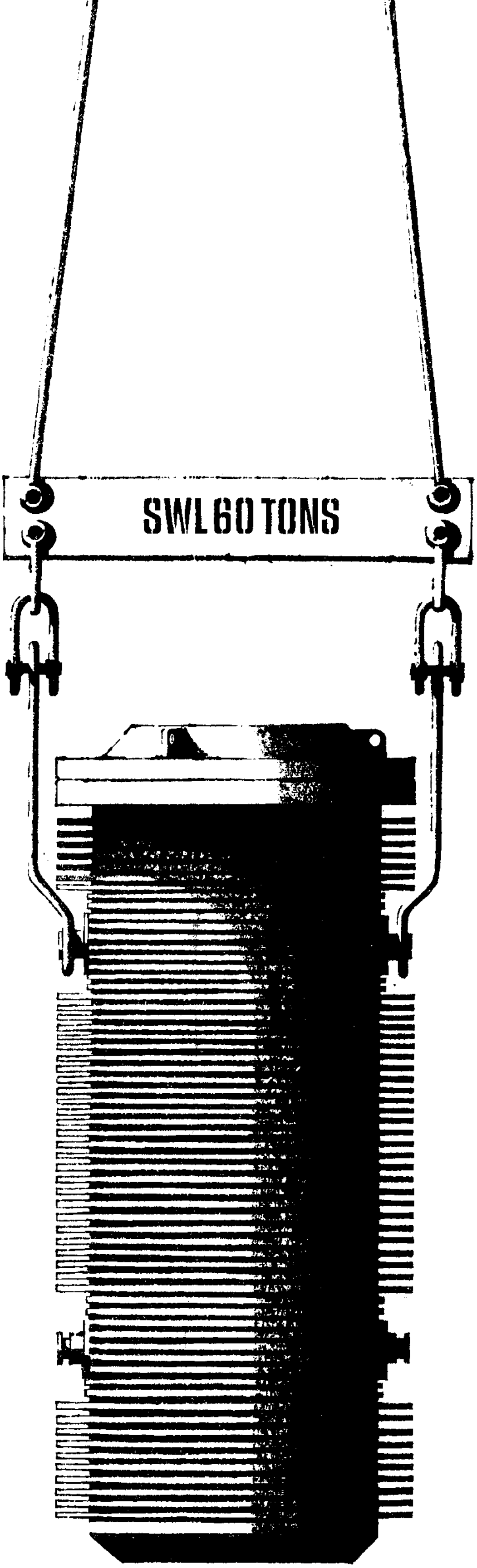
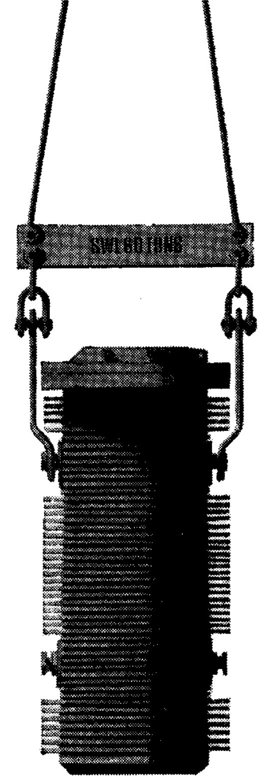
ATOM

Number 135 / **January** 19..

MONTHLY INFORMATION BULLETIN OF

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY


SWL 60 TONS



ATOM

MONTHLY INFORMATION BULLETIN
OF THE UNITED KINGDOM
ATOMIC ENERGY AUTHORITY

NUMBER 135
January 1968

Contents

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 of the work of the Authority may be useful.
Extracts of U.K.A.E.A. material from the bulletin may be freely published provided acknowledgment is made. Where the attribution indicates that the source is outside the Authority, permission to publish must be sought from the author or originating organisation.
Enquiries concerning the contents and circulation of the bulletin should be addressed to
Public Relations Branch

U.K.A.E.A.
11 Charles II Street
London SW1
Telephone 01-930 6262
Information on advertising in ATOM can be obtained from

D. A. Goodall Ltd.
Room 276, 6th Floor
Empire House
St. Martin's-le-Grand
London EC1
Telephone MONarch 0577/8/9

U.K.A.E.A. PRESS RELEASES

Tribology Centre

It was announced on Wednesday, 29th November that the Minister of Technology has approved the formation of a National Centre for Tribology*, to be administered by the Reactor Engineering Laboratory of the Reactor Group of the U.K.A.E.A. at Risley, near Warrington, Lancs. The project has been established under Section IV of the Science and Technology Act, which enables the Minister to require the Atomic Energy Authority to undertake work outside the atomic energy field.

A committee set up in 1964 by Lord Bowden reported in February, 1966 and concluded that industry suffered considerable losses from inadequate appreciation and application of tribology and estimated that savings of up to £500m. p.a. were possible and could be achieved within, say, 10 years if the right action was taken.

The Report recommended that the spearhead of a programme of improved education, research and industrial dissemination of tribology should be the establishment of several national centres of tribology.

The objective of the Centre is to support industry in the solution of tribological problems by providing a consultative service and undertaking research and experimental programmes to deal with specific problems. The Centre will also co-operate with universities in providing facilities for post-graduate training in the subject.

The Authority has for many years undertaken research and development work into lubrication, friction and wear problems associated with their activities in nuclear energy. Nearly all of this work has been related to the operation of engineering components in hostile environments such as gas, water and liquid metal systems usually at temperatures too high for hydro-carbon lubricants.

The Centre will be based initially on a small team of engineers and physicists

*TRIBOLOGY is the science and technology of interacting surfaces in relative motion. In practical terms this includes the general subjects of friction, wear, lubrication and bearing designs and thus affects the whole field of mechanical engineering design.

who have experience in this field and who will be joined during the formative years of the Centre by persons specialising in other areas of tribology in order to widen the range of usefulness of the Centre.

The Engineering Laboratories at Risley have, however, a wide professional experience in mechanical, chemical and instrument engineering development and this, together with the design, manufacture and administrative services available will back up the small professional staff which will form the nucleus of the Centre. For this reason it is believed that the Laboratory can make an effective and immediate start in this new venture.

Many of those widely experienced in tribo-engineering believe that much information already existing in the literature and arising from researches already carried out could be used more advantageously by industry than is the case at present. It is one of the main aims of the Centre to apply itself to the analysis of such information and attempt to supply it in a form more acceptable to the practising engineer rather than concentrate much of its resources on new and costly research programmes.

It is the Centre's intention that it should not overlap or conflict with other tribology centres, research associations, universities or other organisations working in this field, but that it should effectively co-operate with them both in its research programme and in its consultancy activities.

In those activities directly related to specific industrial problems and in its training activities for industry, it is expected that eventually the Centre should become commercially viable.

29th November, 1967

Materials technology

The U.K.A.E.A. has acquired an extensive knowledge of materials through its development of nuclear power for civil and military purposes. This expertise is being exploited through a Materials Technology Bureau at the Atomic Energy Research Establishment, Harwell.

Much of the existing knowledge and experience in the Authority relates to materials, particularly conventional materials for unconventional uses in nuclear engineering and new materials made necessary by the stringent requirements of the nuclear programme.

This experience includes the use of modern techniques for the preparation and fabrication of metals and ceramics, including high frequency and electron beam melting and casting, hydrostatic extrusion, planetary swaging, hot pressing, isostatic pressing (hot and cold) and vibro-compaction of powders. Other examples are ultrasonic machining of glass and ceramics, together with various joining processes including electron beam and friction welding, roll-bonding and the brazing of metals to ceramics.

There is also considerable experience and expertise, particularly at A.W.R.E. Aldermaston, in the organic materials field. Rubber, plastics, adhesives, surface coatings, composites and foams have been developed in many directions to give performances beyond those for normal industrial products.

Acquisition of this knowledge and experience by the Authority has involved close contact and co-operation with sectors of industry concerned with the manufacture and use of a variety of materials, both metallic and non-metallic.

The Bureau is centred at A.E.R.E. Harwell, but the materials expertise of the Authority as a whole is available. Liaison is maintained with outside organisations such as the Royal Radar Establishment, Malvern, and the Electronic Materials Information Centre, so that appropriate problems may be referred to them.

The purpose of the Bureau is to stimulate enquiries on materials from industry and research organisations and to disseminate the knowledge accumulated by scientific and technological staff in the Authority. It is also intended to provide an advice and consultancy service and to stimulate appropriate visits between Authority staff and industrial firms.

This may lead to the use of Authority facilities on specific problems either by visiting technologists or Authority staff. Courses and symposia on special topics will be arranged in collaboration with the Harwell Education and Training Department.

