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February 27, 1961

AEC 755/36

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ATOMIC ENERGY COMMISSION

REPORT BY DR. LOUIS B. WERNER, AEC SCIENTIFIC REPRESENTATIVE, LONDON

Note by the Secretary

The General Manager has requested that the attached memorandum and enclosures from the Director of International Affairs be circulated for the information of the Commission.

W. B. McCool

Secretary

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UNITED STATES GOVERNMENT

Memorandum

TO : A. R. Luedecke, General Manager
THRU: John A. Hall, AGMIA

DATE: FEB 13 1961

FROM : A. A. Wells, Director
Division of International Affairs

SUBJECT: REPORT PREPARED BY DR. LOUIS B. WERNER AT CONCLUSION OF HIS TOUR OF DUTY AS AEC SCIENTIFIC REPRESENTATIVE, LONDON

Attached is a report prepared by Dr. Louis B. Werner at the conclusion of his tour of duty as AEC Scientific Representative in London. Dr. Werner served in the London post from August 1958 until January 1961. Also included is a copy of a Foreign Service Despatch from the Charge d'Affaires, American Embassy, London, to the Department of State. The despatch commends Dr. Werner warmly for his effective performance in London and expresses the views of Sir Roger Makins, Chairman, UKAEA, that relations between the U.S. and U.K. in the atomic energy field are closer than at any time since the war. The despatch states that Dr. Werner made a significant contribution to the smooth working of the U.S./U.K. relationship and thereby to the overall effectiveness of the Embassy.

Dr. Werner's report is in two parts. Part one summarizes the British nuclear energy program. Highlights of this part are:

1. In June 1960, the U.K. Minister of Power announced that the national nuclear power program goals had been reduced to a possible 5000 megawatts of installed nuclear capacity by 1968.

2. The objectives of the U.K. reactor development program are first, to insure successful construction and operation of the power stations now under construction and second, to develop advanced reactors that will provide progressively cheaper power.

3. The Central Electricity Generating Board has been reluctant to order the best developed advanced concepts, the advanced gas-cooled reactor (AGR), on the basis that even more economically promising concepts are expected within a few years. Thus, too short a time exists for full exploitation of AGR, which itself is not yet advanced to the operating prototype stage. The AEA has vigorously pushed the AGR as the most promising candidate for the next generation of

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reactors, and there is no doubt that the CEGB will order a number of AGR stations. For later generations of civil power stations, development of the fast reactor, the high temperature gas-cooled reactor, and to a lesser extent the steam generating heavy water reactor, has been undertaken.

4. The construction of a nuclear propelled merchant ship has received a great deal of attention and study but as of January 1961, no decision by the government had been reached.

5. Faced with the prospect of lean years in the power business, four of the five consortia, which were originally formed to explore commercial applications of power reactors, merged to conserve resources.

In part two of his report Dr. Werner comments on U.S./U.K. cooperation in the civil uses of atomic energy and describes the cooperative programs between the AEC and AEA in advanced gas-cooled reactors, high temperature gas-cooled reactors, the Libby/Cockcroft exchange, nuclear physics chemistry, biological sciences, chemical processing, and feed materials. He also comments on the recently proposed areas of exchange on production plants, diffusion plants and gas centrifuge processes.

Attachments:

1. Dr. Werner's Report
2. Foreign Service Despatch 1354

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BRITISH NUCLEAR PROGRESS AND
US/UK COOPERATION ON THE CIVIL USES OF
ATOMIC ENERGY

Terminal report prepared by:

Louis B. Werner
AEC Scientific Representative
London, England

January 18, 1961

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INTRODUCTION

Possibly none of the international cooperative activities of the Commission has produced a more extensive exchange of scientific information, ideas and technical reports, or has stimulated closer personal working relationships between scientists of two countries than that arising out of collaboration with the UK. An opportunity to observe and participate in this collaboration program for a period of over two years is both a challenging and rewarding experience.

The occasion of the (nearly) biannual replacement of the AEC Scientific Representative in London offers a suitable opportunity to review significant events of the past two years and to record some impressions of the status of the UK nuclear energy program, and US/UK cooperation which may be of interest to the Headquarters staff.

British nuclear energy activities are already widely reported upon and followed with great interest. This is true for several reasons: first, because of the relatively large size and high state of development of the national atomic energy research and development program; second, because Great Britain has had the most advanced construction program in the world for civil nuclear power; and third, because of the high technical capabilities and aggressiveness of British scientists and engineers. One should also refer to British developments in military uses of nuclear energy by virtue of which the UK is our only strong nuclear ally.

