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UNITED KINGDOM ATOMIC ENERGY AUTHORITY

The Report on Windscale

On Friday, 8th November, 1957, the Prime Minister made a statement in the House of Commons on the accident which occurred at the U.K.A.E.A. Windscale Works, Cumberland, on 10th October, 1957. A White Paper on the accident was also placed before Parliament. On the afternoon of the same day a Press Conference was held by the Authority at Church House, Westminster. Printed below is a summary of the White Paper ("Accident at Windscale No. 1 Pile on 10th October, 1957." H.M.S.O. Cmnd. 302. 1s. 3d. net). A report of the Press Conference appears on a later page.

A MEMORANDUM by the Prime Minister, with which the White Paper opens, states that "the accident occurred during a routine maintenance operation called the 'Wigner release' which has to be carried out at intervals."

(In a reactor of the Windscale type, bars of uranium fuel (sealed into metal cans) are arranged in channels through a block of graphite—50 feet in height and width and 25 feet thick. The purpose of the graphite is to slow down the "neutrons" given off in nuclear fission so that the chain reaction can take place. As the neutrons are slowed down they lose energy some of which is stored in the graphite. It is known as "Wigner energy" (being called after a professor at Princetown University who first predicted this effect). To deal with it reactor operators periodically arrange a "Wigner release," to get rid of the "Wigner energy" under controlled conditions. Their method for doing this is to heat the graphite above the temperature which would be normal when the reactor is in everday operation. The "Wigner energy" is then dissipated as heat and the reactor can go back to its normal routine.)

The Prime Minister's memorandum states: "The immediate cause of the accident was the application too soon and at too rapid a rate of a second nuclear heating to release the Wigner energy from the graphite, thus causing the failure of one or more cartridges in the pile, whose contents then oxidised slowly, eventually leading to fire in the reactor. There were no experiments either for civil or military purposes being done in the pile during the time of the Wigner release with one insignificant exception, having no relevance to the accident."

The "insignificant exception" is defined in the report of the Committee of Inquiry, on p. 10 of the White Paper which states: "There are vertical channels in the pile used for experiments connected with the civil reactor programme. At the time of the accident, all of these channels were empty except one which contained a small magnet under test. There were no experiments either for civil or military purposes being done in the pile during the time of the Wigner release, except for the magnet mentioned in the previous sentence." The report points out that lithium-magnesium cartridges were in the reactor "for the purpose of irradiation" (not for experimental purposes).

Weaknesses of Organisation

The Prime Minister states that the Authority ascribe the accident "partly to inadequacies in the instrumentation provided at Windscale for the maintenance operation that was being performed at the time of the accident and partly to faults of judgment by the operating staff, these faults of judgment being themselves attributable to weaknesses of organisation." He adds: "I accept this."

Referring to the Report of the Committee of Inquiry which met under the Chairmanship of Sir William Penney, the Prime Minister comments: "It is a technical document dealing with the design and operation of a defence installation. It also presupposes considerable knowledge of the technology of this particular pile. It would not be in the national interest to publish it. I therefore asked the Committee of Inquiry to prepare a less technical version of their report on the cause of the accident and the measures taken to deal with it."

The Committee of Inquiry express the view in Annex I of the paper that "steps taken to deal with the accident once it had been discovered were prompt and efficient and displayed great devotion to duty on the part of all concerned."

The Committee's report on measures

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The Prime Minister's Statement

THE following statement was made in the House of Commons by the Prime Minister on Friday, 8th November, 1957:

"With permission I will make a statement on the accident at Windscale.

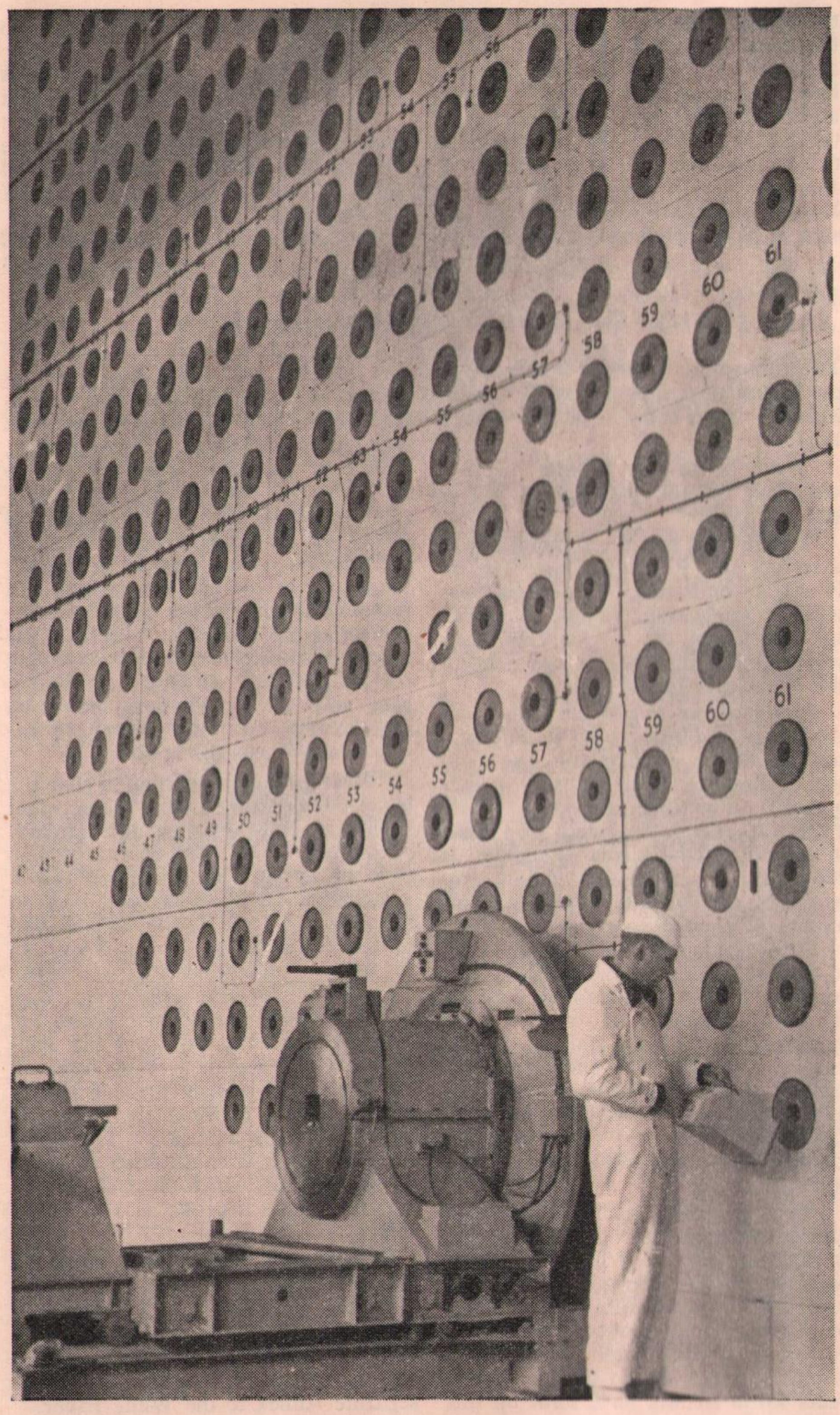
"I have now had the opportunity of assessing the Report of Sir William Penney's Committee. This Report was made to the Atomic Energy Authority to assist them in discharging their responsibility for the management of the Windscale Establishment.

"I am anxious to give the House and the country the fullest possible information about the accident and the measures taken to deal with its consequences. For this purpose a White Paper has been presented to Parliament and will be available today. It contains a less technical version, prepared by Sir William Penney's Committee, of their Report on the cause of the accident and the measures taken to deal with it. The White Paper also contains the Committee's Report on the measures taken to protect those employed at the plant and the general public, together with the comments thereon of a special independent Committee set up by the Medical Research Council. I informed the House on October 29th that I had asked for these comments.

"This accident occurred during a routine maintenance operation, which is described in the White Paper. It was, of course, a serious matter, and caused disturbance to a large number of people. Hon. Members will, however, wish to consider this matter in a proper perspective. In the last twelve years we in Britain have built up this new industry without a single serious injury caused by radiation, and there is no evidence that this accident has done any significant harm to any person, animal or property. That this was so is due to the Atomic Energy Authority's general care for health and safety, to the general effectiveness of the safeguards built into the Windscale piles, and to the courage, energy and resourcefulness of those at the installation after the accident. I believe the House will wish to join me in paying tribute not only to their efforts, but also to the quiet confidence and absence of alarm of the general population in the Windscale area.

"What is important now is that the lessons to be learned from the accident should be fully digested and applied; on the one hand, to do all that is possible to ensure that there will never again be a similar occurrence; and, on the other, to see how the organisation of the Authority can be improved in the light of the Windscale experience. To this end Sir Alexander Fleck has, at my request, agreed to evaluate the technical data derived from the accident and to recommend what measures are needed to remedy the deficiencies in organisation to which the Authority have called my attention. The terms of reference and constitution of three committees, of which he will be the Chairman, are set out in the White Paper.

"Lastly, I can give the House the reassurance that the accident at Windscale has no bearing on the safety of the nuclear power stations being built for the Electricity Authorities. The reasons for this are fully set out in a separate Annex to the White Paper."



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taken by the Authority staff to protect the workers at Windscale and the general public (these included restrictions on the distribution of milk) is given in full. Also included in the White Paper is an independent report by the Medical Research Council who, in their conclusions, say: "After examining the various possibilities, we are satisfied that it is in the highest degree unlikely that any harm has been done to the health of anybody, whether a worker in the Windscale Plant or a member of the general public."

A memorandum by the Chairman of the Atomic Energy Authority, Sir Edwin Plowden, states that the Authority, in addition to taking immediate measures to deal with organisational weaknesses, suggested to the Prime Minister that he should appoint some independent person of standing, who has experience of large-scale organisations operating processes involving hazardous materials, to undertake "a more comprehensive evaluation of the remedies that are required." In his introduction to the White Paper, the Prime Minister announces that he has asked Sir Alexander Fleck, Chairman of Imperial Chemical Industries, Ltd., to undertake this task. Three Committees will be set up under Sir Alexander's chairmanship for this purpose.

Calder Hall and the Commercial Stations

In Annex V to the White Paper, the Authority gives the reasons why a similar accident could not occur in the Calder Hall reactors or in those being built by the Electricity Authorities. This annex is reproduced in full below.

THE accident which happened at Windscale could not happen with the Calder Hall reactors or with the reactors being built for the Electricity Authorities. Important differences exist between the Windscale Piles, the more recently designed Calder Hall reactors, and the still more advanced reactors for the Electricity Authorities. The later reactors incorporate improvements based on the experience obtained in designing and operating the earlier reactors.

In the Calder Hall and Electricity Authorities' reactors Wigner releases will be required much less frequently. The minimum temperature of the graphite at Calder Hall in normal operations is higher than the corresponding temperature at Windscale. The minimum operating temperature of the graphite in the first stations now under construction for the Electricity Authorities will be higher still. For this reason some annealing of the graphite will be going on continuously in the Calder Hall reactors and in the civil power reactors, and the storage of Wigner energy in the graphite will proceed at a much slower rate. All the evidence accumulated up to the present time indicates that these reactors will be able to operate for about five years before a Wigner release is required. This is being continuously checked by monitoring of the graphite in Calder Hall and by accelerated tests of graphite in the DIDO research reactor.

Opposite: The charge hoist space and charging face of No. 2 pile, Windscale. The charge hoist space is pressurised and can be entered by means of an airlock when the reactor is shut down. The picture shows the charge machine and an operator monitoring a loading port.

When a Wigner release becomes necessary, it will not present any hazard because it can be conducted under fully controlled conditions, viz:—

(*a*) Whereas the Windscale Piles are cooled by air the Calder Hall type reactors are cooled by carbon dioxide which does not react with uranium until appreciably higher temperatures than those at which the air reaction starts. In still air uranium oxidises, i.e. the reaction is self-heating at 350°C.; the corresponding temperature with carbon dioxide is 650°C.—700°C. The safety margin during a Wigner release operation will, therefore, be very much greater.