Information Services of a general nature will be provided free of charge. An appropriate charge will be made for consultancy work or for the use of experimental facilities. Patented developments will be the subject of normal commercial licensing. Mr. H. Lloyd, M.B.E., Ceramics Division, Building 35, A.E.R.E., Harwell, is Head of the Bureau.

Biographical note

Mr. Henry Lloyd, M.B.E., C.Eng., A.M.I.Mech.E.

Mr. Henry Lloyd, who has been appointed Head of the Materials Technology Bureau, has been the leader of a group of technologists at Harwell since 1947 who are engaged in developing metallurgical equipment and processes for the manufacture of nuclear fuel elements and nuclear materials.

Mr. Lloyd is 50 years old and was born in St. Helens, Lancashire, and was educated at St. Helens Technical College. From 1932-40 he was a member of the Engineering Division of Pilkington Brothers, Glass Manufacturers, St. Helens, and then worked successively as Metallurgical Engineer for the Ministry of Aircraft Production, Ford (Aero Engines) Co. Ltd., Manchester (1941-45), and for William Jessop & Sons Ltd., Steel Manufacturers, Sheffield (1945-47), before taking up an appointment at Harwell.

7th December, 1967

Radiation protection

WITH the aim of ensuring that exposure of workers to radioactive substances is reduced to a minimum, new draft regulations* were published on 29th November, 1967, by the Minister of Labour.

The regulations impose requirements for the protection of employees in premises covered by the Factories Act, 1961, against ionising radiations arising from unsealed radioactive substances and from objects contaminated by these substances.

The regulations lay down maximum permissible doses of radiation in cases where some exposure is unavoidable. These are in accordance with the latest recommendations of the International Commission on Radiological Protection.

The proposed regulations, which are complementary to the Ionising Radiations (Sealed Sources) Regulations, 1961, revoke the Factories (Luminising) Special Regulations, 1947.

* The Ionising Radiations (Unsealed Radioactive Substances) Regulations 1967. H.M. Stationery Office or through any bookseller, price 2s. 9d. net.

Future of Dragon

The OECD's DRAGON High Temperature Reactor Project at Winfrith, U.K., is to continue at least until 31st December, 1968. This was announced following a meeting of the Board of Management of the Project.

Negotiations leading to this continuation have been under way for some time, but have been inconclusive because of the absence of a decision on the Euratom programme for 1968 and later years. In consequence Euratom has been unable to accept financial commitments for this period.

The difficulty has been overcome through an agreement by the competent authorities that as an interim measure the DRAGON budget for 1968 of £2.1 million should be borne by Austria, Denmark, Norway, Sweden and Switzerland according to their normal shares, with the United Kingdom contributing the balance. This will give further time to negotiate a formal extension of the Project beyond its present term which ends on 31st December, 1967. It has been agreed that such negotiation should be concluded by 31st July, 1968. If such an extension proves possible, full account will be taken of contributions already paid for 1968; if not, Euratom will waive its rights to a share of the written-down value of the fixed assets of the Project on its termination.

Meanwhile it has been agreed that all organisations participating in the DRAGON Project (including Euratom) shall continue to have the same rights—in particular concerning information and the secondment of staff to the Project—as in the past. (O.E.C.D. release)

RCC publications

Two further titles have been added to R.C.C. publications series:

R.C.C. Review 6: "*Sample preparation for liquid scintillation counting*" by J. C. Turner of the Centre's Organic Department; and

Medical Monograph 6: "Diagnosis of thyroid disorders using radioactive iodine" by W. R. Grieg, M.D., M.R.C.P., I. T. Boyle, B.Sc., M.R.C.P., and J. A. Boyle, M.D., M.R.C.P., of Glasgow University Department of Medicine.

IN PARLIAMENT

Desalination

14th November, 1967

SIR D. RENTON asked the Minister of Technology what progress has been made in the search for methods of large scale desalination of water.

Dr. Bray: Steady advances are being made in multi-stage flash distillation which is the best process for sea water conversion in the present range of plant capacities. This type of plant has been built in a number of places abroad, the major part of the capacity by British firms. The most promising alternative processes have now been identified and their likely development during the next decade are being assessed.

Sir D. Renton: Can the hon. Gentleman say what is now the estimated likely cost per thousand gallons of producing desalinised water by the method which he has mentioned, and when we are likely to have that method in mass production?

Dr. Bray: Not without notice. The economics depend on the costs of alternative supplies, and plainly such places as Kuwait, where those costs are very high, can be expected to be among those which make an economic case soonest.

Mr. Maxwell: While congratulating my hon. Friend for the support which his Department gives to desalination research and technology, can he say what steps are being taken to bring about market research to discover which countries could use the equipment? In particular, can he say what assistance is proposed to be given to British industry in order to ensure that the countries needing it have the necessary finance?

Dr. Bray: Extensive market investigations have been made, by the Ministry of Technology, the Atomic Energy Authority and the firm of Hawker Siddeley, which is now assisting Weir Westgarth in the overseas marketing of desalination plant.

Sir H. Legge-Bourke: Does the hon. Gentleman recognise that all that he has said about desalination is of particular importance in the context of the proposal for a Wash barrage, and that if the work on desalination can be accelerated enough it should be possible to save a great capital outlay and provide a cheaper water supply at the end of it?

Dr. Bray: The possibilities of desalination in this country, too, are kept under review.

Air pollution

14th November, 1967

MRS. JOYCE BUTLER asked the Minister of Technology if he proposes that the Harwell five-year research programme on air pollution shall issue interim reports on particular aspects of the problem; and if he will make a statement.

Dr. Bray: The work at Harwell will be reported regularly to the Interdepartmental Committee on Air Pollution Research, whose advice is available to the Clean Air Council. The results of work at Harwell will be published in appropriate journals.

Fusion programme

14th November, 1967

MR. WINGFIELD DIGBY asked the Minister of Technology whether he will reconsider his decision to halve the British research programme on the control of nuclear fusion.

Mr. Benn: No, Sir. But as I told the House in my statement on 26th July, the Atomic Energy Authority will keep the situation under review. This will be done. But the situation has not changed in any way that justified reconsideration of the decision announced in July.

Mr. Digby: Is there not the serious danger that we are sacrificing our long-term interests in this matter, particularly with regard to future supplies of uranium, and will the Minister make available the confidential report on which this decision was based?

Mr. Benn: On the second part of the hon. Gentleman's supplementary Question, I could not publish the report as it was prepared on the understanding that it was a confidential report which was not even addressed to me but to the Atomic Energy Authority. On the first part of his Question, I can assure him that the Atomic Energy Authority considered the matter carefully and, in advising me on the course which I decided to accept, it had in mind the long-term as well as the short-term interests of the British atomic programme.

Mr. David Price: Will the Minister reconsider his decision not to publish the report in view of the considerable doubt which there is in the scientific world, which is very difficult for hon. Members to evaluate? I am not saying that it was a wrong decision, but, without the report, it is almost impossible to know whether he was right?

Mr. Benn: I understand the interest, not only in the scientific community but internationally and generally. The Authority decided that it was necessary to look at the fusion programme, and it decided to set up a committee to report to it. It would be open to very serious objection if internal inquiries by public corporations at the request of their managements were to be published subsequently. In those circumstances, I have to accept my responsibility for the decision, and it would not be possible to publish the report.

Effluent from fast breeder reactors

14th November, 1967

MR. BROOKS asked the Minister of Technology whether, in the light of the difficulties in disposing of the radioactive effluent from fast breeder reactors, he will now reconsider his decision to reduce research expenditure at Culham on fusion reactors.

Mr. Benn: No. The disposal of radioactive effluent from fast breeder reactors presents no problems of a kind different from those already encountered and solved successfully in the operation of existing power reactors.

Nuclear ships

14th November, 1967

MR. WALL asked the Minister of Technology what progress is being made with the design of a nuclear reactor for surface ships; and if he will make a statement.

Dr. Bray: It has long been technically feasible to design and build a small nuclear reactor to power a ship, and the U.K.A.E.A. keep under continuous review improvements in reactor and nuclear fuel technology, in the special context of ship application. But the use of a nuclear propulsion unit depends on the economics of its operation which are related more to the need for high power and intensive utilisation than to reactor design.

Mr. Hooley: Is my hon. Friend aware that four of our major industrial competitors, the U.S.A., U.S.S.R., Japan and Germany, all have prototypes of this kind of ship in action? Is it not high time the shipbuilding industry woke up?

Dr. Bray: We are in constant touch with both the shipbuilders and shipowners, but it does not help the economic and rational development of advanced technology in this country if we ignore valid economic considerations.

