



OPEN DAYS

1956

Atomic Energy
Research Establishment
Harwell

OPEN DAYS 1956

The Atomic Energy Research Establishment is charged with the task of performing basic research and early development work on all aspects of Atomic Energy, and particularly, to provide new ideas on the generation of power from nuclear sources. The recent changes in the security classification of Atomic Energy research projects mean that the exhibits to be shown during the Open Days cover most of the work and the achievement of the Establishment over the first ten years.

For this reason I take particular pleasure in welcoming you to the 'Open Days 1956' on behalf of the Atomic Energy Authority and the Staff of the Establishment.

SIR JOHN COCKCROFT,

Director of the Research Group,

United Kingdom Atomic Energy Authority.

THE ATOMIC ENERGY RESEARCH ESTABLISHMENT**OPEN DAYS 1956**

Press Photographers Open Day	Monday	:	28th May
International Press Open Day	Tuesday	:	29th May
Lord President's Open Day	Wednesday	:	30th May
Technical Press Open Day	Thursday	:	31st May
University Open Day	Friday	:	1st June

THE ATOMIC ENERGY RESEARCH ESTABLISHMENT

SENIOR STAFF

Director: Sir John Cockcroft, K.C.B., C.B.E., F.R.S.

Deputy Director: Dr. B. F. J. Schonland, C.B.E., F.R.S.

Deputy Director (Engineering): Mr. G. W. Raby, C.B.E.

Chief Chemist: Dr. R. Spence, C.B.

Chief Metallurgist: Dr. H. M. Finniston.

Chief Physicist: Mr. D. W. Fry.

Scientific Secretary: Mr. D. R. Willson, M.B.E.

General Secretary: Mr. T. B. Le Cren.

THE ORGANISATION OF THE ESTABLISHMENT

The organisation of the Atomic Energy Research Establishment has to meet the following main requirements; it must provide sufficient central direction and co-ordination to ensure cohesion and planning of the programme as a whole; it must, on the other hand, allow adequate freedom in the scientific direction of each of the Establishment's many fields of activity, and it must provide the essential facilities and services without which a large Establishment cannot operate. Above all, it must be a flexible organisation, in which changes can be made at any time to meet shifts of emphasis in the research and development programme.

The Establishment's research and development is carried on by a number of scientific divisions, each roughly the size of a University department, and under the leadership of a Division Head of status comparable with that of a University Professor. The Divisions of the Establishment, arranged alphabetically, are thus:—

<i>Division</i>	<i>Division Head</i>
*Chemistry	Dr. R. Spence
*Chemical Engineering	Mr. A. S. White
*Electronics	Dr. D. Taylor
Engineering (New Works)	Mr. G. W. Dixon
*Engineering Services	Mr. P. Bowles
*General Physics	Mr. D. W. Fry
*Health Physics	Dr. W. G. Marley
*Isotopes	Dr. H. Seligman
*Medical	Dr. K. Williams
*Metallurgy	Dr. H. M. Finniston
*Nuclear Physics	Dr. E. Bretscher
*Reactor Division	Dr. J. V. Dunworth
<i>Deputy Division Head:</i> Mr. H. J. Grout	
*Theoretical Physics	Dr. B. H. Flowers
Scientific Secretariat (Scientific Secretary: Mr. D. R. Willson)	
Industrial Collaboration Office	Head: Dr. N. F. Goodway
Overseas Collaboration Office	Head: Mr. J. F. Jackson
*Scientific Administration Office	Head: Mr. R. M. Fishenden
Administration (General Secretary: Mr. T. B. Le Cren)	
Head: Mr. A. B. Jones	

** Exhibiting Divisions*

The divisions marked with an asterisk in the list above are showing much of their unclassified work during the 'Open Days 1956'. In this booklet the exhibits are described under the title of the responsible division. It will frequently be found that work on specific projects is shown by several divisions since a single problem often involves techniques in several branches of science.

Medical Research Council Radiobiological Research Unit

The Radio-biological Research Unit will only be open to visitors by special arrangement.

Cockcroft Hall—University Open Day Film Show

On the University Open Day only, films covering some aspects of the work of the Authority will be shown continuously in the Cockcroft Hall Lecture Theatre. The programme will include "Calder Hall", a film about the construction of the first United Kingdom Nuclear Power Station and "New Tool for Industry" which describes some industrial applications of radio-isotopes.

Radiation and Laboratory Hazards

The normal procedures for the control of radioactive and laboratory hazards have been considerably modified for the convenience of visitors. Special precautions have been taken in laboratories and plants so that visitor can enter them with the minimum of restrictions. The few restrictions that are still necessary are indicated by warning notices and it is essential that these notices should be strictly observed.

Security

The Atomic Energy Research Establishment is a Prohibited Place and is subject to the conditions of the Official Secrets Acts. In their own interest visitors are requested to observe the regulations in force.

Visitors may not enter 'closed' areas which are indicated by tapes and warning notices.

Authority cannot be given for visitors to bring cameras within the establishment.

CHEMISTRY DIVISION

Division Head—Dr. R. Spence

General Exhibits*C/1—Building 220.8***FROG SUITING AND LABORATORY AREA**

A laboratory equipped for handling relatively high levels of α -activity is shown. Flexibility is obtained by the use of free-standing glove boxes, all services being fed to the boxes from the roof void. Maintenance and replacement of components inside the boxes is accomplished in a specially designed section of the laboratory to which access may be obtained only in a protective rubber suit.

C/2—Building 220 (Conference Room)

CHEMISTRY OF POWER REACTORS

A. *Heterogeneous Reactors.* These have solid fuel elements with uranium or plutonium as the fissile material. During the operation of the reactor fission products are formed. If allowed to remain in the fuel, some of these absorb neutrons and reduce the efficiency of the reactor. Special techniques are demonstrated which have been developed for the detection and estimation of these fission products.