(*b*) In the Windscale Piles the air coolant is discharged into the atmosphere through a high stack. In the Calder Hall reactors the carbon dioxide coolant circulates in a closed circuit. The use of carbon dioxide as a coolant in a closed system makes it possible to keep the temperature generated by a Wigner release under close control by the use of the main cooling fans.

(*c*) The scanning gear in the Windscale Piles is of the moving type and is designed to move upwards and downwards across the Pile discharge face. At the high temperature experienced during the Windscale accident this gear jammed. The detection equipment in Calder Hall and in the Electricity Authorities' stations is fixed and provides a method of monitoring each fuel element channel without movement. Continuous monitoring, therefore, of the integrity of the fuel sheath will be carried out while Wigner releases are in progress, thus providing continuous information about the condition of the fuel elements. This will enable immediate remedial

Inside No. 1 *pile Windscale after the incident. Scientists dressed in anti-contamination protective clothing are collecting samples of water from the water-duct that runs from the bottom of the pile to the cooling pond. This duct is used to transport discharged fuel elements from the reactor to the pond.*

action to be taken to deal with any damaged fuel element.

(*d*) The fuel cartridges in Calder Hall are of much improved design and experience has shown that their failure rate is much lower than the failure rate of the Windscale fuel elements, and the rate of attack by carbon dioxide has been shown to be very slow. The fuel cartridges for the Electricity Authorities reactors will incorporate these and further improvements.

(*e*) The instrumentation and control system for regulating, inter alia, the rate of pile power change in the Calder Hall and Electricity Authorities' reactors is much improved over those in the Windscale reactors. These improvements will provide additional important safeguards.

As stated above the graphite in Calder Hall is being periodically checked for storage of Wigner energy and accelerated tests of stored energy are being carried out in the Harwell research reactor DIDO. If these and other tests should show any new factors, there is ample time to introduce additional safeguards, e.g. by filling the reactor circuit with an inert gas during the Wigner releases.

Even if a fuel cartridge failed in a reactor of the Calder Hall type and a reaction began between the uranium and the coolant causing a release of fission products into the coolant, it would be immediately detected for the reasons given above and could be brought quickly under control by using the main fans to reduce the temperature. The amount of radioactive material which could be released into the closed circuit would, therefore, be small, and the amount that could escape into the atmosphere from leakages in the closed circuit would be too small to constitute any hazard.

The Press Conference

The extracts below are from statements made at the Press Conference at Church House, Westminster on 8th November, 1957, by Sir Edwin Plowden, Chairman, U.K.A.E.A.; Sir William Penney, member of the Authority and Chairman of the Windscale Committee of Inquiry; and Sir Harold Himsworth, Medical Research Council, who was Chairman of the M.R.C. Committee which investigated the health and safety aspects of the accident.

SIR Edwin Plowden, opening the Conference, said:—

"The Authority have accepted the findings of the Committee of Inquiry and pending receiving Sir Alexander Fleck's recommendations, we have taken steps to strengthen our Health and Safety Organisation and have increased the already extensive research effort which is working on those various aspects of reactor technology which might have a bearing on the accident. We have also asked the Medical Research Council to lay down for our guidance the maximum permissible level of exposure to radioactive substances when exposure takes place for a limited period rather than as a continuous lifetime dose.

"Sir William Penney will tell you how the accident occurred. It was due to human errors, and these errors, in our view, were due partly to weaknesses in organisation and partly to insufficient instrumentation of the pile, so that the people who were operating the pile had not enough information and guidance for the operation they were performing. For these reasons, we consider the responsibility to be a collective one and no disciplinary action will be taken against any individual or group of individuals.

"We also decided that we would like to have the benefit of outside experience in going into what should be done to see that this could not occur again. We therefore recommended to the Prime Minister that he should ask some independent person of standing with wide experience of large scale organisation operating processes involving hazardous materials so that he might recommend technical and organisational improvements.

"The Prime Minister has done this,

and we in the Authority will welcome the appointment of Sir Alexander Fleck, Chairman of I.C.I. Limited, who has undertaken to do this work. This work will involve not only the evaluation of the technical lessons to be learned and the looking at the organisation of the operations branch of the Industrial Group, but it will also involve looking at the relationship of that branch to other branches in the Industrial Group and to part of the Research Group at Harwell. We are quite sure that his unrivalled experience will be of the greatest help to us.

"Naturally, people have been anxious to know whether the Windscale accident carried any implications to nuclear power stations at Calder Hall and for those under construction for the electricity authorities. For this reason we have prepared a note on this subject and you will find at at Annex V of the White Paper. The accident which happened at Windscale could not happen at Calder Hall or at any of the later reactors being built for the C.E.A. and the Scottish Electricity Authority.

"In conclusion, I would like to say two things, first to reaffirm the regret of the Authority for all the disturbance and anxiety which was caused to so many people in the area of Cumberland around the Windscale Works. Second, to say how much we in the Authority appreciate the great devotion to duty of all those at Windscale who so successfully dealt with the accident once it was discovered."

The Causes

Sir William Penney, after outlining the events which occurred at Windscale before and after the accident was discovered, spoke on the causes of the mishap.

"The Committee of Inquiry," he said, "believe that the thing that caused the trouble was the second nuclear heating. Heat was put into the pile, we feel, before it had been shown to be necessary and, for a bit, it was put in too fast. What we think happened was that some uranium fuel cartridges in the front lower part of the pile were damaged by this nuclear heat."

These were not cartridges for which temperatures were recorded, Sir William continued. Those that were being recorded were 16 feet back from the face of the pile.

"The nuclear heat was being applied into the front of the pile," Sir William went on, "so that the operator did not realise that the nuclear heat was a good deal worse in front than it was where his instruments were recording.

"This nuclear heat, we feel confident, caused the failure of one or more cartridges. But now it is a matter of probability. We think it was a fuel cartridge, one or more, which failed and exposed the uranium, which then smouldered and then gradually incubated until the fire was going. But we cannot entirely eliminate the possibility that the second nuclear heating tripped off more Wigner energy and this built up the temperature where some lithium-magnesium cartridges failed. And if this had happened, then these cartridges could have smouldered and caused the fire. These lithium-magnesium cartridges were there as part of the military programme. It was a straight production job: it was not an experiment.

"We looked carefully at a lot of other cartridges that were in the pile, cartridges for producing isotopes for civil and industrial use. We gave them a completely clean bill of health; they did not cause the accident.

"We were also quite sure that it was not just a pocket of Wigner energy which caused it: that is to say, the Wigner energy plus the second nuclear heating did it: it was not just the Wigner energy. And we also exclude that the graphite itself was the cause of the trouble."

Sir William went on to describe the measures taken to protect those working on the site and the public. Those workers most exposed, he said, were the men on the charge hoist who were extracting the uranium slugs. "We have got the records of what doses those men had," he went on, "their film badges showed what they had.

"By the Regulations of the Atomic Energy Authority, no worker shall have more than 3 r in a 13-week period; that is the regulation today. It used to be, until quite recently 3.9 r. There were 14 men who had more than 3 r in a 13-week period, that is to say including the incident, and the highest of these had 4.66 r as against 3 r now, and what it used to be—3.9 r. These men, in accordance with the standard practice, were taken out of contact with all radioactive work. Of course, they will be working, but they will not be working where they can get any more rontgens for some time—another 13 weeks or so.

"After the incident the medical people and others at Windscale did a lot of measurements on our staff as well as on the public to measure the iodine, and what we found was this: the highest value in one worker that we found was 0.5, half a milli-curie of iodine in his thyroid.

"On Thursday the health physics people first found the activity, and one van was already out on routine patrol. The second van was sent out at 3 o'clock on Thursday afternoon, and it was sent out in the direction that the wind-gauge showed, along a cinder-track towards Seascale. This van was given the job of making as quickly as possible a survey of where there was activity. The highest value that they found was near a bridge at Seascale; it was 4 milli-curies per hour, which is a very small value; this, they thought, was coming from stuff drifting overhead.

"The health physicist in charge had to think of three things: he had to think of gamma-radiation to the public; he had to think of breathing risks; and he had to think of ingestion risks that is to say, eating or drinking. By Friday morning he was already collecting samples. He had got samples of the milk from the cows on Friday morning, and he managed to get some from the Thursday afternoon. And from then on samples of milk were taken from the area as a regular thing.

"He concluded—and I am sure absolutely correctly—that there was no inhalation risk to the public; there was no gamma-radiation risk to the public; he concentrated on the ingestion risk —and this was milk and vegetables.

"It takes a certain time for the cow to eat the grass and for the iodine to get into its milk, and it takes time to obtain the measurements. The first measurements of milk were made by Saturday morning, and the first ones were very low; this was some of the earlier milk. It was soon followed by later milk, and by 3 p.m. on Saturday the results of the Saturday morning milk were obtained, and the health physicist then said to the General Manager: 'We must take some of this local milk out of circulation.' That was done."

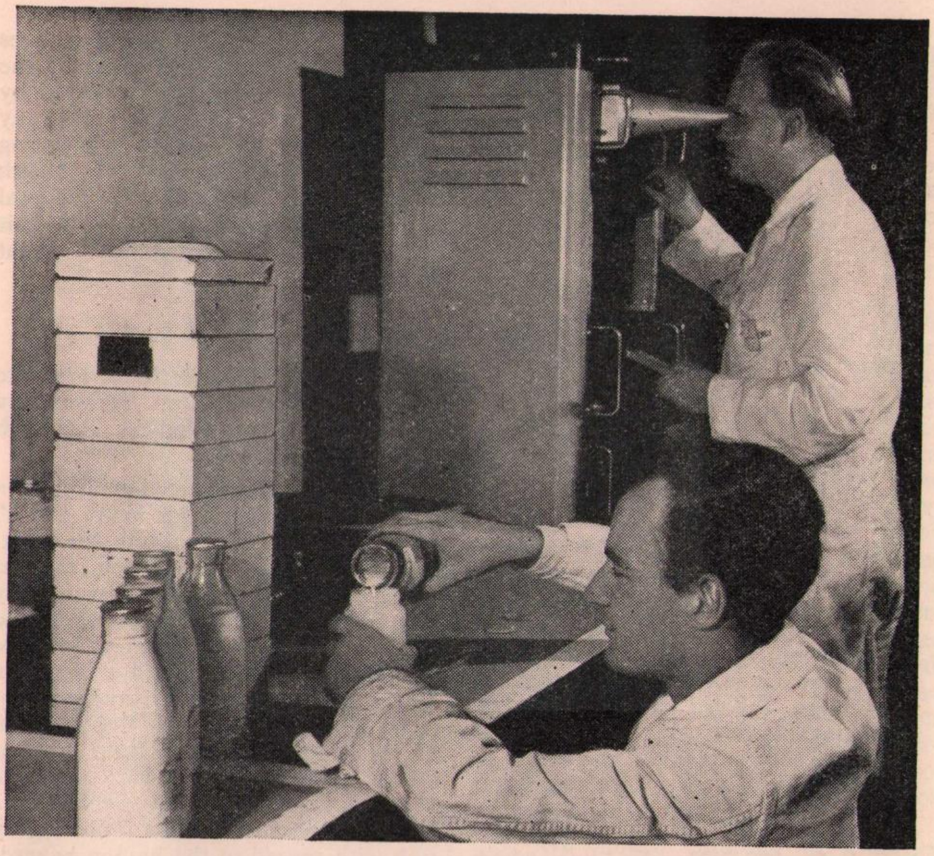
M.R.C. Views

Sir Harold Himsworth, who spoke after Sir William, began by outlining the work of the Medical Research Council on radiation.