A consequence of the mutual regard which the US and the UK have for each others programs, and the interdependence of the two countries in this field, is that a considerable number of visits are made to each other's facilities for exchange of information, for discussions, and for purposes of consultation, starting at the top level with the periodic meetings between the Chairmen of the Atomic Energy Authority and the Atomic Energy Commission. Matters of major importance to the Commission are subjects for staff studies, reporting, and distributions within AEC. However, a large amount of information is also available in special reports on conferences, symposia, technical exchanges, and individual scientists visits, as well as the routine and special reports prepared by the AEC overseas office, and the extensive coverage given by the commercial and technical press.

Some thought has, therefore, been given to the preparation of this report as to what choice of content might be of greatest interest. It has been decided to present a brief recapitulation of the principal activities over the approximate two year period since similar previous reports were issued(1,2) in order that the extensive scope of British activities in civil uses of nuclear energy as well as the scope of US/UK collaboration during this period will be made evident, and some of the principal problems in these areas identified.

(1) "US-UK Cooperation in the Development of Peaceful Uses of Atomic Energy" by Edward L. Brady, AEC Scientific Representative. October 29, 1958.

(2) "Major Developments in Atomic Energy in the UK in the Last Year and Their Bearing on Relations with the US" by Howard Meyers and Edward L. Brady. Foreign Service Despatch 1008, October 24, 1958 (CONF)

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The British program for development of military uses of atomic energy is, of course, a very important one, particularly in the areas of nuclear weapons, and an effective exchange is taking place under the US/UK Agreement for Cooperation on the uses of atomic energy for mutual defense purposes. However, no reference will be made in this report to military developments and collaboration since this is outside the terms of reference of the AEC overseas office.

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PART I

British Nuclear Energy Program

I. GENERAL

The British research and development program in atomic energy covers a broad range of interests from basic physical and biological science to practical applications in many fields. However, the core of the British effort has been its nuclear power program. At its most optimistic point, the UK established national goals of 5000-6000 MW (electrical) generating capacity to be completed by 1965. In addition it was fully expected that a sizeable export market might be developed. With this outlook the technical objective was to provide the means whereby this goal could be reached. Progressing from the experience of the ill-fated Windscale reactors, the Calder Hall (and Chapelcross) design was developed and the stations completed to produce in 1956 the first commercial nuclear power generation in the world. With an attitude of justifiable confidence, efforts were next turned to improvement of the basic Calder design and the indoctrination of the industrial consortia which were to reduce the improved design, with contributions of their own, to economic practice. By 1958, it was already becoming apparent that the competitive practice of nuclear power was not being advanced as rapidly as had been anticipated, and that the expected markets for even the improved designs of Calder type nuclear power stations were not being realized. As is well known, over the following two years these conditions have fully developed and forced a serious contraction of the national nuclear power goals and produced severe strains in the conduct and organization of both public and commercial nuclear energy development. Even before completion of the large civil stations, the technical feasibility of commercial nuclear power was established, but at this point the technical challenge became one of producing economically competitive power through research and development on improved and advanced designs for power reactor systems, and readjustments of the national program, which was aimed toward becoming a major and expanding national industry. It could hardly be said that the British activities over the past two years could be better characterized than in terms of the substantial progress made in nuclear science and engineering and which has intrinsic value quite aside from whether it can immediately be put into practice. Nevertheless, this adjustment to the changing role of nuclear power in meeting domestic as well as overseas power requirements has been an outstanding preoccupation during this period.

II. UK NUCLEAR POWER PROGRAM

The national nuclear power program has been revised on three occasions since it was first outlined in the White Paper of February 1955 which called for installation of 1500-2000 megawatts of nuclear capacity by 1965. In March 1957, the goal was increased to 5000-6000 megawatts by 1965, but in September 1957, the program was cut again effectively by extension of the target date from 1965 to 1966. During 1958 and 1959, it became clear that the gap between conventional and nuclear power generation costs was not narrowing as rapidly as had been predicted. The program was reviewed early in 1960, and in June 1960, the Minister of Power announced that the goals had been reduced to a possible 5000 megawatts of installed nuclear capacity by 1968. Several factors

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impinged on this decision, the continuing surplus of coal in the UK, the availability of oil for import, the unexpected drop in cost of conventional generation of electricity, and the less-rapid-than-expected decrease in nuclear generating costs. The conditions in the UK are not dissimilar to those existing in other countries, but irrevocable commitments have been made in the UK which caused greater strain in making the downward adjustment. Long term commitments to purchase uranium oxide at prices above present market value have been made, fuel fabrication facilities sufficient to support a large scale industrial nuclear power program have been constructed at a cost of £17 million, graphite in excess of current needs has been ordered, and organizations and staffs for commercial exploitation of nuclear power have been brought into existence.