Methods are shown for determining the composition of fuel elements before and after irradiation. Procedures have been developed for the regeneration of spent fuels and the first stage is illustrated.

B. *Homogeneous Aqueous Reactor.* A working model of the reactor is shown. This reactor utilises a fuel of enriched uranyl sulphate dissolved in heavy water. Advantages are the elimination of costly fabrication and canning procedures and the possibility of continuous chemical processing to remove fission product neutron poisons. The reactor core is surrounded by a heavy water thorium dioxide slurry which produces U^{233} . The uranium is separated and fed into the core system to replace that lost by fission. Methods are shown for the analysis of fission products from this reactor and of corrosion products from the fuel circuit.

C. During the operation of all reactors neutron capture in the fuel leads to the formation of heavier elements. This is shown in an illuminated chart. Specimens of compounds of these heavy elements are displayed.

C/3—Building 10

RADIATION CHEMISTRY

Radiation chemistry is the study of chemical reactions which are induced or affected by ionising radiations. A reaction of importance in certain nuclear reactors is the formation of nitric acid on irradiation of nitrogen gas in the presence of water. This reaction is demonstrated and its significance explained.

Certain properties of some solids are markedly affected by radiation and examples of coloration of glasses and changes in properties of plastics are shown.

As the changes induced by radiation are dependent upon the amount of radiation energy absorbed by the system, this quantity is of great importance. The calorimeter which is demonstrated has been developed to measure the energy absorption from pile radiation.

C/4—Building 149

SELF CONTAINED EFFLUENT DISPOSAL

The problem of effluent disposal will increase greatly as the atomic energy programme develops. Attempts are being made to develop a system whereby the actual discharge is reduced to a minimum. Highly active wastes will be converted to solids which may be safely stored. Low-activity wastes, comprising the bulk of the effluent, will be treated chemically, then decontaminated further in soil beds, and finally passed through an electrolytic unit. Using a demineralised water supply it is hoped to produce a final effluent which can be recycled. Such a scheme is also economical in water consumption. A working model of part of this system is shown.

ADDITIONAL EXHIBITS—"UNIVERSITY OPEN DAY" ONLY

C/5—Building 220.8

High pressure laboratory equipment—Apparatus for the investigation of chemical properties of aqueous solutions up to 350 °C and 3000 p.s.i. pressure.

C/6—Building 220

a wing

Anion and cation exchange methods for separating trans-uranic elements.

C/7

High temperature vacuum apparatus for uranium fuel processing utilising platinum-wound furnace or high frequency induction heater.

C/8

α -counting equipment—Identification and estimation of α -emitting nuclides by measurement of α -particle energies.

C/9

Calorimetry—Thermochemistry of the actinide elements.

C/10

Americium super-cow—Ion exchange separation of americium from plutonium rich in the isotope of mass 241.

C/11

Mass spectrometry of the actinide elements.

C/12

High temperature vacuum apparatus for plutonium fuel processing, utilising a graphite resistance-furnace.

C/13—Building 220

 β wing

Double-focussing mass spectrometer (independent fission yield of rare gases).

C/14

Automatic counting equipment for finding the energy of α - or β -particles.

C/15

Fission chemistry—Chemical effect of fission recoil and the condition of newly formed atoms.

C/16

Chemical processing—Separation techniques for irradiated reactor fuels using fluoride processes.

C/17

Measurement of fission yields and radiochemical constants.

C/18

Ruthenium chemistry—Nitrato and nitro complexes of nitrosyl-ruthenium arising from processing of solutions or irradiated uranium in nitric acid.

C/19

3ft. thick concrete cell for remote handling of highly radioactive sources.

C/20

β -counting equipment.

C/21

Polonium chemistry.

C/22—Building 10

Chemical crystallography—Guinier-type focussing powder cameras and single crystal micro-handling techniques.

C/23

Uranium and thorium chemistry. Structural and chemical studies of oxides and fluorides and their hydrates.

C/24—Building 146

Emission spectroscopy—Spectroscopic equipment including 21ft. spectrograph employing a new grating mounting.

C/25

High frequency titrimetry—Conductometric titrations in non-aqueous solvents and concentrated aqueous solutions.

C/26

Infra-red spectroscopy—Prism and grating research instruments and a novel single-purpose analytical instrument.

C/27

A lead-shielded kilocurie cobalt 60 source for the investigation of γ -ray effects on chemical systems.

C/28

2 M.V. Van der Graaff accelerator—used to study the effects of electrons or X-rays on gases, liquids or solids.

C/29—Building 148

Coulometry—Analysis by measuring the number of coulombs in electrochemical reactions.

C/30

Quantitative analysis by mass spectrometry—Determination of trace quantities of elements by the stable isotope dilution method.

C/31—Building 149

Square wave and pulse polarographs—Modern developments of the polarograph and their use in electrochemical research and analytical chemistry.

CHEMICAL ENGINEERING DIVISION

Division Head—Mr. A. S. White

General Exhibits**CE/1—Building 351****REACTOR FUEL PROCESSING**

Processing of reactor fuel elements is required to repair irradiation damage and to remove fission products which absorb neutrons. The cost of processing is a substantial fraction of the cost of nuclear power. This work is aimed at reducing the cost of processing.

In existing processes the irradiated fuel element is dissolved in acid, the fission products are removed by *solvent extraction* and the fuel element is refrabricated. The development of a solvent extraction process from test tube to pilot plant is demonstrated.