Sir H. Legge-Bourke: While nobody will dispute that final observation, will the hon. Gentleman agree that the more one studies the paper read by Mr. Teesdale in March this year to the Royal Institute of Naval Architects about composite nuclear powered merchantmen the more one comes to the conclusion that there is a serious need to re-establish something like the Padmore Committee to go into this all over again?

Dr. Bray: I am not sure that a committee is the right way to tackle this. There are evolutionary developments, of which the container ship is a recent and very interesting example, in shipbuilding. I can assure the hon. Gentleman that we are not waiting for a committee to study this sort of question.

A.W.R.E. civil work

21st November, 1967

MR. BRIAN PARKYN asked the Minister of Technology what was the amount of work carried out, as a percentage of total expenditure, between defence and civilian projects by the Atomic Weapons Research Establishment, Aldermaston, during each of the past three years.

Dr. Bray: The proportion of total expenditure at Atomic Weapons Research Establishment attributable to civil work during the past three years is:—

1964-65	14 per cent.
1965-66	15 per cent.
1966-67	17 per cent.

Anglo-American co-operation

21st November, 1967

SIR C. TAYLOR asked the Prime Minister whether he will seek agreement from the Governments of the United States of America and Canada to the publication of documents setting out the history of Anglo-American co-operation in the field of atomic energy, as governed by the 1943 wartime and 1948 post-war agreements on this subject.

The Prime Minister: No, the normal

rules about the publication of State Papers of historical interest apply in this field as in others.

Dounreay staff

21st November, 1967

MR. RANKIN asked the Minister of Technology what steps he is taking to stop the brain drain at Dounreay.

Mr. Benn: I have nothing to add to the open letter that I addressed to the staff of the Atomic Energy Authority on 15th November concerning the attempt of the Westinghouse Corporation to recruit British scientists and engineers with experience of liquid metal-cooled fast reactors. I have also discussed the subject with senior management and staff representatives from Dounreay and Risley.

Mr. Hector Hughes asked the Minister of Technology how many scientists and other workers in Dounreay Experimental Station in Aberdeenshire have left it and gone to the United States of America within the last six months; why they left; how it has affected the work of the station; and what steps he plans to continue to expand the work of the station.

Mr. Benn: I am informed by the A.E.A. that two employees have left the Dounreay Experimental Reactor Establishment to go to the United States of America during the last six months. One was a senior machine operator who accompanied her American husband back home. The other was a Scientific Officer who mentioned better pay as his main reason for leaving. The loss of these staff had no effect on the work of the Establishment. The Dounreay Establishment is engaged on an important programme of work, including the development of fast reactor systems which will keep it busy for many years to come.

Pay discussions

23rd November, 1967

MR. EVELYN KING asked the Minister of Technology if he is aware that dissatisfaction among employees at Winfrith about pay is growing; on what date the issue was referred to the National Board for Prices and Incomes; and when he expects the findings of that Board to be made known.

Mr. Benn: I am very well aware of the dissatisfaction. The matter was referred on 17th October to the National Board for Prices and Incomes, which hopes to have its report ready before Christmas.

Enriched uranium

5th December, 1967

DR. DAVID OWEN asked the prime Minister what specific Anglo-American agreement prevents Great Britain sharing with other European countries the technology of partially enriched uranium.

The Prime Minister: None, Sir.

Dr. Owen: Is my right hon. Friend aware that the United States Atomic Energy Commission has already started to negotiate with private industry for the sharing of technology, which implies that it does not take a secret agreement very seriously? Can he press the Americans to try to ensure that we can share his technology with our European partners?

The Prime Minister: In my first Answer, I explained that there is no such, as my hon. Friend put it, " specific " Anglo-American agreement preventing a sharing with European countries of this technology. There are difficult questions about our national and commercial interests if we made this available except as part of something extremely valuable to ourselves. This is why I stressed the importance of co-operation in my speech at Guildhall. We must be dominated in this matter by considerations of national interest but there is no such agreement as envisaged by my hon. Friend.

Sir H. Legge-Bourke: Will the right hon. Gentleman seriously consider taking some active steps to bring about a decision from Euratom first of all to continue financing the DRAGON project?

The Prime Minister: In my first question and I should be grateful if the hon. Gentleman would put it down on the Order Paper. With regard to general relations with Europe, we are only too anxious to enter into bilateral or multilateral nuclear agreements, whether for the provision of reactors or, as in the Question, for the provision on a European and not on an American basis of enriched fuel.

Mr. Hogg: Has not the difficulty always been the extraordinary reluctance of European Powers with atomic inclinations to make use of our vastly superior technology? Will the right hon. Gentle-

continued on page 20

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

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

General Isotope Course
22nd January to 16th February, 1968.

Intended to give a good practical introduction to the use of radioisotopes in research and technology, with particular concern for the problems of the students. Opportunities for carrying out work in connection with students' own needs. Fee: £105 exclusive of accommodation.

Pulse Techniques in Nuclear Particle Counting
29th January to 2nd February, 1968

Arranged for U.K.A.E.A. graduate staff, this course will be of interest to others working in the field. Fee: £26 5s. exclusive of accommodation.

Magnet Design
12th to 16th February, 1968
29th April to 3rd May, 1968

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

Radiological Protection
19th to 23rd February, 1968

Designed to give users of radioactive substances and radiations in industry, research or teaching a broad introduction to the principles and practice of radiological protections, with a strong emphasis on practical considerations. Fee: £26 5s. exclusive of accommodation.

An appreciation course for management in Non-Destructive Testing
4th to 6th March, 1968

Based on new techniques and approaches to non-destructive testing that have been developed by the U.K.A.E.A. Designed for users in other industries who should be familiar with the scope of the subject and the basic procedures in common use. Fee: £26 5s. exclusive of accommodation.

Radioisotope Methods in Chemistry
4th to 22nd March, 1968

Intended to give graduate chemists a sound introduction to radioisotope methods. There is scope for carrying out individual experimental work. Fee: £78 15s. exclusive of accommodation.

High Voltage Technology
13th to 21st March, 1968

Intended for graduate engineers and scientists who are new to high-voltage technology, or whose experience has been limited to a specialised aspect. Fee: £36 15s. exclusive of accommodation.

Process Instrumentation
18th to 29th March, 1968

Intended for graduates who are working on the instrumentation of process plant, nuclear reactors and scientific apparatus or who have a direct interest in the subject. A visit will be arranged to a process plant or a power station where modern control techniques are being applied. Fee: £52 10s. exclusive of accommodation.

Science and Mathematics Teachers
1st to 5th April, 1968

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

Great Britain — an alternative economical source of enriched uranium fuel

The following paper by Dr. N. L. Franklin, Deputy Managing Director, Production Group, United Kingdom Atomic Energy Authority, was given to the Swiss Association for Nuclear Energy at a meeting in Zurich, 26th October, 1967.

Introduction

In establishing our claim to be considered as an alternative economical source for enriched uranium fuel it is first necessary to answer the question "why is an alternative source of supply required?". It is clear that the demand for enriched uranium in the world outside the Communist bloc seems certain to outstrip the capacity of the separation plants at present owned and operated by the U.S.A.E.C. We will turn in a moment to attempting an estimate of when this demand might exceed the American plants stated capacity and by how much, but it is necessary first to ask whether the simplest course, in any event, is not to continue to rely upon the single monopoly supplier who will doubtless expand his production capacity as and when required.

The answer to this question lies in an area where political and commercial issues are intermingled. One of the advantages of nuclear energy to a country without sufficient indigenous resources to provide all her own fuel needs is that it considerably reduces the import requirements of fuel below the levels associated with fossil fuels. Nonetheless such imports are still required and general commercial experience suggests that the importer is in a much stronger position if he is able to call upon the services of more than one supplier. This general truth has been sharply brought home to us in the United Kingdom during the last year by the impact of affairs in the Middle East on our oil import position.

The terms on which the U.S. offer to provide enriched uranium or toll enrichment services have been very clearly defined and in particular are applied without any distinction between American and foreign users. It is open to customers to conclude long term supply contracts to cover the life of their reactors subject to the amounts concerned being within the limits laid down in the inter-Governmental Agreements covering the transfer of enriched uranium from the U.S. to another country. These arrangements at present provide a reliable basis for the supply of enriched uranium, but the inevitable disadvantages to a purchaser of there being but one monopoly supplier remain. There is the further point that it is known that the U.S. are contemplating either transferring some of their present capacity to private ownership or when new capacity is required having this provided by private companies. In this circumstance it is possible that conditions could be applied to the sale of enriched uranium to influence the choice of reactor systems in a foreign country. In the U.K. we have taken the decision to use the basis offered by our existing Capenhurst facility and by our experience of the relevant technology to provide virtually all our own enriched uranium needs from our own plant. However, further additional capacity can readily be provided in the mid 1970's and it is our view that the nuclear industry as a whole would benefit from the existence of an alternative supplier as a check against the creation of an absolute monopoly in the future and to allow an element of price competition in the supply of this basic commodity.