The present rate at which stations are being ordered, viz. one station per year, is sufficient to reach the current goals when the tenth station is authorized, if the generating capacity of the Atomic Energy Authority's dual purpose reactors is also taken into account. The Central Electricity Generating Board has recently applied to the Ministry of Power for consent to build the ninth station, but planning has not yet begun for the tenth.

It is generally agreed that nuclear power must eventually provide an increasing proportion of the power demands of the UK. The Chairman of the Atomic Energy Authority, Sir Roger Makins, has made his views clear on this point, and urged the staff of the AEA to regard the challenge of developing economically competitive nuclear power as one which is as great as the earlier challenge to produce the first successful operating nuclear plants at Calder Hall. The present research and development program in nuclear power is dually oriented, supporting both the current power program based on the Calder type reactors as well as undertaking the development of advanced types of reactor systems which will comprise future stations. The Chairman of the Central Electricity Generating Board, Sir Christopher Hinton, also has fully acknowledged the eventual need for increasing amounts of power generation by nuclear means, but at the same time has warned that expenditures for nuclear research and development must be examined in relation to expenditures for conventional research and development and ultimately must be justified on the basis of savings to the electricity consumer. Thus the ultimate role of nuclear power is felt to be assured, but matters of emphasis and timing have been and will continue to rest on technical and economic developments. Hinton has predicted the economic break-even point* will occur between 1965-1970, but should this fail to occur a further extension of the nuclear construction program would undoubtedly be urged. This would be resisted by the AEA and UK nuclear industry whose vested interests would be affected. The AEA has argued that something like the present construction program (which is costing the nation of the order of £900 million) is essential for development of improved systems, for preservation of the nuclear industry, and to provide healthy competition to the conventional electricity generation industry.

*The lowest current estimated costs are 0.55-0.67 pence/kilowatt hour nuclear and 0.50-0.64 pence/kilowatt hour for coal fired stations.

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III. REACTOR DEVELOPMENT PROGRAM

The published objectives of the reactor development program are first, to insure successful construction and operation of the power stations now under construction and second, to develop advanced reactors that will provide progressively cheaper power.

A. Civil Power Program

During the past two years, the principal effort has continued to be placed on the civil power program, specifically to insure maximum reliability and lowest possible generating cost for the magnox (Calder Hall type) systems. Work has progressed in several areas:

Reactor Physics - attention was paid to changes of reactivity with length of irradiation (including the effect of plutonium build-up) and the moderator temperature coefficient of the graphite moderator; the results have shown how these changes affect the design of reactor control systems.

Graphite Moderator - studies on the rate of build-up of Wigner energy in graphite have lead to lower estimates of stored energy in reactors in the commercial stations than previously had been assumed. As a result, sleeving of fuel channels to raise graphite operating temperature was concluded to be unnecessary and was abandoned. Further refinement of information on dimensional changes in graphite under irradiation was also achieved. It was realized that shrinkage could occur under the conditions of operation of the civil reactors and a significant design modification of the graphite core was made. Work on the reaction between CO_2 and graphite led to the conclusion that no problem will be encountered in the magnox reactors.

Fuel elements - the principal technical problem is the performance of the civil fuel elements under irradiation. It is considered essential that the elements be capable of irradiation to an average of 3000 megawatt days per tonne. Testing irradiation in Calder Hall reactors is providing the data required to evaluate the fuel elements in this respect but the number of elements which have received this degree of irradiation is still too small to draw statistically valid conclusions. The AEA, nevertheless, is optimistic, but a senior CEGB staff member has privately expressed his belief that 3000 MWD/te is the theoretical upper limit and hardly likely to be achieved practically.

Recognizing the importance of examination of large numbers of irradiated elements in order to solve problems of swelling of natural uranium metal fuel, leaks in cartridges, and other difficulties limiting irradiation, the AEA authorized and now has under construction extensive high radiation level fuel element examination caves and metallurgical laboratories at Windscale.

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Aerodynamic instability ("rattling") of fuel elements in the Bradwell design of reactor core during passage of CO_2 coolant gas through the fuel channels was discovered and required last-minute redesign of the fuel elements with consequent delays in manufacture of the fuel. Delivery of fuel for Bradwell and Berkeley, the first of the two civil stations to be completed, is now taking place. These reactors will go critical before the end of 1961.