To avoid the expensive 'metal $\rightarrow$ solution $\rightarrow$ metal' stages, *high temperature metallurgical processes* are being developed. The fuel is kept in the metallic state and melting, slagging and vaporisation techniques are used to remove neutron absorbers. Fuel element fabrication is still required. Equipment for research into the melting and casting process is shown.

Work on processing problems involved in the *homogeneous aqueous reactor* system is demonstrated. In this system solid fuel elements are replaced by using a liquid fuel and consequently the limitation of physical breakdown under irradiation is removed and the expensive fuel element fabrication stage is avoided.

CE/2—Building 353**MINERAL DRESSING GROUP**

The Crushing Section, including equipment for the crushing, screening and sampling of ores, is available for inspection.

In the Main Mineral Dressing Laboratory, the concentration of ores by water tables, spiral concentration and flotation, is demonstrated and magnetic separators, heavy liquid separation,

cyclones, super-panner and other ancillary operations and equipment are operated. Demonstrations of the fluorescence of minerals under ultra-violet light, specimens of thin sections, polished sections, autoradiograph and various equipment employed in the Mineralogical Section are also exhibited.

The Mineralogical Laboratory and Preparation Laboratory are open for inspection and demonstrations of zeta-potential and contact angle measurements are given in the Physical Measurements Laboratory.

CE/3—Building 353

HIGH EFFICIENCY LIQUID-LIQUID CONTACTORS

In the case of extraction processes requiring a large number of stages, it is often advantageous to use some type of mechanical extractor as opposed to conventional packed towers. The enhanced turbulence in such contactors leads to increased extraction efficiencies which in turn enable the size of unit required for a given separation to be reduced considerably. This is particularly important in the nuclear energy field since considerable economies in building as well as in shielding can then be effected.

Rotary and pulsed types of contactors are demonstrated as well as a new type of mixer-settler unit which has no moving parts in contact with the process fluids.

CE/4—Building 392

DISSOLUTION IN LIQUID METALS

An understanding of the processes involved in the dissolution of solid metals in liquid metals is of considerable importance in combatting corrosion in liquid metal coolant channels. Mercury is the most convenient liquid metal to investigate and the dissolution of various metals in this under different turbulent conditions is being investigated. As the amalgams formed oxidize in air the experiments are conducted in an argon atmosphere in a 'glove box'. This box will stand evacuation so that traces of residual air can be easily removed. Identical experiments are being carried out on the dissolution of organic acids in water.

This process is known to be diffusion-controlled so that a comparison between the aqueous and mercury experiments will indicate which mercury/solid metal systems are also diffusion-controlled.

The equipment is being adapted for use with liquid bismuth.

CE/5—Building 358

HYDROGEN LIQUEFIER

A Joule-Thomson liquefier which produces 20 litres of 50/50 ortho/para liquid hydrogen per hour for periods of at least ten hours is shown.

In each of the three stages liquid nitrogen is boiled under reduced pressure and the ingoing hydrogen at 160 atmospheres is:

- (1) cooled regeneratively to 64°K when it is passed through beds of catalyst to provide ortho-para conversion.
- (2) cooled to 70°K when it is passed through beds of activated charcoal to remove impurities which would otherwise solidify between 64°K and 20°K (e.g. nitrogen).
- (3) further cooled to 64°K, and then cooled by the unliquefied hydrogen, followed by expansion to 1.5 atmospheres to yield liquid hydrogen at 20°K.

The liquefaction coefficient is about 25%. The ingoing hydrogen is cooled by the unliquefied effluent hydrogen and the evaporating nitrogen.

ADDITIONAL EXHIBITS—"UNIVERSITY OPEN DAY" ONLY

CE/6—Building 353

Experimental Graphite Plant—A pilot plant for the experimental manufacture of carbon and graphite.

CE/7

Surface Properties of Graphite—An apparatus for studying how liquid sodium corrodes and penetrates graphite when used as a coolant.

CE/8

Disposal of long lived fission products—Strontium 90 and caesium 137 are permanently fixed to montmorillonite clay by firing at high temperatures.

CE/9

Batch fractional liquid-liquid extraction—An extraction process for separating pure solutes from a multicomponent mixture by a batch-wise method using 100% initial reflux.

CE/10

Particle size reduction—An apparatus for the reduction of materials to approximately 5–15 microns size.

CE/11

Chromatographic Techniques—A demonstration of the chromatographic technique of separating mixtures of metallic salts.

CE/12

Colorimetric Analysis—A demonstration of analysis by means of the measurement of intensity of coloured complexes.

CE/13

Activation Analysis and Counting techniques—Analysis by activation.

CE/14

Fluorimetry—Analysis by measurement of the fluorescence produced by action of ultra-violet light.

CE/15

Polarography—The polarographic method of analysis first developed by Heyrovsky of Prague.

CE/16

pH Measurement—The measurement of acidity or alkalinity by instrumental or colorimetric means.

CE/17—Building 392

Liquid metal loops for dynamic corrosion studies—Loops for determining the rate of corrosion of specimens in liquid sodium.

ELECTRONICS DIVISION

Division Head—Dr. D. Taylor

General Exhibits*E/1—Building 347.3***TRANSISTOR DIGITAL COMPUTER . . . CADET**

This is one of the few examples of the use of transistors in a computer.

Compared with thermionic valves, transistors have the advantage of low operating voltages and power consumption, compactness and potential reliability. The model shown has 320 transistors and no thermionic valves, and requires a power consumption of only 70 watts.

Numbers and instructions are fed into the computer on punched cards, and are stored on a magnetic drum store with a capacity of more than 500,000 binary digits.

The computer can be used for an almost unlimited range of tasks, provided they require only the basic operations of addition and subtraction.

