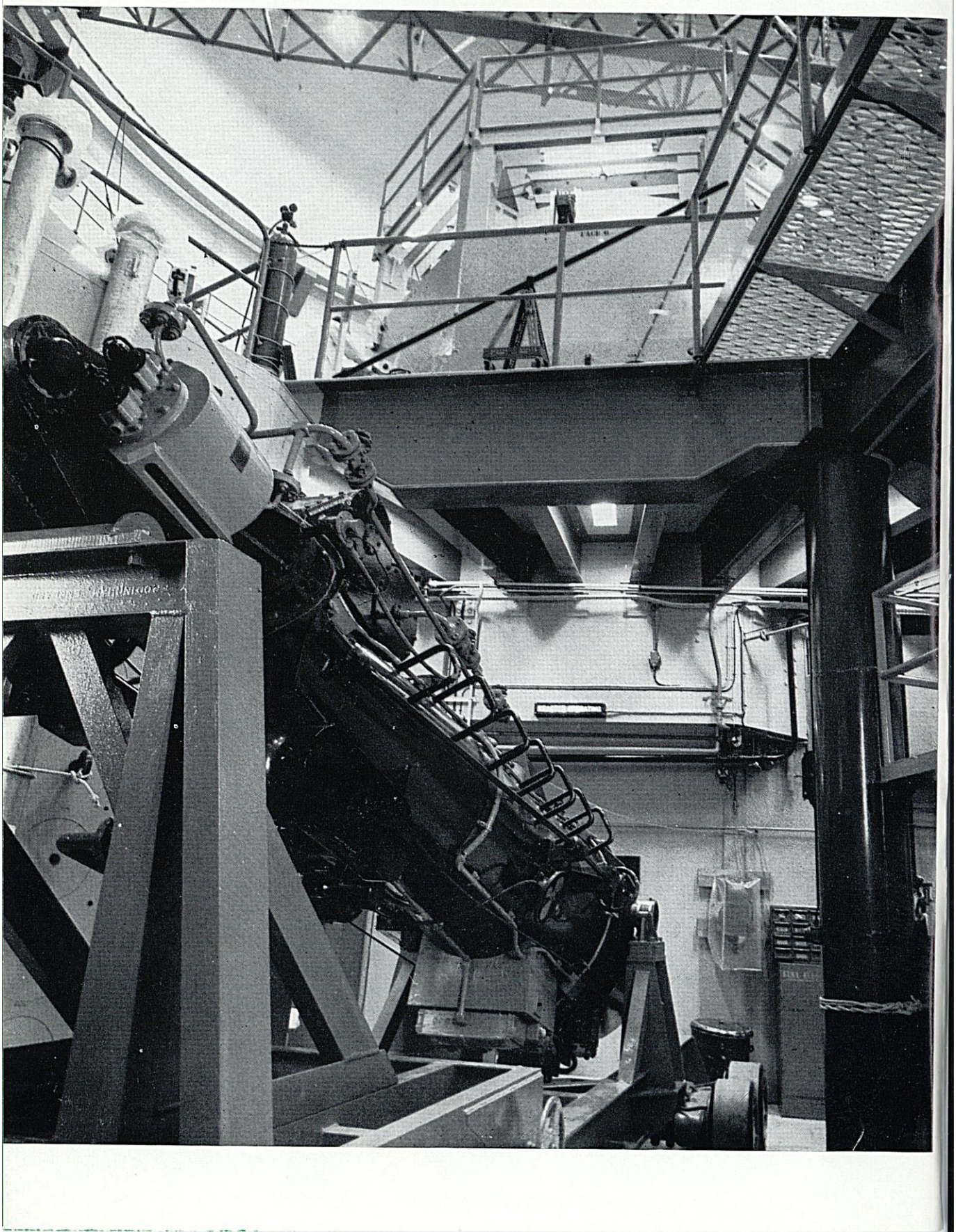
A BRIEF GUIDE TO THE AUSTRALIAN ATOMIC ENERGY COMMISSION RESEARCH ESTABLISHMENT



THE AUSTRALIAN ATOMIC ENERGY COMMISSION

is responsible directly to:

The Minister for National Development, Senator the Hon. W. H. Spooner, M.M.