"We have, of course, done work in the field of radiation for many years," he said, "in connection with the treatment of cancer, and when nuclear energy was developed it was very natural that we should be interested on the health side and happened to have a good deal of knowledge accumulated. So we have been working intensively doing research on the problem of the human hazards from nuclear energy ever since the war; and last year in June 1956, we published a White Paper assessing the present position with regard to the human hazards from this source of energy. Since that White Paper people have frequently asked what we were doing. We have been working very intensively on a specialised committee on all the different aspects of the problem. We have frequently advised Government Departments and the Authority. So that as regards this particular incident it was therefore perfectly natural that the Ministry of Agriculture, Fisheries and Food and the Authority should get in touch with us and start asking questions about particular aspects of the problem on the 15th October, and we summoned in our vast experience. . . . .

"We were, of course, given a copy of Sir William Penney's Report; we were given the records of the estimations that were made, maps showing the daily changes in the measurements, and in addition we asked for further analyses to be done.

"We agree straight away that the assessment was correct. The iodine was the thing to go for. These samples



In the Windscale laboratories routine analyses of environment samples are normally carried out. These samples include vegetable matter, animal matter and water. During the Windscale incident the number of analyses was greatly increased, samples being collected by a large fleet of vehicles some of which were equipped to test air, soil and vegetation on site. In the laboratories, the minute quantities of radioactive material are finally estimated by proved radiometric methods.

collected on the shelf enabled us to have further analyses made to supplement the picture.

"When the Medical Research Council produced the White Paper on the hazards to man of nuclear and allied radiation, we were considering certain types of exposure. But in relation to 'fall out'—that is the thing we are mainly concerned with here, 'fall-out' from this incident—we were considering atomic bomb explosions. But that is a different situation from this. When an atomic bomb goes off, the energy is such that the radioactive substances produced are shot right up into the stratosphere where they remain as a bank, which slowly settles over the years, thus gradually increasing the amount on the ground.

"But this is different. The stuff which escaped from Windscale up the stacks had nothing stronger behind it than the hot air which was making it rise like smoke does out of an ordinary chimney. Therefore it went up and came down quickly, and in our Report we felt quite justified in saying that the period between 1630 hours on the 10th October and 1510 hours on the 12th October could be regarded as the period in which the emission was occuring. It had gone up and it was coming down, and we are not expecting a long pay-off afterwards.

"That does make rather a difference

to the way that one looks at some of the figures. If you are dealing with 'fall out' from an atomic bomb explosion that will go on for years, naturally you will lay down doses that people may take in day after day after day; but when you are dealing with a shorter term, you would obviously lay down rather different doses, and I have to admit that, as far as those who have been concerned with the investigation are concerned, we have not got down to laying down the slightly bigger doses that one could take in a temporary incident of this kind."

Speaking on the measures taken to protect workers, Sir Harold said: "The little bit of extra exposure that was recorded on the film badges could quite easily be compensated for by putting the men out of contact with radiation for a little while. We are quite sure that the decontamination measures were adequate. We are sure that the amount of iodine absorbed would do nobody any harm.

"In paragraph 10 of our Report we say that among the workers the highest level of radioiodine measured in the thyroid gland was half a milli-curie. Now, just to put that into its proper perspective, every day in hospitals up and down this country radioactive iodine is being used in the diagnosis of diseases of the thyroid gland. If he had gone to the hospital and had a test, he would have had about 3 milli-curies in his gland afterwards, to see if his gland was normal.

"We were just a little concerned when we heard that some men had looked inside the pile, because it is known that neutrons can cause cataract, but we were quite satisfied on the evidence that when they looked in there could not have been any neutrons coming out.

"As regards the measures to protect the general public, we entirely agree that the health physics people up there assessed the position quite correctly, that is, that inhalation and external irradiation were not going to prove much of a problem: they would be well within acceptable limits. The risk was from food. In regard to food, we have to consider four main radioactive substances: iodine, strontium 89, strontium 90 and caesium. I might just mention why these were important. Iodine, when it gets into the body, is sucked out and concentrated in the thyroid gland and it is all sucked up there. Therefore if you get a dose which, averaged over the whole body, might be negligible, it can if concentrated in the thyroid gland be dangerous. The two strontiums are similarly concentrated in the bones. Caesium differs because it is diffused throughout the whole body. Those are what we brought our attention to.

Caesium Negligible

"First of all it was clear that vegetables, eggs, meat and water supplies were perfectly all right. Either indi-vidally or taken together they would not do anybody any harm. The only food of importance was milk, and we concentrated on that, and we paid our attention to the most vulnerable person in the population, namely the young child living entirely on cow's milk—and children are known to be more sensitive to radiation than adults. If there was no threat to that child, then there was no threat to anybody. We then examined the various isotopes that were in the milk and the strontiums were well below any level which could cause harm. The caesium was well below, at a negligible level. That is rather important because it was the caesium which could have produced genetic effects.

"The isotope which had been regarded as the important one was iodine, and we quite agree that the level taken of 0.1 milli-curies as the level at which milk should be taken out of circulation was quite correct, and that no harm could possibly have come to anybody from taking milk containing less than 0.5 milli-curies.

"Now, inside the area the milk had been replaced by uncontaminated milk coming from outside, and what we had to calculate was that in the period in which they were taking the contaminated milk before the uncontaminated milk came in—had anybody got a dose that was too big? And again we went for the child, and we came to the conclusion that, taking the worst possible set of circumstances, the highest figures available, the dose that could have been got by a child would have been very unlikely to have done any harm at all. . . .

"We felt that we could justifiably say that it was in the highest degree unlikely that any harm had been done to anybody in the whole of the incident. That is our considered conclusion about the whole matter."

Genetic Hazard

Replying to a question on the possibility of genetic hazards, Sir Harold said:

"It is perfectly true that the relationship between radiation and genetic change is such that for every increase of radiation you can expect an increase in mutation rates. But we are dealing here with the most minute levels—so small that one could not expect to find any genetic changes at all. The amount of radioactive contamination of the air was extremely small indeed and it was very short-lived, being iodine.

"The one we looked for was caesium 137, because it is dissolved in all the water in the body and flows into every cell in the body, including the reproductive cells. That was the one real hazard to look for in the genetic sence, and it was extremely low. If you say is there a theoretical possibility, I think the answer must be yes. If you say is there a practical possibility, I would feel justified in saying no."

Achievement

Sir Edwin Plowden ended the Conference by saying:

"I would like just in conclusion to say that I do think we should get this accident into perspective. It has obviously caused great anxiety and disturbance to a lot of people, but perhaps I can say, as a newcomer to the atomic energy industry, and neither as a scientist nor an engineer, that we must remember the achievement of these people who in the last twelve years have created a new industry in this country, without a single loss of life from radiation, and with an industrial health record that compares more than favourably with that of comparable industries.

"They have tested and manufactured a whole range of nuclear weapons during that period, making us one of the three countries in the world that do possess those weapons, and at this time of Sputniks I think it is not inappropriate to remember that this is still the only country in the world which has got an industrial nuclear power station actually working, and it is the only one to have a massive commercial nuclear programme actually in being and with four stations of nearly 1,400 megawatts of power under construction. I think we should remember that when we consider the accident.

"We in the Authority have a lot to learn from it, and we will learn from it. Industries, like people, learn from their mistakes."

Symposium for Sydney

SENATOR W. H. Spooner, M.M., Australian Minister for National Development announced on 20th September, 1957 that a major symposium on the peaceful uses of atomic energy would be held in Sydney during the week 2nd - 6th June, 1958.

Senator Spooner stated that the symposium is being sponsored by representatives of the Universities, professional institutes, industrial firms, power authorities, Commonwealth and State Departments and the Australian Atomic Energy Commission.

The symposium would be a forum for the discussion of technical and scientific aspects of the peaceful uses of atomic energy. Papers would be presented by overseas scientists as well as many Australian contributors.

Particular attention would be given to the part atomic energy will play in the development of Australia.

Senator Spooner said that several public lectures were being arranged. These would be given by well known authorities in the atomic energy field.

A special atomic energy exhibition was being organised to show developments in uranium mining, research into nuclear power and the industrial uses of radioactive isotopes.

U.K.A.E.A. Press Release

"Neptune" Critical at Harwell

"Neptune," a zero energy reactor built at the Atomic Energy Research Establishment, Harwell, is now in operation. It went critical (started working) for the first time at 8.50 p.m. on 7th November, 1957.

"NEPTUNE" will be used to study the detailed behaviour of neutrons in water-moderated core designs, with specific reference to a pressurised water reactor for submarine propulsion. The reactor will be used to check the design calculations for the land-based prototype submarine reactor, for which civil engineering work has begun at the Authority's establishment at Dounreay. The work with "NEPTUNE" will be carried out by the Admiralty team at Harwell in association with Authority staff.

"NEPTUNE" uses enriched uranium as the fuel and ordinary water as the moderator; no special cooling is required since only a few watts of heat will be generated. The reactor has been designed to allow the rapid assembly of many different kinds of cores. The core of the reactor is formed by assembling boxes of fuel element plates inside a large heavily shielded aluminium tank which contains the water moderator. The level of the water in the tank can be adjusted precisely to any required level and is used as one means of regulating the reactor. An additional method of control is by a neutron absorbing cadmium rod, moving vertically in or out of the reactor core. The reactor is shut off by allowing two groups of neutron absorbing plates to fall by gravity into the core, and by dumping the water at the same time into storage tanks situated beneath the reactor. The reactor is not pressurised, but the water can be heated to about 90°C. to study the variations in neutron behaviour caused by increased moderator and fuel temperatures.

Rolls-Royce Ltd., as a member of Vickers Nuclear Engineering Ltd., were responsible to the Admiralty for the design and construction of "NEPTUNE." The Atomic Energy Research Establishment was responsible for providing detailed advice, particularly on physics, instrumentation and safety, during the design and construction stages, and also for supplying the reactor building, essential services, and fuel.

The principal sub-contractors in the design and construction of the reactor itself were Elliott Bros. (London) Ltd. and Head Wrightson (Teesdale) Ltd. A list of sub-contractors, showing their contributions, is given below:—

Rolls-Royce Ltd. (Responsible for project as a whole and for the design, manufacture and installation of all items with the exception of instrumentation and electrical power supplies).

Elliott Bros. (London) Ltd. (Responsible for the design, manufacturing and installation of all instrumentation and electrical power supplies).

Head Wrightson (Teesdale) Ltd. (Complete erection of reactor on site).

G. Hopkins and Sons Ltd. (Manufacture of:- control mechanisms, reactor pumps, water level probe, main dump valves, various items of pre-fabricated pipework, reactor tank internal top structure).

The A.P.V Co. Ltd. (Reactor tank, dump tank, transfer tanks, auxiliary pumps).

J. Thorp & Sons Ltd. (Structural steelwork and crane gantry).

F. E. Robinson (Horton) Ltd. (Steelwork and driving mechanism for shutters, source winding gear).

Evans Bros. (Concrete) Ltd. (Precision cast concrete beams).

Peter Lind & Co. Ltd. (Precision cast concrete beams).

W. E. Chivers & Sons Ltd. (Reactor building and pit).

The Clayton Crane & Hoist Co. Ltd. (Reactor crane).

Marston Excelsior Ltd. (Light alloy water cooler).

Keith Blackman & Co. Ltd. (Cooler fan and ducting).

Heatrae Ltd. (150 KW. water heater).

R. Hutcheon Duthie Ltd. (Electrical power wiring).

[*Continued on page 30*

British Nuclear Station for Italy

THE Nuclear Power Plant Company Ltd. have received from Ing. Mattei, President of Ente Nazionale Idrocarburi, Rome, a letter of intent to negotiate the construction of Nuclear Power stations in Italy, and also to conclude a long term agreement for mutual co-operation on the design and development of power reactors. The agreement will be made between N.P.P.C. and AGIP Nucleare, a subsidiary of E.N.I. and will refer to reactors of the gas-cooled type.

Throughout the negotiations, both parties have had the co-operation of the United Kingdom Atomic Energy Authority.

The first station to be constructed under this arrangement will have an output of 200 megawatts and will involve the manufacture in the United Kingdom of considerable quantities of plant. The Nuclear Power Plant Company will be responsible for the overall design and satisfactory commissioning of the station, while AGIP Nucleare will place all local contracts and will carry out the site erection.