*E/2—Building 374.1***REACTOR INSTRUMENTATION EXHIBITS***A—Reactor Simulator*

This instrument simulates the dynamic behaviour of a small experimental reactor when the shut-off and control rods are moved. The 'reactor' can be started up by withdrawing the shut-off and control rods; the apparent rise in power level is traced out on a logarithmic scale recorder. Steady power level control or controlled shut-down is possible and automatic shut-down will take place if the rate of rise of the power level or the absolute power level is permitted to exceed certain present values.

B—ZEUS Power Level Instrumentation

An example of one channel of the pulse counting power level instrumentation built into the ZEUS reactor is shown. The absolute power level and the 'doubling time', the time taken for the power to double, are drawn on a logarithmic scale recorder. Any chosen doubling time can be preset on a calibrated control and the consequent power rise is shown on the power level recorder. Automatic shut down is induced by an excessive power level or by a doubling time which is too low.

E/3—Building 347.1

Geological Survey Instruments

Displayed in this section are typical instruments used extensively for the express purpose of locating and making a primary estimate of the quality of uranium and thorium bearing ores. These ores emit gamma rays which may be detected by sensitive Geiger-Müller and scintillation counters embodied in the instruments.

Initial surface prospecting is undertaken according to circumstances, using instruments in low-flying aircraft, in vehicles, or on foot using the portable lightweight instruments.

Further detailed search and assay by trained geologists may be accomplished with the more complex and accurate survey instruments, supported by borehole logging equipment for sub-surface exploration.

ADDITIONAL EXHIBITS—"UNIVERSITY OPEN DAY" ONLY

E/4—Building 347.3

Demonstration Transistor Circuits.

- (i) A point contact transistor scaling circuit with a maximum counting rate of 2.5 Mc/s.
- (ii) A junction transistor scaling circuit with a maximum counting rate of 500 Kc/s.
- (iii) A Geiger counter and decade scaler operated by point contact transistors.

- (iv) Dekatron scaling tubes and a mechanical register driven by junction transistors.
- (v) Digital storage system utilising transistors and a magnetostriction delay line.

E/5—Building 347.3

Automatic control of counting experiments—Radioactive disintegration rate is measured in a time automatically controlled for quickest results.

E/6

Magnetic memory scaling circuit, with magnetic indicator—New type scaling circuits using magnetic core storage, and needing very low power.

E/7

100-channel kicksorter with automatic punched-card read-out system.

E/8

General purpose analogue computer—This instrument is used especially for reactor design studies.

E/9—Building 154

Neutron detectors for nuclear reactor control—The exhibits include D.C. ionisation chambers with boron-lined electrodes or boron trifluoride gas fillings, fission counters and boron trifluoride proportional counters.

E/10

Two-crystal gamma scintillation spectrometer—The Compton continuum in a sodium iodide crystal is removed by subtraction of that from an anthracene crystal.

E/11

Special nucleonic instruments for clinical use—

- (i) Clinical monitor—A complete counting equipment in one convenient unit.
- (ii) Recording count-rate meter—Used for recording transient effects of radioactive tracers in the body.
- (iii) Radioisotope standard dose-measuring equipment—Standard beta/gamma ionisation chamber and D.C. amplifier for assay of radioisotope consignments, etc.

ENGINEERING SERVICES DIVISION

Division Head—Mr. P. Bowles

General Exhibits*ES/1—Building 9***MAIN ENGINEERING WORKSHOPS**

The range of exhibited work, including machined and fabricated parts, covers a wide variety of metals and some plastics, examples of brazed and welded fabrications in ferrous and non-ferrous metals, pressure and vacuum equipment and precision mechanical movements. Each exhibit is shown adjacent to the section responsible for the work.

*ES/2—Building 338.4***REMOTE HANDLING GROUP***A—Demonstration Room*

A series of models and apparatus for the remote handling of radioactive materials is shown.

- (i) A simple glove box, showing the method of glove changing and P.V.C. bag sealing.
- (ii) Isotope can opening station.
- (iii) Alpha-beta/gamma, box with lead shielding spherical housings and handling tongs and lead glass viewing windows.
- (iv) Pneumatic conveyer.

B—Manipulator Room

'Master-Slave' mechanical manipulator of the 'over the wall' kind with a zinc bromide viewing window.

ADDITIONAL EXHIBIT—"UNIVERSITY OPEN DAY" ONLY*ES/3—Effluent Plant*

Effluent Treatment Plant—All effluent discharges from the Establishment eventually reach the River Thames. The treatment plant has been built for the chemical treatment of these effluents, in order to remove the radioactivity and allow the bulk of the liquids to be discharged to the river without hazard to the general public.

GENERAL PHYSICS DIVISION

Division Head—Mr. D. W. Fry

General Exhibits**GP/1—Building 7***Cyclotron*

The 110 inch frequency modulated cyclotron has been used since December 1949 as a source of high energy protons and neutrons in a programme of fundamental nuclear research. The maximum proton energy is 175 MeV at an orbit radius of 50.4 inches and the mean internal current is approximately 1 micro-amp. The repetition rate is 100 per second. The cyclotron itself can be seen as well as a diffusion cloud-chamber and other pieces of detecting equipment.

GP/2—Building 7*Large electromagnetic isotope separator*

This is the largest electromagnetic separator in Europe and is used for providing isotopes of all the elements up to uranium. The material to be separated is produced as an ion beam. This passes into a magnetic field where the isotopes of different mass are deflected to different extents so that they can be caught in separate collections.

Ion beam: 100 mA at 30 KV.

Type: 180° mass separator of 2ft. radius.

