ATOM

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MONTHLY INFORMATION BULLETIN OF

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

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ATOM
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S.G.H.W.R. on power

THE Steam Generating Heavy Water Reactor—S.G.H.W.R.—at the Atomic Energy Establishment, Winfrith, Dorset, was brought to full power operation of 100 megawatts of electricity on Thursday, 25th January, 1968.

The reactor, which has been designed, developed and constructed by the United Kingdom Atomic Energy Authority, first produced electricity for the national grid on 24th December, 1967.

Commercial designs of the S.G.H.W.R. of up to 500 megawatts electrical are already available and are fully competitive with other reactor systems.

The Authority, in co-operation with Finnish industry, has prepared a tender to supply a S.G.H.W.R. power station to Imatran Voima Oy (I.V.O.), the state-owned electricity utility of Finland. Detailed negotiations on this bid are due to start shortly. In addition teams of engineers from Australia and New Zealand are working at the Authority's Reactor Group headquarters at Risley, Lancashire, on a design study of a natural uranium fuelled S.G.H.W.R. Interest in this reactor system has also been shown by a number of other countries.

Background note

The Steam Generating Heavy Water Reactor is a direct cycle system, moderated by heavy water and cooled by boiling light water. The core of the reactor consists of a bank of pressure tubes which pass through vertical tubes in a calandria or tank containing the heavy water moderator. Each pressure tube contains a single fuel cluster and the heat generated is removed by light water passing up the tube and being partially turned into steam. After separation in a steam drum the steam passes directly to a turbine.

Though the S.G.H.W.R. is an advanced reactor system, it is based on well-proven technology. The simplicity of construction and uncomplicated design of the reactor have produced a number of attractive features.

The majority of components call for straightforward manufacturing techniques, eliminating or easing the need for on-site fabrication and reducing capital costs and construction time.

The use of a pressure tube system eliminates the need for the manufacture and transport of heavy, expensive pressure vessels such as are required for boiling water and pressurised water reactors. Designs for commercial power stations are based on the same pressure tube design, the basic unit of construction, as used in the Winfrith reactor and larger outputs are obtained simply by increasing their number.

The direct cycle system eliminates the need for expensive heat exchangers.

Potential loss of the heavy water moderator is virtually eliminated by maintaining the calandria containing it at near atmospheric pressure.

There is considerable development potential in the system. Although the most favourable economics require the use of low-enrichment uranium fuel, the S.G.H.W.R. design can be reoptimised to enable natural uranium to be used. This has considerable attractions for countries having indigenous supplies of uranium.

Refuelling can be carried out on or off-load. In the latter case refuelling is done two or three times a year at weekends and ensures a high reactor availability. Operating characteristics are such that the system is well suited to following variable load conditions.

The system has excellent plutonium conversion characteristics, an important factor where integration with plutonium fuelled fast reactors is envisaged.

26th January, 1968

A.E.A. appointments

THE United Kingdom Atomic Energy Authority announce the following appointments:—

Dr. R. Spence, C.B., F.R.S., Director of the Research Group, is leaving the Authority at the end of March, 1968, to take up an appointment with the University of Kent at Canterbury.

With effect from 1st April, 1968, Dr. J. B. Adams, C.M.G., F.R.S., Member for Research, will also act as Head of the Research Group.

With effect from the same date Dr. W. Marshall has been appointed Director of the Atomic Energy Research Establishment, Harwell, and Dr. R. S. Pease has been appointed Director of the Culham Laboratory.

Biographical notes

Dr. W. Marshall

Dr. Walter Marshall will be 36 in March. He was born and went to school in Cardiff, and took his B.Sc. (1st Class Honours) in Mathematical Physics at Birmingham in 1952, and his Ph.D. in 1954. He joined the Atomic Energy Research Establishment at Harwell in that year and from 1957 to 1959 spent two years in the United States at Berkeley and Harvard before returning to Harwell. In 1960 he was appointed Head of the Theoretical Physics Division at Harwell, and in 1964 he was made a member of the Research Group Management Board. In the same year he was elected a member of the Council of the Institute of Physics and the Physical Society, appointed Kelvin Lecturer of the British Association for the Advancement of Science, and awarded the Maxwell Medal for outstanding contributions to theoretical physics.

On 1st March, 1966, Dr. Marshall was appointed Deputy Director of the A.E.R.E., Harwell, and on 1st February, 1967, received the additional appointment of Deputy Director of the Research Group. He has had special responsibility for reviewing and reformulating the future programme at Harwell.

Dr. R. S. Pease

Dr. Pease is aged 45. He went to Bedales School and took Part I of the Natural Sciences Tripos at Cambridge in 1942 and spent four years doing war-time operational research before going back to Cambridge in 1946 to take Part II of the Natural Sciences Tripos in Physics; he proceeded to the M.A. degree in 1951. He joined the Atomic Energy Research Establishment at Harwell in 1947 in the General Physics Division and moved to the Controlled Thermonuclear Reactions Division on its formation in 1958, and in 1960 became its head. When the Culham Laboratory was set up in 1961 to do research in plasma physics and nuclear fusion, Dr. Pease was appointed head of one of the Experimental Divisions and in 1967 became Head of the Laboratory and an Assistant Director of the Research Group. The University of Cambridge awarded him the Sc.D. degree in 1964.

5th February, 1968

Siting of nuclear power stations

The following statement on the siting of nuclear power stations was made by the Minister of Power in the House of Commons on 6th February, 1968.

THE MINISTER OF POWER (MR. RICHARD MARSH): It has previously been Government policy that nuclear power stations should be built on remote sites. In view of the knowledge of the safety factors we now have, some modification of this policy is now feasible, while still maintaining a proper standard of public safety.

The advice given to the Secretary of State for Scotland and me by our independent Nuclear Safety Advisory Committee is that in a country such as the United Kingdom the major contribution to public safety derives from the high standard of design, construction and operation of nuclear power plants. As the result of advances in technology we are advised that the safety of a gas-cooled reactor in a prestressed concrete pressure vessel is such that it may be constructed and operated much nearer built-up areas than we have so far permitted.

We have accepted this advice, but each application for a site will, of course, be considered individually.

Mr. Leadbitter: That Answer is welcome and reassuring, and it augurs well for the projection of the nuclear power programme in the future. Can my right hon. Friend now say that the sites at Heysham and Hartlepool fall within the terms of his statement, and, based on the criterion of safety, are acceptable to the Government for development?

Mr. Marsh: Yes, in terms of safety.

Sir D. Renton: The Minister has said that nuclear power stations may now be built much nearer to built-up areas than formerly. How close does he mean?

Mr. Marsh: It is impossible to say, because this will depend upon each site. One wants a population density which is sufficiently light so that, in the event of any very unlikely occurrence, at least the population could be moved from the immediate surroundings of, say, a mile and a half, or two miles or so. This would mean within most areas like Hartlepools or Heysham. This question would be open to discussion in relation to each individual site.

Mr. Rankin: Will my right hon. Friend assure us that nothing in the statement he has just made will negative the Government's promise to build a nuclear power station at Invergordon?

Mr. Marsh: I do not think that that comes within the Question.

Mr. Lubbock: Is the Minister aware that there are valuable overseas contracts, such as the one for B.A.S.F. in Ludwigshafen, which could be secured if it is the policy of Her Majesty's Government to set an example by siting nuclear power stations in the centre of large conurbations? Is he also aware that in London, in particular, there are many antiquated coal-fired stations occupying large chunks of land which could be released if it was the Minister's policy to put nuclear stations in Greater London itself. Will he therefore give consideration to this matter—in Greenwich, for example?

Mr. Marsh: That latter sally raises an entirely different point. As the hon. Gentleman says, the power station in Ludwigshafen is very close to a centre of population, and another station will be built 20 miles north-west of Hamburg. There is no reason why a British nuclear station could not be used for that site.

Mr. McGuire: Is my right hon. Friend aware that this review will cause some of us great disquiet, because this is a new and untried technology and there is ample proof throughout the world that the nuclear power stations in this country can be very dangerous? My right hon. Friend should hesitate very long before deciding to build in this way, because it is a new and untried technology and the results, if anything goes wrong, could be disastrous.

Mr. Marsh: My hon. Friend is not on this occasion being his normal, restrained self. Far from this being an untried technology, the United Kingdom has 132 reactor years of experience. That is a great deal of experience. It would be a great mistake for people to raise fears which are not justified. There has never been an accident to a nuclear power station in this country.