Atom Exhibition for Newcastle

AN exhibition designed to give a comprehensive picture of atomic energy's contribution to the life of the nation today and its future role is to be presented at King's College, Newcastle-on-Tyne, from January 6th-10th, 1958.

Prominent in the exhibit will be a working model of Calder Hall. A colour film will explain—with animated diagrams—the principles on which the Calder Hall station operates.

Another section of the exhibit will illustrate the uses of radioisotopes—in research, in medicine, in agriculture and in industry. A section on "health and safety" shows the measures taken by the Authority for the protection of its staff and of the general public against radiation hazards.

The exhibition also gives an outline of the organisation of the U.K.A.E.A. and of the careers opportunities which it offers.

Reference Pamphlet on U.K. Nuclear Energy

A NEW pamphlet, "Nuclear Energy in Britain," No. 28 in the Central Office of Information's reference series, gives an account of Britain's achievements in developing the peaceful uses of nuclear energy. Starting with a brief history of the role of British scientists in the evolution of nuclear physics, the pamphlet outlines the growth and present organisation of the nuclear energy enterprise, the functions of the various authorities in relation to it, and the part played by industry.

The central chapters describe the research background which led to the world's first large-scale nuclear power station at Calder Hall and the progress so far achieved in the programmes laid down for the development of power-producing reactors by the Atomic Energy Authority and the electricity authorities. The production and applications of isotopes are described and there is an account of the arrangements, through the Combined Development Agency and bilateral contracts, by which raw materials are obtained.

The pamphlet ends with a review of Britain's progress in evolving improved types of nuclear power reactors, including the Dounreay fast breeder reactor, the possibilities of power from controlled thermonuclear reaction and present work on nuclear propulsion.

Appendices give particulars of experimental and power reactors in Britain and of organisations and firms concerned with nuclear energy. There is a short bibliography, a glossary of terms and a map showing the siting of nuclear establishments.

The pamphlet is obtainable, price 3s. 0d. (by post, 3s. 4d.) from Her Majesty's Stationery Office.

N. Wales Inquiry

THE Minister of Power has decided to hold a public local inquiry into a proposal of the Central Electricity Authority to build a nuclear power station at Trawsfynydd in North Wales. The proposed site is in the Snowdonia National Park.

The date of the inquiry has not yet been fixed.

In Parliament

Power Programme Rephasing

30th October, 1957

MR. PEART asked the Postmaster-General how the atomic energy programme will be affected by Government policy to restrict public investment.

Mr. Maudling: As my right hon. Friend the Chancellor of the Exchequer informed the House yesterday the rephasing of the nuclear power programme may involve the postponement by one year of the date by which we complete our programme of 5,000 to 6,000 megawatts of nuclear capacity.

Safety at Bradwell

29th October, 1957

MR. A. B. C. HARRISON asked the Paymaster-General whether he will take steps to prescribe safety precautions in the construction of the nuclear power station at Bradwell, in order to ensure that an occurrence similar to that which recently happened at Windscale will not be likely to happen.

Mr. Maudling: The reactors at Bradwell power station will be of the improved Calder Hall type employing a closed carbon dioxide cooling circuit and incorporating many improvements on the Windscale type of reactor. I can however, assure my hon. Friend that in the construction of Bradwell full account will be taken of any relevant lessons that may emerge from the report of the Committee of inquiry into the Windscale accident.

E.E.C. and Euratom Treaties

30th October, 1957

MR. FLETCHER-COOKE asked the Secretary of State for Foreign Affairs whether he will arrange for copies of the Treaties establishing the European Economic Community and the European Atomic Energy Community, which were signed at Rome on 25th March last, to be made available to hon. Members in English.

Mr. Ian Harvey: Authorised English editions of both Treaties and of the connected documents have been published by the Secretariat of the Interim Committee for the Common Market and Euratom in Brussels. Copies are available in the Vote Office for hon. Members requiring them. They are also on sale through Her Majesty's Stationery Office.

Radiation Hazards

31st October, 1957

MR. AWBERY asked the Minister of Labour what steps are being taken to revise the factory regulations to bring them up to date to meet the rapid changes now taking place in manufacturing establishments and the growing dangers of radioactivity, particularly in our atom-explosive factories.

Mr. Carr: A preliminary draft of regulations dealing with the use of sealed sources of radioactive substances in industry was published in July. Comments on this draft are now being considered. Work has started on the preparation of regulations dealing generally with open sources.

31st October, 1957

MR. FRANK ALLAUN asked the Prime Minister if, in the light of the subsequent events at Windscale, he has considered the Trade Union Conference resolution, submitted to him, asking the Government for an immediate inquiry into, and report on, health hazards arising from the use of radioactive materials, whether for military, industrial or other purposes.

The Prime Minister: Health hazards arising from the use of radioactive materials are under constant study by a number of expert bodies in this country and by international agencies on which this country is represented. Reports are issued as the results of measurements, and the conclusions to be drawn from them, become available.

Draft regulations governing the use of ionising radiations in industry and a code of practice governing the use of radioactive substances in hospitals have recently been issued. The legislation which governs the discharge of radioactive wastes is under review now. With so much attention and effort being devoted to this subject, I see no advantage in an additional or special inquiry.

Mr. Allaun: Is it not correct that the M.R.C. Report presented last year was based on investigations carried out nearly three years ago and which are now out of date, and that since then radioactivity has greatly increased and that all scientific opinion favours a reduction of the safety limit allowed?

The Prime Minister: That is why these draft regulations governing the use in industry to which the hon. Gentleman's Question referred have been issued and why the code of practice for the use of radioactive substances in hospitals has been issued. All I had to answer was whether some new and different system of management and inquiry into these affairs should be instituted. In my view, the instruments which we have at our service are the right ones and should not be added to and might even be impeded by superimposing another inquiry on them.

Mr. J. Hynd: Can the Prime Minister say who has issued these regulations in industry and whether they are available to the public or are in the Library?

The Prime Minister. This Committee was set up under the Act of 1948 and the code of practice and the regulations are issued in the ordinary way by the appropriate authorities, just like regulations governing factories.

Buffelsfontein Development

31st October, 1957

MR. ALLAUN asked the Prime Minister what proposals have been made by the Combined Development Agency, representing Great Britain, the United States of America and the Union of South Africa, for the next stage in the development of uranium, following the opening of the Buffelsfontein mine uranium plant near Klerksdorp.

The Prime Minister: The Buffelsfontein Uraniun Plant recently opened in South Africa was the final plant to come into commission as a result of the arrangement entered into in 1951 between the South African Atomic Energy Board and the Combined Development Agency representing the United Kingdom and the United States of America. No proposals have been made by the Agency to the Board for further development, but the Agency now has under consideration proposals made by the Board for the supply of additional uranium.

Civil Service Transfers to U.K.A.E.A.

31st October, 1957

MR. WILLEY asked the Prime Minister whether on grounds of public policy, he will instruct Departmental heads to facilitate the transfer of officers from the Civil Service to the Atomic Energy Authority, in view of the speedy progress in research and development in atomic energy.

The Prime Minister (Mr. Harold Macmillan): Heads of Departments are already aware that it is the policy of the Government to facilitate transfers from the Civil Service to the Atomic Energy Authority.

Mr. Willey: In view of the importance of getting the right people in the right place at the right time in this branch of research, will the right hon. Gentleman consider any cases I refer to him where that seems not to have occurred?

The Prime Minister: I should be happy to consider any individual cases. but is is only fair to the Authority to say that about 6,000 established civil servants have been transferred to the Atomic Energy Authority since it was set up. some 5,700 as part of the original transfer and some 300 since.

Controlled Thermo-Nuclear Fusion

11th November, 1957

MR. MASON asked the Prime Minister if he will make a statement on controlled thermonuclear fusion; whether encouraging results have yet been achieved during experiments; and to what extent research and development is being encouraged in this field.

Mr. Maudling: The experimental apparatus at Harwell known as ZETA is now operating. Discharges through heavy hydrogen gas have yielded very high temperatures. Experiments are going on to identify the source of the accompanying neutron emission which probably arises from thermo-nuclear reactions but may possibly be due to

[*Continued on page 21*

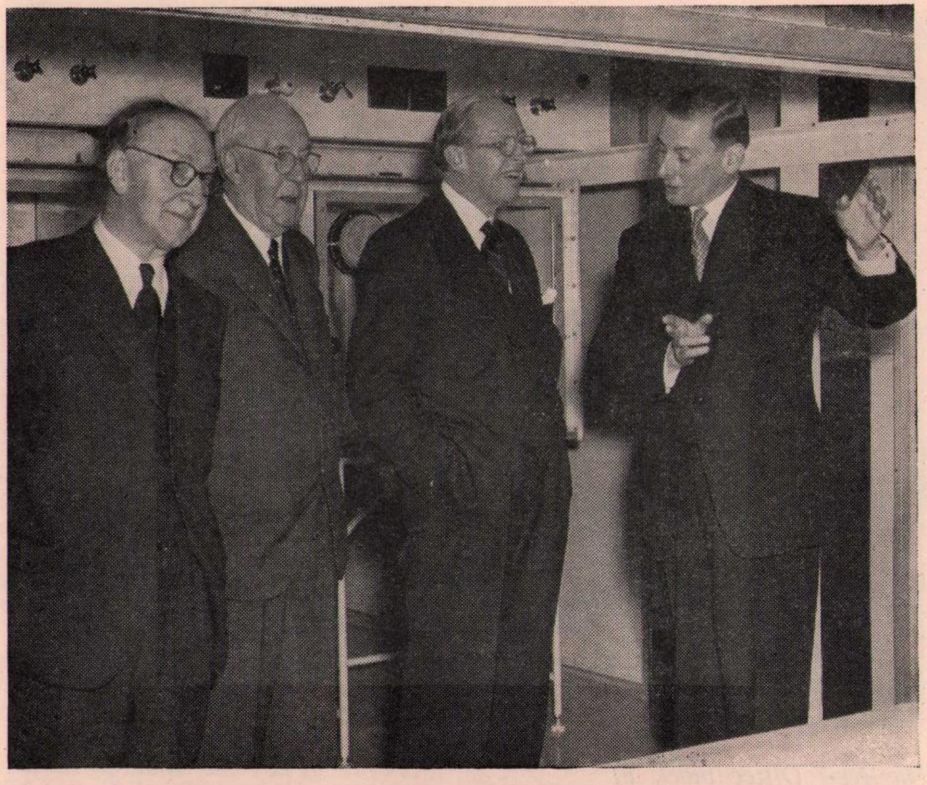
The New Office block at the Radiochemical Centre, Amersham.

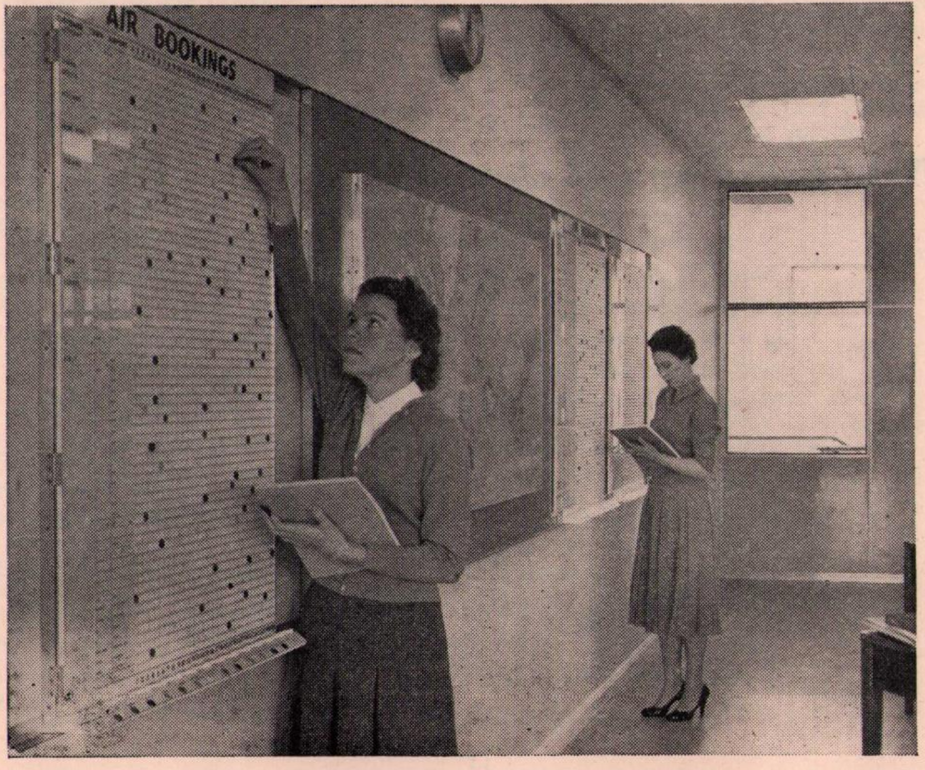
New Buildings at the R.C.C.