Members of the Commission are:

Chairman:— Professor J. P. Baxter, C.M.G., O.B.E., B.Sc., Ph.D. (Birm.), F.A.A., A.M.I.Chem.E., F.R.A.C.I., M.I.E. (Aust.).

Deputy Chairman:— H. G. Raggatt, C.B.E., D.Sc., F.A.A.

Commissioners:— Professor Sir Leslie Martin, C.B.E., Ph.D. (Cantab.), D.Sc. (A.N.U., Melb.), F.R.S., F.A.A., F.Inst.P., B. F. Dargan.

Executive Member:— A. D. McKnight, C.B.E., LL.B.
(On leave from 1.12.60.)

Deputy of Executive Member:— M. C. Timbs, B.Ec., A.A.S.A.

THE AUSTRALIAN ATOMIC ENERGY COMMISSION

was created in April, 1953, by an Act of Parliament which gave it statutory powers within the constitutional authority of the Commonwealth Government.

Its functions concern:

- development of practical uses of atomic energy for industrial and other purposes;
- scientific research within the Commission, and in universities and other institutions; and
- training of scientists and engineers to meet the needs of nuclear technology in Australia;
- discovery and production of uranium and nuclear materials.

The Head Office of the Commission is at 45 Beach Street, Coogee, and is responsible for the general control of all the Commission's activities. In particular, the Head Office is concerned with policy matters, raw materials (including the Rum Jungle uranium mine and treatment plant), liaison with other Government departments, public and Press relations, extra-mural and university research on atomic energy, and liaison with international and overseas atomic organisations.

Left: A 19-ton, heavily shielded flask used to transport highly radioactive materials from HIFAR reactor at Lucas Heights to the active handling cells.

THE RESEARCH ESTABLISHMENT

In September, 1954, the Commission submitted plans for the creation of an atomic energy research and development organisation in Australia. Commonwealth Government approval of this plan paved the way for the building of the A.A.E.C. Research Establishment at Lucas Heights, on the fringe of the metropolitan area, 20 miles south of Sydney.

The initial program, which has now been completed, provided for the construction of a high flux research reactor, laboratories and workshops for research into nuclear energy.

Staff for the Research Establishment, now numbering more than 800, were recruited mainly in Australia. Research teams have kept abreast of current developments overseas by means of staff postings to atomic energy establishments in countries with which Australia has exchange agreements.

The building program on the 160-acre site involved construction of:

- a heavy water moderated research reactor known as HIFAR (High Flux Australian Reactor) with a maximum flux of 1.8×10^{14} neutrons per sq. cm. per second and a maximum heat output of 10,000 kilowatts;
- a low power graphite/light water moderated reactor known as MOATA, with a maximum flux of 10^{11} neutrons per sq. cm. per second and a maximum heat output of 10 kilowatts;
- laboratories for research in chemistry, chemical engineering, health physics, radiation biology, reactor physics, technical physics, isotopes, metallurgy and engineering;
- library;
- gatehouse, garages, stores, boiler house, effluent treatment plant and control laboratory, and laundry and decontamination centre;
- administrative buildings.

The work of the Research Establishment is carried out by joint teams of scientists and technologists organised into sections, each under its own head, and with defined research activities.

For administrative purposes the Research Establishment is divided broadly into two main groups, one dealing with research activities and the other with service and operational activities.

RESEARCH ACTIVITIES

The research program of the Australian Atomic Energy Commission is aimed primarily at:—

- the development, in co-operation, where possible, with other countries such as the U.K., U.S.A. and Canada, of a type of power reactor which may be suitable for use in Australia;
- the provision of radiation sources and radioisotopes and methods for their use as required for medical and industrial purposes and for agriculture and research;
- the study of problems associated with the large-scale use of radioactive materials, including the biological effects of radiation; and
- the provision of special facilities that may be needed for post-graduate research and training by Australian universities.

The main research project is the development of a high temperature gas-cooled reactor (HTGCR) in which fuel elements consisting of enriched uranium and fertile thorium may be used, and for which beryllia and beryllium are being considered as moderator. Carbide fuels and graphite cans are also being studied.