B. Advanced Reactor Development

Improvement in successive designs of the civil magnox stations have resulted in a corresponding decrease in capital costs (from £150 per kilowatt sent out for first station to £110 per kilowatt sent out for the sixth station) and hence generating costs for this type of reactor have also dropped. This trend will eventually cease but since it has not yet done so, the industrial consortia have some basis for their contention that the present magnox design should be pushed to its limit before the expensive process of designing commercial stations around advanced reactor concepts is begun. The Central Electricity Generating Board has been reluctant to order the best developed of the advanced concepts, the AGR, on the basis that even more economically promising concepts are expected within a few years. Thus, too short a time exists for full exploitation of AGR, which itself is not yet advanced to the operating prototype stage. However, with the future of nuclear power development dependent upon achievement of an economically competitive system, the AEA has vigorously pushed the AGR as the most promising candidate for the next generation of reactors, and there is no doubt that the CEGB will order a number of AGR stations. During the past two years the AEA has begun supplying the industrial consortia with AGR information to enable design on full scale civil stations to be undertaken, and the CEGB may offer the consortia the choice of proposing either a magnox or AGR station when tenders for later stations are called for.

For later generations of civil power stations, development of the fast reactor (FR), the high temperature gas-cooled reactor (HTGR), and to a lesser extent the steam generating heavy water reactor (SGHW), has been undertaken.

A.G.R. - construction of a prototype was begun in November 1958 at the Windscale site. It is now in a well advanced state and will be completed and possibly started up before the end of 1961. Progress has been smooth with the exception of the development of beryllium metal as a canning material. It was originally planned to use about 10% stainless steel clad elements in the first core loading as backup for the beryllium clad elements. It is now planned to use only a few percent of beryllium clad elements in the first core. In spite of this, the AEA continues to be optimistic regarding the eventual successful use of this material. In consideration of the importance of a comprehensive understanding of the reactor physics of AGR systems, the construction of the experimental zero energy high temperature research reactor HERO was begun and will be completed during 1961. Fuel and moderator temperature coefficients, effects of plutonium containing fuels, etc. will be determined. Work with existing exponential stacks has been underway for some time. The AGR will have a positive moderator temperature coefficient of reactivity. Ex-

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perimental and theoretical work has demonstrated the adequacy of the proposed control system. The extent of CO_2 graphite reactions in AGR has been given considerable attention. It is believed that control of the CO_2 coolant composition will adequately restrict undesirable graphite reactions.

Fast Reactor - this type of reactor is generally considered to offer the best prospect for eventual low-cost nuclear power in the UK, perhaps in the 1970s. Emphasis is placed on the fast reactor as a burner of plutonium (from civil power stations) rather than as a breeder. The AEA's experimental fast reactor at Dounreay first became critical in November 1959, and subsequently operated intermittently at low power. Problems were encountered with fuel cladding failures, Na-K coolant clean-up, liquid metal seals, gas entrainment in the coolant, etc. The reactor was shut down in 1960 for core and other design modifications and scheduled for resumption of operation early in 1961. One of the important uses of the facility will be for fuel testing. Study and design of a civil power prototype fast reactor has been started. Construction of a zero energy facility at Winfrith Heath for study of the reactor physics of fast systems has been authorized.

High Temperature Gas Cooled Reactor - this system is also regarded as a very promising candidate for low cost nuclear power in the 1970s. British development of this system is being undertaken largely through participation in the OEEC-sponsored Dragon project involving construction of an experimental HTGC reactor at the AEA's reactor development site at Winfrith Heath. Construction of the reactor was begun during 1960. When the Dragon cooperative program is completed, it is very likely, if the project has been successful as is fully expected, that the AEA will establish its own program for exploitation of this system, and plans to this effect are being made. The British have expressed an interest in obtaining U-233 from the US for experimental studies supporting thorium burning systems of the HTGC type.

The heated zero energy reactor ZENITH, which was designed to support the HTGC program, was completed at Winfrith Heath and reached criticality in December 1959. Leaks in the coolant system postponed measurements with a heated core, but during 1960 the facility began providing reactor physics data and information relevant to such systems.

Steam Generating Heavy Water Reactor - at a time when it was not felt the success of the AGR could be confidently predicted, it was decided that an alternative system should be explored. Evaluation of the SGHW design, a pressure tube, superheating, 500 MW(e), concept has shown considerable economic promise. Estimates of power costs from SGHW are fully competitive with the AGR estimated costs. The AEA has decided that it does not have the capability to undertake a full-scale development program on the SGHW at this time. However, a two-year $1 million program was authorized toward the end of 1960. Research and development work will include zirconium pressure tube development, core physics, and reactor control.

C. Marine Reactors

On the military side, plans and progress are well known in respect to construction of the Dreadnought through special arrangements for procurement of the propulsion system from the US.