On Friday, 1st November, 1957, two new buildings were inaugurated at the Radiochemical Centre, Amersham, by The Most Honourable The Marquis of Salisbury, K.G. Comprising a radiochemical laboratory and a block of offices, the extensions will enable the Centre to meet the increasing demand for its products, which has more than trebled during the past three years.

The laboratory, which is a single-storey building of 12,000 sq. ft., is the second part of a group of buildings specially designed for processing radioisotopes, including the separation of pure radioactive isotopes from material irradiated in the Authority's reactors; the synthesis of "labelled" compounds for research; and the manufacture of radiation sources for industrial and medical use. The scale of radioactive operations will be about one hundred times greater than previously.

The standards of radiological safety and control of radioactive




AIR BOOKINGS

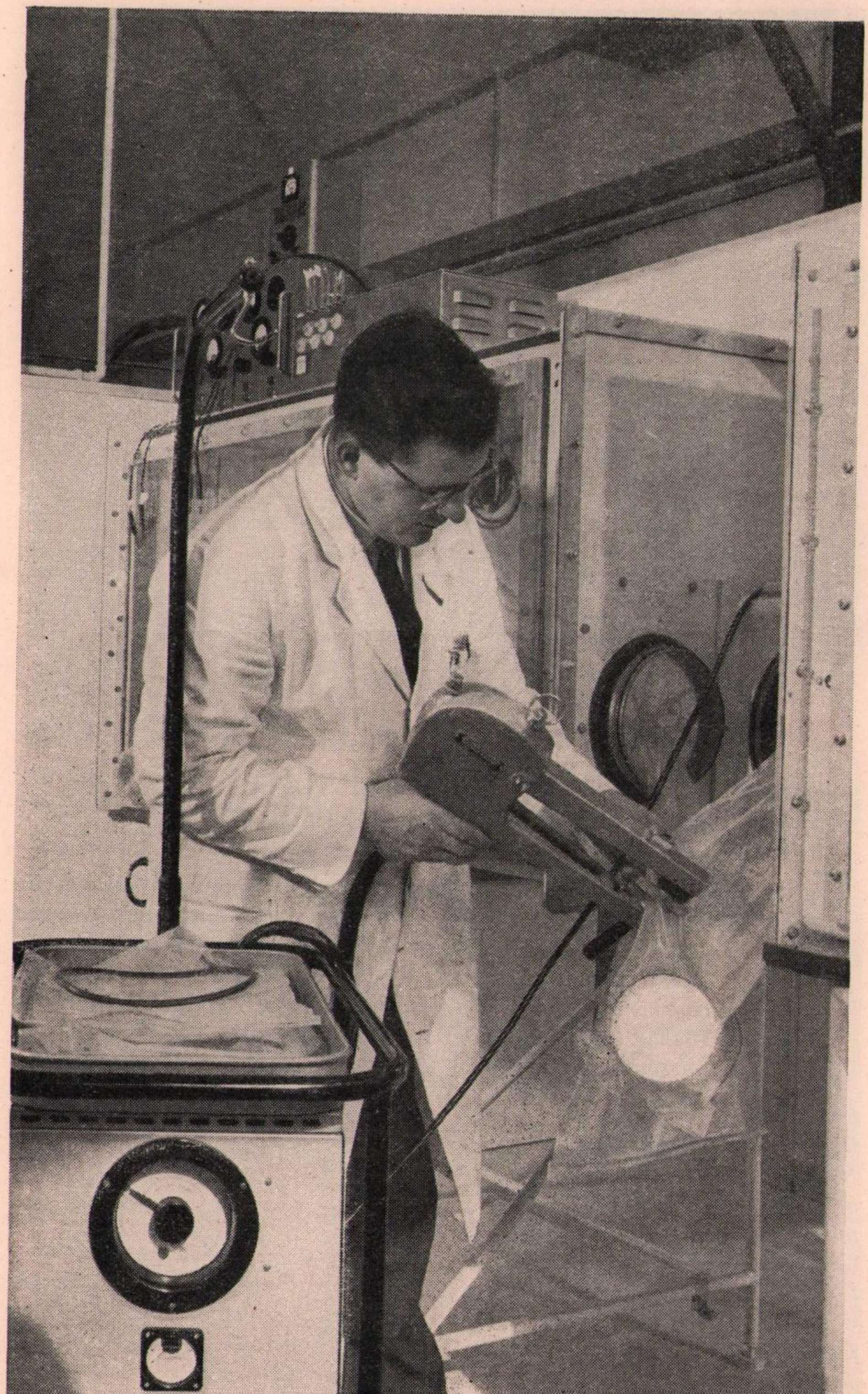
A production line for the preparation of radium clinical appliances.

contamination within the laboratory building are substantially higher than has been possible hitherto in this type of work and conform to the most recent international recommendations.

The administrative building, covering 15,000 *sq. ft., houses the commercial department, which now deals annually with some* 18,000 *consignments of radioisotopes exceeding* £400,000 *in sales value. Over* 70 *per cent. of this total is exported.*

Left, above: Dr. W. P. Grove, General Manager, R.C.C., explains methods of handling radioactive material to (L. to R.): Sir J. Cockcroft, Sir H. Dale and Lord Salisbury. Below: A wall chart used for recording air, rail and sea consignments of radioisotopes due for despatch.

Overleaf: A plant for the production of multi-curie polonium-beryllium neutron sources in the new laboratories.



In Parliament

[*continued from page 16*

other complex nuclear processes. Although the successful operation of ZETA is an important step forward, many major problems remain to be solved before the practical application of thermo-nuclear reactions can be considered, and the work must be expected to remain in the research stage for some years. Research and development in this field are being given the highest priority.

Export of Reactors

11th November, 1957

Mr. Mason asked the Prime Minister to what extent we have made progress in the development of a package atomic reactor for export purposes; and what progress we have made in obtaining markets for this type of product.

The Paymaster-General (Mr. Reginald Maudling): I have been asked to reply. Recent studies have suggested that the Calder Hall type of reactor should be capable of modification to produce electricity at a competitive price from small stations of about 20-30 megawatts capacity. In addition, a number of other reactor systems are being investigated that might be suitable for electricity generation in smaller power stations. Two United Kingdom firms have marketing rights for small power reactors of United States design. United Kingdom manufacturers have received a number of inquiries and are actively exploring possible markets for the types which they can offer.

Nuclear Progress

12th November, 1957

Mr. Hector Hughes asked the Prime Minister if he will make a statement on the advances made up-to-date in Britain in the uses of nuclear energy for peaceful purposes generally, and, in particular, in relation to shipping.

The Prime Minister: Full details of the work of the United Kingdom Atomic Energy Authority on the peaceful uses of atomic energy are given in the Authority's Third Annual Report, published last July. The construction of the first four power stations of the civil nuclear power programme is under way. Studies of the economic propulsion of merchant ships by nuclear power, covering several types of reactor, have been put in hand under the direction of the Committee under my hon. Friend the Civil Lord of the Admiralty.

U.K.—U.S. Exchanges

Mr. Mason asked the Prime Minister how far there is free exchange of atomic energy information for peaceful purposes with the United States of America; and if he will list the pacts and agreements ruling this exchange.

The Prime Minister: There are continuous and valuable exchanges between the United States Atomic Energy Commision and the United Kingdom Atomic Energy Authority of information and experimental data on the work which each country is doing on the peaceful uses of atomic energy. These exchanges are governed by the Agreement between the United States and United Kingdom Governments for Co-operation on the Civil Uses of Atomic Energy concluded in June, 1955 (Cmd. 9560), as amended in November, 1955 (Cmd. 9677), and June, 1956 (Cmd. 9789).

Ministerial Responsibility

12th November, 1957

Mr. G. R. Strauss asked the Prime Minister whether, in view of the fact, as disclosed by the recent accident at Windscale, that the responsibility for atomic energy matters involves much detailed study of highly technical problems, he will consider transferring that responsibility from himself to a senior Minister in the House of Commons.

The Prime Minister: No, Sir; I consider that the existing arrangement is the most suitable at the present time.

Mr. Strauss: Does not the Prime Minister agree that it is wrong in principle that a Prime Minister, who is bound to be burdened with many matters of broad and important policy, should be burdened with the detailed affairs that are bound to arise from time to time in an organisation such as the Atomic Energy Authority?

The Prime Minister: I think that

there are disadvantages but, on the whole, at the present time, when the various uses of atomic power are so much in the field that the Prime Minister of the day must in any case have under his control, I think there are advantages, and that it works pretty well. With regard to the detailed work, I am very much helped in discharging it by my right hon. Friend the Paymaster-General.

Factory Inspectors

12th November, 1957

MR. MASON asked the Minister of Labour if he will consider setting up a department within the Factory Inspectorate to select and specially train inspectors for the atomic energy power stations.

Mr. Carr: A training programme is being carried out covering protection against radiation hazards in industry generally, including atomic energy power stations. Four inspectors in the Chemical and Engineering Branch and 21 inspectors in the districts have already been trained, and 50 more are to be trained, under this programme. In addition, two inspectors in the Chemical and Engineering Branch have received training in the design, maintenance and running of reactors. It is not considered necessary to set up a special department.

Fall-out in Northumberland

13th November, 1957

MR. OWEN asked the Prime Minister if he will make a statement concerning the quantity of radioactive fall-out in the County of Northumberland, especially in the area of the Cheviot Hills.

The Prime Minister: No specific measurements of radioactive fall-out have been made in Northumberland, but measurements for the neighbouring County of Durham, with a similar soil and rainfall, have been published in the Atomic Energy Research Establishment's Report A.E.R.E. HP/R.2353, which is in the Library. Following the Windscale accident, monitoring was carried out in Cumberland, near the Northumberland border and just south of the Cheviots, and it was found that the pattern of radio-activity had not changed.

Strontium 90

14th November, 1957

MR. FRANK ALLAUN asked the Prime Minister if his attention has been drawn to that section of the report prepared by the Atomic Energy Authority and placed in the House of Commons Library showing that in 1956 the two dead children whose bones showed the highest radiostrontium activity contained 1.55 strontium units and 1.3 strontium units, but that already in 1957 a one-year old Cumberland child showed 2.3 strontium units and a six-months old Liverpool child 2.4 strontium units, or a quarter of what is considered the maximum permissible dose; and whether he will in this light reconsider his decision to proceed with further hydrogen bomb explosions.

The Prime Minister: The Medical Research Council has recommended that the level of strontium 90 in the bones of the general population, with its proportion of young children, should not exceed 100 strontium units. The recent figures of 2.3 and 2.4 units which the hon. Member quotes are only a small fraction of this. They are the highest so far observed in this country and are well above the average level. The situation with regard to strontium 90 is being kept under close and continuous review. I have said that there will be no further tests in the immediate future.

W. African Research

14th November, 1957

MR. E. L. MALLALIEU asked the Secretary of State for the Colonies if he will consider the setting up of a committee of inquiry into the possibilities of establishing a research centre on nuclear energy in West Africa.