Research work is carried out by the following sections:

POWER STUDIES

A number of overseas countries are engaged in developing, constructing and operating nuclear power stations of various kinds and it is the responsibility of the Power Studies Section to keep a close watch on these activities and to compare the relative merits of different concepts from the Australian standpoint.

The section also keeps in close touch with Australian power generating authorities; keeps them posted on developments in the nuclear power field, and with their assistance assesses the relative economics of nuclear and conventional power in the different States.

A watch is also kept on the development of nuclear reactors for special purposes such as marine propulsion, process steam generation, etc.

The ultimate aim is, in co-operation with the various State authorities, to draw up a nuclear power program which will be in the best interests of the country as a whole.

ENGINEERING RESEARCH

The Engineering Research Section deals with both theoretical and experimental aspects of the design of reactors to be used for producing electrical power. A wide range of work is involved, embracing nuclear, mechanical, thermal and economic aspects. Their interaction and effects on operating conditions and performance have to be investigated, at first broadly and then in increasing detail until a final specification can be established.

The starting point is the calculation of neutron behaviour in a reactor core. This is treated on the basis of simple geometrical shapes and idealised neutron theory in order to find which of the many possible combinations of fissile, fertile and moderating materials are likely to give suitable reactor sizes and conversion ratios. The work is then extended systematically to more practical cases, with increasing complexity of calculation but over a narrower range of conditions, until the best compositions, operating conditions, control arrangements, etc., can be defined.

The nuclear physical concepts of the reactor core have to be translated into a practical design, so a parallel study is required of how the heat generated in the reactor is to be removed and converted into electrical power most efficiently and economically. There are complicated relationships between temperatures and temperature differences in the reactor and heat exchanger, power required to circulate the coolant gas, capital cost of reactor and cost of fuel, the efficiency of the steam or gas turbine cycle, etc., which are formulated and optimised in order to reduce the cost of generated electricity. This production cost will be the governing factor in deciding the usefulness of the nuclear power plant.

This study and calculation are supplemented by experimental work, first to obtain data on which the calculations are to be based and finally to verify the

predicted performance of components and of the reactor as a whole. The equipment required ranges from fairly simple apparatus to test the efficiency of sealing of flanged joints, to models of a complete fuel channel operating as near as possible to the temperature, pressure and irradiation conditions expected in the reactor.

CHEMISTRY

The Chemistry Section is mainly concerned with the Establishment's materials research program which has as its object the development of improved fuel and moderator materials for a high temperature gas-cooled reactor, with particular emphasis on beryllium-based fuels.

The work of the section involves a wide range of inorganic and physical chemistry and the provision of a comprehensive analytical service. Much of the work involves the use of radioactive isotopes and the section is housed in the only major laboratory in Australia specially designed for this type of work.

In addition to the main radiochemical laboratories there is a high flux irradiation facility and a special laboratory for low background radiochemical analysis. Very active samples can be handled in a "hot cell".

The section is organised into three groups:

Reactor Fuel Group

The work of this group is mainly in the fields of high temperature inorganic chemistry and radiochemistry. The program includes:—

(a) Study of the reaction of metallic beryllium with potential coolant gases, including the protective action of oxide films and irradiation effects.
(b) The chemistry of beryllium oxide systems.
(c) Diffusion studies in beryllium and beryllia-based fuels including fission product diffusion.
(d) Radiochemical studies of the thorium-uranium 233 systems.
(e) A range of physical measurements, including thermal conductivity, particle size, etc., for fuel and moderator materials.