Mr. Doughty: As modern coal-burning techniques have improved enormously, would it not be better for the Minister to concentrate more on coal-fired stations, thus ensuring employment for miners?

Mr. Marsh: I think that the hon. and learned Gentleman is joining the fuel policy debate rather late in the day.

Mr. Shinwell: Does my right hon. Friend realise that there are other considerations apart from safety ones? Will he take into account in the future, apart from what is contemplated for Scotland in this particular instance, that there are social, industrial and security considerations which cannot be ignored?

Mr. Marsh: I take my right hon. Friend's point entirely. I have made a statement purely on the safety aspect. This in no way impinges on any other aspect.

Mr. Deedes: Does not the Minister's statement mean that some half dozen of these stations which have been put in remote areas and many miles of highly controversial pylon and overhead lines are now proved to be unnecessary?

Mr. Marsh: I do not think that it means that the stations are unnecessary. The stations which are farthest from centres of population—Dungeness and Wylfa—are about 60 miles from such centres. I think that it was right to wait until there was this firm evidence. This is a serious decision to take. The Nuclear Safety Advisory Committee has considered this matter and has come to a decision. I think that it was right to change the policy. This does not make the original policy wrong.

Mr. Manuel: Does my right hon. Friend recognise that there is a great deal of concern on the question of safety? Is he aware that during the past year there have been two mishaps in Scotland where dangers were very evident from radiation spread and that strict precautions had to be taken? If my right hon. Friend has moved so quickly from the previous position to that which he has enunciated today, he should tell us what grounds he has for proceeding to change the policy?

Mr. Marsh: I think that my hon. Friend should give his grounds for making that statement. I repeat that there have not been any accidental radioactive releases by United Kingdom power stations.

Mr. Edward M. Taylor: Does the right hon. Gentleman agree that the building of nuclear power stations in remote areas has some positive advantages in regional development? Will he keep this aspect in mind as well as the safety aspect?

Mr. Marsh: I think that there are also advantages in having these stations near centres of population in terms of amenity and of transmission costs.

Mr. Palmer: Would my right hon. Friend in this connection look at the American experience and refer particularly to that part of the Report of the Select Committee on Science and Technology which deals with the siting of nuclear power stations and which points out how in the United States they are getting much closer to centres of population?

Mr. Marsh: Yes. I think that there is a general recognition in advanced nations using nuclear power stations of the ability to do this in the light of experience.

Earl of Dalkeith: Will the Minister carry out a public opinion poll in any area where he is considering setting up a station, if it is in a highly populated area, before he takes a decision to site it there?

Mr. Marsh: That would be an interesting but not particularly practical constitutional innovation. I have made a statement purely on the safety aspect of siting nuclear power stations. If the hon. Gentleman believes that they are unsafe, he should say so. I do not think that it is either necessary or practical to conduct what I may describe as Gallup polls.

Mr. Ginsburg: Will my right hon. Friend publish the report of his experts? Without being alarmist, will he specifically tell the House whether there would be any danger in the hypothetical event of an aircraft crashing into a nuclear power station?

Mr. Marsh: There is no danger of a nuclear explosion in any one of these stations. The report of the Nuclear Safety Advisory Committee is highly technical, but I will consider the suggestion my hon. Friend has made as to publishing it.

Marine Propulsion

19th December, 1967

MR. WILLEY asked the Minister of Technology whether he will set up a departmental committee to examine the possibilities of nuclear marine propulsion in the light of the experimental work being carried out in other industrial countries, details of which are in his possession.

Mr. Benn: I have nothing to add to the statement I made in reply to a Question by my hon. Friend the Member for

Sheffield, Heeley (Mr. Hooley) on 5th December, in which I made it clear that the issue is being re-examined.

Mr. Willey: That was a helpful reply, but in view of the Select Committee's recommendations and of the danger that we may lose ground to our competitors in shipbuilding, will my right hon. Friend look at this matter again urgently?

Mr. Benn: I am looking at it again urgently. That was what my right hon. Friend complimented me on doing. The problem is not whether we can have a reactor in a ship, but whether it will be economic. That has always been the argument. We now bring together under the Ministry of Technology the Atomic Energy Authority, the shipbuilding industry, the nuclear industry, the marine engine industry and the British Shipbuilding Research Association. Therefore, it falls for me to examine it.

Sir H. Legge-Bourke: Would not the Minister agree that a committee similar to the old Padmore Committee might well be the best method of accelerating a decision in this matter? We have waited a long time for the decision. Although Lord Penney's voice is always well listened to, surely there are other considerations which demand other action.

Mr. Benn: Nobody has waited for a decision. There has been a decision that we will go ahead with this project when it shows promise of being economic. That is the criterion by which we have to judge all our investments. Nobody doubts that it can be done technically. I do not think that a committee is necessary when all the responsibilities in this matter have been, for this purpose among others, brought within my Department.

Thermonuclear fusion

19th December, 1967

MR. ALISON asked the Minister of Technology what expenditure is proposed in future for the British research programme on the control of thermonuclear fusion.

Mr. Benn: The intended reduction in expenditure on the fusion programme was indicated in my statement of 26th July and I have nothing to add.

Mr. Alison: Is the right hon. Gentleman aware of the terrifying problem of atomic waste which will arise from this concentration on the fission programme, particularly as the Government are to generate so much electricity by nuclear power? Will he take steps to rehabilitate the programme for nuclear fusion?

Mr. Benn: The Culham Establishment was set up to provide a means of generating electricity by means of fusion. It is now generally recognised all over the world that this programme is well over the horizon, 10, 20 or 25 years ahead, and on the advice of the Authority I assented to its recommendations that the programme should be run down. I think it was right and that I was right to accept its advice.

Mr. David Price: Will the right hon. Gentleman think again about the transfer of Culham from the A.E.A. to the Science Research Council, so that fusion can take its place with other long-term scientific projects in any review which the Government may be making in sacred cows on long-term science?

Mr. Benn: The hon. Gentleman has made this point before, and he will have noticed that recently I announced that part of the work at Culham on the astrophysical side is to be undertaken by the Science Research Council. I have told the hon. Gentleman before, and I tell him again now, that I take seriously the proposals that he makes.

Desalination plant

19th December, 1967

MR. MAXWELL asked the Minister of Technology whether he has commissioned studies of the potential market in desalination plant over the medium and long term throughout the world; and if he will make a statement.

Mr. Benn: Yes. The United Kingdom Atomic Energy Authority have carried out such studies in consultation with industry. In the four years to the end of 1966 installed capacity in the developing countries rose from 17 to 80 million gallons per day. With the urgent need for additional water in both developing and industrial countries, there is every expectation that this trend will continue and, indeed, be accentuated. This is an important and rapidly growing market in which the prospects for British industry, which pioneered its growth, are most promising.

Mr. Dalyell asked the Minister of Technology what study he has made of Mr.

de Rothschild's proposals on Water for the Middle East, in relation to desalination plants, details of which have been sent to him; and if he will make a statement.

Dr. Bray: The Department participated in a detailed inter-departmental study of the proposals. Technically, the proposals were feasible; but they presented substantial economic and political difficulties. For example, the water produced would have been unacceptably dear for most agricultural use.

A.E.A. structure

19th December, 1967

MR. ALISON asked the Minister of Technology what proposals he has for changing the present structure of the United Kingdom Atomic Energy Authority.

Mr. Benn: None at present.

Mr. Alison: Is the right hon. Gentleman aware that it is timely to consider a change? Is he aware of the abysmal record of the United Kingdom in the export of nuclear reactors, and is it not right to consider restructuring the Authority on the lines of the American Atomic Energy Authority?

Mr. Benn: This is the subject of the Select Committee's Report on the nuclear power industry. As the hon. Gentleman knows, the Government are considering this Report, but I have no proposals to put forward at the moment.

Euratom projects

19th December, 1967

MR. J. H. OSBORN asked the Minister of Technology what projects in the field of atomic energy research he is now supporting or sponsoring in conjunction with Euratom at present; if he will tabulate in the OFFICIAL REPORT the total cost, the percentage of British financing involved and in which country or countries research and development work is now being carried out for each respective project; and to what extent any of these joint projects are being delayed pending a decision on finance by Euratom.

Mr. Benn: We have no atomic energy project with Euratom exclusively. Euratom is a major partner in the DRAGON High Temperature Reactor project. That project will continue at least until 31st December, 1968, now that Her Majesty's Government's offer to bear most of the cost next year has been accepted.