Supply and demand

Let us then examine the relationship between capacity of the present American plants and the foreseeable world demand for enriched uranium.

Following the recent flood of orders for nuclear power stations in the U.S. and with the growing world-wide realisation of the competitive attraction of nuclear power, there has been, over the past twelve months, a series of upward revisions by the responsible authorities of

Table 1. Estimated separative work requirements 1975/1980.

	1975	1980
U.K. (for comparison only)		
Nuclear Capacity MW(E)	13,500	28,000- 40,000
Separative Work requirements (tes SW p.a.)	1,250	2,500- 3,500
U.S.A.		
Nuclear Capacity MW(E)	50,000-75,000	120,000-170,000
Separative Work requirements (tes SW p.a.)	8,000-12,000	13,000- 22,000
Euratom countries		
Nuclear Capacity MW(E)	15,000-25,000	40,000- 60,000
Separative Work requirements (tes SW p.a.)	1,500- 3,500	3,500- 7,000
Other European countries		
Nuclear Capacity MW(E)	6,000-12,000	15,000- 30,000
Separative Work Requirements (tes SW p.a.)	600- 1,800	1,500- 4,500
Rest of the World (excluding Communist Bloc) ...	9,000-18,000	25,000- 50,000
Separative Work requirements tes SW p.a.	900- 2,700	2,000- 6,000
Total (excluding U.K.) Separative Work tes SW p.a.	11,000-20,000	20,000- 40,000

forward estimates of nuclear generating capacity. Taking these into account, revised estimates of future world demand for enrichment services, details of which are given in Table 1, indicate that the demand from the free world (excluding the U.K.) is likely to be between 11,000 and 20,000 tes S.W. per annum in 1975 and between 20,000 and 40,000 tes S.W. per annum in 1980.

On the minium figures, the U.S. could supply the total demand from their existing plants until the late 1970's; on the maximum figures, demand would exceed capacity by about 1974. However, there are a number of measures which the U.S.A.E.C. could take to extend this latter date, for example, stocks could be built up in the early years and the existing capacity could be increased by incorporating further improvements in plant efficiency.

A further factor which must be considered in this context is the possible size of military stockpiles of enriched uranium which could conceivably be diverted to peaceful uses. The actual sizes are, of course, not known but Stoller and Associates have suggested that some 300,000 s.t. of natural uranium ore have been used for military purposes to date. One might speculate that the resulting stockpile of highly enriched uranium is measured in hundreds of tonnes of 93% U-235. One hundred tonnes of 93% U-235 is equivalent, after allowing for the necessary blending operation to produce "civil" enrichments, to something less than 15,000 tes of Separative Work. The interest charges on pre-production included in the latest U.S.A.E.C. announcement on the costs and price of Separative Work may also suggest a stockpile of this order. This quantity is of the same order as the estimates of total annual requirements for 1975 and it appears on this admittedly rough analysis that the release of stockpiled quantities might affect the date at which new capacity is required by periods of perhaps one to three years. On balance we conclude that new diffusion plant capacity could be needed as early as 1976 and at latest by 1978 or 1979.

The U.S.A.E.C. have stated that they require three to four years' construction time for a new plant and one year to complete initial formalities. This brings the earliest likely decision date to 1971 or 1972 for the construction of new plant in the U.S. The pattern of ordering enriched uranium by contracts of several years' duration means that the capacity of the existing American plants will have been fully committed by about this date also. The question of whether or not to continue to rely on American sources or whether to support the establishment of an alternative source is then clearly one which will come to a head within the next two to three years and one which deserves preliminary examination at this time.

Cost targets for an alternative supplier

I have outlined earlier the general arguments as we see them against the maintenance of a monopoly supplier of enriched uranium. If we accept the desirability of there being more than one supplier we have to ask what price, if any, need be paid for the benefits of an alternative source of supply. In terms of the economy of the nation or a group of nations the risks associated with imports from a monopoly supplier must have a quantifiable value and some premium in the form of a higher price or reduced earnings on investment could be justified on this account. We recognise, however, that in practice the majority of nuclear reactors in Europe are likely to be operated by privately owned utilities whose managers, responsible to the shareholders, will scarcely be in a position to pay any significant premium. We, therefore, take it as an essential target for the long term at least that an alternative supplier of enriched uranium must be able to offer broadly competitive terms.

The information recently published by the U.S.A.E.C. enables a rough breakdown to be made of the cost structure of the American plants. This shows us the target which we, or any other potential second source of supply, will have to meet.

Table II

Component	Cost of separative work $/kg
Electricity—at 4 mills/kWhr. ... ... approx.	11.5
Capital Depreciation—over 35 years, original capital cost $2.300m	3.65
Interest charges on outstanding capital—at 5% p.a.	2.93
Labour charges and other operating costs ...	2.4
Other costs—administration charges and overheads, etc.	0.87
	$21.35/kg S.W.

Any new supplier, in attempting to match these costs, is confronted with four major factors:—

(i) The scale of the U.S. operations—for example, any one of the U.S.A.E.C.'s three plants would on our estimates be able to supply virtually all the European demand likely to arise before the late 1970's.

(ii) The U.S. plants use electricity at 4 mills/kWhr, a figure well below the national tariff rates common in European countries.

(iii) Construction of the U.S. plants was completed about fifteen years ago and any new plant built today must face a considerable escalation in capital costs.

(iv) The U.S. cost structure is based on a 35 years' capital depreciation period coupled with a low rate of interest, whilst any new plant operating on a wholly commercial basis will be required to earn a rate of return more in line with normal commercial practice.

On the last point, in setting their new price level of $26/kg S.W. the U.S.A.E.C. have in fact included a contingency margin which it is argued is sufficient to allow for a total rate of return on capital of 7½% p.a.—said to be a " possible composite cost of money . . . associated with a privately financed enrichment enterprise." It is arguable, however, whether such a rate of return is adequate for a genuinely commercial venture.

As an indication of the total effect of the last three factors it is of interest simply to re-examine the cost breakdown if we merely insert 1967 money values, a " commercial " rate of return on capital and a typical European tariff for electricity. (Table III).

This simple and rather arbitrary calculation leading to costs 60% higher than the new U.S. price serves to illustrate the magnitude of the task facing anyone seeking to establish an alternative source of supply. How then are we in the United Kingdom facing the problems in these four areas in our efforts to offer a competitive price?

The U.K. position

The scale of the programme

Following completion of the installation of 5,000 MW of magnox reactors the current U.K. programme for nuclear power envisages the installation of some 8,000 MW of capacity between 1970 and 1975 and a continuing expansion thereafter. Until the advent of the fast reactor in the later 1970's the U.K. reactor installation will be of A.G.R.'s using enriched uranium. The corresponding estimates for

Table III

Component	Cost of separative work $kg
Electricity, at, say, 8 mills/kWhr ...	23.0
Capital depreciation—over 20 years, with original capital inflated by, say, 35% ...	8.5
Interest charges on outstanding capital—say 8% p.a. ...	7.0
Labour charges and other operating costs—as before ...	2.4
Other costs—as before ...	0.9
	41.8 $/kg S.W.

the requirements of Separative Work to fuel this programme are given in Table IV.

Table IV

Year	1975	1980	1985
Cumulative Thermal reactor Capacity MW(E)*	13,000	28,000	39,000
Separative work required tes/a	1,250	3,000	3,400

*Includes 5,000 MW(E) of magnox reactors.

Our diffusion plant at Capenhurst was built to supply a military requirement which by 1962 had been substantially fulfilled. Development work since that time has been devoted to the adaptation of the plant to civil requirements and to the improvement of the efficiency of the separating stages. The first stage of the modifications to the plant are now well in hand and will be completed by 1970 when the plant capacity will exceed 400 tes p.a. S.W. New and larger separating stages of greater efficiency are now under development and will be installed to extend Capenhurst capacity as required during the 1970's.

It will be seen that to meet U.K. demands alone capacity must exceed 1,000 tes p.a. by 1975 and reach 3,000 tes p.a. by 1980. We believe that the economies of scale in diffusion plant operation are such that by the time outputs from Capenhurst significantly greater than 1,000 tes S.W. p.a. are reached, the costs associated with the extensions to capacity beyond this level will not vary markedly with further increases in output. It should be noted in passing that the same arguments would not necessarily apply to a completely new plant where very significant expenditure on buildings, access roads, electrical supplies, services, etc., would be met and would clearly result in economies of scale continuing to larger outputs.