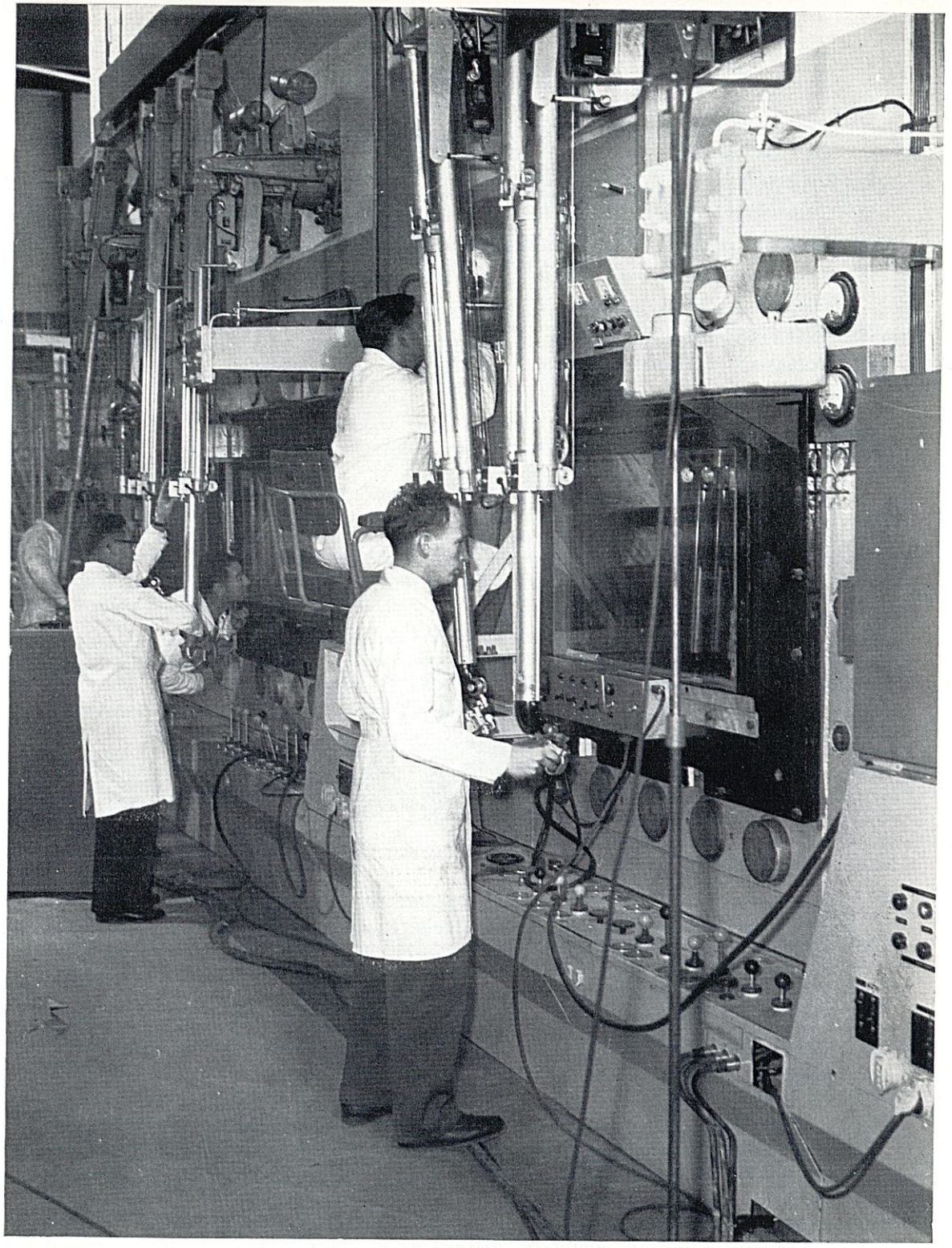
Chemical Processing Group

This group is concerned with the study of the reprocessing of irradiated nuclear fuels and associated moderator materials. The program of the group includes:—

(a) Dissolution studies of beryllium- and beryllia-based fuels.
(b) Solvent extraction processes for the recovery of uranium, thorium and beryllium.
(c) Ion exchange studies.
(d) Studies of complex compounds of beryllium.
(e) Irradiation effects in chemical processing.
(f) Methods for the treatment of low activity wastes.

Analytical Group

This group is responsible for the provision of a Site Analytical Service including analytical aspects of the materials research program. Responsibilities of the group include the development of a wide range of new analytical procedures, chemical control of the HIFAR reactor and assistance with health physics surveys.



At the working face of the high activity cells where operators of the master slave manipulators are shielded from radiation by 3' 6" thick walls of steel aggregate concrete and 3' 8" thick high-density lead-glass windows.