Detailed information about the DRAGON is as follows:

> The total budget of the DRAGON reactor project for the period 1st April, 1959 to 31st December, 1967, is £26·5 million, of which the United Kingdom and Euratom shares are 40·8 per cent. and 46 per cent. respectively. The extension for the calendar year is expected to cost £2·1 million of which the United Kingdom will provide 86·6 per cent. on the basis described in my reply of 25th July to the hon. Member for Stockport, North. Research and development work for the DRAGON project is now being carried out in Austria, Belgium, Denmark, France, Germany, Holland, Italy, Norway, Sweden, Switzerland, United Kingdom and United States of America.

Programmes Analysis Unit

19th December, 1967

MR. DALYELL asked the Minister of Technology what work the Programmes Analysis Unit at Harwell is doing to select projects concerned with the development of the marine environment.

Dr. Bray: The Programmes Analysis Unit is carrying out a study of the benefits which might attend the application of technology in national research and development programmes within those fields of marine science and technology for which the Ministry are responsible.

Nuclear Power Programme

21st December, 1967

MR. McGUIRE asked the Minister of Power whether he will revise the nuclear power programme now that the estimated cost per unit sent out from Dungeness B nuclear power station is higher than the cost per unit sent out from coal-fired stations like Cottam, in view of the fact that the Fuel Policy White Paper assumed that it would be cheaper.

Mr. Freeson: There is no change in the estimates which calls for a revision of the nuclear power programme.

Mr. Albert Roberts asked the Minister of Power what is the cost per annum of nuclear power research; and to what extent it is a direct charge on the production of electricity produced by a nuclear power station.

Mr. Freeson: About a quarter of the Central Electricity Generating Board's revenue expenditure of £5 million on research and development in the latest year related to nuclear research, and the whole of this expenditure is charged to revenue account. As regards the United Kingdom Atomic Energy Authority's research and development expenditure, which is primarily the responsibility of my right hon. Friend the Minister of Technology, I would refer my hon. Friend to paragraphs 7 and 8 of the Authority's Introductory Memorandum published in the Report of the Select Committee on Science and Technology on the Nuclear Reactor Programme and to Appendix 3 to the Minutes of Evidence.

Mr. Albert Roberts asked the Minister of Power what is the estimated cost per unit sent out by the coal-fired power station at Cottam and the nuclear station Hinkley Point B, on the basis of a 75 per cent. load factor and eight per cent. interest rate and including the royalty paid to the Atomic Energy Authority.

Mr. Freeson: 0.56d. and 0.52d. respectively.

Mr. McGuire asked the Minister of Power if he will state the reasons for the increase in capital costs at the Dungeness B nuclear station from £104.82/kW in March 1967 to £110/kW now.

Mr. Freeson: Because interest during construction was calculated at 5½ per cent. in March 1967 and at 8 per cent. now, as mentioned in my reply to my hon. Friend the Member for Blaydon (Mr. Woof) on 13th December.

Power costs

17th January, 1968

Mr. Leadbitter asked the Minister of Power what is the nuclear cost per unit of electricity at Hinkley B power station; what is the nuclear fuel cost per unit at that station; and how this compares with the cost per unit of coal.

Mr. Freeson: The estimated baseload generation cost for Hinkley Point B nuclear power station is 0·52d./kWh of which the fuel cost accounts for 0·11d./kWh. Both figures allow for the effect or devaluation. The coal-fired power station at Drax has an estimated base-load generation cost of 0·60d./kWh of which fuel cost accounts for 0·38d./kWh.

Mr. Leadbitter asked the Minister of Power what is the latest calculated cost per unit of electricity at the Dungeness B nuclear power station; and how this compares with the best coal-fired station which can be built sited on a coalfield producing the cheapest coal.

Mr. Freeson: the latest estimate of the base-load generation cost for Dungeness B is 0·57d./kWh including the royalty payable to the U.K.A.E.A. and an allowance for the effect of devaluation. The latter was not included in the estimate in the reply I gave to my hon. Friend the Member for Mansfield on 13th December.

The estimate for Drax, the latest coal-fired station ordered, is 0·60d./kWh.

Mr. Leadbitter asked the Minister of Power if he has completed his cost-benefit study on the issue of a coal or nuclear power station at Hartlepool; and if he will make a statement.

Mr. Marsh: The study is not yet complete

Mr. Leadbitter asked the Minister of Power to what extent in drawing up the nuclear power generating programme he made a comparison with the programme in the United States of America in terms of numbers of stations, operating, under construction, on order and planned.

Mr. Freeson: Conditions in the United States were fully appreciated when the nuclear power programmes were drawn up. However, those conditions are not necessarily relevant to a United Kingdom programme. The rate of ordering new power stations must be related to the rate of growth of demand of electricity and the total size of the system.

AGR exports

17th January, 1968

Mr. Leadbitter asked the Minister of Technology what progress has been made in promoting exports in advanced gas-cooled reactor power equipment.

Mr. A. Benn: Tenders for advanced gas-cooled power reactors have been submitted in the Argentine and Belgium, and will shortly be submitted in the Netherlands and Italy. A licensing agreement has been reached with a German firm.

Discussions have been held with firms and generating organisations in a number of other countries and in some instances indicative prices have been quoted to the latter.

Hunterston B progress

17th January, 1968

MR. EADIE asked the Secretary of State for Scotland how far advanced is the building and preparation of Hunterston B nuclear power station; and how many men are employed at present on the project.

Mr. Ross: Soil stripping of the main construction area and excavation to rock on the main station site are now well advanced.

At the beginning of this month the construction site labour force numbered 138 men.

Heysham

19th January, 1968

MR. MCGUIRE asked the Minister of Power what planning objections have been raised against the proposed nuclear station at Heysham.

Mr. Freeson: None at present, though the local planning authority is awaiting details of the nuclear safeguarding requirements which are expected to be made known shortly.

Authority staffing

22nd January, 1968

MR. EVELYN KING asked the Minister of Technology to what extent the implementation of paragraph 48 of Command Paper No. 3515 will affect the number of persons employed at Winfrith.

Mr. Benn: The detailed action needed to achieve the acquired savings is being studied by the Atomic Energy Authority. It is not possible at this stage to say what the precise effect will be on the staffing of individual Authority establishments.

Fuel Policy White Paper

22nd January, 1968

MR. MCGUIRE asked the Minister of Power (1) whether, in reviewing the Fuel Policy White Paper, he will arrange to republish the information contained in table F on page 78, on the basis of the ground rules described in paragraph 5, and state whether the figures thus arrived at represent the Government's latest estimates of comparative generating costs.

(2) why, in the Fuel Policy White Paper, the figures for generating costs of nuclear and conventional power stations given in table F on page 78 were not shown on the basis of the more precedent ground rules set out in paragraph 5 of the White Paper.

Mr. Marsh: The figures of generating cost per unit in table F of Appendix III were given solely for the purpose of comparison with those in the 1965 White Paper on Fuel Policy (Cmnd. 2798). While this method is useful for comparing stations of a similar type, for the reasons given in paragraph 4 of the Appendix it can be misleading for comparing nuclear with conventional power stations. A better method of comparison is that given in table G for which the more severe ground rules were used.

Estimates of base-load generating costs on the basis of pence per kWh at the coal-fired and nuclear power stations listed in table F have been given in answer to Questions on 21st December, 1967 and 17th January, 1968. These are the C.E.G.B.'s latest estimates for the stations specified and reflect the more prudent ground rules mentioned in paragraph 5 except that the cost assumed for the initial charge of uranium fuel is the best available estimate for each station.

Insurance

23rd January, 1968

MR. EADIE asked the Minister of Power what insurance cover is taken out for nuclear power stations; and if any private insurance company has offered or been given the opportunity to give insurance cover.

Mr. Freeson: The Nuclear Installations Act, 1965, requires all nuclear licensees, including the Generating Boards, to provide £5 million cover against third party liability in respect of each licensed site. The Boards effect this cover by means of insurance policies negotiated with a syndicate of British insurers. Insurance against material damage on the sites themselves is provided in a similar manner.

Nuclear energy programme

26th January, 1968

MR. THOMAS SWAIN asked the Minister of Power if he will now appoint an independent body to conduct a complete investigation into the cost of the production of nuclear energy.

Mr. Marsh: As I said in reply to my hon. Friend, the Member for Ince, on 11th December, I know of no "independent" body with a comparable degree of expertise or experience in this field to the Atomic Energy Authority, the Central Electricity Generating Board and the Chief Scientist's Division of my Department, all of whom took part in the studies of nuclear energy costs recently made as part of the fuel policy review.