If, to the U.K. demand, we add a significant fraction of the estimated European demand for enrichment, then it will be seen that the size of the plant would approach the size of any one of the present U.S. plants, and on these grounds, therefore, we feel that such a plant would suffer no significant disadvantage as a result of the scale of operations.

Electricity tariff

The electricity demand in a diffusion plant producing about 3,000 tes of S.W. p.a. is of the order of 1,000 MW. The load factor of this demand is, of course, ideally 100% but the nature of the plant is such that the load can be drastically reduced for short periods if the supply system would otherwise be overloaded and the demand is, therefore, a very attractive one from the point of view of the electricity supply grid. The nature of the demand also means that full advantage can be taken of the very high availability achievable with on-load refuelled nuclear reactors, the limit being set only by the maintenance requirements of the reactor itself. In these circumstances it is clear that a diffusion plant can benefit to the full from the low power costs resulting from operation of a nuclear reactor in this way, either as an independent source of supply or coupled to a national grid system giving the additional advantage of interruptability of demand at peak load periods. You will have seen the recent announcement by the U.K. Government of its intention to make special arrangements for electric power supplies to large industrial users, and we expect that arrangements on these lines will enable power to be supplied to Capenhurst at a tariff not very different from that applying to the U.S. plants.

Escalation of construction costs

The only defence which we or, indeed, any new operator in Europe or the U.S.A., can have against increases in cost due to escalation is through improvements in technical efficiency since the U.S. plants were installed. Such improvements can either directly result in a lower capital cost per unit of separative work, or in a lower electricity consumption, or in a combination of the two. The original U.S. plants cost $2,300m or about $130,000 per te of separative work. Estimates of the extent of inflation in the U.S. over the past fifteen or twenty years suggests that in today's money values this figure might be $170,000. Our present best estimates suggest that capital costs per te S.W. somewhat less than this figure can be achieved, with electricity usages no greater than those published from the U.S. plants.

Rate of return on capital

The U.K.A.E.A. in its trading operations is required by the Government to earn a return on capital invested sufficient to cover depreciation, interest charges and to provide a surplus as in a normal commercial operation. For the provision of enrichment services we expect at the present time to be required to provide a return on capital invested which results in total charges per unit of capital nearly twice those currently applying to the U.S. plants.

Summary

In summary then we believe that the technical efficiency of our plants will go some way towards offsetting the effects of escalation in capital cost. In addition, we are, of course, attempting to minimise our operating costs, both in terms of direct labour and materials, and of indirect expenses by the maximum use of automatic control and programming of the plants. However, the capital charges which we shall have to meet impose a very serious burden in seeking a competitive position. The net effect as we see it at present is that we expect to achieve costs which are of the order of 15% greater than the present U.S. price when the second phase of the expansion of Capenhurst gets underway in the early 1970's.

A 15% increase in the cost of separative work represents an increase of some 7 or 8% in the price of enriched uranium at the enrichment levels common in power reactors or some 0.08 mills/kWhr in the generating cost.

In considering this margin it is relevant to note that in Europe the costs of transport of enriched uranium, together with associated charges for stockholding, etc., may be somewhat less for supply from a plant in Europe than for the case where transatlantic transport is involved. The margin in total cost to the reactor operator may, therefore, be less than the cost figures imply.

U.K. terms for supply for enrichment

The margin of 15% which I have quoted relates to the early 1970's. The costs thereafter can be expected to fall in some measure as the plant size increases and, more importantly, following the progressive introduction of the results of longer term development work now in hand. These cost reductions could, however, only be reflected in prices for long term contracts covering, say, 10 years, from the date when we can begin to provide surplus capacity in 1973.

We shall, however, be able to quantify these improvements in more detail when the development work has progressed to the prototype stage during the course of next year. We intend then to propose firm contract terms and prices before the end of 1968 and in good time to allow an assessment to be made by potential customers of our position as an alternative supplier before final decisions on any other extensions of separation capacity need to be taken.

The proposals which we shall make will be specifically for the provision of a toll enrichment service, although we would, of course, be willing to provide or procure natural uranium ore in addition, and to convert customers' ore into UF_6 for feed to our enrichment plant. In making a toll enrichment service available we should contract to supply a given amount of separative work, leaving the customer free to choose product, feed and waste enrichment within fairly broad limits. Detailed procedure for advance notice of requirements, feed deliveries and production times will also be laid down.

Low-grade uranium ores

A half-day symposium on "Low Grade Uranium Ores and their Processing" is to be held by the British Nuclear Energy Society on 25th March, 1968. Further information is obtainable from the Secretary, B.N.E.S., 1-7, Great George Street, London, S.W.1.

A.E.A. Reports available

THE titles below are a selection from the December, 1967, " U.K.A.E.A. list of publications available to the public ". This list is obtainable free from the Librarian, A.E.R.E. Harwell, Didcot, Berkshire. It includes titles of all reports on sale, translations into English, books, periodical articles, patent specifications and reports which have appeared in the published literature. It also lists the Depository Libraries in the U.K. and the countries with official atomic energy projects who receive copies of U.K.A.E.A. unclassified reports.

AEEW-M 745
Fundamental Calculations and Estimation of Accuracy in Heavy Water Standards. By P. R. Rowland. May, 1967. 21 pp. H.M.S.O. 3s. 6d.

AEEW-R 498
The Winfrith DSN Programme, Mark 2. By C. Green. September, 1967. 51 pp. H.M.S.O. 8s.

AEEW-R 551
On the Importance of Fast Scattering Data for Aluminium in the Interpretation of Results from H_2O-Moderated Lattice Experiments. By F. J. Fayers and M. J. Terry. July, 1967. 14 pp. H.M.S.O. 3s. 6d.

AEEW-R 553
Dryout During Flow and Power Transients. By D. Moxon and P. A. Edwards. 1967. 42 pp. H.M.S.O. 7s.

AERE-M 1911
Multiple Elastic Scattering of Thermal Neutrons by Polycrystalline Lead. By G. D. Wignall. June, 1967. 4 pp. H.M.S.O. 1s. 9d.

AERE-R 5021
Calculation of Noise/Signal Ratio of a Nuclear Pulse Amplifier Employing Gated Active Integration. By M. O. Dieghton. May, 1967. 40 pp. H.M.S.O. 8s.

AERE-R 5112
Some Ways of Recording Optical Spectra Using Image Intensifiers. By P. Iredale and D. J. Ryden. October, 1967. 13 pp. H.M.S.O. 3s. 6d.

AERE-R 5523
Further Investigation of Silt Movement in the Ebb Channel, Firth of Forth, Using Radioactive Tracers, 1966. By D. B. Smith, T. V. Parsons and P. L. Wearn. July, 1967. 17 pp. H.M.S.O. 5s.

AERE-R 5550
Oil Pollution at Sea. Studies in Connection With the Torrey Canyon Episode. Edited by H. A. C. McKay. September, 1967. 44 pp. H.M.S.O. 8s.

AERE-R 5552
The Effect of Moisture on the Inhibitory Action of Phosphorus Oxychloride on the Air Oxidation of Graphite. By J. B. Lewis, A. N. Moul and R. Murdoch. July, 1967. 19 pp. H.M.S.O. 3s.

AERE-R 5571
An Elementary Account of the Theory of Image Contract in Electron Microscopes. By M. J. Makin. September, 1967. 52 pp. H.M.S.O. 7s.

AERE-R 5598
The Data Link Controller for the Fast (880 k BIT/SEC) A.E.R.E. Data Links. By J. S. Austin. October, 1967. 11 pp. H.M.S.O. 3s.

AWRE 0-77/67
Electrical Breakdown in Vacuum. By W. D. Owen and M. H. Davies. November, 1967. 29 pp. H.M.S.O. 5s. 6d.

AWRE 0-78/67
Electrical Breakdown Between a Plasma and an Electrode at a Negative Potential. By W. D. Owen. November, 1967. 11 pp. H.M.S.O. 1s. 9d.

PG Report 792(W)
The Experimental Determination of the Photopeak Efficiencies of NaI(Tl) Detectors for Cylindrical Gaseous Sources. By V. Barnes and J. J. Wilson. 1967. 10 pp. H.M.S.O. 1s. 9d.

PG Report 807(W)
Collection of Krypton and Xenon from Reactor Coolant Gas in Preparation for Gamma Spectrometric Counting. By R. L.D. French. 1967. 9 pp. H.M.S.O. 1s. 9d.

RCC-M 210
Cerium (IV)—Arsenite Reaction in Microdetermination of Iodine for Specific Activity Measurement. By A. Appleby and R. E. Spillett. October, 1967. 9 pp. H.M.S.O. 1s. 9d.