Magnet: 400 tons weight. Field up to 6,000 gauss, uniform to 1/5,000.

GP/3—Building 412*Proton linear accelerator and high energy accelerator development*

1. A new injector accelerator of the Cockcroft-Walton type (500,000V), together with specially developed high voltage apparatus. There will be demonstrations of high voltage effects.

2. The first "tank" of a 50 MV proton linear accelerator and the associated auxiliary equipment. This receives particles from the 500,000 V injector and accelerates them to 10 MV.

* 3. The magnet laboratory, in which experiments are being performed in connection with the design of larger accelerators for energies of 2,000–7,000 MV.

4. The workshop, in which special apparatus for the accelerator programme is constructed, with examples of the work done.

5. Triode valve design for supplying R.F. power to the proton linear accelerator. Frequency: 200 Mc/s. Peak power output: 2 megawatts. Pulse length: 350 microseconds. Repetition rate: 50 per second.

GP/4—Building 428

High resolution electromagnetic separator

This is an isotope separator for active materials with special emphasis on high resolution for the heavy elements.

GP/4—Building 428

It has the same principle of operation as the large electromagnetic separator.

Ion beam: 1 mA at 40 kV, radius: 4.

Enhancement*: 40, in the region of mass 240 for 1 mass separation.

Magnet: 90° sector. Field up to 6,000 gauss, uniform to 1/5,000. Weight: 30 tons.

*Defined as $x_f(x_0 - 1)/x_0(x_f - 1)$; where x_0 and x_f are the initial and final fractional composition of the required mass.

GP/5—Buildings 36 and 36.2

Glassblowing

This group produces and erects all the special glass apparatus required in the Establishment and therefore covers an unusually wide range of work, from pieces weighing 20 lb. or more (for which some machinery has to be used) to pieces weighing a few

grains requiring delicate bench work. Six different kinds of glass-metal seals are made in many sizes and eight sorts of glass are regularly worked. A great deal of high vacuum apparatus is constructed. Cutting, grinding and silvering are also important sections of the work.

ADDITIONAL EXHIBITS—"UNIVERSITY OPEN DAY" ONLY

GP/6—Building 154

Mass spectrometry

Instruments for the isotopic analysis of gaseous materials, together with one instrument designed specifically for the routine isotopic analysis of materials in a solid form.

GP/7—Building 60

Fractional distillation

Fractional distillation column for the production of C^{13} (60% concentration) and O^{18} (7% concentration) by distillation of carbon monoxide at $-200^{\circ}C$.

HEALTH PHYSICS DIVISION

Division Head—Dr. W. G. Marley

General Exhibits**HP/1—Building 364**

A study of the radiological dose resulting from the radioactive fallout in the U.K. from distant nuclear explosions.

Systematic measurements of fallout have been made in the U.K. since early 1951 and the results enable the dose received by the population from this source to be assessed relative to that received from natural sources. In addition the uptake by the body of certain biologically important radioactive isotopes is being studied.

The exhibit includes displays of equipment for the collection of air and rain water samples and for the measurement of the concentration of radioactive dust. Methods of examining individual particles from the fallout debris will be demonstrated. Some of the important results of the study will be displayed pictorially and graphically, including variation of concentration of radioactive dust with time, distance, and height in the atmosphere. The relative contributions of thermonuclear and atomic explosions are compared.

Samples of soil, vegetation, milk, animal and human bones are being analysed to determine the uptake of the long-lived strontium isotope and the demonstration will include a section on the route of uptake into animals and humans.

HP/2—Building 364

Radiation in nature and at work

The exhibit demonstrates the various contributions to the natural background of radiation to which mankind has always been exposed. It gives examples of the recommended safe levels of radiation and of how these can be measured. It also indicates the principal methods used to maintain healthy working conditions in laboratories.

Visitors are invited to operate the equipment.

HP/3—Building 364

Properties of radiation

Working exhibits demonstrate some of the properties of alpha, beta, and gamma radiation.

ISOTOPE DIVISION

Division Head—Dr. H. Seligman

General Exhibit**1/1—Building 10***Isotope Handling Hall*

Isotope Store, in which isotopes are placed on removal from BEPO. The radiation is used for research purposes while the isotopes are awaiting despatch. Isotope consignments are handled and measured in a series of lead brick cells surrounding the centre store. Isotope transport cases of different types are on view.

Pile irradiations—cabinet 1 shows the methods by which isotopes are produced.

Gamma radiography—cabinet 2 shows samples of radiographs obtained using the isotopes cobalt 60, iridium 192 and thulium 170. Thulium 170 has interesting applications to medical radiography.

Medical applications—cabinet 3 shows applications of isotopes to medicine, including tracer work, radiotherapy and teletherapy.

Irradiation effects—cabinet 4 shows industrial and agricultural applications of radiations from the waste products (fission products) from atomic power stations and reactors.

MEDICAL DIVISION

Division Head—Dr. Katherine Williams

General Exhibits*Med/1—Building 364**Beryllium Monitor*

An instrument capable of giving an immediate figure for the concentration of beryllium and its compounds in air has been developed at A.E.R.E. Air is drawn through a spark gap and the resulting light is passed into a spectrograph and received by a photo-electric cell sensitive to the wavelength of one of the beryllium lines. The current output from the photocell is amplified and used to actuate a recorder which gives a continuous trace of beryllium concentration in air. The monitor has first to be calibrated using known beryllium concentrations. It can, when suitably modified, be used for measuring the amounts of other toxic materials in air.