The National Coal Board also participated in the second stage of this work.

Mr. Swain asked the Minister of Power whether, in view of the present economic situation, he will suspend a major part of the nuclear energy programme; and if he will make a statement.

Mr. Marsh: No. Lower load expectations and the need for economy in capital expenditure have slowed down the start of new generating capacity of all types.

Research and development

29th January, 1968

MR. DAVID PRICE asked the Minister of Technology (1) what discussions have been held with the Atomic Energy Authority about the proposed reduction in the nuclear research and development programme of the Authority;

(2) what savings will be obtained as a result of the proposed reduction in the nuclear research and development programme of the Atomic Energy Authority.

Mr. Stonehouse: Discussions have been held with the A.E.A. about the savings which could be made in expenditure on the Authority's research and development programme as part of the recent review of public expenditure in 1968-69 and 1969-70. It has been agreed that reductions will be made amounting to over £3½ million in 1968-69 and £6 million in 1969-70. The effect of these reductions is now being studied in detail by the Authority.

Dungeness 'B' costs

29th January, 1968

MR. SWAIN asked the Minister of Power, in view of the 20 per cent. increase in the forecast cost of electricity from Dungeness 'B' nuclear power station, what the ultimate cost of electricity is likely to be from this station.

Mr. Freeson: I have no reason to suppose that the present forecast of 0·57d. kWh for base-load operation over a 20-year life will be materially increased in real terms.

Hunterston 'B'

5th February, 1968

MR. LUBBOCK asked the Secretary of State for Scotland if he will publish details of the successful tender for Hunterston 'B', in the same form as the table given on page 392 of the report of the Select Committee on Science and Technology on the United Kingdom Nuclear Reactor Programme.

Mr. Ross: Assuming, for comparative purposes, the same ground rules as were used by the Central Electricity Generating Board in compiling the table, the South of Scotland Electricity Board's estimate for Hunterston 'B' is as follows:

HUNTERSTON 'B'

	MW
1. Station output	1,250
2. Output to the Grid System ..	1,250
	Per cent.
3. Station thermal efficiency ..	41·7
	£m.
4. Tender price .. .. .. } 5. Capital cost adjustment .. }	82·72
6. S.S.E.B. direct contracts .. } 7. S.S.E.B. engineering charges.. }	5·335
8. Construction cost of station..	88·055
9. Interest during construction..	10·1
	£/kW
10. Total capital cost	78·52
11. Initial fuel charge	11·21
	89·73
12. Final fuel credit	1·39
13. Replacement fuel	28·54
14. Availability adjustment ..	—
15. Other work costs	7·56
16. Insurance	2·61
17. Total	127·05
	d./kWh
18. Generating cost	0·455

Aluminium smelter

6th February, 1968

MR. J. H. OSBORN asked the Minister of Power what consideration he has given to setting up an advanced gas-cooled nuclear reactor, or a modern thermal power station close to the steelworks of Sheffield with a view to supplying electricity at below average prices on the same basis as electricity offered to aluminium and ferro-alloy smelters.

Mr. Freeson: My right hon. Friend has given no general directions to the Central Electricity Generating Board on these matters, nor would it be appropriate for him to do so. He is, however, willing to authorise the Board to negotiate special contracts for long-term supplies to selected large-scale new consumers, subject to the conditions set out in the Government statement of 4th October, 1967.

Nuclear reactor programme

6th February, 1968

SIR H. LEGGE-BOURKE asked the Minister of Technology what is the result of the joint consideration by his Department, the Ministry of Power, the Central Electricity Generating Board and the Atomic Energy Authority of the recommendations of the Select Committee on Science and Technology on the Nuclear Reactor Programme; and what action will be taken to implement the above recommendations and the alternatives set out on pages lxxx-lxxxii of the Report of the Select Committee.

Mr. Benn: The Committee's Report is a major element in a series of discussions on the future structure of the nuclear power industry and related matters.

Complex issues are involved, and my right hon. Friend the Minister of Power and I intend to have more discussions with the industry. I hope to be able to make a statement before the Easter Recess.

Deferred power station

6th February, 1968

SIR G. SINCLAIR asked the Minister of Power which new power station will be deferred as a result of the cutback in the electricity industry's investment programme following devaluation.

Mr. Marsh: Final decisions have not yet been taken.

Dungeness 'B'

6th February, 1968

MR. WOOF asked the Minister of Power (1) what is the percentage increase in the estimated capital and operating costs of Dungeness 'B' nuclear power station between July, 1965 and the present; and when the station is expected to be operating;

(2) if he will state the reasons for the increase in the estimated capital and operating costs of Dungeness 'B' nuclear power station between July, 1965, and the present.

Mr. Freeson: The estimated base-load generating cost (including capital charges and operating costs) has increased by about 25 per cent. since July, 1965. The C.E.G.B. advise that the increase is made up as follows:

	Per cent.
Increase in price levels including the effects of devaluation	8
Changes in ground rules i.e. the use of 8 per cent. discount rate (in place of 7½ per cent.) and the use of the same rate for interest during construction (instead of 5½ per cent.)	7
Inclusion of royalty payable to the A.E.A.	3
Other causes	7

The station is expected to begin operating in 1970.

Surface materials in radioactive areas

THE first part of a new British Standard giving recommendations for the assessment of surface materials to be used in radioactive areas, gives a method of test for ease of decontamination.

BS 4247: Part 1: 1967—*Recommendations for the assessment of surface materials for use in radioactive areas. Part 1: Method of test for ease of decontamination*—gives a standard method which has been prepared with the collaboration of the Atomic Energy Research Establishment at Harwell, the Berkeley Nuclear Laboratories, the Paint Research Station, and the Admiralty Research Laboratory.

Attention is being given to the choice of surface materials to be used in working areas which are subject to radioactive contamination, because of the growing production and use of radioactive substances.

This standard test has been prepared as a preliminary to preparing a guide to the choice of materials, so that the relative "decontaminability" of various surface materials can be assessed.

Copies of BS 4247: Part 1 may be obtained from the BSI Sales Office, 101/113 Pentonville Road, London, N.1. Price 5/- each (postage 6d. extra to non-subscribers).

Power to fulfil

This article, written by Lord Penney when he was Chairman of the Authority, appeared originally in the Indian Science Reporter, published by the Indian Council of Scientific and Industrial Research.

The nature of technology

TECHNOLOGY is the modern talisman, often endowed with almost magical powers that can be put to work to change a people's fortunes. It is a talisman in which it is right to have faith, because it has the power to fulfil the hopes that rest upon it. It can be the key to economic growth.

Yet to find the right place for technology in a nation's structure poses difficult problems. Technology knows few frontiers. Its vanguard hurries on apace and will not stop for others to catch up. Countries strung out along the development line find themselves made increasingly more distant one from the other as the exponential growth rate operates.

Through the work of the Scientific Advisory Committee of the Secretary General of the United Nations, and of the International Atomic Energy Agency Scientific Advisory Committee, I have seen some of the problems that arise in the technological field in developing countries. My concern with civil nuclear energy in the U.K. and with technology generally has shown me that similar problems arise in a more advanced country. Indeed nuclear energy, with its wide span of application, from the huge power station with an output of millions of kilowatt hours per year to the radioactive source no bigger than a child's finger, is an excellent example of the pervasiveness of modern technology. Moreover, it is one to which India as well as the United Kingdom decided in the post-war years to devote scarce resources.

In industrial growth, much can be achieved in all countries through what has been called low technology, involving small improvements in widely-used products—in the field of housing, food and drink for example. But for high technology, science-based, more and more it is size that counts—size of market, of inter-disciplinary concentration, of financial resources for both R. & D. and exploitation. This is the nature of the technology gap. It is a gap not of intellectual capacity but in available resources and ability to deploy them.

A feature of this advanced technology is the large international industrial concern, able to deploy the scale of effort necessary to keep up with leaders. Technological advances and economies of scale in production yield a diversity of products and volume of output which only supra-national markets can absorb. These international business organisations have large resources of capital, scientific manpower, industrial skill and high grade salesmen whose integrated efforts are of great benefit to developing countries. They also involve some degree of national dependence on outside decisions when local manufacturing concerns are set up. Clearly for the developing country the advantages of such local concerns are considerable. Production in such cases is often an evolutionary process. Initially it may consist of little more than the assembly of components shipped out by the advanced country. As skills and facilities increase, some of the components are produced locally, until finally the developing country is itself manufacturing most or all of the complete article. This evolutionary process has been successfully followed in the production by developing countries of vehicles, domestic appliances, electronic equipment, pharmaceuticals, etc. I come to its application in the nuclear field later on.

