiation Hazards.

Bagdad Pact

191. Her Majesty's Government have offered assistance to the Bagdad Pact countries (Iraq, Pakistan, Iran and Turkey) in the setting up of a Training Centre in Bagdad for radioisotope techniques. A meeting of experts in atomic energy from each member country was held in Baghdad early in 1956 to discuss ways and means of establishing such a Centre. The experts drew up a series of practical recommendations to take effect in stages and these were endorsed by the Economic Committee and the Council of the Bagdad Pact in Tehran in April, 1956. Help given by the United Kingdom in the first instance will include the gift of equipment, and the secondment of Authority staff to supervise, to teach and to service the development of the Centre until local staff have been sufficiently trained to take over responsibility. It will also include the training at Harwell of instructors for the Centre from the Pact countries.

Colombo Plan

192. Her Majesty's Government have expressed their willingness to participate in any measures which may be taken to facilitate the training of students from the Colombo Plan countries (India, Pakistan, Ceylon, Burma, Thailand, South Vietnam, Laos, Cambodia, the Philippines, Indonesia, and Japan) in atomic energy techniques. Assistance may include the offer of places at the Isotope and Reactor Schools at Harwell.

Organisation for European Economic Co-operation

193. Anxious to be in a position to exploit the industrial uses of nuclear energy as soon as might be practicable in their individual circumstances, and recognising that it would be impossible for many countries to establish and support on a purely national basis a research and development programme on the scale necessary to ensure this, the O.E.E.C. countries have during the past year been considering a number of proposals for closer European co-operation in the atomic energy field.

194. A small O.E.E.C. working party spent several months in 1955 in a searching investigation of the practical possibilities for effective European co-operation in this field. This party visited and sought information from all the existing atomic energy organisations, including the U.K. Authority, and published its report at the end of the year. At their meeting in February, 1956, the O.E.E.C. Council of Ministers set up a special committee to consider and put forward specific proposals for implementing the main recommendations of the working party's report. The topics to be studied by this committee include arrangements for technical training, the setting up of joint projects, security measures, standardisation of equipment and components, the liberalisation of trade in nuclear materials and equipment, and the harmonisation of atomic energy legislation and regulations.

195. Her Majesty's Government have stated their intention to co-operate within O.E.E.C. in the atomic energy field as fully as possible, and U.K. representatives are, with technical help from the Authority, playing an active part in the work of the special committee. But because the U.K. project possesses a full range of facilities, it is unlikely that the U.K. will itself need to participate in joint industrial projects. Such surplus capacity as the U.K. may have for fuel element fabrication and chemical processing will at all times be made available to such of the other O.E.E.C. countries as may wish to avail themselves of it.

" Euratom "

196. The " Messina " group of countries (Belgium, France, Western Germany, Italy, Luxembourg and the Netherlands) have been considering the possibility of establishing an organisation which would operate through pooled resources. These countries have nevertheless participated in the O.E.E.C. discussions described above.

European Council for Nuclear Research (C.E.R.N.)

197. Sir John Cockcroft and staff of the Authority have continued their participation in the meetings of C.E.R.N. and its committees and in the design and construction of the equipment for the international laboratory under construction at Geneva.

European Atomic Energy Society

198. The staff of the Authority have continued to play an active part in the work of the Council and Working Group of the Society and particularly in the technical conferences organized by the Working Group. In December, 1955, the Society paid a visit to Calder Hall.

APPENDIX I

MEMBERSHIP OF ATOMIC ENERGY AUTHORITY

Chairman

Sir Edwin Plowden, K.C.B., K.B.E.

Members

Sir John Cockcroft, K.C.B., C.B.E., F.R.S.
(Member for Scientific Research)

Sir Christopher Hinton, F.R.S.
(Member for Engineering and Production)

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)

Part-time Members

The Rt. Hon. Viscount Cherwell, C.H., F.R.S.

Sir Luke Fawcett, O.B.E.

Sir Ivan Stedeford, K.B.E.

Sir Rowland Smith

Mr. C. F. Kearton, O.B.E.