Mr. Profumo: No, Sir. My right hon. Friend is anxious that the Colonial Territories should share to the full the benefits of the peaceful application of nuclear energy, and training courses on nuclear subjects are available here for qualified people from West Africa. But the West African Governments have not proposed the establishment of a research centre, and probably feel, as I do, that there are at present more urgent tasks for their available financial resources.

Radioisotope Waste Disposal

Printed below are extracts from a paper, entitled " Problems of Waste Disposal in the Wide Scale Use of Radioisotopes" given by Dr. W. G. Marley, Head of the Health Physics Division, A.E.R.E., Harwell, to the U.N.E.S.C.O. Conference on " Radioisotopes in Scientific Research " held in Paris from 9th - 20th September, 1957.

THE impressive story of the breadth and range of applications of radioactive isotopes described at this Conference gives some indication of the extent of the benefits which could accrue to mankind from these developments. The standard of public health and the well-being of populations from the health viewpoint is critically dependant upon the standard of living and the resources of the community and these in turn will profit greatly from the widespread development of the use of radioactive isotopes in improving our knowledge and our technology. The resulting benefits to public health are distinct from those which might arise directly from the use of radioactive isotopes in public health research and they may be even more significant. It is therefore important that the use of radioactive materials, as well as the development of atomic energy, should be pushed forward with the maximum expedition. The considerations to which I have to draw your attention in regard to the control of radioactive waste materials are therefore formulated with a view to facilitating the expanded use of radioactive materials to the benefit and well-being of mankind.

It is now generally recognised that the exposure of living tissue to ionising radiations can be only deleterious and the extension of the use of radioisotopes therefore presents the problem of minimising the human exposures which must necessarily result.

The Natural Background

Populations have been exposed all down the ages to the natural radioactivity background arising from cosmic radiation, gamma radiation from the earth's crust and from building materials, and the radiation from natural potassium and radium in the body and the radioactive gases in the atmosphere. In the U.K. for instance, the level of exposure from this cause over wide areas of the country is about 3 rad (in the body) per generation (30-year period). In some towns in the U.K. the level is some 15 per cent. higher whilst in Stockholm it is understood to range up to 70 per cent. higher. In certain notably radioactive areas of the world (e.g. Travancore in India, and in Brazil) the level is thought to range up to more than 10 rad per generation. No statistically significant differences have been observed so far in the incidence of those diseases or conditions known to arise from acute radiation exposure, although some limited statistics are available from areas with rather small differences in background.

Permissible Levels of Exposure

Experience gained over the last 60 years from the exposure of human beings to X-rays and ingested radium, from the occupational hazards of medical radiologists and miners of radioactive ores and from the studies of victims of atomic bomb explosions has provided an extensive basis for fixing acceptable levels for occupational exposure of human beings to ionising radiation. From this experience and the data obtained from the vast amount of animal experimentation, the International Commission on Radiological Protection has formulated recommended maximum permissible levels for occupational exposure, and these are now internationally accepted. In 1956 the Commission extended further its recommendations and designated limits for the cumulative dose up to age 30 and in each subsequent decade. The permissible levels recommended by the

TABLE I

Typical Maximum permissable levels for occupational exposure (I.C.R.P. 1953)

Isotope	M.p.l. in body micro C	Critical Organ	M.p.l. in air micro C/cc.	M.p.l. in water micro C/cc.
Ra^{226}	0·1	Bone	8×10^{-12}	4×10^{-8}
Pu^{239}	0·04	Bone, Cut	2×10^{-12}	3×10^{-6}
Sr^{90}	1	Bone	2×10^{-10}	8×10^{-7}
Sr^{89}	2	Bone	2×10^{-8}	7×10^{-5}
I^{131}	0·6	Thyroid	6×10^{-9}	6×10^{-5}
P^{32}	10	Bone	1×10^{-7}	2×10^{-4}
Na^{24}	15	Lung, body	1×10^{-6}	8×10^{-3}

Commission are not expected to cause any deleterious or objectional effects on the health and well-being of the individual at any time during his lifetime. Examples of these levels for radioactive isotopes within the human body are shown in Table I.

Apart from the first three isotopes listed in the Table and a few other alpha active materials, the majority of isotopes have a maximum permissible level in drinking water of about 10^{-4} micro C/cc. or higher.

The figures given in Table I relate to occupational exposure to ionising radiation, but persons exposed occupationally comprise only healthy adults under medical supervision. The general population, on the other hand, includes persons who are not completely healthy and numbers of infants and children who are more radiosensitive than adults. For these reasons, the various authorities, including the U.S. National Committee on Radiation Protection and the International Commission on Radiological Protection, recommend that members of the general public should not be exposed to levels exceeding 1/10 of the occupational permissible levels. In public health problems, where a source of pollution affects only a small number of people, this may well be the appropriate factor. Where, however, substantially the whole population of a country is involved, further considerations, such as those concerning the statistical incidence of diseases such as leukaemia, which may be induced by radiation and those concerning genetic effects, become of importance.

Various authorities have now expressed their views regarding the limitation of these levels. The British Medical Research Council, for instance, have commented that it is unlikely that any authoritative recommendation would suggest a figure for permissible radiation exposure for the *whole* population of a country greater than a level of twice the natural background level above the background level. Since the background level in the U.K. is about 3 roentgen in a 30-year period (one generation) the limit suggested would thus be less than 6 r per 30 years. The United States National Academy of Sciences—National Research Council Committee on Radiation Effects has suggested a limit of 10 roentgen in 30 years. Similar levels have been suggested by other competent bodies and these levels must be recognised as indicating the order of the dose above the natural background which, on present information, is considered acceptable for a whole population over long periods of time without undue deleterious long-term effects.

Similar considerations may well apply to certain somatic effects and especially to the possible incidence of leukaemia. In a recent British report, Court Brown and Doll have established a relationship between radiation exposure incurred in intense isolated doses, and the incidence of leukaemia. Assuming that a linear relationship exists at the very low exposure rates, which, it is stressed, has not been proved, the induction of leukaemia by radiation would be about 10^{-6} cases per year for every man-roentgen total-body exposure in a population. A similar conclusion is reached by Lewis. There would thus be close similarity on this hypothesis, between the significance of radiation exposure levels in relation to possible genetic effects and to possible increases in the incidence of leukaemia.

On the basis of these considerations the exposure of whole populations would need to be governed by the following principles:—

(a) The irradiation of members of the general public and indeed, of any individuals, should be kept to the lowest practicable level.

(b) The exposure of individual members of the general public should not be allowed to exceed 1/10 of the corresponding maximum permissable occupational levels of exposure.

(c) The average gonad or whole body exposure of the population from all man-made sources of ionising radiations should not be allowed to exceed about 6 - 10 rem per head in a 30-year period.

(d) Provided these requirements are met, there should be no necessity to make a complete prohibition of the discharge of radioactive materials and, in fact, the penalty to the population of such a prohibition may well be severe.

Radioactive Nuclides in Human Food Chains

The concentrations of radioactive isotopes in biological materials forming part of human food chains has now been extensively studied. Much of this work has related to contamination of crops and herbage, the contamination of which is unlikely to arise as a result of the applications of radioactive isotopes, nevertheless the information is of considerable value. The release of radioactive nuclides in the form of dust or vapour over agricultural land can lead to the entry of nuclides into the human food chain, either by direct contamination of crops used for human consumption or by contamination of herbage which is grazed by dairy cattle. Extensive studies have been made on behaviour of Sr^{90} in the human food chain and the subsequent build-up in the human body. The fission product isotope I^{131} has also been extensively studied and it has been found that the permissible level in air over pasture-land is about 1,000 times lower than that for direct human breathing. Although this isotope is used extensively in medical practice, it is unlikely as a result to be released as a vapour to the atmosphere.

Aqueous Systems

Biological concentration also occurs to a significant extent in aqueous systems and concentrations in plankton and water-fowl of isotopes such as P^{32} have been observed to exceed 10,000 times that in the water. In surveys of radioactivity in fish in White Oak Lake in the Oak Ridge National Laboratory, U.S.A., it was found that every fish assayed had selectively accumulated radioactive materials in the tissues far in excess of the amounts which occurred in the water in which they lived. The selective concentration of radio-strontium in the skeleton and other hard tissues (not normally eaten) was to the extent of 20 - 30,000 times as great as that in the water. The amounts of radioactive materials accumulated in the soft tissues were 40 - 50 times lower than those accumulated in the skeleton, the primary radio-element concentrated in the soft tissues being caesium. These studies suggest that in circumstances where large numbers of fish are caught and eaten by riverside populations, especially if the bones are eaten, the level of activity in the fish may become the limiting hazard, rather than that of the water which may be used for drinking.

Sea Water Radioactivity

However, another aspect of the build-up of activity in biological organisms is that the water is incidentally cleaned up considerably by absorption on biological organisms and mud and this is particularly important where a long stretch of slow-moving river exists between the source of effluent and water supply intakes. Advantage can be taken of this factor, where the extent of the clean up has been evaluated.

Corresponding concentrations in marine plankton and fish have been observed in studies on the fate of radioactivity in sea water and it is apparent that biological concentration factors are of predominant importance of any coastwise disposal of active wastes.

Sources of Radioactive Wastes

The principal sources of radioactive wastes which are of concern to public health and which arise from the uses of radioactive isotopes are listed below.

(a) *Hospitals*

Diagnostic procedures: wastes negligible.

Therapeutic procedures: P^{32}, I^{131}, and Au^{198} used in large quantities.

Teletherapy sources: no wastes except possibly in the exceptional event of a serious fire.

(b) *Industrial Isotope Uses*

Tracer, process and research experiments: small quantities of active wastes, but possible widespread use.

Production control: usually short-lived isotopes and small effluent hazard, but may be widely used in the future: possible additional dose to population from contamination in the final product. sold to the public

Radiographic sources and static climinator sources: no wastes: escape in the exceptional event of serious fire also negligible.

Radiation chemistry: use of large sealed sources made from f.p. wastes normally no effluent, but potential release in accident or fire needs consideration.

(c) *Research Institutes and University Laboratories*

Tracer experiments: small quantities of active wastes, but widespread use.

Special experimental use: wastes require special consideration.

Laboratories producing special isotopes in cyclotrons: quantities very small and isotopes valuable; wastes likely to be negligible.

The problem of radioactive wastes from the various applications of radioactive isotopes is, of course, dwarfed by the radioactive waste problem arising from factories processing isotopes or manufacturing isotope appliances and especially from certain atomic energy processes. Whilst some nuclear reactors and research facilities may well be widely destributed, it seems likely that nuclear power stations, requiring large quantities of condenser water, will be located either in the vicinity of large rivers or on the seaboard and, moreover, they are not likely to give rise to significant radioactive wastes in normal operations. The separation of the fission products from the spent fuel is normally performed in chemical separation plants remote from the reactor location. The radioactive waste problem from such plants is considerable and great care is necessary in their location if a high standard of protection against the radioactivity is to be afforded to the general public. The field of atomic energy wastes is rather outside the scope of the present lecture.

It is possible to sum up the various sources of isotope wastes since they appear to fall into two distinct classes. The first includes the medical therapy centres and other comparable large users of radioactive isotopes: in this class it would also be desirable to place as a precautionary measure institutions using very large fission product sources industrially for radiation chemistry. The second class includes most other users, since the levels of radioactivity released from most other isotope applications are relatively small. However, this class includes an exceedingly large number of users: the amount of radioactivity involved at each location is relatively small, but in aggregate may well be comparable with that arising from therapy centres. Before considering the implications of this situation we shall consider the possible modes of disposal of radioactive wastes.

Release of Gaseous Wastes

Gaseous wastes from fume hoods in laboratories and isotope handling rooms in hospitals require no special precautions provided the outlet is clear of windows. The only significant problems of gaseous (and particulate) waste are from atomic energy installations and in such instances the breathing hazard at a distance from an outlet may be estimated by Sutton's theory of atmospheric diffusion. In general, gaseous wastes are essentially of local concern since they can affect only a very small fraction of the population and genetic considerations are hardly of significance.