Another feature of advanced technology is the need for state intervention. There are limits on what private industry can do unaided. The scale of development may be so large or the cost of equipment so great that the economic base required is too much for private industry. New breakthroughs may take a decade or two to reach full commercial exploitation. Sheer complexity in an interdisciplinary sense is also a limiting factor. What is at stake is not the fact of state intervention, but its nature and extent. Leaving aside the fall-out from military and space programmes, there is still, even in the most technologically advanced country, the U.S.A., a large role for public action, including the effect of the government's activities as a buyer.

These are difficult matters for the advanced countries. In developing countries, the problems are correspondingly greater. It is open to them to borrow technology as they borrow capital, and thus take advantage of what has been worked out, often at considerable cost, by those in the lead. A decision of this type requires careful thought. The alternative, and it is one which India, spurred on by Dr. Bhabha's vision, has chosen in the atomic energy field, is to set out to develop their own capability, borrowing only for a limited period and taking full advantage of local resources to hand. Economic policy will provide the background for this choice. There are strong incentives to make full use of natural resources—uranium and thorium in the case I have mentioned—plus skilled manpower. The scale of the domestic market, and the desire to minimise overseas purchases on balance of payments grounds and develop indigenous capability in manufacturing capital goods, are other very relevant factors.

Just what can be spent on the purchase of technology must be a matter for each individual country. In the U.K. the Board of Trade carried out an interesting survey recently, which showed that, in overseas technological royalty transactions, there was an adverse balance in 1964 of £18m. with the U.S.A., but with the world generally there was a favourable balance of some £3m.

The problem of choice

Science and technology are interwoven. It is not possible to separate them. Governments have to choose what support to give in face of competing claims from other sectors and arrange appropriate machinery to ensure that they get the best advice from scientists, technologists and economists before decisions are made. In the U.K., the support of science and technology has been expanded enormously since the war, and public expenditure on civil R. & D. grew from about £7m. in 1946 to its present level of some £260m. The working population of scientists and engineers has nearly trebled in the past twenty years. There is of course still an area of " little science " where rewarding advances are possible. Public funds can be rightly used to support first class people with promising ideas, where expensive equipment is not involved (though even here the cost of scientific work per scientist seems to go up over the years as the permanent equipment needed becomes ever more complex). Selection can be by their peers. But " big science " is beginning to dominate, and its claims for public support are raising new and difficult problems for the governments concerned. There is a limit to resources, and there is just not enough to go round. International co-operation is one way out—in Europe in respect of high energy physics and space it is one that has gained much support. As one gets nearer to industrial application, commercial considerations arise—as they have for instance in the European Economic Community, where it is being argued that perhaps too much effort has been put into international R. & D. projects and not enough into national ones.

The size and complexity of modern research reinforces the need for national laboratories. A national laboratory, whether in atomic energy or operating over a wider field, will be doing something that is different in kind to what can be done in industry, because the timescale is different. A few companies can afford to take a long-term view but the majority cannot. In particular, where horizons are short, where the scientific basis of the technology underlying products and processes is narrow, and where the market is very competitive, there is not likely to be much investment in research. Viewed nationally, however, this state of affairs cannot be regarded as satisfactory. A variety of considerations may be relevant—balance of payments, availability of employment, social factors, and political issues such as the overseas control of industry in the country concerned. Hence the case for national laboratories, anticipating industrial requirements on a timescale longer than that over which most firms can afford to operate. In this way, resources of staff and equipment can be concentrated, an interdisciplinary approach brought to bear, and a close interaction of basic and applied research developed. The work of such laboratories must of course be carried out in close consultation with industry e.g. by industrial representation on advisory committees. Moreover, the laboratories would be wise to accept a proportion of " trouble-shooting " problems of short-term industrial concern, which will make an immediate contribution to productivity, provide revenue, and cement the desired close relationships. Due weight must also be given to medium- and long-term problems, and part of this will involve technological forecasting of the future. Even now, the time taken from a major technological discovery to its commercial application and a real impact on the economy is measured in periods up to twenty years.

For developing countries, where resources are at a premium, the choice of areas to support is bound to be that much more difficult. Pure research has its attractions, not least to those engaged in it; but it uses resources that could be used in other ways. A measure of expenditure can be justified as a desirable form of national activity, part of the search for truth. Without some such effort, the best brains may move overseas. Clearly each country has to work out for itself what value it puts on the prestige of scientific accomplishment.

Knowledge can be acquired in other ways. I have noted how Dr. Bhabha encouraged the research scientist in India to make a major contribution to the application of knowledge through technology. In addition to pure research, there is what is now called objectively-oriented basic research, which underpins the development and use of technology. Some activity in this field is essential, whether to secure greater understanding for applied R. &. D. directed to specific ends, or to know what to purchase from overseas. The precise mix must be decided in each country, but it is better if the machinery for choice does not try to draw too sharp a distinction between technology and the science underlying it.

The United Kingdom Atomic Energy Authority are currently devoting some 25% of their civil R. & D. expenditure to basic research. Industry in advanced countries such as the U.S.A. and U.K. spends about 5% of its R. & D. funds on basic research.

Few countries can cover the whole domain of scientific research and development in all fields. Most countries have to make choices. What is important is that in the fields chosen one should aim for technological excellence, for without this it is difficult, if not impossible, to compete.

Nuclear energy

The U.K. and India have this in common —that in the immediate post-war years both countries chose to concentrate scarce resources on nuclear energy for civil uses. In many ways, the choice for the U.K. was an easier one, and the very fact that we adopted from the outset what can be seen in retrospect as an ambitious programme, brought with it economies in scale, particularly in the fuel cycle services accompanying the power reactor programme. The choice made by India needed courage and a very long vision. Since that time we have followed somewhat divergent paths in the nuclear field. Let me turn now to the particular paths followed.

The planning of Harwell officially started in 1945, and Europe's first nuclear reactor, GLEEP, was commissioned there two years later. It was 1956 before Calder Hall, the world's first industrial-scale nuclear power station was completed, and six more years passed before in 1962 Berkeley, the opening station of the first British nuclear power programme of 5,000 MW, was commissioned. This programme, which represents an investment by the electricity generating authorities of some £750m. (including initial fuel charges) in the period 1961-69, has developed the application of nuclear energy to electricity generation to the point where it is competitive with coal. Capital as well as generating costs have fallen progressively as sizes of the natural uranium gas-cooled reactor stations have increased and the technology has advanced. The advanced gas-cooled reactor (A.G.R.), using a low enriched fuel, has been chosen for Britain's second nuclear power programme of 8,000 MW, which will entail an investment of £700m.-£800m. (including initial fuel charges) by the generating authorities in 1970-75 and a correspondingly large investment in the production of enriched uranium and associated fuel facilities. These A.G.R. stations will generate electricity at a cost below that of contemporary coal-fired power stations, and the gap will widen as the A.G.R. programme develops. The cheapest power of all should come when commercial fast reactors come into use, perhaps ten years from now. Their generating costs should be significantly below those of thermal reactor stations, with capital costs no higher. The British development programme for fast reactors started fifteen years ago and currently employs nearly 700 qualified scientists and engineers out of some 1,900 working on the U.K. reactor R. & D. programme. If the fast reactor is as successful as we expect, and the nuclear share of the expanding electricity market continues to increase, plutonium supply could be a limiting factor on fast reactor installation in the 1980's. A sizeable thermal reactor programme would then still be needed. We shall soon have to choose where to concentrate our development effort for this need. The choice seems likely to lie between the steam generating heavy water reactor (S.G.H.W.R.), using low enriched uranium, or a logical extension of the gas-cooled line, either a variant of the DRAGON high temperature reactor (H.T.R.), with helium cooling and low enrichment, or development of the A.G.R., perhaps with coated particle fuel.

Behind the nuclear power programmes lies the major fuel cycle service provided by the U.K. Atomic Energy Authority, with large scale plants at Springfields for producing uranium metal and for manufacturing fuel elements, at Capenhurst for making enriched uranium, and at Windscale for fuel reprocessing. The trading activities here exceed £30m. a year and are run on a commercial basis, with a target surplus similar to those set for nationalised industries in the U.K. A significant amount of the output is exported.