The group uses a range of modern techniques including:—

(a) Polarography and other electrochemical methods.

(b) Ultra-violet, visible and infra-red spectrometry.

(c) X-ray diffraction and x-ray fluorescence analysis.

(d) Radiochemical analysis including gamma spectrometry and low background analysis.

(e) Mass spectrometry.

(f) Vacuum fusion analysis.

METALLURGY

Metallurgy Section is concerned with the materials problems associated with the development of an Australian high-temperature gas-cooled reactor, and the main emphasis is on the materials for the core of this reactor. Two types of fuel element are being studied, one of which is essentially metallic and is based on beryllium, whilst the other is ceramic and is based on beryllium oxide.

The activities of the various groups in the section are as follows:—

Mechanical Metallurgy Group: responsible for—

Research into methods of fabricating nuclear materials, and fuel elements.

Provision of nuclear materials to other projects.

The laboratory is well equipped for both pilot plant and small production scale work on powder metallurgy, vacuum casting, extrusion, rolling, etc., and for mechanical testing of products.

Irradiation Group: responsible for—

Design and construction of complex rigs to irradiate materials in the research reactor HIFAR.

Post-irradiation examination of irradiated samples by remote control in heavily shielded "hot-cells", utilising master-slave manipulators and assisted viewing by periscope and television.

Investigation of the damaging effects of neutron bombardment on fuels and other materials.

Ceramics Group: responsible for—

Development of high-temperature fabrication techniques for ceramic fuels. Investigation of the effects of particle size, impurities, and fabrication variables on the physical, mechanical and irradiation behaviour of beryllia.

Physical Metallurgy: responsible in general for investigations into the dependence of metal behaviour on atomic structure.

The laboratories are well-equipped and include facilities for mechanical testing, metallography, electron and x-ray diffraction, electron microscopy and x-ray micro-analysis.

Process Development: responsible for—

Welding of nuclear metals.

Development of methods of melting and casting to produce purer grades of beryllium.

Production of single crystals of beryllia.

Non-destructive testing.

Neutron Diffraction: The following projects are being studied—

The position of atoms in crystals of compounds containing heavy and light atoms.

Magnetic structures in transition metal systems.

Point defect distributions in irradiated solids.

Inelastic scattering of sub-thermal neutrons from solids and liquids.

REACTOR PHYSICS

Reactor Physics Section is responsible for providing information on the nuclear performance of reactor systems under study, and for nuclear and neutron physics studies. The section is arranged in three groups:—

Nuclear Measurements Group is concerned with the study of neutron absorbing and scattering properties of individual materials used in reactor systems, the distribution of neutron energies in such systems as may be investigated, and with fundamental nuclear and neutron physics studies.

The group has special counting techniques for radioactive sample measurement at its disposal, including multichannel pulse height analysers, beta-gamma and gamma-gamma coincidence units. In the study of neutron energy spectra in reactor systems it has developed neutron time-of-flight measurement techniques and equipment is available for use on the HIFAR and MOATA reactors. Other equipment is available for neutron cross-section measurements, including pile oscillators and neutron converters.

Critical Measurements Group is responsible for carrying out experimental investigations into the critical nuclear behaviours of assemblies consisting of nuclear fuel, fertile material which will produce nuclear fuel, and neutron slowing down materials (or moderators). The data obtained are used to give information on optimum core performance for reactor systems. The group is responsible for the supervision of MOATA, a 10 kilowatt research reactor, installed to study the various assemblies proposed for the Commission's reactor program. Apart from the research program, the group is responsible for the supply of information relating to the physics of HIFAR. It is also responsible for the approval of assemblies of nuclear fuel as safe from criticality hazards.

Theoretical Reactor Physics Group is responsible for the theoretical study of the physics of reactor systems, for the assessment of data produced by the experimental groups to give a theoretically correlated set of information for reactor core design, and for theoretical nuclear and neutron physics studies. The group has access to various large digital computers and a considerable amount of numerical work is done on systems which are not amenable to direct analytical solution. The section has at its disposal the reactor MOATA, a number of special facilities on the reactor HIFAR and will in due course have a 3 MeV van de Graaff accelerator available.