The construction of a nuclear propelled merchant ship has received a great deal of attention and study but as of January 1961, no decision by the Government had been reached. In 1959, at the request of the Admiralty, seven industrial firms and the AEA submitted studies covering pressurized water, gas and steam cooled, boiling water and organic moderated reactors for propulsion of a nuclear powered tanker as specified by the Yarrow Admiralty Research Department. The AEA study for an AGR system was withdrawn when it was realized the system was too large to be suitable for this application. The Admiralty's Galbraith Committee concluded that only the OMR and BWR had near future potential. Responsibility for nuclear ship development was transferred to the Ministry of Transport near the end of 1959 and shortly thereafter a call for tenders, to be supported financially partly by the Ministry, was issued for only the two best developed designs. Five designs were received in response by the end of July 1960. A Government decision is still pending. It seems clear that none of the 5 studies promises an economically competitive ship, and the Government is faced with the decision of whether and on what basis a nuclear ship could be built and operated. If a favorable decision is reached, Government financial support is inevitable.

D. Research Reactors

A wide variety of research reactors has been made available in the UK, almost exclusively in the facilities of the AEA. New reactors completed or whose construction was begun during 1959 and 1960 include ZENITH and HERO already referred to above; HERALD (5MW(t)) at Aldermaston; MERLIN (5MW(t)) at Associated Electrical Industries, Aldermaston; JASON (10kw(t)) at Hawker Siddeley Corp. Langley; NESTOR, a modified JASON, et Winfrith Heath. No research reactor operating at above zero energy has yet been installed in a university. A plan now exists whereby a number of reactors are to be made available to universities through Government financial support, but no funds have been provided as yet. Attempts by US industry to sell research reactors in the UK have not been successful to date, although an agreement was made between a US and a UK firm to market a US design in the UK. Considerable interest developed in obtaining US U-235 for fuel as a means of reducing the cost of research reactors. The AEC determined that US U-235 might be made available under the terms of the US/UK civil bilateral in instances where US designed reactors were concerned and agreements with US manufacturers were in effect. No requests have been made as yet for supply of US U-235.

IV. PRODUCTION PROGRAM

During the last two years an increase in all phases of the production activities of the UK has been effected. For fiscal year 1959-60, the production of fissile material rose by 40% and of electricity by over 300%. The actual production figures for U-235 and plutonium are withheld in the interests of national security.

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A. Uranium Production

A new uranium production plant at Springfields has been completed and commissioning is essentially complete. A uranium concentrate solvent type purification plant was brought into operation. A full scale prototype fluidized bed plant for continuous conversion of uranium nitrate to tetrafluoride has been put into operation although not into routine full scale production.

B. Fuel Element Production

A new factory for manufacture of uranium slugs for the AEA's production reactors and fuel elements for the new civil power stations has been placed into operation. The plant has a capacity of over 300,000 uranium metal fuel elements per year and represents an investment of around £17 million. Production of fuel elements is underway for the first reactors to be completed in the civil power program, and deliveries are being made to Bradwell and Berkeley.

C. Plutonium and Power Producing Reactors

During 1960 the last of the four Chapelcross reactors was brought up to power giving the AEA a total of eight dual purpose reactors (four at Calder Hall). The power level of the Calder reactors has been raised to 210 MW(t) or 46 MW(e) (plus excess steam). It is thought the power level may be raised to 230 MW(t), the limit being imposed by the capacity of the heat exchangers. Average load factors reported in 1960 were 90%, and up to 97% between fuel loading and discharge.

D. Plutonium Extraction Plants

Increased chemical processing capacity will be required to handle fuel from the civil power reactors. In anticipation of this need, a new plant was designed and is now under construction at Windscale, the site of the AEA's existing chemical processing plant. The new plant is based on use of tri-butyl phosphate for extraction. It is due to be in operation in 1963.

E. Isotope Separation

A construction program was completed at Capenhurst in November 1959 to extend the capacity of the diffusion plant. The existing plant is incapable of supplying the anticipated total military and civil power requirements. Purchase of U-235 from the US for civil requirements is being explored by the UK as an alternative to further expansion of diffusion plant capacity. Owing mainly to the higher cost of electrical power, the cost of British U-235 is considerably greater than US U-235. It is therefore economically attractive to purchase U-235, but politically unattractive to be dependent on US supplies. The AEA would prefer to obtain sufficient material to meet their needs for some years and thus defer the ultimate decision on new plant construction.

V. GENERAL RESEARCH AND DEVELOPMENT

The extremely wide scope of R&D programs underway during the past two years could in itself justify a comprehensive report.