This brief review of Britain's activities gives an idea of the magnitude of the effort that lies behind our nuclear power programmes. The results are available to the world through our nuclear consortia and the Authority in respect of fuel cycle services. To the U.K., this expenditure represents an investment for the future, in which nuclear power will play an ever increasing part to the benefit of the whole economy.

India's approach to the development of nuclear energy illustrates what can be done by a developing country with the necessary basic raw materials, resources of scientists and technologists, and a growing manufacturing capability. In the power reactor field, relying initially on imported technology, primarily from North America, national capacity is being developed in natural uranium heavy water reactors, engineering and management responsibility for power projects taken over, and the foreign exchange content of projects reduced. At the same time fuel plants on an industrial scale are planned, and looking to the future a fast reactor R. & D. effort is to be mounted.

To the developing country without uranium resources and with only limited manufacturing capability, the question of introducing nuclear power is not so obvious. The question may be one of timing. Particularly where cheap conventional fuel is not available, there will be a natural desire to get on terms with this important new technology with its potential of low cost electricity as soon as possible. Dependence on overseas supply for both reactor and fuel may mean a heavy call on scarce foreign exchange. Yet it is as well to be realistic about this. Technology does not advance irrespective of price and cost factors. And for a country with a small nuclear power programme and limited indigenous resources, an attempt to make a significant domestic contribution to reactor or component development, or the nuclear fuel cycle, can be enormously expensive. Such a country can, at relatively modest additional cost, look to overseas suppliers for services in this respect. It is more logical to do this, choosing if desired some particular aspect of reactor or fuel development for a limited effort on which to gain some experience.

If the saving of overseas expenditure is an important consideration, the fabrication of fuel locally is the first component of the fuel cycle which is likely to be considered. The cost of cans and components can account for between one-third and two-thirds of the manufacturing cost, exclusive of fissile material. If there is no suitable established industry to manufacture these items, the proposition is a good deal less attractive. The construction and operation of nuclear fuel reprocessing plant is unlikely to be justified economically in a country with only a small nuclear power programme.

Nuclear energy is playing no small part in promoting the development plans of nations, whether advanced or not so advanced. Nuclear power stations provide an economic means of generating electricity where indigenous fuel or water power is not available. The future will see them linked to desalination plants to provide fresh water as well, for exciting prospects are opening up in this field, but here again, the timescale may have to be long because of the competition for scarce resources.

The most widespread and ever increasing application of nuclear energy to the needs of mankind is, however, as radioisotopes; and developing countries have been quick to adapt them to their requirements in the agricultural field, in environmental studies, in medicine and in industry. India's excellent work in this field is being watched with great interest.

In both the U.K. and India, atomic energy was chosen after the war for a major government effort. That effort has covered a wide span of basic and applied research and yielded valuable dividends. In the U.K., as more resources become available for other priorities, the proportion of effort devoted to atomic energy has fallen—from 36% of government expenditure on civil R. & D. five years ago to 19% last year. The growing demand for electricity ensures an expanding need for nuclear power. Technology will not stand still, and there will be a continuing case for nationally supported R. & D. in this field. In India, the road is somewhat longer, and the target of self-sufficiency imposes special problems, while for others along the development line the most sensible present course in economic terms may be to move slowly and cautiously and to rely initially on the overseas supplier. The contribution which the peaceful uses of atomic energy can make to human well-being is enormous, but the timescale is not the same in all countries. The more advanced countries must share the heavy costs of development, but in time all countries will share in the benefits.

Cobalt-60 for Sweden

A consignment of 215,000 curies of cobalt-60 has been shipped from Harwell to a factory near Gothenburg, in southern Sweden.

This is probably the biggest single cobalt-60 consignment ever moved from one country to another. It will be installed in a gamma sterilisation plant built by the British firm H. S. Marsh Nuclear Energy Ltd., of Southampton Street, Reading, Berks., for the Swedish firm Radona A.B. The plant will be used to sterilise medical goods and will eventually have 1,000,000 curies of cobalt-60.

Lead shielding applications

"Lead Shielding Applications" is the first of a new series of bulletins, on the use of lead for radiation shielding, published by the Lead Development Association.

In 1966 the Association issued "Lead for Radiation Shielding", the first comprehensive text book ever to be published on this subject. The new bulletin series will complement this volume by showing a wide variety of illustrated examples of good practice in the design and manufacture of lead-shielded equipment and provide potential users with useful background information on the techniques and range of products offered by the lead shielding industry.

This first bulletin covers the whole field of use of lead shields: in nuclear power stations, transport containers, hospitals, laboratories and factories. Later issues will highlight each of these areas in turn and deal with them in much greater detail.

Copies of " Lead Shielding Applications " are available free of charge from the Lead Development Association, 34 Berkeley Square, London, W.1.

Nuclear electronics symposium

The Société Française des Electroniciens et des Radioélectriciens is organising an International Symposium on Nuclear Electronics conjointly with the French Atomic Energy Commission. The symposium will be sponsored by the International Atomic Energy Agency.

The meeting will be held in the Palais des Congrès at Versailles, France, on 10th-13th September, 1968.

The 1968 symposium is a follow-up to the Nuclear Electronics Conferences held in Belgrade in May 1961 and in Bombay in November 1965 and to the International Symposia on Nuclear Electronics held in Paris in September 1958 and in September 1963. It will be devoted to the electronics associated with experimentation in the field of nuclear and corpuscular physics.

Further information is available from Colloque International sur l'Electronique Nucléaire, P.O. Box 17, 78, Chatou, France.

A.E.R.E. Post-Graduate Education Centre

The following courses are due to be held at the Post-Graduate Education Centre, A.E.R.E., Harwell, Didcot, Berks. Further information and enrolment forms can be obtained on application.

Science and Mathematics Teachers

1st to 5th April, 1968

Intended to give a background knowledge of current developments in some of the subjects investigated at A.E.R.E. and provoke interest in recent applications rather than to provide material directly applicable to a school syllabus. For science teachers the course will cover some applications of nuclear physics, particularly those at A.E.R.E. For mathematics teachers the course will comprise a series of lectures with the emphasis on practical mathematics at A.E.R.E. with particular reference to the impact of computers on the formulation and solution of problems encountered in scientific research. There will also be an alternative section giving an introduction to the use of radioisotopes in schools in the physics, chemistry and biology syllabus. Fee: £3 3s. exclusive of accommodation.

Measurement of Radioactivity

22nd April to 10th May, 1968

Intended for those having elementary knowledge of radioactivity who need to have theoretical and practical knowledge of a wide variety of counting methods with special reference to their interrelation, scope and limitations. Fee: £78 15s. exclusive of accommodation.

Advanced Reactor Technology

22nd April to 17th May, 1968

Designed for experienced physicists and engineers. The main emphasis will be on reactor systems already developed or now being developed for industrial exploitation. The first week of the course will be at A.E.R.E., Harwell, followed by one week at the Calder Operation School and two weeks at A.E.E., Winfrith. Fee: £105 exclusive of accommodation.

Magnet Design

29th April to 3rd May, 1968

Intended for design engineers and scientists with or without experience in the field. Covers basic theory, materials, Fabry factors for coils forces on coils, digital and analogue computation and computer calculations, field-measurement techniques, technology of low temperature and cryogenic magnets, practical winding design and construction techniques, superconducting and pulsed magnets. Fee: £26 5s. exclusive of accommodation.

Reactor Safety

6th to 31st May, 1968

Designed to cover all aspects of nuclear technology relating to safeguards and safety assessments of the more important reactor systems and intended for senior engineers and scientists with some years experience, preferably in reactor design and/or operation. They should be engaged now or in the future on the safety assessment, regulatory control, or inspection of nuclear reactors. Fee: £105 exclusive of accommodation.

Radioisotopes in Industrial Measurement and Control

20th to 24th May, 1968

Intended for professional engineers and others who need to keep up-to-date with modern methods of examination and control. Among the subjects included are: industrial tracing, mixing and bulk flow, wear measurement, radioactivation analysis, γ-radiography, thickness and density measurement and X-ray spectrometry. Fee: £26 5s. exclusive of accommodation.

Introduction to Reactor Instrumentation and Control

23rd to 31st May, 1968

Held at Durley Hall, Bournemouth, and intended primarily for graduates who are new to the nuclear reactor field and who need a broad knowledge of these subjects. Participants should have some basic knowledge of nuclear reactors, electronics, the measurement of physical quantities and automatic feedback control. Fee: £36 15s. exclusive of accommodation.