CHEMICAL ENGINEERING

The Chemical Engineering Section is responsible for the study of chemical engineering problems involved in the design, construction and operation of plant associated with the atomic energy program. This requires the development and use of new techniques and specialised facilities. The work is directed towards problems in plant design and operating and maintenance procedures to reduce investment and operating costs without sacrifice of safety or process efficiency.

The section is divided into three groups whose functions are to study chemical engineering problems in chemical processing, materials research and waste disposal.

The Aqueous Separations Group

- responsible for developing aqueous techniques for recovering uranium economically from oxide and metal fuels. This involves experimentation with inactive continuous liquid-liquid extraction equipment using systems of low uranium concentration and high beryllium concentrations. Equipment to carry out a complete flow sheet study under active conditions is being designed. Physical schemes for recovering uranium from ceramic fuels are also under study.

The Non-Aqueous Research Group

- responsible for high temperature materials and advanced processing research. Fluid bed techniques are being used to produce beryllium oxide coated beryllium metal powder and beryllium oxide coated uranium dioxide powder for material evaluation. Oxide and metal fuel samples are being halogenated in a fluidised bed to develop a more direct method of recovering uranium than presently known.

The Effluent Research Group

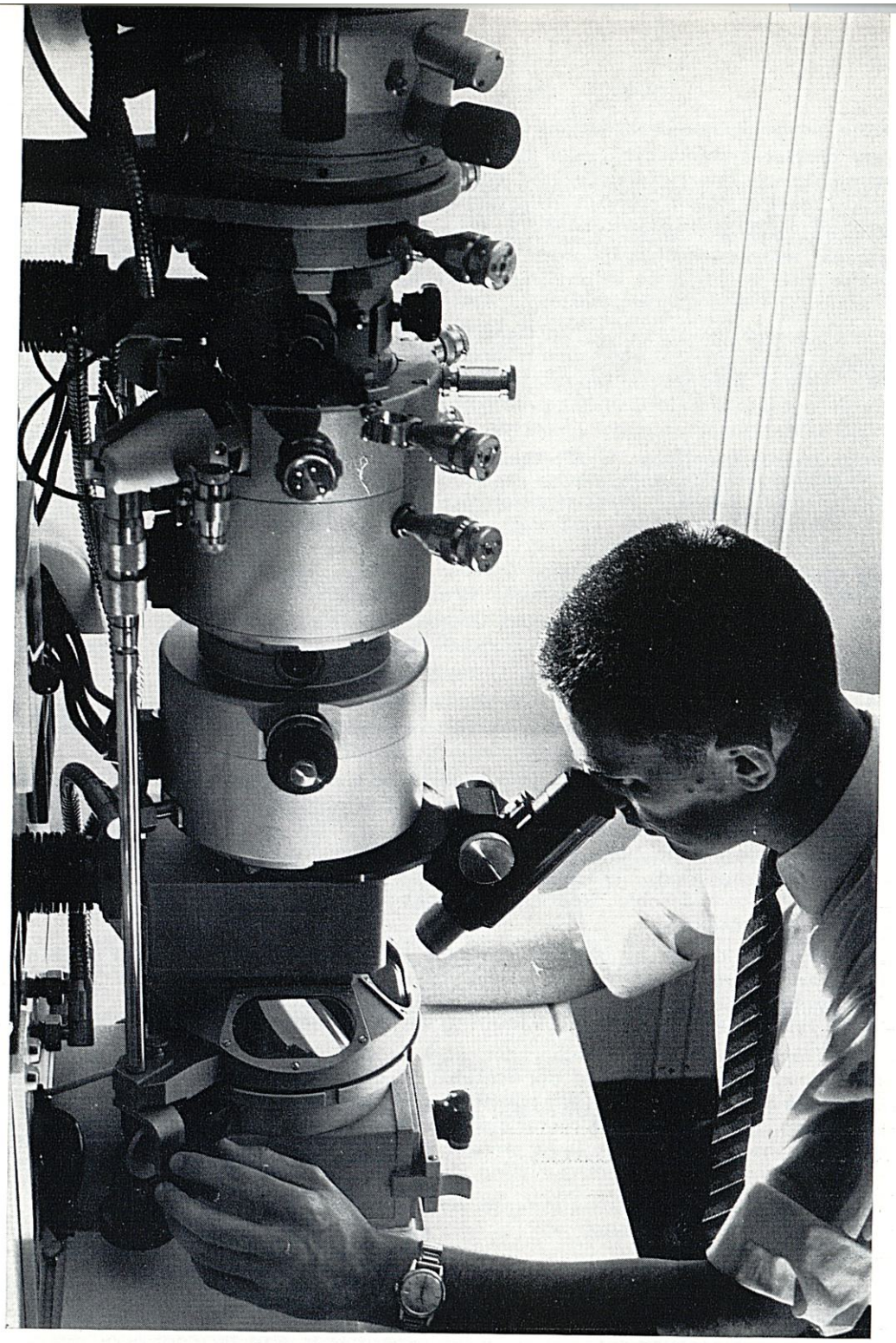
- responsible for carrying out research on waste disposal problems. Current problems include devising a method of handling sludge produced in the Effluent Treatment Plant and the fixation of activity from low and medium level liquid wastes on samples of zeolites of Australian origin.