RCC-R 209
Studies of the Effects of Radiation on Aqueous Solutions of 3:5-Diiodotyrosine. By A. Appleby. July, 1967. 35 pp. H.M.S.O. 5s.

TRG Report 1455(R/X)
Thermal Insulation in Relation to Cryogenics. By S. D. Probert. 1967. 105 pp. H.M.S.O. 15s.

TRG Report 1550(C/X)
Final Report on the Creep Properties of Molybdenum at 650°-750°C. By J. E. Bowers, R. D. S. Lushey and P. W. J. Sansom. January, 1967. 25 pp. H.M.S.O. 5s. 6d.

Radioisotopes in food processing

Part 1 Radioisotope instruments

This article, by R. M. Longstaff, Wantage Research Laboratory, U.K.A.E.A., is the first of two that appeared originally in Food Processing and Marketing *to whom acknowledgment is due. The second,* Analytical and tracer techniques, *will be published in the February issue of* ATOM.

APPLICATIONS of radioisotopes (other than for radiation processing) fall into two main categories. The first comprises instruments (which may be linked with control systems) incorporating a piece of radioactive material, in conjunction with a detector of the radiation it emits, to ascertain some property such as position, level, density, thickness or composition. The second comprises tracer investigations, where a small quantity of a suitable radioactive substance is introduced into a material or process and followed with a radiation detector in order to learn about the movement and distribution of the "labelled" material or to study the dynamics—or the faults—of the system.

Applications of both kinds find uses in the food industry, in production control, process studies, plant maintenance, laboratory analysis and research work. The present article describes the use of radioisotope instruments in the food processing and packaging industries, with emphasis on the production side; a second article will conclude this survey and also deal with radioactive tracer techniques in the industry.

The use of radioisotopes as components of instruments for production control, and of radioactive tracer techniques for studying the movements and distribution of materials, have already achieved wide use in many industries, including those connected with food. In these applications the amounts of radiation used are far too small to produce any detectable effect upon the materials studied. The amounts involved may conveniently be compared with the amount of light needed to see an object or to read a label by, whereas that required for radiation treatment of food is comparable with the amount of light required to ripen a crop or to bleach linen. For this reason applications of the kinds to be considered here are specifically exempted from the regulations that have been introduced to control food irradiation, although legislation exists to ensure the radiological safety of workers and the public.

Radioisotope instruments

A radioisotope instrument is simply a device for studying something by shining on to it the invisible radiations from a small quantity of a suitable radioactive substance (the "source,"), and measuring with an electrical detector either the radiations that penetrate to the other side or those that are scattered back towards the source. All materials absorb radiation to a greater or lesser extent so the amount of radiation reaching the detector will depend upon the amount and nature of the material it has encountered. The signal from the detector can be interpreted variously in terms of the location, density, thickness or composition of the material, and can be used to actuate indicating or recording instruments; sometimes it can be fed back into the system to give a degree of automatic control of the characterestic measured. Radioisotope instruments show a number of clear advantages over their more conventional counterparts. One of the most important of these is the ability to make measurements on an object without having to touch it, and another is the ability of the radiations to penetrate substantial thicknesses of opaque materials. These qualities allow measurements to be made on hot or easily-marred surfaces, on rapidly-moving materials, or on the contents of closed vessels or pipes, where physical or chemical conditions may make other techniques unsuitable. Radioisotope sources are robust and self-contained, operating independently of external power supplies. The signal from the detector is electrical, and is therefore compatible with other electrical systems or it can be easily linked to pneumatic or hydraulic control systems.

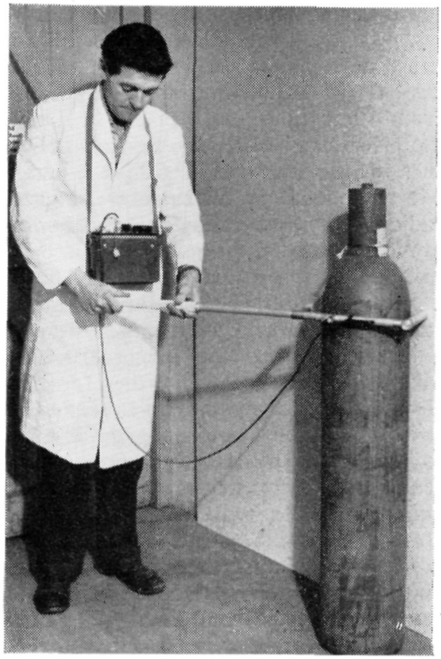
Although a radioactive source can be regarded as giving off radiation all the time, nevertheless the energy is in fact emitted in individual pulses that arise from changes taking place in single atomic nuclei—hence the irregular clickings characteristic of a Geiger counter. Most industrial instruments register radiation by integrating the number of events detected during a preset time interval. The greater this number, the better is the precision and steadiness of the reading, but (for a given source strength and arrangement) the longer the time taken to achieve it, and therefore the slower the effective response of the instrument. In every case a compromise has to be reached between the response speed required of the system on the one hand and the radiological safety and cost of a larger radiation source (or the cost of more sophisticated detecting equipment) on the other hand. In practice the effective response times of most industrial radioisotope instruments range from a few hundredths of a second for package-filling monitors up to several minutes for some analytical devices. An important characteristic of a radioactive source is that, unlike a light or an X-ray machine, it cannot be switched off, but its activity will die away at a characteristic rate: this is usually expressed in terms of the "half-life" or halving-time of the particular radioactive substance concerned —that is to say the time taken for half of the total number of radioactive atoms present at any time to emit their radiations and become stable. Halving-times of all radioisotopes are accurately known (they vary from fractions of a second to millions of years), so the decay-rate of a source is predictable and is taken into account in the calibration and routine maintenance (or automatic decay-compensation) of the instrument. The useful lives of radioisotopes used in industrial instruments usually range between about one and ten years, and recalibration or source replacement is often undertaken on a contract basis by the supplier of the instrument.

The three most important classes of radioisotope instruments used in the food industry are (1) gauges for measuring the levels of materials in storage or process vessels, (2) monitors for checking the correct filling of packages, and (3) gauges for measuring the density of materials (and hence, indirectly, for learning something about their composition). Other instruments include thickness gauges for measuring the thickness or mass per unit area of sheet or strip material (including vessel or pipe walls), and analytical instruments which rely on specific interactions between the radiation and a particular component of a mix. Other devices use the ionisation produced by a radioactive source for chromatographic analysis, for smoke-detecting alarms and for the elimination of static electricity. The examples given below of particular applications will serve, it is hoped, to illustrate the variety and adaptability of radioisotope instruments, and encourage an extension of their present rather limited use in the food industry.

Level gauges

Radioisotope level gauges are already fairly widely used in the food industry, particularly for control of the bulk storage of raw materials and intermediates. They can operate through opaque vessel walls up to several inches thick without requiring any access whatever to the interior. They are very reliable and can be left to operate unattended in remote situations, and the radiation source requires no power supply. Accuracies can be as good as $\pm\frac{1}{8}$ in. Usually they are installed as simple "go/no-go" switches (sometimes known as gamma-switches) each comprising a source, a detector and an indicator. The source and detector are usually located level with one another on opposites sides of the vessel and the indicator shows whether or not the contents of the vessel reach a level high enough to obstruct the radiation beam. The signal may also be used to actuate a recorder or an alarm system, or to control valves. The gauges may be used in pairs, one at maximum level and the other at minimum; in this arrangement they are sometimes used for automatic metering of the ingredients of a mix. Isotope level gauges are used on containers of all kinds, including silos for storing sugar-beet, lime or grain, and storage or process vessels for chemicals, fats, oils and many other materials. Where it is difficult to ascertain the contents level in a reaction vessel because of foaming or high temperature or pressure, or the turbulent

Fig. 1. *A portable radioisotope gauge being used to check the level of liquid carbon dioxide in cylinders.*



state of the contents (as, for example, in a fluidised bed), isotope gauges may be found to be the only suitable method. They are particularly valuable for finding the surface levels of liquefied gases under pressure in cylinders (Fig. 1) where the only alternative technique is weighing: a simple hand-held gauge consisting of source, detector and indicator will find the surface level in a few seconds without the need to move the cylinder or its connecting pipes. Although this device was originally designed for checking gas cylinders in fire-fighting installations there is no good reason why it should not be used in mineral water factories, breweries and bottling plants or anywhere else where carbon dioxide is widely used. It can be equally useful for measuring liquid chlorine, ammonia, sulphur dioxide,