Secretary

Mr. D. E. H. Peirson

APPENDIX II

ATOMIC ENERGY AUTHORITY ESTABLISHMENTS SENIOR STAFF AS AT 31st MARCH, 1956

LONDON

E. J. S. Clarke, T.D.	Principal Officer in Charge Metals
C. J. Highton	Principal Legal and Lands Officer
W. F. Jenkins, C.B., C.B.E. ...	Principal Finance Officer
A. W. Griffiths	Principal Patents Officer
J. C. Walker	Officer in Charge Collaboration
Dr. A. C. W. V. Clarke	Establishments Officer
J. Lloyd, O.B.E.	Chief Labour Officer
E. Harris	Director of Accounts
R. A. Browning	Director of Contracts
J. Parkin, O.B.E., M.C.	Officer in Charge General Administration
T. B. LeCren	Officer in Charge Finance
E. H. Underwood, O.B.E. ...	Director of Public Relations
J. A. Jukes	Economic Adviser

INDUSTRIAL GROUP

(*Headquarters, Risley*)

W. L. Owen, C.B.E.	Director of Engineering and Deputy to Managing Director
K. B. Ross, O.B.E.	Director of Operations
L. Rotherham	Director of Research and Development

INDUSTRIAL GROUP (*continued*)

J. C. C. Stewart	Director of Technical Policy
D. A. Shirlaw, C.B.E.	Director of Administration
D. R. Newman	Director of Accounts and Stores
D. D. W. Cole, C.B.E.	Deputy Director (Operations)
P. T. Fletcher	Deputy Director (Engineering Services)
J. B. W. Cunningham	Deputy Director (Civil Reactors)
P. V. Danckwerts	Deputy Director (Research and Development)
T. L. Viney	Deputy Director (Works and Buildings)
H. Cartwright	Assistant Director (Experimental Reactors)
W. Davies, O.B.E.	Assistant Director (Works)
H. V. Disney, C.B.E.	Assistant Director (Diffusion Plants)
R. V. Moore, G.C.	Assistant Director (Civil Reactors)
C. J. Turner, C.B.E.	Assistant Director (Chemical Plants)
E. L. Ashley	Chief Engineer (Construction)
H. F. Bannister, O.B.E.	Chief Engineer (Supply)
J. W. Kendall	Chief Engineer (Fast Reactor Design)
G. R. Howells, M.B.E.	Adviser (Chemical Engineering)
Dr. A. S. McLean	Group Medical Officer

Production Factories

Springfields	Works General Manager	Dr. H. Rogan
Northern Group Factories ...	Works General Manager	H. G. Davey, O.B.E.
Capenhurst	Works General Manager	S. F. Hines, O.B.E.

Experimental Stations

Dounreay	Works General Manager	S. W. Joslin, C.B., C.B.E.
Calder Hall	Works Manager ...	K. L. Stretch

Research and Development Laboratories

Springfields	Head of Laboratory ...	J. Harper
Windscale	Head of Laboratory ...	D. R. Mackey
Capenhurst	Head of Laboratory ...	—
Culcheth	Head of Laboratory ...	Dr. A. B. McIntosh
Dounreay	Head of Laboratory ...	C. R. Tottle

RESEARCH GROUP

Atomic Energy Research Establishment, Harwell

Dr. B. F. J. Schonland, C.B.E., F.R.S. ...	Deputy Director
G. Raby, C.B.E.	Deputy Director (Engineering)
Dr. H. M. Finniston	Chief Metallurgist
Dr. W. Fry	Chief Physicist
Dr. R. Spence, C.B.	Chief Chemist
D. R. Willson, M.B.E.	Secretary
Dr. K. Williams	Group Medical Officer

Radiochemical Centre, Amersham

Dr. W. P. Grove	General Manager

WEAPONS GROUP

Atomic Weapons Research Establishment, Aldermaston

W. R. J. Cook, C.B.	Deputy Director
C. A. Adams	Chief of Research
J. E. Adamson	Principal Administration Officer

Admiral P. W. B. Brooking, C.B., D.S.O., R.N. (Ret'd)	Assistant Deputy Director
J. R. V. Dolphin, C.B.E.	Chief Engineer
Dr. J. V. Lynch	Group Medical Officer
Fort Halstead (Research and Development)	
Dr. A. H. Davis, C.B.E.	Deputy Director
Woolwich Common (Electronics Engineering)	
C. Smith	Manager
Proof Range	
E. H. Mott, O.B.E.	Senior Superintendent

APPENDIX III

Balance Sheet of the United Kingdom Atomic Energy Authority as at 31st March, 1955

FOREWORD

1. The United Kingdom Atomic Energy Authority came into being on 19 July 1954 under the provisions of the Atomic Energy Authority Act, 1954, and, by the Atomic Energy Authority (Appointed Day) Order, 1954, the Authority assumed control of the existing Atomic Energy undertaking on 1 August 1954.