TECHNICAL PHYSICS

The Technical Physics Section is concerned with general problems of electronic, electrical and physical instrumentation. These cover control and safety systems for new reactors, instrumentation for "loop" experiments, electronic circuit development, testing and maintenance.

Development and design activities are undertaken with the objective of having many of the more common electronic instruments used in the Establishment built in Australia. Manufacture is undertaken from designs approved or developed by the Technical Physics Section. Equipment made under contract includes transistorised scalers, various types of voltage or current stabilised power supplies, amplifiers, gamma monitoring systems, transistorised furnace controllers, etc.

Also new instrument techniques are developed and applied in research investigations into the physical properties of materials.



A high resolution electron microscope which is finding wide application at the Lucas Heights Research Establishment.

Future reactor systems are under consideration and investigation of problems in instrumentation has resulted in the construction of a small analogue computer to study reactor stability and kinetic behaviour. More reliable control and instrumentation systems using transistors, etc., are being developed.

Nucleonic instrumentation involves research into the detection of nuclear particles and the interpretation of information from such detectors. Special interest is being taken in solid state detectors.

Acceptance and maintenance functions include detailed acceptance tests of all electronic and electrical instruments and commissioning of assemblies of equipment. This is followed by repairs and adjustments as necessary. A wide range of high quality standardising equipment is available for the calibration of electrical and physical instruments. Records are kept of all instruments.

General service functions include the design and manufacture of specific measuring instruments and equipment as required at the Research Establishment. Considerable development work is often necessary in these designs.

ISOTOPES

The activities of the Isotopes Section include:—

- An advisory and consulting service to industry and scientific research on the applications of radioisotopes; a field service is also provided.
- Radioisotope production in the reactor HIFAR, and
- Research and development work on technical and scientific applications of radioisotopes and radiations.

In the advisory and consulting work, advice on the use of radioisotopes and direct practical assistance is available to outside organisations. Such assistance includes the development of special equipment and the conduct of field and factory tracer experiments. A service is also available for high intensity gamma ray and neutron irradiation. The activities of the Advisory Service are steadily increasing, and considerable practical assistance has already been given in a wide range of applications.

The production of isotopes covers a wide range including tracers for scientific, industrial and medical use, radiography and other sources for industry, radio-therapy sources, including very high specific activity cobalt 60 for teletherapy and other radioisotopes requiring very high neutron fluxes.

The research and development work is mainly concerned with investigations into new techniques and applications, but a substantial effort is directed towards the use of high intensity radiation for sterilisation, insect control, food preservation, modification of materials and promotion of chemical reactions. Radiation for these applications is at present obtained from used HIFAR fuel elements, which contain highly radioactive fission products.

HEALTH PHYSICS

The Health Physics Section at the A.A.E.C. Research Establishment has two basic responsibilities:

- To ensure, through safe design of all experiments and by continual monitoring, that no research worker or any member of the general population is exposed to excessive doses of radiation of toxic materials;
- to carry out research in the field of radiological protection.