Radiological Protection

10th to 14th June, 1968

Designed to give users of radioactive substances and radiations a broad introduction to the principles and practice of radiological protection. Fee: £26 5s exclusive of accommodation.

Isotopic thermoelectric generators

BRITISH built isotopic thermoelectric generators are today in operation at a number of locations in the seaways of Europe, being utilised to power marine navigational aids. The technical development, applications and potentialities of these important new low-to-medium power sources, in which Britain leads the world, were the subjects of a colloquium organised by G. V. Planer Ltd. and Submarine Cables Ltd. in co-operation with the Atomic Energy Research Establishment, Harwell. It was attended by an invited audience representing various interested sectors of industry and Government, both from this country and abroad.

The colloquium, held on 30th January at the Washington Hotel in London, was chaired jointly by Dr. M. J. Poole, Head of the Applied Physics Group at Harwell, Dr. G. V. Planer of G. V. Planer Ltd., and Mr. G. H. Foot of Submarine Cables Ltd.

In his introductory remarks, Dr. Poole pointed out that power sources operated by isotopic thermoelectric generators afford considerable advantages of unattended maintenance-free operation over long periods of perhaps 5-10 years. Such requirements exist in locations which are remote or inaccessible and which therefore would involve costly maintenance and refuelling operations. Typical applications include marine and aircraft navigational aids, telecommunication systems, submarine cable repeaters and unmanned weather stations.

The colloquium was broadly based on the RIPPLE (Radio Isotope Powered Prolonged Life Equipment) project commenced at Harwell some 5 years ago, which has now reached the commercial exploitation stage. The joint sponsors of the colloquium, Submarine Cables Ltd., and G. V. Planer Ltd. have been collaborating with A.E.R.E. over the past few years in an intensive programme of development of isotopic thermoelectric power generators. The two firms are now the U.K.A.E.A. licensees for the commercial exploitation of, respectively, full generator systems and thermoelectric modules.

Two lines of discussion emerged during the course of the colloquium. One was the present practical operation of generators in such applications as marine navigational lights and aircraft ground radio beacons. The other was the direction of technical effort towards generators having higher efficiencies and hence lower prime cost, as well as towards generators having higher power outputs so as to extend their use to a wider range of applications.

Performance details of the RIPPLES which have so far been produced and operated in the field were reviewed in a lecture by Mr. F. W. Yeats of A.E.R.E. RIPPLES V, VI and VII are 1-watt generators having a minimum planned life of 5 years and are now being used to power marine warning lights in an evaluation conducted jointly between the U.K.A.E.A. and the lighthouse authorities of the U.K., Sweden, and Denmark. RIPPLE V was first operated over 14 months ago and after 6 months continuous running in the laboratory, was then installed off the Kent coast in May 1967 to mark the cooling-water intake of the Dungeness nuclear power station. RIPPLE VI, which became operational over 8 months ago, was installed in the Stockholm Archipelago in October 1967; RIPPLE VII became operational some 9 months ago and was installed off the coast of Denmark in August 1967. Mr. Yeats reviewed the characteristics of these units and confirmed that they have functioned satisfactorily since they first became operational.

RIPPLES I and II are 75 and 90mW demonstration generators and were first operated nearly 3 years ago, in March 1965. These are still functioning successfully, demonstrating their long term reliability, and have been transported to many parts of the world for display purposes. RIPPLE II was featured in the U.K. Pavilion at Expo '67. RIPPLE III, a 750mW experimental prototype was loaned to the U.S. Navy in March 1967 and will shortly undergo deep sea trials in the Pacific Ocean. RIPPLE IX, a 4W unit powering an aircraft ground radiobeacon, is to be installed in the very near future on the approaches to Benbecula airport in the

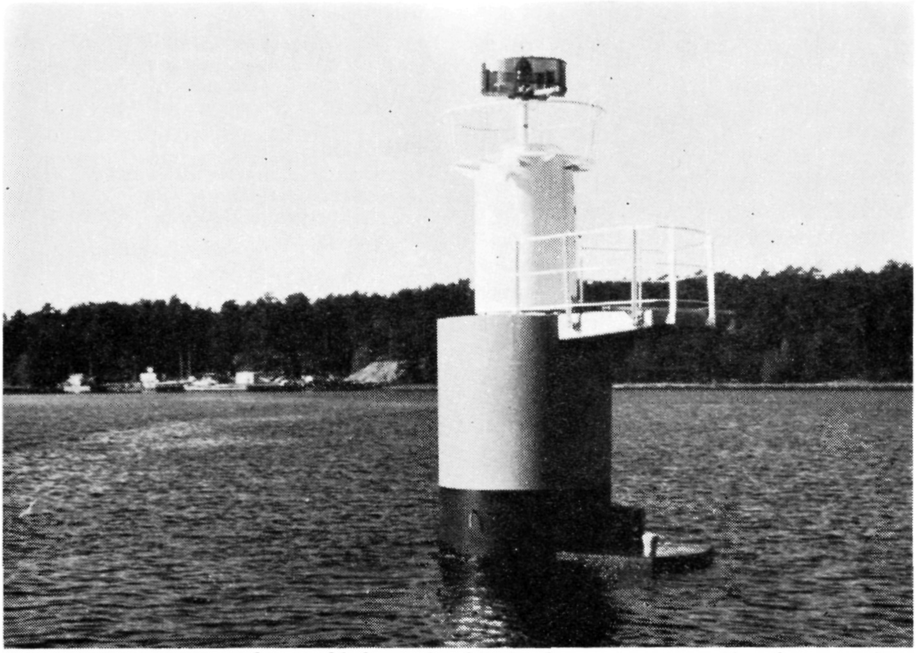
Hebrides. RIPPLE IV, a 2W submarine cable repeater, is now in an advanced stage of construction, and a prototype of the series X RIPPLES (which will cover the ranges 8-40W output) is also under construction.

The opening lecture by Mr. L. S. Phillips of G. V. Planer Ltd. dealt with the general principles governing the selection of materials and constructional techniques of isotopic thermoelectric generators, and the attainment of maximum conversion efficiencies. The generators comprise basically a radioisotope heat source (strontium 90), thermoelectric modules to convert the heat to electrical energy and a unit to convert the output of the thermoelectric modules to the voltage required in the particular application. The paper discussed the importance of ensuring absolute reliability of the thermoelectric modules and the methods adopted to achieve this object.

Thermoelectric materials were discussed by two speakers. Mr. Christie of G. V. Planer Ltd. examined the practical aspects of the preparation and the properties of the materials now available for thermoelectric generation. He also dealt in some detail with the problem of producing modules having a maximum degree of reliability.

Looking at the theoretical background of the materials, Dr. H. J. Goldsmid of Bath University of Technology reviewed the parameters which led to the development of existing alloys and examined the factors limiting their performance. With these points in mind Dr. Goldsmid considered

The first British isotope-powered marine light to be used abroad (right) is installed on the west coast of Sjaeland, alongside the existing acetylene lamp.



A RIPPLE generator in the Stockholm archipelago. The generator provides electricity for a flashing navigation light marking a group of rocks called Tegelhallorna which are a hazard to shipping entering and leaving the port of Stockholm.

ways in which existing thermoelectric alloys can be improved, concluding that there is here considerable scope for advancement, and hence the promise of a really worthwhile increase in overall generator efficiency.

The practical aspects of RIPPLE generators were developed in more detail by three speakers, each covering a particular field of application. Mr. I. C. Clingan of Trinity House considered the requirements of power, life, maintenance, refuelling, safety and cost. He concluded that a considerable potential existed for the use of isotopic generators, both for minor and major marine navigational aids.

Mr. J. O. Clark of B.O.A.C. similarly discussed the economic and commercial potential of isotopic generators in civil aviation, emphasising the significance of the additional freedom thereby afforded to aviation authorities in the siting of communication and navigation aids. He detailed the first application to civil aviation of the RIPPLE IX ground radio beacon in the Hebrides.

In the concluding lecture, Mr. J. Rice of Submarine Cables Ltd. summarised the practical aspects and potentialities of isotopic generators for both terrestrial and submarine application. These included considerations of performance and life in relation to dimensions, weight, and prime-cost, as well as the applications foreseen on land and at sea in locations where regular access is difficult or expensive.

After a final period of lively discussion, particularly centred around the comparative economics of isotopic power generators and alternative types of generation, Dr. J. Gaunt of A.E.R.E., in conclusion summed up the present situation as one of commercial exploitation of the existing range of isotopic generators, backed up by the new generation of more efficient, higher powered systems now coming into being.