2. The first Balance Sheet of the Authority, as at 31 March 1955, is presented in the form prescribed by Treasury directive under the provisions of Section 4 (3) of the Atomic Energy Authority Act, 1954.

The Operating Account for the period from 1 August 1954 to 31 March 1955 is withheld from publication in the interests of national security.

3. Although the Authority have receipts from sales of goods and services, substantial funds are needed to finance large programmes of capital projects and research. These funds are provided by the Office of the Lord President (Atomic Energy) out of moneys voted by Parliament.

4. A commercial system of accounting had been in operation for some years at some of the establishments taken over by the Authority and steps were taken to introduce a similar method of accounting at other establishments whose accounts had previously been aligned primarily to Vote accounting.

5. A first essential to the Authority's accounting was the preparation of a Statement of Assets and Liabilities taken over by the Authority at 1 August 1954 under Section 2 (1) of the Atomic Energy Authority Act, 1954. Where commercial accounting already existed, the recorded written-down values of fixed assets were adopted. Where information as to written-down values was not available, it was decided to proceed on the basis of an " as found " inventory, *viz.*:—

Land—at cost, due allowance being made for sales.

Buildings—at cost, or estimated cost at the time of construction, less depreciation.

Plant, Equipment, &c.—at cost or estimated cost at the time of acquisition, less depreciation.

The records previously maintained were, with some exceptions, sufficient to evaluate stocks and work in progress, and the ascertainment of debtors and creditors presented no problem.

6. The Balance Sheet at 31 March 1955, as prescribed by the Treasury, is in conventional form and sets out the assets and liabilities of the Authority at that date. The Capital Account shows the net value of assets less liabilities taken over at 1 August 1954 and the additions thereto during the period, from which is deducted the net cost of operations on revenue account for the period from 1 August 1954 to 31 March 1955.

7. The Authority have adopted normal commercial accounting principles, including the division between capital and revenue, so far as is practicable in the unique circumstances. The transactions on revenue account, and the conventions adopted in relation thereto, can be summarised as follows:—

(*a*) The Industrial Group operates factories and the whole cost of operation is regarded as recoverable in the price of its products. Expenditure on research and design in aid of future projects is carried forward for later amortisation and recovery.

(*b*) The whole of the cost of the operation of the Research Group less the proceeds of sales of radioactive substances, electronic equipment and other income, is regarded as the cost of fundamental research in the atomic energy field to be borne by the Exchequer.

(*c*) The Weapons Group undertakes the production of components for weapons and research work in connection with weapons, both under contract from Ministry of Supply. It also undertakes other advanced research. The cost of the operation of this Group, less the amounts chargeable to Ministry of Supply for production and research, and other income, is regarded as a charge to be borne by the Exchequer.

8. Provision is made in the accounts for depreciation and special depreciation of buildings, plant, &c., on a straight-line basis on original cost or estimated cost, the main rates used being:—

	Per cent.
Permanent buildings, including ancillary services and houses ...	$2\frac{1}{2}$
Temporary buildings, including ancillary services and houses	5
Buildings and services—process areas	10
Gaseous diffusion plant and equipment	5
Reactor and chemical process plant and equipment	10
Other plant and equipment	$7\frac{1}{2}$
Transport vehicles	20
Office machinery	$7\frac{1}{2}$
Furniture and fittings	5
Furniture and fittings, hostels	10

9. The accounts include a charge for interest on capital which has been calculated, at rates prescribed by the Treasury for Government trading accounts, on the average capital employed during the period. The rates were varied during the period and resulted in weighted averages of 3·78 per cent. for fixed capital and 3·25 per cent. for working capital.

10.—(*a*) The Authority have introduced a contributory Superannuation Scheme for non-industrial employees, the employee contributing 6 per cent. and the employer 8 per cent. of salaries. Non-industrial staff who, at 31 March 1955, remained on secondment pending their acceptance or rejection of the Authority's offer of employment retained their benefits under the Superannuation Acts. Industrial workers who have accepted the Authority's offer of employment retain their superannuation rights under a special arrangement and workers who remain on secondment retain their rights under the Superannuation Acts.