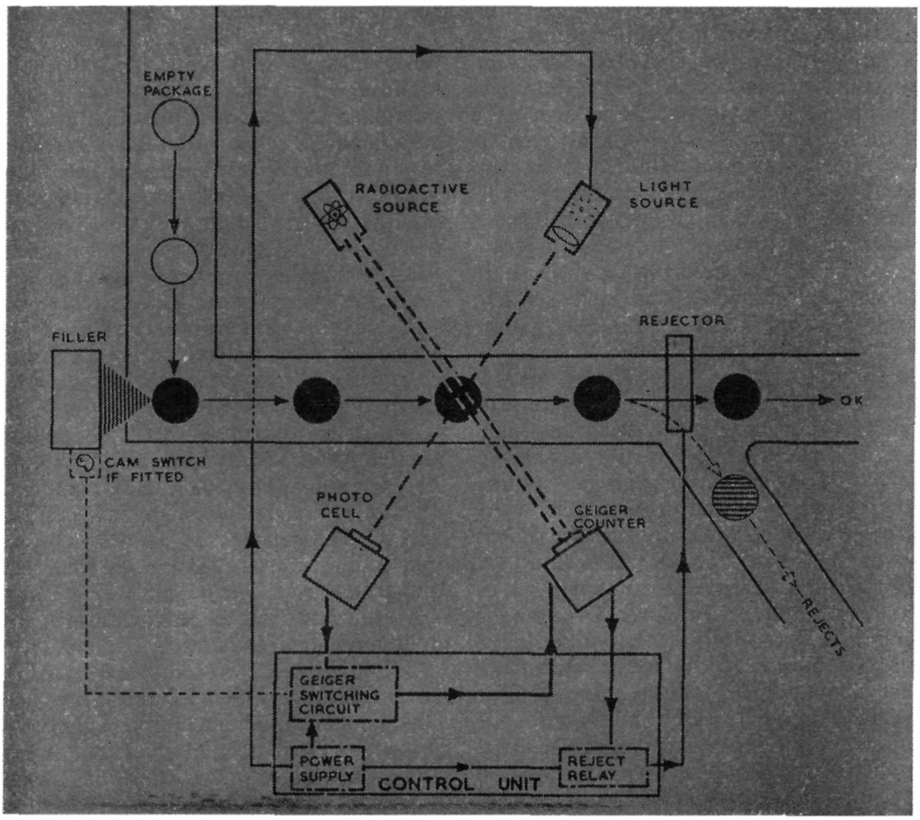


Fig. 2. *Diagram showing the method of operation of a package-filling monitor: the light-beam is used to ensure that the Geiger counter only operates when a package is in position in the radiation beam.*

liquefied petroleum gases, aerosol propellants or refrigerant materials, or indeed for checking levels in almost any vessels up to about 10 in. in diameter.

Modifications of the simple on/off level gauge can be designed to give continuous indication over a range of levels; these use multiple or extended sources or detectors covering a significant depth of the vessel, or systems in which the radiation beam passes vertically or at an angle through the vessel and its contents. In "hunting" level gauges the source and detector are mounted on vertical rails and move automatically to follow the level of the contents. Costs of fixed level gauges range from about £200 upwards, depending largely on the source strength required, while a portable gas-cylinder gauge costs about £140.

Package monitors

Monitoring packages of materials sold by volume can usually be regarded as a special application of level gauging, in which each package in turn comes between the source and the detector. If the radiation is still able to reach the detector, then the contents-level in the package must be too low and the package is automatically rejected. Accuracies can be within $\pm\frac{1}{16}$ in. (Fig. 2). It is possible to check as many as 200 cans/min. on a single production line; counting time must therefore be very short, so it is necessary to have a radiation source of sufficient strength to ensure statistical reliability, while at the same time it must not be so strong that it gives rise to unacceptable radiation levels. (Where really quick response rates are required an X-ray machine is sometimes used as a source of radiation: this can give a much more intense beam requiring a shorter counting-time, but it is more expensive to install, operate and maintain than a radioactive source, and it is equally subject to radiological safety regulations.) Typical food products regularly checked by radioisotope package monitors include soft drinks, beer, milk and milk products, soups, vegetables, meat and biscuits, which may be packed in a variety of cans or cartons (Fig. 3). A type of package monitor widely used in the pharmaceutical and cosmetic industries is designed for flat packages containing a specified number of tablets, or for tubes of paste, etc. Here the passage of radiation in excess of a specified amount indicates a gap in the contents of the package. This principle can equally well be used for monitoring flat packs of confectionary or collapsible tubes of pastes or sauces, etc. Package monitors can usually be adapted to count the items monitored, or used independently as counting devices. Radioisotope package monitors commercially available in the U.K. range in price from about £320 upwards, depending largely upon the required operating speed. Some suppliers of packaging machines fit radioisotope monitors as standard or optional extras.

Density gauging

Radioisotope density gauges operate by measuring the amount of radiation that can penetrate a fixed thickness of the material under test—the higher the density the lower the reading on the detector. Measurements, which may be continuous, can be made through a special flow-cell or simply through the walls of a suitable section of pipe or vessel (Fig. 4). Since the density of specific gravity of a material under constant conditions is dependent upon its composition, this type of gauge can very often be used to monitor automatically the composition of process materials or finished products. Only one component can be determined at a time in this way, and the readings may be significantly affected by variations in temperature or pressure (particularly in aerated products) or in moisture content; subject to these limitations, density changes ± 1 per cent. can usually be measured, and can be related to composition. It is sometimes possible to feed the signal from the density gauge back into the system that controls the concentration of the component studied, to give a degree of automatic control over the process. Examples of actual applications include monitoring the concentrations of sugar solution, glycerine, fruit juices, pastes, syrups or condensed milk in evaporators, raw sugar in melting vessels, and milk of lime in mixers. In heterogeneous systems density gauges are used for measuring the air content of ice-cream mixes, the fat content of baby-foods and the meat content of noodle soup. The density of solid materials in bulk can be measured by means of a

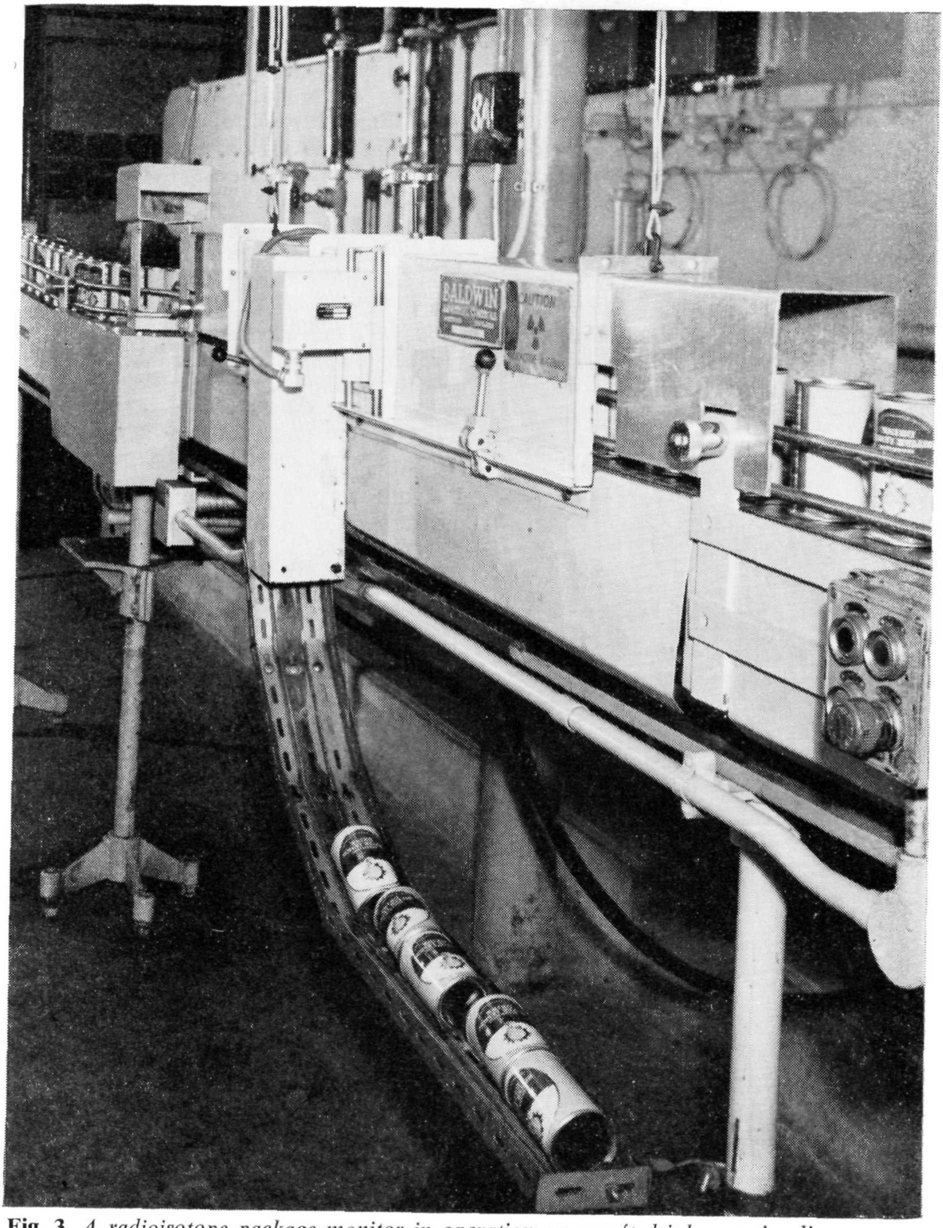


Fig. 3. *A radioisotope package monitor in operation on a soft drinks canning line.*