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The principal research center at Harwell undertakes a great deal of high level basic research in the nuclear and related sciences. However, in comparison with an American counterpart, Argonne National Laboratory for example, considerably more emphasis is given to applied work in support of specific technical problems which are faced in the civil power program, reactor development, production, etc. The AEA in its last annual report called attention to a number of R&D areas where notable results were obtained during the previous year including nuclear physics research; the test of the principal of equivalence postulated in the general theory of relativity; solid state physics, including a study of change of thermal resistance with isotopic concentration radiation chemistry, including degradation of organic materials of the type used as solvents in chemical processing, and degradation of organic compounds related to those proposed for use as moderators and coolants. The report also mentions studies of radioactive aerosols; criticality calculations, in which it is stated that unified theory has been checked with good agreement against American experiment results; research on applications of radioisotopes, including gamma sterilization and work done with the "package irradiator." Several special subjects are discussed: the development of gas bearings; development of "flash radiography", a technique for obtaining short-duration (0.2 microsecond) radiographs of systems opaque to ordinary light and moving at high speed; and the development of very high speed cameras having exposure times of the order of 1/10 microsecond. Reference to several other subjects can be found in a subsequent section in this report on US/UK Exchanges. However, one topic, controlled reactions, merits particular attention at this point. In recognition of the importance which the AEA attaches to CTR work and in view of the limitations of the Harwell site, the Authority granted approval in January 1960 for establishment of a new site for all AEA-sponsored CTR work at Culham near Oxford. The Director-designate of the new establishment is Dr. John Adams, presently Director-General of CERN. During 1959 and 1960, CTR work centered about the ZETA device at Harwell, the Sceptre device at Aldermaston Court (Associated Electrical Industries Laboratories), and a number of smaller experimental devices. The research done comprised essentially an investigation of plasma physics, with particular reference to the mechanism of energy loss from these devices. In view of recognized limitations of the existing device, a plan was approved for the construction at Culham of a new device to be known as the Intermediate Current Stability Experiment (ICSE). The object of ICSE was to be investigation of the stability of an improved "pinch" configuration and to check the main predictions of the present stability theory. However, in September 1960 the AEA announced that construction of ICSE would take more effort and resources than was considered justified for a single experiment in view of the state of knowledge of plasma physics, and that the project was being dropped in favor of a broader program with a number of smaller experiments covering diagnostics and advanced techniques for production of high temperature plasmas. Reconsideration will be given to construction of a large controlled thermonuclear device when a better basis for deciding upon the nature of the device has been established.

VI. ORGANIZATION AND NEW FACILITIES

A. Atomic Energy Authority

During the past two years changes in the membership as well as the functional responsibilities of the Authority occurred. The old Industrial Group was split into the Development and

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Engineering Group and the Production Group. The Authority members assumed administrative responsibilities as heads of the various Groups as well as holding policy responsibilities as members of the Authority. Lord Plowden resigned as of the end of 1959, and the chairmanship was assumed by Sir Roger Makins. Sir John Cockcroft resigned as full-time member with his appointment as Master of Churchill College, Cambridge, and appeared to be taking less and less active part in the affairs of the AEA, even in his capacity as part-time member.

Growth and development of all the Authority's facilities was observed. But in addition to completion of facilities already referred to such as the Chapelcross power station, the Springfields feed materials plant and fuel element manufacturing plant, an important new facility was added with the opening of the Research Group's new reactor development center at Winfrith Heath, Dorset.

A new centralized health and safety organization was announced by the AEA as of July 1959 which established closer coordination of the Authority's activities in this field.

An examination of the AEA's Industrial Group by the Parliamentary Select Committee on Estimates resulted in a complimentary report issued in July 1959.

B. Central Electricity Generating Board

The Board's most notable accomplishment lay in the implementation of the nuclear civil power program to which reference has already been made. This was carried out under a functional organization which combined responsibilities for both nuclear and conventional power in common organizational units. The CEGB, as a nuclear power station operator, established its requirement for an independent nuclear R&D program to serve its special needs. In support of this policy, a new research center at Berkeley was nearing completion as of the first of 1961.

C. Ministry of Power

Under the Nuclear Installations (Licensing and Insurance) Act 1959, the responsibility for licensing of nuclear installations was vested in the Ministry of Power. As an implementing measure an Inspectorate of Nuclear Installations was organized. AEA facilities are exempt from the licensing provisions of the Act.

D. Ministry of Science

On October 14, 1959, the Prime Minister announced a transfer of Ministerial responsibility for atomic energy matters from himself to the Minister for Science. The former Prime Minister's Atomic Energy Office accordingly was transferred to the newly established Ministry for Science under a new title of Atomic Energy Division. The unit continued to be headed by Mr. Michael Michaels.

E. Industrial Consortia

Faced with the prospect of lean years in the nuclear power business, four of the five consortia, which originally were formed to exploit commercial applications of power reactors, merged to conserve resources. This leaves three major consortia

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active in the UK: United Power Company Ltd. (General Electric-Simon Carves Ltd-Atomic Power Constructions); English Electric-Babcock and Wilcox-Taylor Woodrow; and the Nuclear Power Group (formerly AEI-John Thompson and Nuclear Power Plant CO.).