*Med/2—Building 364**Mercury Vapour Detector*

This instrument gives an immediate indication of concentrations of mercury metal vapour in air. Air is drawn into a tube by a small jar, the tube being fitted with quartz end-windows. At one end of the tube is an ultra-violet light and at the other end a photocell sensitive to the wavelength of that light. Any mercury vapour drawn into the tube results in light absorption and causes a variation in current output from the photo-cell which is connected, via a Wheatstone bridge circuit to a micro-ammeter which is calibrated in terms of mercury concentration in air.

ADDITIONAL EXHIBITS—"UNIVERSITY OPEN DAY" ONLY*Med/3—Building 364*

Medical X-ray department—Image intensifier, minimum radiation dose techniques, recording of epidermal ridge and blood capillary details of fingers.

Med/4—Building 364

Sampler used in checking concentrations of toxic materials in air.

Med/5

Counters for determining the radioactivity in samples of biological material.

Med/6

Monitor for determining the radioactive hydrogen (tritium) content of urine.

Med/7

Fluorimeter used to estimate the amount of uranium in urine.

Med/8

Haematology department—various apparatus demonstrated.

METALLURGY DIVISION

Division Head—Dr. H. M. Finniston

General Exhibits**M/1—Building 393***Metallography*

Two high-frequency furnaces and an argon arc-furnace used for preparing uranium, thorium and zirconium alloys, are on view. The argon arc-furnace, which is fitted with a rotatable multi-impression hearth, will be demonstrated at intervals. Other exhibits include a vacuum zone-melting apparatus for use with the high-frequency furnaces, and diagrams showing the constitution of uranium and thorium alloy systems and the recrystallization behaviour of uranium, illustrated with typical photomicrographs.

M/2—Building 220.8*Plutonium Metallurgy*

The metallurgy of plutonium is of increasing importance to the nuclear power programme, since this metal will form a relatively large part of the supplies of fissile material available for fuelling power reactors. Plutonium, which is artificially produced by irradiation of natural uranium, has to be handled by special glove-box techniques, since it presents an extreme toxicity hazard.

Means of melting and studying plutonium and plutonium alloys by the special techniques required are being demonstrated. For the convenience this exhibit can best be visited jointly with the Chemistry exhibits in Building 220.

M/3—Building 35.8*Powder metallurgy, Ceramics and Cermets*

Fabrication techniques for many of the metals of major interest in reactor construction were relatively undeveloped before the advent of nuclear power. Such metals include the

basic fuel uranium, the breeder material thorium, zirconium a canning material, and beryllium both a moderator and a canning material. In addition the refractory compounds of some of these metals, e.g. the oxides of uranium, beryllium and thorium, and uranium carbide, are of interest where very high temperatures are encountered in service conditions. Examples of these materials fabricated by conventional and unconventional methods are shown together with typical examples of fuel elements.

M/4—Building S37

Post-Irradiation Examination of Fuels

Knowledge of the irradiation behaviour of fuels is essential to successful reactor design. Specimens of potential fuels, made from enriched uranium or plutonium, are irradiated in reactors and are brought here for examination.

The toxicity of the materials used requires the operations to be performed in sealed boxes. The high beta gamma activity caused by irradiation make it necessary to surround the boxes with lead walls.

The facilities being demonstrated include:—

(i) *De-canning box.*

The irradiation assemblies are stripped and the specimens removed from their cans.

(ii) *Examination box*

Dimensions, density and hardness of the specimens are determined, the surface inspected and photographs taken.

(iii) *Remote metallography by television*

Examination of the internal structure of irradiated metal assists in understanding the effects of radiation and in developing improved fuel elements for reactors. The lead shielded boxes exhibited are equipped for the preparation and microscopical examination of specimens of up to 10 curies of β/γ -activity. Apparatus is provided for embedding the tiny specimen in plastic to assist handling and to polish it by mechanical, chemical or electrolytic methods. The polished sample is examined with a remotely operated microscope, the image from which is

received by a television camera and displayed on the screen of a cathode ray tube.

(iv) *Re-canning box*

Specimens are re-canned for further irradiation.

(v) *Decontamination box*

ADDITIONAL EXHIBITS—"UNIVERSITY OPEN DAY" ONLY

M/5—*Building 393*

A spectrophotometer for the Schumann U.V. region.

M/6

Nuclear magnetic resonance in metals, particularly in Cu^{63} .

M/7

Measurement of resonance and damping of transverse oscillations in a specimen. Measurement of effect of irradiation on the elastic modulus of metals.

M/8

Mechanical properties of irradiated and worked metals.

M/9

Synthesis of gemstones by Vernuill blowpipe furnace. Collection of irradiated gemstones.

M/10

The disordering of solids by atomic radiation, particularly the effect of neutron bombardment on electrical resistivity.

M/11

Purification of uranium by zone melting and electrolysis.

M/12

X-ray diffractometer for the study of highly radioactive materials.

M/13—*Building 10*

Neutron diffraction: its application to the study of physics and chemistry of the solid state.

M/14—*Building 153*

Electron microscope: studies of particle size and shape, biological material, and surface structure by replica methods,

NUCLEAR PHYSICS DIVISION

Division Head—Dr. E. Bretscher

General Exhibits*NP/1—Building 8**Electrostatic generator and Cockcroft-Walton set*

The principle of the electrostatic generator is that the charge is carried up by a belt to a terminal at the top which thereby attains a high voltage. Breakdown is prevented by enclosing the machine in a tank at high pressure. The electrostatic generator is one of the best machines available for precision work in nuclear physics, not so much for its voltage (5MeV) or its current (25 microamperes), but for the high stability (± 1 KeV) with which the voltage can be maintained.

The Cockcroft-Walton set is used to accelerate a beam of deuterons to any energy up to 500 KeV. These deuterons, falling on a target containing either deuterium or tritium atoms, cause them to disintegrate to give a powerful source of neutrons. The neutron beam is then used to investigate the properties of materials. Neutron energies are measured by the proton recoil spectrometer also shown.