Discharge of Liquid Wastes

The permissible level of discharge to rivers depends on the use which is made of the water. Considerable quantities of radioactivity may be safely discharged when there is no subsequent human drinking, such as in rivers carrying large quantities of trade wastes, where biological concentration and absorption on surfaces become the dominant factors and levels of 1 μc/ml may well be acceptable. Where the water is used subsequently for human drinking the permissible level in the water depends on the population exposed. By grouping the radioative isotopes according to the order of the permissable levels of ingestion a simple formula may be derived which enables routine control by simple radiochemical asseys of the different classes of activity, using the data and formula shown in Table II.

This method of control is used in the active waste discharge to the River Thames from the Atomic Energy Research Establishment at Harwell. In this instance the population involved is over 6 millions and the value of S has accordingly been set at 100.

Radioactive liquid wastes from processes involving applications of isotopes can in most instances be safely discharged through public sewerage system. The extent to which the practice is satisfactory depends largely on the nature of the isotope and the subsequent use of the water again for human drinking. For many large sewerage systems, a level of 10^{-3} μc/ml in the sewage waste of the *premises* will provide sufficient dilution in the town's sewage for isotopes of moderate or slight toxicity. Each situation should, however, be considered quantitatively before the discharges are accepted. Some attention also has to be paid to the possible accumulation of radioactive materials in the sewage treatment plant, and studies have been made of the behaviour of isotopes in such plants and in water purification plants. It is also important to ensure that unnecessary radiation exposure of workers handling isotopes is avoided by appropriate laboratory procedures; for instance, in order to prevent local absorption on pipes and fittings, dilution of the activity with stable isotopes of the same substance is sometimes advantageous.

There are four principal methods of

TABLE II

Class of activity	Representative occupational m.p.l. μc/ml.	Toxicity ration in drinking water
Radium	4×10^{-8}	2500
Other alpha activities	$2{\cdot}4\times10^{-7}$	420
Sr.^{89} Sr^{90} mixture	2×10^{-6}	50
Other beta activities	1×10^{-4}	1

Permissible discharge given by:—

$$2500\,(\text{Ra}) + 420\,(\text{alpha}) + 50\,(\text{Sr}) + (\text{Beta}) = 260\ V/S$$

where

V	is river flow in m^3/sec. at the water supply intakes.
S	is large population safety factor or the ratio of the permisable level for the population to that for occupational exposure.
Ra	is permissible discharge of radium in curies/month (other activities similarly).
(alpha)	is the permissible discharge in curies/month of alpha active materials other than radium.
(Sr)	is the permissible discharge in curies/month of strontium isotopes.
(beta)	is the permissible discharge in curies/month of beta active isotopes excluding strontium.

disposing of solid wastes, namely, incineration, closed storage, open burial, and sea disposal. Incineration is especially valuable for treating animal carcases and as a means of reduction of volume, but gives rise to active gases and ash. The discharge of the gases should be clear of windows and should be monitored periodically. Burial may be used on permanently enclosed ground at levels depending on the rainfall such that the local ground water is not raised locally above the m.p.l. for non-occupational exposure. Highly radioactive solid wastes from isotope usage can safely be disposed of in the oceans and this subject is considered separately below.

Disposal of Wastes to the Seas

The disposal of radioactive wastes arising from the uses of isotopes (as distinct from certain atomic energy operations) may well be made in shallow coastal waters. The important requirement is that the disposals of solid materials should be made so that they cannot be entangled with the trawling gear of fishermen, and it is suggested that recognised dumping points be established for such disposals. Permissible discharges into coastal waters can be evaluated from the British experience extending over many years in regard to the discharges from the Windscale Atomic Energy Plant in Cumberland. Studies were made of the movement of surface waters and of the breeding and migratory habits of fish of economic importance, and the build-up of activity in biological systems and on the shore line. The results of this work show that, without any restriction on the normal commercial fisheries and without any hazard from the use of neighbouring beaches for recreation or of seaweed in specialised types of food, no hazard to the population should arise even if discharges are made at the rate of several hundred curies per day and the aggregate population exposure is negligible. It is quite clear that radioactive wastes from the applications of radioactive isotopes could well be disposed of in this way, with negligible exposure of local or general population.

There is no necessity to have recourse to the deep oceans for disposal of wastes from isotope practice. Moreover, methods have been worked out for the handling, separation, utilisation and safe storage of the high-activity fission products from a nuclear power programme without there being any incentive to use the deep oceans for the high activity long-lived materials, and it is quite clear that such power programmes can be embarked upon without any significant public health hazard being necessarily incurred from the enormous quantities of radioactive fission products produced.

Discussion on Control of Wastes

It is possible to draw some general conclusions regarding procedure in the control of radioactive wastes.

(i) It is recommended that in each district where significant quantities of radioactive materials are utilised a careful survey should be made of the sources of drinking water both as regards large populations and local populations. It is possible at once from such a survey to evaluate the extent of the controls which are necessary. It would be necessary to define for each supply the factor S by which the occupational maximum permissible levels are to be reduced and this is likely to range from 10 for small populations to about 100 where a substantial part of the population of this country is involved. It is likely that many supplies will be derived from sources which cannot be contaminated by radioactive wastes.

(ii) It is recommended that a continuous record is kept of the distribution of the larger quantities of isotopes in each country. Little significance attaches to the use of quantities in the microcurie range but the distribution of millicurie quantities and particularly curie quantities (mostly to therapy centres) can be analysed to ensure that the waste from these particular locations does not contaminate to an excessive degree the drinking water supplies of local or large populations. In some instances no restrictions are necessary, since the effluent from the district is not used for public drinking water. This is the situation, for instance, at the Radiotherapy Centre at Cambridge in England where the river below the town is not used for drinking water purposes. On the other hand, some centres are located on rivers used for public supply. In some of these instances it is still often sufficient simply to know the total quantity of radioactivity introduced into the centre, from which it can be seen at once that the river cannot be excessively contaminated.

(iii) As far as possible it is desirable to ensure that trade wastes carrying large quantities of radioactive materials are conducted away in trade sewers to a tidal estuary so that drinking water pollution cannot arise from this cause. This is particularly important in regard to premises where very large quantities of radioactivity (in the megacurie range) are manipulated. The problem with chemical separation plants in connection with the atomic energy industry is particularly severe and great care is necessary in the location of such plants.

(iv) Existing legislation in many countries relating to the discharge of noxious materials may not be adequate or appropriate to control properly the discharge of radioactive materials and may need revision. It is important to recognise that the public health hazards from such materials are to a large extent nationwide and legislation which involves local control is often inadequate. This is particularly the case with radioactive pollution of rivers. Legislation needs to take account of the large number of users of small quantities of isotopes so that negligible organisational and administrative work is entailed in the control without any loss in the control of large discharges.

(v) A special problem exists in regard to discharge to rivers where the river flows through successive countries and it is strongly recommended that formal collaboration be set up regarding the pollution of such rivers with radioactive waste materials. This is particularly important where chemical separation plants associated with atomic energy projects are located near such rivers. An extensive radiological study, involving considerable experimental discharges, may well be justified on the fate of radioactive nuclides in such river systems.

(vi) It is recommended that the public health authorities in countries utilising radioactive isotopes should have specialists sufficiently well informed on the measurement and biological characteristics of these materials to excercise centralised control and, in many instances, this will involve actual measurement of samples at very low levels of radioactivity, for which a special laboratory and facilities are desirable.

With careful planning and proper quantitative supervision of the disposal procedure there is no doubt that the widespread use of radioactive nuclides in scientific research, in medicine, and in all branches of industrial technology can be greatly expanded without any risk to the public health.

Conference Papers.

ABSTRACTS of all papers given at the U.N.E.S.C.O. Conference (except those given in the evenings) have appeared in the *International Journal of Applied Radiation and Isotopes*, Volume 2, Nos. 3/4, 1957. A list of the U.K. papers is given below. All the original papers may be inspected at the U.K.A.E.A. London Office, St. Giles Court, W.C.2.

1. An array of Geiger Counters for Measuring Chromatograms or Other Distributions of Radioactivity. C. W. Gilbert and J. P. Keene, Christie Hospital and Holt Radium Institute, M/c. U.K.

4. Simple Liquid Scintillation-Counter for Measuring Tritium and Carbon-14. C. P. Haigh, EKCO Electronics Ltd., Southend-on-Sea, U.K.

10. Radiation Labelling of Organic Compounds with C^{14}. C. N. Turton, Isotope Division, A.E.R.E., Harwell, U.K.

15. The Szilard-Chalmers Reaction in Metal Pthalocyanines Irradiated in a Nuclear Reactor. G. B. Cook, B. R. Payne and Mrs. P. Scargill, Isotope Division, A.E.R.E., Harwell. U.K.

16. The Extraction of Individual Fission Products from Chemical Process Wastes. K. Saddington, Industrial Group, A.E.A., U.K.

17. An Electromagnetic Isotope Separator for the Enrichment of Radioistotopes. M. L. Smith, General Physics Division, A.E.R.E., Harwell, U.K.

19. The Design and Construction of Large γ-Irradiation Facilities. G. S. Murray and R. Roberts, Isotope Div., A.E.R.E., Harwell.

21. The Effect of γ-Irradiation upon Polyethylene Oxides. R. W. Pearson, Isotope Div., A.E.R.E. and Dunlop Research Centre, Birmingham, U.K.

31. The Interaction of Impurity Atoms with a Metal Solvent. T. Pyle and R. Shuttleworth. Metallurgy Dept., University of Leeds, U.K.

53. The Development of γ-Ray Spectrometry Applied to the Analysis of Radio-

isotopes. D. H. Pierson and P. Iredale, A.E.R.E., Harwell, U.K.

59. The Reaction between isotopically-Labelled Methyl Radicals and Methane. F. S. Daintaon, K. J. Ivin and F. Wilkinson, School of Chemistry, Leeds Univ., U.K.

63. Radioactive Methods for Labelling and Tracing Sand and Pebbles in Investigations of Littoral Drift. D. B. Smith and J. D. Eakins, A.E.R.E., Isotope Division, Harwell, U.K.

66. The Use of Radioactive Tracers in the Study of Passive Films on Metals. D. M. Brasher, C. P. De, A. H. Kingsbury and A. D. Mercer, Department of Scientific and Industrial Research, Chemical Research Laboratory, Teddington, U.K.

67. A Radioisotopic Study of the Effect of Surface Conditions during Wear of Tungsten Carbide. J. Golden and G. W. Rowe, Tube Investments Research Laboratories, Hinxton Hall, Cambridge, U.K.

78. Sulphur Metabolism in Fungi. June E. Robson, Isotope Division, A.E.R.E., Harwell, U.K.

91. The Study of Microsomal Protein Fractions by Means of Radioactive Amino Acids. P. Cohn and J. A. V. Butler, Pollards Wood Research Station, Chalfont St. Giles, Bucks, U.K.

93. Tracer Studies on the Biochemical and Morphological Significance of Subcellular Structures Derived from Bacillus Megaterium. A. R. Crathorn and G. D. Hunter, Chester Beatty Research Institute, Institute of Cancer Research, Fulham Road, London, S.W.3, U.K.

110. The Interpretation of Radiosodium Tissue Clearance Measurements as Applied to Peripheral Circulation Studies. W. Gemmell, Plastic Surgery Centre, Odstock Hospital Salisbury, Wilts, J. J. Haxhe, Laboratoire de Chirurgie Experimentale, Université de Louvain, Belgium, and N. Veall, Guy's Hospital Medical School, London, S.E.1, U.K.

113. Isotopic Studies of Globulin Production in Extravascular Sites. F. Gregoire, J. H. Humphrey and A. S. McFarlane, The National Institute for Medical Research, The Ridgeway, Mill Hill, London, N.W. 7., U.K.

115. The Labelling of Ram Semen with P^{32} and Stearic Acid-1-C^{34} in Vivo. R. M. C. Dawson, Agricultural Research Council Institute of Animal Physiology, Babraham, Cambridge, U.K.