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Part II

US/UK Cooperation on the Civil Uses of Atomic Energy

The period since the signing of the US/UK Bilateral Agreement in 1955 has seen a progressive increase in cooperation between the two countries in civil uses of atomic energy. New areas of collaboration have been successfully established, and others have been extended. Bilateral exchanges in atomic energy matters have contributed significantly to the general deepening of Anglo-American relationships. Sir Roger Makins, Chairman of the AEA, has stated his view publicly that relations between the US and the UK are closer in respect to atomic energy collaboration than at any time since wartime collaboration.

This is not to say that a completely free exchange has been achieved, for significant areas are limited by classification and, on the British side, by imposition of commercial restrictions. During the past two years, exchanges have been extended into areas which were formerly restricted, and further moves in this direction are in prospect.

I. REACTOR TECHNOLOGY

A. Advanced Gas-Cooled Reactors

In November 1959 an agreement for exchange of information on gas-cooled reactors was reached between the Chairmen of the Atomic Energy Commission and the Atomic Energy Authority. The agreement related to the development, design, construction and operation of the AGR and HERO at Windscale and the EGCR at Oak Ridge. The agreement was implemented during 1960 through designation of AEC and AEA principal exchange officers who are responsible for over-all coordination of the exchange, and panel members in nine categories of information who promote, coordinate, and act as prime contacts for the exchange in each category. Formal procedures for handling exchanged documents in accordance with the provisions of the agreement were also established, especially in reference to prohibition on publication of certain types of reports. By the end of July 1960, five visits by US groups had been made to the UK and six visits by UK personnel to the US had been made. Subjects covered include: reactor design, design and programming of irradiation experiments, reactor physics, physical behavior of graphite under irradiation, beryllium clad fuels, experimental loops and in-pile facilities, beryllium development, operation of AGR-type stations, organization, and administration. By this date over seventy reports and memoranda had been exchanged, in addition to various drawings, etc. Joint experiments involving irradiation of beryllium-canned UO_2 specimens at Oak Ridge have been conducted.

The AGR/EGCR Agreement excludes detailed manufacturing information for fuel elements and detailed reactor design information. However, each party agreed to advise the other on particular questions involving reactor design detail of the other's reactor. Under this provision, the US has requested and received assistance in solution of specific problems relating to gas bearing design and operation. A US proposal for an exchange of general information on this topic was declined by the AEA. The agreement also provided for removal of the 1 January 1957 cut-off date established under the earlier Calder Hall Agreement for information on Calder Hall and Chapelcross reactors.

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Reference was made to this provision in transmitting an AEC request for a discussion on uranium metal fuel elements. The AEA responded with the observation that very little new information on Calder Hall type elements had been developed; that nearly all new data related to fuel elements for the new civil power stations and was, therefore, proprietary information not available for exchange.

During negotiations preceding the AGR/EGCR Agreement the AEA firmly turned down a proposal for long-term exchange of personnel on the basis that the Authority was not in a position to have US personnel working in proximity to proprietary developments.

B. High Temperature Gas-Cooled Reactors

The second major development in reactor collaboration over the past two years was the agreement between the AEC and OEEC's Dragon Project for a broad exchange on HTGC, which was concluded in March 1960. Implementation of the exchange has been established along the lines set up for the AGR exchange. By the end of 1960 some sixty reports had been sent to Dragon by the AEC and a similar number sent by Dragon to AEC. Nine visits involving over twenty US personnel have been made to the UK, and two visits to the US involving twelve members of the Dragon Project have been made. A draft of the first year report has been prepared by the Dragon Project and submitted to the AEC for review. The report calls attention to the value both parties have already received from the exchange. Nineteen subjects are listed on which exchange has taken place, including reactor physics, critical facility experiments, compatibility of materials, high density graphite, fuel element design, etc. As yet, less information in the engineering field has been exchanged. Both parties have expressed a keen interest in long-term assignments of personnel to the other's programs. To date, this has not been possible since agreement on the rights to inventions, etc. made by assigned personnel has not been reached. At the end of December 1960 a further proposal on patents was submitted by the AEA on behalf of Dragon for AEC consideration.

II. TECHNICAL EXCHANGE

A. Libby/Cockcroft Exchange

By exchange of letters in September 1958, five technical areas were identified by the scientific members of the Authority and the Commission, and an agreement reached for improving technical co-operation in basic research and development in these areas. During the next two years progress was made in all subjects covered by the agreement, although some proceeded more smoothly than others.

The CTR exchange had been in operation prior to the Libby/Cockcroft Agreement, and continued to be one of the most effective and satisfactory exchanges. Regular joint meetings were held, reports and newsletters were exchanged, and long-term cross-assignments of personnel to US and UK facilities occurred. The principal complaint from the British side is that they have been unsuccessful in getting AEC approval for assignment of personnel to certain of the sites, such as Los Alamos, where major unclassified CTR programs are under way.