*NP/2—Building 8**Linear Accelerator*

This equipment is used to study the neutron cross-section of nuclei of interest both to the atomic energy project and to basic science. The source is a block of uranium from which neutrons are ejected by bombardment with a large current of high energy electrons from a linear accelerator.

The distribution in energy of the neutrons is measured by timing their flight electronically over distances of between 10 and 55 m. from source to detector. The neutrons travel in evacuated tubes to avoid being scattered away by the air. The nuclear properties of sample materials are deduced from the

changes in the neutron distributions caused when samples are placed between the source and the detector.

NP/3—Building 8

Magnetic Recorder for Nuclear Pulses

Detectors which measure also the energy of nuclear particles, e.g. scintillometers, require expensive pulse analysers to determine the energy spectrum. Detector pulses, for the first time, can be recorded on magnetic tape, using commercial decks, such that the pulse amplitudes are faithfully reproduced. Tapes may be stored and played back indefinitely without deterioration; playback speed ratios may be increased up to several hundred-fold, so reducing the analysing time by an equivalent factor.

Of greater importance for basic research is the ability to record on the same tape simultaneously but separately, outputs from several detectors measuring, for instance, coincident radiation from a single source.

NP/4—Building 10

Fast Chopper

This instrument measures total neutron cross-sections in the energy range 1–1000 eV. A neutron beam from the pile strikes a 4 cwt. steel rotor revolving at 9,600 r.p.m. and bursts of neutrons are generated through narrow slits cut across the rotor. Neutron velocities (and hence energies) are determined from the time taken for the burst to travel a distance of 33 m. The total cross-section of a sample is determined from the attenuation of the neutron beam. Cross-sections as a function of neutron energy provide information on slow neutron parameters and, in the case of fissile material, basic data for reactor calculations.

ADDITIONAL EXHIBITS—"UNIVERSITY OPEN DAY" ONLY

NP/5—Building 10

The crystal spectrometer, which produces monoenergetic neutrons having energies from 0.05 eV to 30 eV.

NP/6

The cold neutron apparatus, used to study the thermal vibrations of solids and liquids.

NP/7—Building 8

Experiments on neutron emission accompanying fission by 150 MeV neutrons.

NP/8

Photographs of and results from the Culham extensive air shower array.

NP/9

Apparatus to record Cerenkov pulses from the night sky associated with cosmic-ray electron showers in the atmosphere.

NP/10

Proportional counters for studying mesic X-rays with high resolution.

NP/11

The He^3 spectrometer, used to measure the energy of neutrons in the range 100–1000 KeV.

NP/12

The boron pile, a high sensitivity, energy independent, neutron counting array.

NP/13

Model of new 25 MeV high current linear electron accelerator and building.

NP/14

Klystron valves to be used in the new 25 MeV linear accelerator.

NP/15

High efficiency scintillation detector for neutrons from the linear accelerator.

NP/16

Silver samples for use in accurate neutron resonance measurements.

NP/17—Building 151

Apparatus for measuring angular and direction-polarisation correlations between cascade gamma rays.

NP/18

Coincidence comparator for measuring gamma-ray lifetimes in the range 5×10^{-10} to 10^{-11} seconds.

REACTOR DIVISION

Division Head—Dr. J. V. Dunworth

Deputy Division Head—Mr. H. J. Grout

ENGINEERING OF REACTORS**General Exhibits****RD/1—Building 10***The Engineering of Reactors and Associated Plant*

The activities of design, construction and operation of nuclear reactors, zero energy systems and special experimental plant are shown, and models of certain Harwell reactors operating or under construction are on view.

RD/2—Building 10*Reactor 'BEPO'*

This general purpose reactor, which is air cooled, graphite moderated and natural uranium fuelled, came into operation in June, 1948. The maximum thermal neutron flux available is 1.5×10^{12} n/cm.²/sec. at a reactor power of 6.5 megawatts. It provides facilities for pile neutron research, radioactive isotope production, irradiation chemistry and metallurgy and reactor engineering research. The reactor comprises a graphite cube of 26ft. side surrounded by thermal and biological shields. The 40 tons of uranium fuel is in rod form and lies in horizontal cooling channels in the graphite cube. Horizontal and vertical experimental hole facilities are provided, of which about sixty are in use.

RD/3—Building 10*Reactor 'DIDO'—Model*

DIDO, which is almost completed, will be used as a materials testing reactor. It is heavy-water cooled and moderated, and

utilises highly enriched uranium, alloyed with aluminium, as fuel. It is housed in a sealed cylindrical building.

With its high intensity neutron flux of 10^{14} neutron/cm²/sec at a designed heat output of 10,000 KW, the reactor's main purpose will be the irradiation of materials to be used in future reactors. Radiation damage particularly can be studied. High specific activity isotopes for medical and industrial use will be produced and facilities will be available for research in neutron physics and radiation chemistry.

RD/4—Building 10

Reactor 'PLUTO'—Model

PLUTO, which is scheduled for completion in mid-1957, will be used as a materials testing reactor of a more specialised type than DIDO. It is heavy-water cooled and moderated and utilises highly enriched uranium alloyed with aluminium as fuel. At a power of 10,000 KW, a maximum flux of 10^{14} n/cm²/sec. will be available. The reactor, like DIDO, is housed in a sealed cylindrical building.

Future reactor fuel elements will be irradiated under conditions closely representing their environment. By this method it will be possible to check heat transfer, corrosion, mass transfer, radiation damage, radiation decomposition and fluid fuel chemistry.