probe comprising a radiation source and a detector, which is inserted into the bulk material: the amount of radiation reaching the detector is closely dependent upon the density of the material. The major use of this type of instrument is in association with moisture measurement in soil and minerals (see below), but it could be used equally well in the food industry where a measurement of bulk density would be useful. On-line density gauges at present cost from £900 upwards while the bulk density gauge normally forms part of a combined moisture and density gauge which sells for some £1,000, either part alone costing about £750 complete.

Thickness gauges

Radioisotope thickness gauges are used very extensively in industries producing the materials that go to make food packages, including plastics, plain and coated

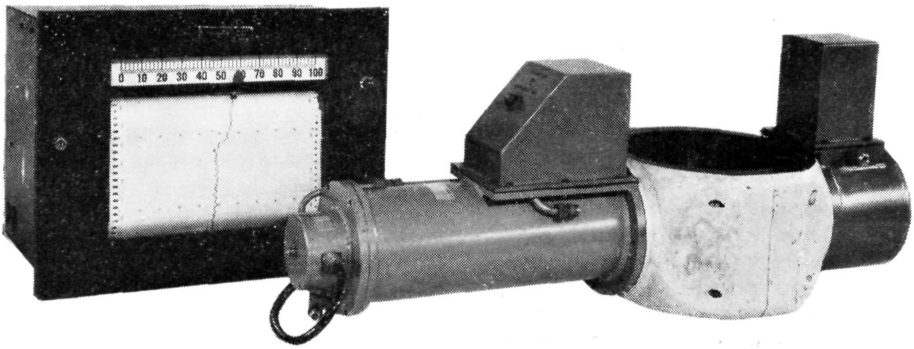


Fig. 4. *A radioisotope fluid density gauge and recorder for installation on a pipe-line; the heavy yoke is tailor-made to fit around the pipe.*

paper and plain, plated or lacquered sheet metal. They measure the basis weight or mass per unit area of the product, which must have substantially constant composition (and therefore density) if the figure is to be used as a true measure of thickness. The same technique has been applied in the food industry for measuring (for example) the thickness of dough sheet in biscuit making, but it has usually been found that variations in composition, and especially in moisture content, give rise to unacceptable errors, and other methods such as mechanical probes are generally preferred. An indirect method of thickness control for this purpose has been reported from Russia: this, which is claimed to give good results and a high degree of accuracy, uses a radioisotope gauge to monitor the size of the opening between the two rolls producing the dough sheet.

Continuous weighing

A system based on a radioisotope technique has been developed in the U.S.A. for continuously weighing materials on moving conveyors. The system uses the principle of the basis weight gauge, measuring the absorption of radiation by the material occupying a unit area of a moving conveyor belt. This figure is automatically combined both with the speed of motion of the conveyor and with the time during which the measurement is carried out, to give the amount of material transported during that time. It is claimed to be giving particularly satisfactory results in the continuous automatic handling of potatoes at rates of up to 30 tons/hr., both for stock control purposes and for the automatic control of subsequent processing operations.

Moisture gauges

Radioisotope moisture gauges are used in a number of industries. Their operation depends upon the slowing-down effect that hydrogen nuclei have upon neutrons (which have approximately the same mass), the neutrons being produced by the action of a radioactive source on beryllium. The measurement in fact indicates the hydrogen content of the sample, which can only be interpreted in terms of moisture if the base material contains a comparatively small and accurately known amount of hydrogen in forms other than water. It is difficult to see any direct application of this technique to foodstuffs or intermediates, because practically all of these contain substantial and often variable amounts of combined hydrogen. However, it has indirect applications in the control of mineral raw materials such as coke and lime and (with the bulk density gauge described above) of soil, sand or cement.

A.E.A. at Inspex '67

The U.K.A.E.A. participated in the 2nd Engineering Inspection and Control Exhibition, at the Royal Horticultural Society's Halls, Westminster, from 13th-16th November.

The exhibit demonstrated the presentation of dimensional data as applied to the inspection of small-bore thin walled tubing of the type used for reactor fuel claddings. The principles, however, may be applied to any dimensional data which can be provided as electrical signals.

The equipment included compatible standard measuring devices and incorporated a number of electronic control units developed by the Reactor Fuel Element Laboratory, Springfields.

Liquid metal valve

The British Ermeto Corporation Limited of Maidenhead have been licensed by the U.K.A.E.A. to manufacture a range of high temperature stainless steel bellows sealed valves.

This type of valve has been in use for several years primarily to handle liquid metals, e.g. sodium, and also gases at temperatures up to 600°C and pressures up to 150 p.s.i. At lower temperatures they will accept higher pressures, for example 400 p.s.i. at 400°C. Test pressure is 1200 p.s.i. at ambient temperature. The valve is vacuum tested to ensure a standard of leak tightness of better than 1 clusec to atmosphere, and better than 10 clusecs across the closed seat. The service life of the valve exceeds 10,000 operations under the most severe design conditions.

All parts of the valve in contact with the working fluid are stainless steel, argon arc welded. The seat plug is Stellite coated.

A secondary gland packing of compressed nickel foil is fitted so as to prevent gross leakage of the working fluid in the event of a bellows failure. A back seat enables the valve to be sealed off until it can be replaced. A drain off connection is provided between the bellows and the secondary gland; this connection is sealed off automatically when the valve is opened against the back seat.

A special feature of the design is a pack of belleville spring washers in the thrust head assembly. This accommodates differential expansion between the valve spindle and the body. Overloading, which would damage the working parts, is thus avoided.

The valve is fitted with a capstan type handwheel which is carefully matched to the thrust head so as to achieve optimum seat loading and prevent overstressing.

The valves are currently available in 1 in., 2 in. and 4 in. nominal bore. The stub pipes are normally arranged for butt-weld connections, but other types of connections can be provided, according to customers' requirements.

For further information contact the British Ermeto Corporation Ltd., Maidenhead, Berks. Telephone No. Maidenhead 23423. *8th December, 1967*

IN PARLIAMENT

continued from page 6

man make clear both the advantages of their doing so to them and the reluctance of the Government to do so except on a mutual basis of advantage?

The Prime Minister: Yes, Sir. I entirely agree. The difficulty outlined by the right hon. and learned Gentleman has been the difficulty all along and it still is. Indeed, in Versailles in June, I discussed this question with President de Gaulle and it is a fact that, despite their great advantage in water power, we are fully competitive, without those advantages in our production of enriched uranium 235. Of course we shall be glad, on a mutually advantageous basis, and only on such a basis, to work with our French friends or anyone else in making Europe less dependent on outside supplies, both of reactors and fuel.

Mr. Lubbock: Has the Prime Minister noted the view of the Select Committee on Science and Technology that internationalisation of our fuel enrichment capability offers an excellent opportunity for collaboration between us and the E.E.C.? Does not this concept fit in well with the ideas he has expressed so enthusiastically for a European technological community?

The Prime Minister: I have noted that important recommendation by the Select Committee and I fully agree with it. Indeed, this view is the basis of what I said at Guildhall and in recent talks with the Belgian Prime Minister and of all our approaches on the atomic side of technological co-operation with our partners in Europe.

Mr. Biggs-Davison: In view of yesterday's statement about non-proliferation, with its European implications, may I ask whether the right hon. Gentleman will give an assurance that nothing will be done under the cloak of international security to deprive Britain of her lead in the civil uses of atomic energy?

The Prime Minister: I am not quite sure to which statement the hon. Gentleman is referring, but in the matter of civil use of atomic energy we are absolutely free. We intend to use that freedom to work with our partners in Europe and more widely in the promotion of our national interest and in the promotion of exports.

Printed by Straker Brothers Ltd., 194-200 Bishopsgate, London, E.C.2.