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Comprehensive exchanges have also been undertaken in uranium oxide, plutonium, gas coolant compatability, and, to a lesser degree, beryllium. In each area visits by teams of specialists have been made, reports have been exchanged, and various individual scientific contacts established. In general, both the US and the UK have found these exchanges of great interest. However, there has been some concern expressed on the British side that too much emphasis was given to technology rather than basic science, contrary to the original intent. The British participation is complicated by a certain amount of rivalry between the Development and Engineering Group at Risley and the Research Group at Harwell, both of which undertake work in these subjects. The Research Group is anxious to continue these exchanges with emphasis on basic research, thus eliminating complications arising from commercial utilization of the information on these subjects, and from the divided administrative responsibility for the exchanges in the UK. With the conclusion of the AGR/EGCR Agreement, the AEA has proposed that certain topics involving applied technology might appropriately be handled under this arrangement. These and other UK views have been reported to AEC and are under consideration by the staff.

B. Nuclear Physics

Progress in exchanges under this subject occurred mainly through the usual scientific channels, viz., individual scientists' visits, attendance at international meetings, scientific publications, etc. More formal activities in nuclear cross-sections undertaken by the Tripartite Nuclear Cross-Section Committee continued effectively, and were extended to include participation in the European and American Nuclear Data Committee under the auspices of OEEC.

C. Chemistry

In addition to an extensive exchange of information through usual scientific contacts, this area has continued to support long-term exchange of personnel. Throughout the last two years, two to three chemists from the US have been assigned to the Chemistry Division at Harwell for 6-month to 1-year tours of duty, and UK scientists have likewise been assigned to AEC facilities. One special subject being considered for a US/UK basic science exchange in Chemistry at the present time is corrosion.

D. Biological Sciences

Excellent personal contacts between US scientists and their British colleagues have been responsible for an effective continuation of exchanges in biological and medical subjects. British scientists are meeting much the same problems as US scientists, and the research programs of the two groups reflect this fact. A summary of research in the life sciences in Britain was compiled by AEC London and showed the types of problems under investigation and the relative emphasis applied to their solution. The body mainly concerned with biological research in the UK is the Medical Research Council. The AEA, which undertakes work in support of its own Health and Safety problems, is being extended an opportunity to attend AEC Biomedical Program Directors' Meetings, and general close collaboration is being encouraged by both AEC and AEA.

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E. Chemical Processing

The principal discussion held on this topic involved, on the UK side, the chemical process planned for the new plant now under construction at Windscale. During a visit by a US team in November 1959, the UK representatives reviewed the flow sheet developed by them and received comments from US representatives. An earlier visit to Savannah River was made by a UK team in May 1959, at which time information on operation of chemical processing plants and other topics were discussed.

F. Feed Materials

A number of visits were made by US representatives to discuss various aspects of feed materials technology. The commissioning of the new feed materials plant at Springfields, which utilizes fluidized bed processes, was of particular interest to the US visitors. It is believed that further discussions on fluidized bed processes would be of considerable value to the US.

G. New Areas of Exchange

Several topics which have previously been restricted as to exchange between the US and UK have recently been reconsidered. These are production plants, diffusion plants, and gas centrifuge development. Agreement has been reached on a gas centrifuge exchange, and a preliminary US/UK meeting on this subject held in the UK in December, 1960, indicated that a valuable joint program in this field should be possible. The other topics are still under consideration following submission of an AEC proposal to AEA in December, 1960.

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FOREIGN SERVICE DESPATCH

FROM : American Embassy LONDON NO. 1354

TO : Department of State, WASHINGTON January 23, 1961

SUBJ : British Nuclear Progress and U.S./U.K. Cooperation on the Civil Uses of Atomic Energy

There are enclosed, for the information of the Department, six copies of a report prepared by Louis B. Werner, Scientific Representative of the Atomic Energy Commission, at the conclusion of his tour of duty at this post. The Department will find of particular interest the sections of the report dealing with the U.K. nuclear power program, including plans for future reactor development, and with U.S./U.K. cooperation in the civil uses field.

The Embassy takes this occasion to commend Dr. Werner warmly for his effective performance here. The view of the Chairman of the U.K. Atomic Energy Authority, Sir Roger Makins -- that relations between the U.S. and the U.K. in the atomic energy field are closer than at any time since the war -- is, in the Embassy's opinion, a fair statement of the position. This close relationship makes for a heavy volume of work for the AEC representative in London, work requiring not only a broad technical and scientific competence but also the temperament and skill for dealing with a wide variety of personalities concerned with atomic energy in this country. Dr. Werner has made a significant contribution to the smooth working of this relationship and thereby to the over-all effectiveness of the Embassy.

Walworth Barbour
Charge d'Affaires ad interim

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