RD/5—Building 10

Reactor 'LIDO'—Model

LIDO, an enriched uranium solid fuel, demineralised light water moderated, reflected and cooled, thermal reactor giving 100 KW and 10^{12} neutron/cm²sec, is intended primarily for shielding studies. It is a 'swimming pool' type reactor.

A portland concrete tank contains demineralised water which is pumped through a filter and cooler. A movable trolley with control platform has a submerged framework housing plate-type,

natural convection cooled, fuel elements. Cadmium bearing rods driven within certain fuel elements control the reactor. Large aluminium panels in the tank provide areas for testing shielding. Biological shielding is provided horizontally by the concrete tank and vertically by the water.

ADDITIONAL EXHIBITS—"UNIVERSITY OPEN DAY" ONLY

RD/6—Building 10

Pippa channel in BEPO: a test loop to study the graphite—CO₂ reaction in prototype power reactors under design.

RD/7

Medium pressure water loop in BEPO: to provide design and operational experience of pressurised water systems.

RD/8

Sodium loop Mk. II: provides facility for dynamic corrosion studies in liquid sodium under irradiation.

RD/9

Hollow uranium fuel elements in BEPO: both water and air cooled, these provide a high energy neutron irradiation facility.

RD/10

Isotope irradiation devices:

- (i) pneumatic "rabbit" device for short irradiations (less than 1 minute) with immediate delivery to users in other buildings through underground lines;
- (ii) belt device for irradiation periods over one minute;
- (iii) large sample device using vertical hole for samples up to 3" diameter.

RD/11

Fission product detector: samples reactor coolant for escape of radioactive fission product from damaged fuel element sheath.

RD/12

Dust activity detector: samples reactor coolant for dust made radioactive during passage through reactor.

RD/13

BEPO uranium bars: an historical survey.

RD/14

Reactor analogue computer: for studying the kinetic behaviour of nuclear power plants.

RD/15

Reactor training simulator: a device which simulates realistically the behaviour of a zero energy reactor.

RD/16

Reactor control systems: diagrams showing various ways of controlling nuclear reactors and power plants.

RD/17

Reactor control system components.

PHYSICS OF REACTORS

General Exhibits

RD/18—Building 8

REACTOR 'GLEEP'

GLEEP was the first nuclear reactor to be constructed in Europe. It was designed to run at levels up to 100 KW without elaborate cooling arrangements, and employs a natural uranium/uranium oxide/graphite system. It is used at present for both research and materials testing; for example: the quality of uranium metal, graphite, and structural and cladding materials for other reactors is determined in this reactor. GLEEP also provides a source of slow neutrons for exponential and biological experiments. To meet all these commitments, the pile is run at a steady power on a twenty-four hour schedule.

RD/19—Building 401

REACTOR 'ZEUS'

ZEUS is a fast reactor with an enriched uranium core. It is a low energy version of the 60 megawatt fast reactor now being

built at Dounreay in the north of Scotland. ZEUS is run at a power of less than a 100 watts and therefore needs no provision for cooling the core, the sodium coolant used in the Dounreay reactor being replaced by aluminium and magnesium castings. Measurements on ZEUS provide design and operation data and basic information on the physics of this type of reactor.

RD/20—Building 401

REACTOR 'DIMPLE'

DIMPLE is a low-powered, thermal-neutron reactor. The heavy water moderator is contained in a tank which is surrounded by a graphite reflector. Outside this is a concrete radiation shield. The reactor fuel is submerged in the heavy water. Both the type of fuel and its arrangement in the tank can be changed quickly so that what is, in effect, a different design of reactor can be built up in a matter of a few days.

One of the first functions of DIMPLE is to carry out the experimental work for DIDO, the new and more powerful heavy water reactor which is now being built at Harwell to provide the high neutron flux essential for some research purposes.

RD/21—Building 401

NATURAL WATER—*Uranium approach to criticality facility*

The facility is used for the construction of assemblies of enriched uranium and natural water. These assemblies are located in a "core" tank which itself sits inside a larger "reflector" tank. Loading of uranium is begun at the centre of the tank and neutron fluxes in the assembly are measured at convenient intervals as the loading progresses. The neutron fluxes are measured by two boron trifluoride pulse counters. In the event of emergency neutron-absorbing control rods drop into the core and the water moderator is released into a dump tank. The purpose of these experiments is to determine the sizes of the various arrays at which a self-sustaining chain reaction may be maintained.

SCIENTIFIC ADMINISTRATION OFFICE

Head—Mr. R. M. Fishenden

ADDITIONAL EXHIBIT—"UNIVERSITY OPEN DAY" ONLY

S/1—Building 329/1

Library and Information Services—Librarian: Miss M. Gosset

The reading room of the main library will be open to visitors. In addition to the permanent collection of books, periodicals, and bibliographies, there will be a special exhibition of reports, bibliographies, reading lists and other material issued by the Establishment. The exhibition will include information on the major theoretical and practical applications of nuclear energy and members of the Information Staff will be available to explain to visitors the ways in which information may be obtained from the Establishment.

THEORETICAL PHYSICS DIVISION

Division Head—Dr. B. H. Flowers.

ADDITIONAL EXHIBIT—"UNIVERSITY OPEN DAY" ONLY

TP/1—Building 8

The Punched Card Installation

The installation uses the standard commercial punched card machinery. Arithmetical and logical operations are carried out on cards punched in decimal code with 80 decimal digits per card. The use of this installation is illustrated by means of a simple numerical example of the well-known 'Monte Carlo' method of estimating the value of a definite intergral, and at the same time an improved 'Monte Carlo' procedure for the same integral is demonstrated.

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The Abbey Press, Abingdon.