116. Metabolic Interrelationship between Blood and Milk Lipids in the Lactating Dairy Cow. R. F. Glascock, D. J. McWeeny and R. W. Smith, National Institute for Research in Dairying, Reading, U.K.

137. Feeding and Digestion in Marine Copepods. S. M. Marshall and A. P. Orr, Marine Station, Millport, Scotland, U.K.

143. Experiments on the Metabolism of Certain Fission Products in Dairy Cows. C. R. Coid, L. J. Middleton, B. F. Sansom and Helen M. Squire, Agricultural Research Council, Radio-biological Laboratory, Compton, nr. Newbury, Berks, U.K.

145. Radioactive Tracer Investigations of the Absorption of Serum Albumin on Glass Surfaces. G. W. Reed and R. E. Rossall, Department of Medical Physics and Department of Medicine, University of Leeds, U.K.

175. Discrimination between Strontium and Calcium in Plants and Soils. R. P. Martin, P. Newbould and R. S. Russell, University of Oxford, U.K.

181. Measurement of Ionic Fluxes in Red Beet Tissues using Radioisotopes. G. E. Briggs, A. B. Hope and M. G. Pitman, University of Cambridge, U.K.

189. The Production of "Threshold" Nuclear Reactions in a Graphite Reactor. C. E. Mellish, J. A. Payne and R. L. Otlet, A.E.R.E., Harwell, U.K.

195. Fluid Density Measurements in Enclosed Systems. J. F. Cameron, Isotope Division, Atomic Energy Research Establishment, Harwell.

215. A Determination of the Heat of Sublimation and Vapour Pressure of Mercury Diphenyl at 25°C., Using Mercury-203. A. S. Carson, D. R. Stranks and B. M. Wilmshurst, University of Leeds, U.K.

Evening Lectures

2. Problems of Waste Disposal in the Wide Scale Use of Radioisotopes. Dr. W. G. Marley, Head, Health Physics Division, A.E.R.E.

3. Isotopes and Radiation Energy in Industry. Dr. Henry Seligman, Head, Isotopes Division, A.E.R.E.

4. The Future of Atomic Energy. Sir John Cockcroft, F.R.S., Director, A.E.R.E.

Experimental Studies of the Movement of Strontium and Calcium From Soil to Man.

9. Soil and Plants. Prof. R. Scott Russell, University of Oxford.

NEPTUNE Contractors

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Rodene Electrical Co. Ltd. (Main electrical power contactor panel).

Mawdsleys Ltd. (Motor generator set for clean power supply).

Hadley Telephone and Sound Systems Ltd. (Intercommunication equipment).

F. G. Miles Ltd. (Main shut-off absorbers and coarse water level switch. Ion chamber mountings).

The Palatine Tool and Engineering Co. (Surbiton) Ltd. (Fine control valve).

Blocktube Controls Ltd. (Control system for fine control valve).

Boremaster Ltd. (Lattice plate and fuel element locking bars).

C. W. Fletcher and Sons Ltd. (Fuel element boxes and various items for core assembly).

The Magnetic Valve Co. Ltd. (Electrically operated valves).

Terraspan Ltd. (Various items of prefabricated pipework and stainless steel assemblies).

Stemco Ltd. ("Gilbarco" water level indicator).

(Joint Release by Admiralty and U.K.A.E.A.) *11th November, 1957*

Patents Abstracts

The Abstracts on these pages are of British Patent applications made by the United Kingdom Atomic Energy Authority. For further details, application should be made to Mr. T. Benson-Gyles, Patents Branch, U.K.A.E.A., Bedford Chambers, Covent Garden, London, W.C. 2.

U.K. Application No. 27838/56

Inventors: D. T. Livey and P. Murray

Cermets comprising mixtures of silicon metal and uranium oxide

The cermets comprise 5% to 25% by weight of silicon and 95% to 75% by weight of uranium dioxide or U_3O_8. The cermets are formed by cold compacting a mixture of the components as powders in a mould at 1,000 p.s.i., heating the mixture to 1,000°C., and hot pressing at 2,000 p.s.i. and at least 1,400°C. The products have low porosities, high oxidation resistance compared with uranium dioxide, especially between 600° and 800°C., and improved thermal shock resistance compared with uranium dioxide. These properties combined with the low neutron absorption of silicon, and the ease of separation of the components during processing after use, make the cermets suitable for use in nuclear reactors operating at temperatures up to 1,000°C.

U.K. Application No. 27102/56

Inventor: P. A. Egelstaff

Glass Scintillators Containing Organic Phosphors

Scintillators are used in conjunction with photomultiplier tubes to detect and measure nuclear radiations, particularly gamma rays. In order to achieve high efficiency with gamma rays the scintillator should absorb as much of the energy of the incoming gamma rays as possible, and it is therefore advantageous to include in the scintillator elements of high atomic number. Similarly, slow neutrons can be detected and measured by incorporating in the scintillator additional elements which have large cross-sections for $(n,\alpha,)(n,\alpha)$ or other suitiable reactions, so that the neutrons are detected by means of the resultant gamma rays, alpha particles, etc.

Glasses are not normally used as scintillators for the reasons that they tend to absorb their own light radiation and that the light they emit is not of a wavelength best suited to excite the photocathodes of photomultiplier tubes, but it is possible to include in glasses oxides of heavy and of neutron-absorbing elements.

Efficient scintillators can be made by dissolving various organic phospors in transparent plastics, but it is not possible to dissolve in these plastics additional heavy elements or neutron-absorbing elements.

In the present invention a scintillator comprises a low melting-point glass having dissolved in it an organic phosphor which is stable at the melting point of the glass. The glass may also incorporate, together or separately, elements of high atomic weight and elements having a high absorption cross-section for slow neutrons.

U.K. Application No. 32013/56

Inventor: G. B. B. Chaplin

Operation of Transistors with Zero Leakage Currents

Transistors possess the disadvantage that it is not possible to, reduce, for example, the collector current completely to zero by cutting off the emitter current. There remains a minimum leakage current which varies between transistors and is also temperature dependent. The same is true of the other electrode leakage currents. These varying currents can give rise to output drifts.

In transistor circuits designed according to the present invention, the electrode leakage currents are substantially

U.K.A.E.A. Mobile Exhibition

The U.K.A.E.A. have available for loan a mobile "packaged" exhibition. It consists of eight four-sided panels showing:

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2. *The work carried out by the A.E.R.E., Harwell.*
3. *The work carried out by the Industrial Group.*
4. *The build-up of Britain's Power Programme.*
5. *How a Reactor works.*
6. *The uses of Radio-isotopes.*
7. *Careers in the A.E.A.*
8. *Health and Safety in the A.E.A.*

Each panel is L-shaped, free standing and measures 6′ 4″ high, 7′ 7″ long and 6′ 1½″ deep when opened out. The exhibition may be borrowed as a whole or in groups of one or more panels.

The exhibition is particularly suitable for technical colleges and sixth form science students. Applications to borrow the panels should be addressed to Public Relations Branch, U.K.A.-E.A., St. Giles Court, London, W.C.2.

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eliminated, and hence the drifts reduced, by arranging that no potential differences exist between the relevant electrodes. The specification describes, by way of example, a low-drift "chopping" or clamping circuit and a low-drift amplifier.

U.K. Application No. 32021/56
Inventor: A. J. Harris

Means for sorting objects according to dimensions

Means for sorting tokens according to a critical dimension comprises a rotary plate having radial slots of a size to admit tokens of a range of sizes, a central circular plate attached to the rotary plate to support one end of the token, a first fixed arcuate plate having an edge of decreasing radius of curvature to force a reference face of a token into contact with the reference face of the central plate, a further fixed arcuate plate underlying part of the plate having slots and a series of measuring plates extending over the outer portion of the radial slots, the inner edges of the measuring plates being stepped to provide decreasing distances between their inner edges and the central circular plate and a chute to deliver tokens to the rotary plate having radial slots.

U.K. Application No. 32649/56
Inventor: D. A. Watt

Combined Pump and Transformer Compensated Version

This application is for a Patent of Addition to British Patent 738,764 (Watt). In the present application the latter pumps are compensated to produce higher pressures by arranging to return the electrode current through the air gap in the manner described in British Patent 693,834 (Pulley). The current winding preferably consists of a number of preferably single-turn mutually insulated loops, as applied to another type of pump shown by Messrs. B.T.H. at the 1955 Geneva Conference on the Peaceful Uses of Atomic Energy.

U.K. Application No. 34247/56
Inventor: K. Plummer

Underwater Lamp

A container having a circular sealing ring which can seal about the neck of an electric lamp bulb to render the container watertight is fitted with a bulb holder which is free to move laterally so as to accommodate itself to eccentricities between the neck and contact cap of any bulb inserted through the sealing ring.

U.K. Application No. 23524/56

Inventor: D. G. Stevenson

Washing Devices

A washing device which contains the soiled liquid from the washing comprises a head portion having an inlet for cleansing liquid, a skirt of resilient flexible substance extending from the head portion to make contact with the surface to be cleaned and contain the cleansing liquid delivered by the inlets and suction means to draw off the soiled liquid contained by the skirt. The skirt portion may have a double wall, the inner wall being serrated at the edges which touch the surface.

U.K. Application No. 32820/56

Inventor: J. M. Wanklyn

Zirconium alloys containing tantalum and nickel for corrosion resistance to water at high temperatures

"Breakaway" in the corrosion of alloys of sponge zirconium and tantalum by high-temperature high-pressure water and steam is considerably delayed by the addition of 0·5% to 1·0% by weight of nickel. The improved alloys comprise 1% to 5% tantalum, 0·5% to 1·0% nickel, remainder zirconium which may contain impurities, particularly nitrogen.

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Development after 1960
Sir John Cockcroft, to International Bank for Reconstruction and Development.

Preserving Food by Radiation
G. S. Murray and T. Horne, to Annual Conference of Sanitary Inspectors' Association.

December

Calder Hall Type Reactors in Nuclear Power Generation
Sir Christopher Hinton, to BNEC Symposium.

The Contruction of Calder Hall
R. V. Moore, G.C., to BNEC Symposium.

Effluent Disposal at Windscale
F. R. Farmer, to BNEC.

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J.A. Jukes, to W. of England Fuel and Power Conference.

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K. B. Ross, O.B.E., to Inst. Chem. Eng., Glasgow.

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Sir John Cockcroft, to Nat. Industrial Conference Board, Paris.

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Sir John Cockcroft, to Dutch Engineering Society.

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J. A. Jukes, to O.E.E.C. Information Conference on Nuclear Energy.

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Sir John Cockcroft, to Polish Academy of Science.

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J. A. Jukes, to World Power Conference, Belgrade.

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Research and Development for Fuel Element Manufacture
Dr. H. K. Hardy, to O.E.E.C. Information Conference, Amsterdam.

September

Pumped Storage and Nuclear Power
Sir Donald Perrott, at opening of N.S.H.E.B. Errochty Station.

Reactor Reasearch and Development
C. A. Rennie, to O.E.E.C. Management Conference, Amsterdam.

October

Industry's Role in Nuclear Development
Sir Christopher Hinton, at Engineering, Marine Welding and Nuclear Energy Exhibition.

Nuclear Propulsion of Aircraft
Dr. J. V. Dunworth, to R. Aero. Soc., Folkestone.

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Isotopes and Radiation Energy in Industry
Dr. H. Seligman, to U.N.E.S.C.O. Radioisotopes Conference, Paris.

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Problems of Waste Disposal in the Wide Scale Use of Radioisotopes
Dr. W. G. Marley, to U.N.E.S.C.O. Radioisotopes Conference.

ATOM

Monthly bulletin of the U.K.A.E.A. is distributed to the staff of the Authority, to similar organisations overseas, to industrial firms concerned with the exploitation of nuclear energy, to the press and to others to whom a record of information on the work of the Authority may be useful.

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Enquiries concerning the contents and circulation of the Bulletin should be addressed to Public Relations Branch, U.K.A.E.A., St. Giles Court, London, W.C.2. Tel. Museum 6838, Extns. 1814 (Editorial) and 1801 (Circulation).

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