Pending clarification of the position of individual employees, the Authority's liability at 31 March 1955 has been estimated and provision made therefor in the accounts.

(*b*) The Provision for Superannuation in the Balance Sheet comprises the estimated liability referred to in (*a*) above and the deductions made from employees who had elected to join the Authority before 31 March 1955.

21 February 1956.

BALANCE SHEET AS

	£	£
I. CAPITAL ACCOUNT		
Net value of assets less liabilities taken over on 1 August 1954, being CAPITAL ACCOUNT at that date	154,659,335	
Add—		
Net advances from Lord President's Office (Atomic Energy)	25,789,462	
Net assets taken over from Ministry of Works	54,648	
Interest on Capital for the period	3,999,988	
	184,503,433	
Deduct—		
Net Cost of Operations for period from 1 August 1954 to 31 March 1955	10,385,129	
Capital Account at 31 March 1955		174,118,304
II. RESERVE FOR LOSSES (in lieu of insurance)		
Amount charged to operating costs for the period ended 31 March 1955		700,000
III. CURRENT LIABILITIES		
Trade Creditors and Accrued Charges	2,770,109	
Provision for Superannuation	521,114	
		3,291,223
		£178,109,527

NOTES: 1. Capital commitments at 31 March 1955 in respect of New Works and Housing amounted to £58 million.

2. The Authority do not insure and carry their own risks for fire, explosion, common law, third party and similar accidents. In the period 1 August 1954 to 31 March 1955 claims as settled were charged to operating costs. A reserve for losses in lieu of insurance has been created.

3. Provision for Superannuation—see para. 10 of the Foreword to the Accounts.

ENERGY AUTHORITY

AT 31 MARCH 1955

	As valued at 1 August 1954 plus additions at cost less disposals	Depreciation	
	£	£	£
I. FIXED ASSETS, at cost or estimated cost less depreciation:			
Freehold Land	309,698	—	309,698
Buildings, Housing and Hostels	42,721,148	1,381,812	41,339,336
Plant and Machinery, Ancillary Installations, Motor Vehicles, Loose Apparatus, Tools and Equipment	54,331,506	2,428,316	51,903,190
Furniture, Fittings and Office Machinery...	1,335,184	34,315	1,300,869
Capital Assistance—assets with assisted contractors	638,845	61,756	577,089
	£99,336,381	3,906,199	95,430,182
Assets in course of construction			14,587,536
			110,017,718
II. SPECIAL DEVELOPMENT AND DEFERRED REVENUE EXPENDITURE CARRIED FORWARD:			
Initial production expenses and expenditure on commissioning new plants		1,326,207	
Research and Development expenditure in aid of design		1,170,990	2,497,197
III. LOANS, ADVANCES AND INVESTMENTS, AT COST:			
Loans and advances for the production of uranium, including accrued interest		22,405,761	
Shares in Geothermal Development Ltd.		10,000	
Investment—3% Electricity Stock 1968–73 deposited with the Supreme Court under Sec. 35 (4) of the Road Traffic Act 1930 (Market value £14,337)		14,871	22,430,632
IV. CURRENT ASSETS:			
Work in progress		29,729,516	
Stocks of raw materials and stores		11,408,614	
Debtors and Payments in Advance		1,239,727	
Balances with Paymaster General, with Bankers and in hand		786,123	43,163,980
			£178,109,527

E. N. Plowden, Chairman.
D. Perrott, Member.

APPENDIX IV

CONFERENCES HELD AT THE ATOMIC ENERGY RESEARCH ESTABLISHMENT FROM 1st APRIL, 1955 to 31st MARCH, 1956

Conference on Particle Acceleration, 13th and 14th May, 1955.

Conference on Electronic Instruments for Technical College Teachers, 17th and 18th June, 1955.

Conference on Soil-Plant-Animal Relationships of Fission Products, 20th–23rd July, 1955.

Health Physics Conference, 29th July–2nd August, 1955.

International Conference on Radiobiology, 14th–17th August, 1955.

Informal Conference on Genetical Research, 19th–20th September, 1955.

Conference on Electro-Magnetically Enriched Isotopes, 13th–16th September, 1955.

Neutronics Symposium, 25th–28th October, 1955.

Heavy Elements Symposium, 8th December, 1955.

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