The theme of the colloquium was illustrated by a comprehensive display of generators and components. These included RIPPLE II, powering a marine, flashing light unit shown by A.E.R.E., a 4W generator powering an underwater hydrophone system and a submarine cable system; the last two were constructed by Submarine Cables Ltd. The direct conversion of heat to electrical energy employing thermoelectric modules was demonstrated practically by G. V. Planer Ltd., together with a display of a range of production and experimental generator modules, and an illustration of their general construction.

A.E.A. Reports Available

THE titles below are a selection from the February, 1968, "U.K.A.E.A. list of publications available to the public". This list is obtainable free from the Librarian, A.E.R.E. Harwell, Didcot, Berkshire. It includes titles of all reports on sale, translations into English, books, periodical articles, patent specifications and reports which have appeared in the published literature. It also lists the Depository Libraries in the U.K. and the countries with official atomic energy projects who receive copies of U.K.A.E.A. unclassified reports.

AERE-Bib 158
List of Unclassified Documents, Lectures, etc. by the Staff of the Analytical Sciences Division, A.E.R.E., Harwell, 1967. Compiled by J. M. Leatham. January, 1968. 13 pp. H.M.S.O. 2s. 6d.

AERE-M 1763
A Calibration Rig for Gamma Radiation Close-rate Meters. By J. Stephenson. November, 1967. 36 pp. H.M.S.O. 6s.

AERE-R 5086
Yields from Neutron Induced Fission. By I. F. Croall. November, 1965. Unclassified reprint, January, 1968. 31 pp. H.M.S.O. 4s. 6d.

AERE-R 5436
Natural Convective Boiling of the Alkali Metals—A Critical Review. By J. G. Collier and P. G. Kosky. September, 1967. 79 pp. H.M.S.O. 11s.

AERE-R 5587
The Separation, Purification, Mounting and Counting of Fission Products. By J. G. Cuninghame, J. A. B. Goodall, G. P. Kitt, C. B. Webster and H. H. Willis. October, 1967. 83 pp. H.M.S.O. 12s.

AERE-R 5591
The Gamma Irradiation Facility on the Harwell Linac. By C. A. Baker, P. P. Thomas and D. R. Williams. November, 1967. 17 pp. H.M.S.O. 4s.

AERE-R 5606
Chromatographic Determination of Hydrogen Isotopes in Zirconium Alloys by Carrier Gas Extraction. By R. Perkins and M. J. Moreton-Smith. December, 1967. 9 pp. H.M.S.O. 1s. 9d.

AERE-R 5637
The Determination of Plutonium Alpha Activity in Urine by Surface Adsorption and Ion Exchange. By J. D. Eakins. December, 1967. 14 pp. H.M.S.O. 2.s 6d.

AERE-R 5639
The Mechanical Properties of Hydrogenated Zircaloy-2 Containing Selenium Additions. By G. P. Walters. December, 1967. 13 pp. H.M.S.O. 3s.

AERE-R 5642
Assessment of Data from an Automatic Neutron Diffractometer Installation. By J. W. Hall and K. C. Turberfield. November, 1967. 10 pp. H.M.S.O. 1s. 9d.

AWRE O-63/67
Neutron Cross Section of Copper in the Energy Range 0.0001*eV to* 15 *MeV—Sources of Data for Files* 249 *to* 251 *in the UKAEA Nuclear Data Library.* By S. M. Offord and K. Parker. December, 1967. 77 pp. H.M.S.O. 11s.

AWRE O-71/67
Theoretical and Experimental Field Limitations in Cylindrical Flux Compression Experiments. By C. S. Speight. December, 1967. 23 pp. H.M.S.O. 4s.

CLM-R 75
High Frequency Electrostatic Waves in a Non-Uniform Plasma in the Presence of a Magnetic Field. By C. N. Lashmore-Davies. 1967. 17 pp. H.M.S.O. 3s.

PG Report 775(CA)
Analytical Method for the Determination of Strontium in Bone, Milk and Vegetable Ashes Using the Unicam SP 90 *Atomic Absorption Spectrophotometer.* 1967. 6 pp. H.M.S.O. 1s. 2d.

TRG Report 1424(R)
Fuel Management Studies for the Dungeness B Reactor. By D. E. Billington and M. H. Dean. February, 1967. 24 pp. H.M.S.O. 3s. 6d.

TRG Report 1466(R)
Attow. A Two-Dimensional Shielding Program. By W. D. Collier and G. C. Curtis. 1967. 56 pp. H.M.S.O. 8s.

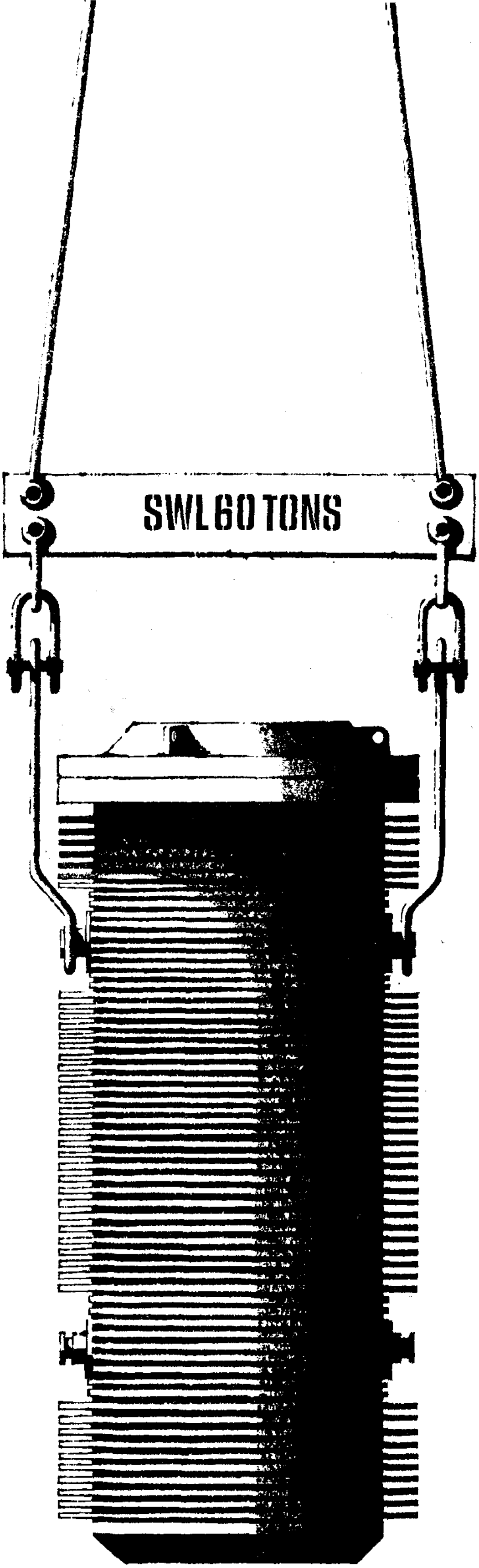
TRG Report 1561(D)
Calculation of Relative Displacement Damage Rates in Differing Reactor Types. By I. R. Birss. August, 1967. 16 pp. H.M.S.O. 3s.

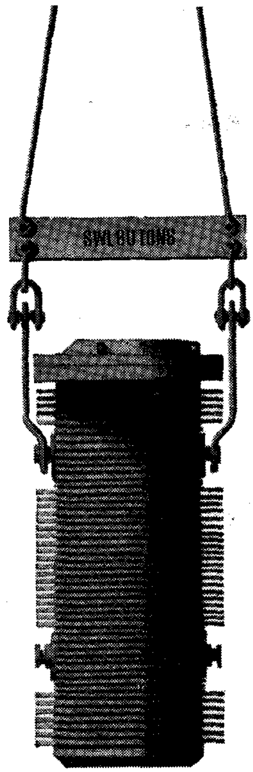
TRG Report 1578 (W)
The Adsorption of Krypton and Zenon from Argon by Activated Charcoal. By D. A. Collins, R. Taylor and L. R. Taylor. September, 1967. 18 pp. H.M.S.O. 2s. 6d.

Medical Monograph

A new Medical Monograph "The study of vitamin B_{12} absorption using labelled cobalamins", by D. L. Mollin and A. H. Waters, has been published by the Radiochemical Centre, Amersham.

Copies are available from the Radiochemical Centre, Amersham, Bucks.





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