To discharge these responsibilities, the section has been organised around three main groups:

Health Physics Operations—This group provides the day-to-day control of radiation hazards, investigates incidents, maintains complete records of all personnel exposures and offers formal training in health physics monitoring procedures and methods.

Environmental Studies—As well as conducting regular surveys of the environment of Lucas Heights to ensure that the work of the establishment is not leading to any accumulation of hazardous materials off site, some studies are also being made of physical and biological mechanisms by which such materials are incorporated into the environment.

Radiological Physics—This group is concerned with the more fundamental aspects of health physics. Some of the studies being undertaken by this group are centred around the many different processes which are responsible for the absorption of energy from radiations when they interact with matter. Others are concerned with the development of nuclear radiation detectors and the measurement of radioactivity, particularly at very low levels. One such project, for example, is the building of a "total body counter", a very sensitive detector of gamma radiation, which is capable of measuring and identifying the presence of minute amounts of radioactivity inside the human body at levels far below that which would cause any significant biological damage.

RADIATION BIOLOGY

The Radiation Biology Section is concerned with biological research and with the health of staff members. Its activities are grouped accordingly:

1. Laboratories are equipped for a wide range of investigations. Particular emphasis is laid on the primary cellular effects of radiation and this necessitates investigations of various fundamental problems of cell structure and physiology. Other work includes development of improved methods of assessing radiation injury or contamination.
2. The medical aspects of radiation protection of staff are carried out and facilities for diagnosis and treatment in the event of radiation accidents are provided. Other problems of industrial medicine are also dealt with and there is provision for emergency treatment of accidents not involving radiation.

OPERATIONS DIVISION

ENGINEERING SERVICES

The Engineering Services Section originally superintended the erection of the high flux research reactor HIFAR and is now subdivided into the following groups:

Reactor Operations Group is responsible for the safe and efficient operation and maintenance of HIFAR together with its auxiliary and ancillary equipment.

Site Operations Group operates and maintains all plant on the site such as boilers, major ventilating systems, electrical, mechanical, water and sewerage services and is responsible for radioactive waste disposal.

Workshops Group is responsible for the fabrication of experimental equipment required by research teams, complex rigs and assemblies for insertion into HIFAR, the manufacture of lead shielding, the machining of graphite, and other workshop activities of a delicate and intricate nature.

Design and Construction Groups deal with the design and construction of most plant and equipment required by the Research Establishment, including design and construction of experimental rigs required by research teams, additional laboratories and other buildings, remote handling cells and associated equipment.

Safety Group is responsible for safe industrial practices, prevention and control of fire and radiation hazards, and the operation of the Site Emergency Organisation.

ADMINISTRATIVE SERVICES

The Administrative Section is responsible for the general administration of the Research Establishment and covers purchasing, accounting, salaries, stores, records, transport, recruitment and grounds maintenance.

LIBRARY

The Library has the most comprehensive collection of atomic energy literature in Australia together with the necessary coverage of the supporting sciences and technologies. A library service is provided to meet the needs of the Research Establishment and, in atomic energy and associated matters, the needs of other research workers in Australia.

AUSTRALIAN INSTITUTE OF NUCLEAR SCIENCE AND ENGINEERING.

The headquarters of the Australian Institute of Nuclear Science and Engineering is located at Lucas Heights adjacent to the A.A.E.C. Research Establishment.

The Institute is an organisation established jointly by the Commission and the Australian Universities. Its purpose is to stimulate research and training in nuclear science and engineering, to make the unique facilities of the Research Establishment available for use in university projects, and to promote co-operation between the Commission and the universities.

The Institute's operations include the following:

(a) Creation of research facilities at Lucas Heights for use of member organisations, and arranging for the universities to use facilities established by the A.A.E.C.

(b) Co-ordinating research effort and encouraging university research and training by means of grants, post-graduate studentships and fellowships, conferences and short-training courses, and the collection and distribution of scientific and technical information to members and other interested bodies.

1,000-ton extrusion press installed in Metallurgy Building at the A.A.E.C. Research Establishment.

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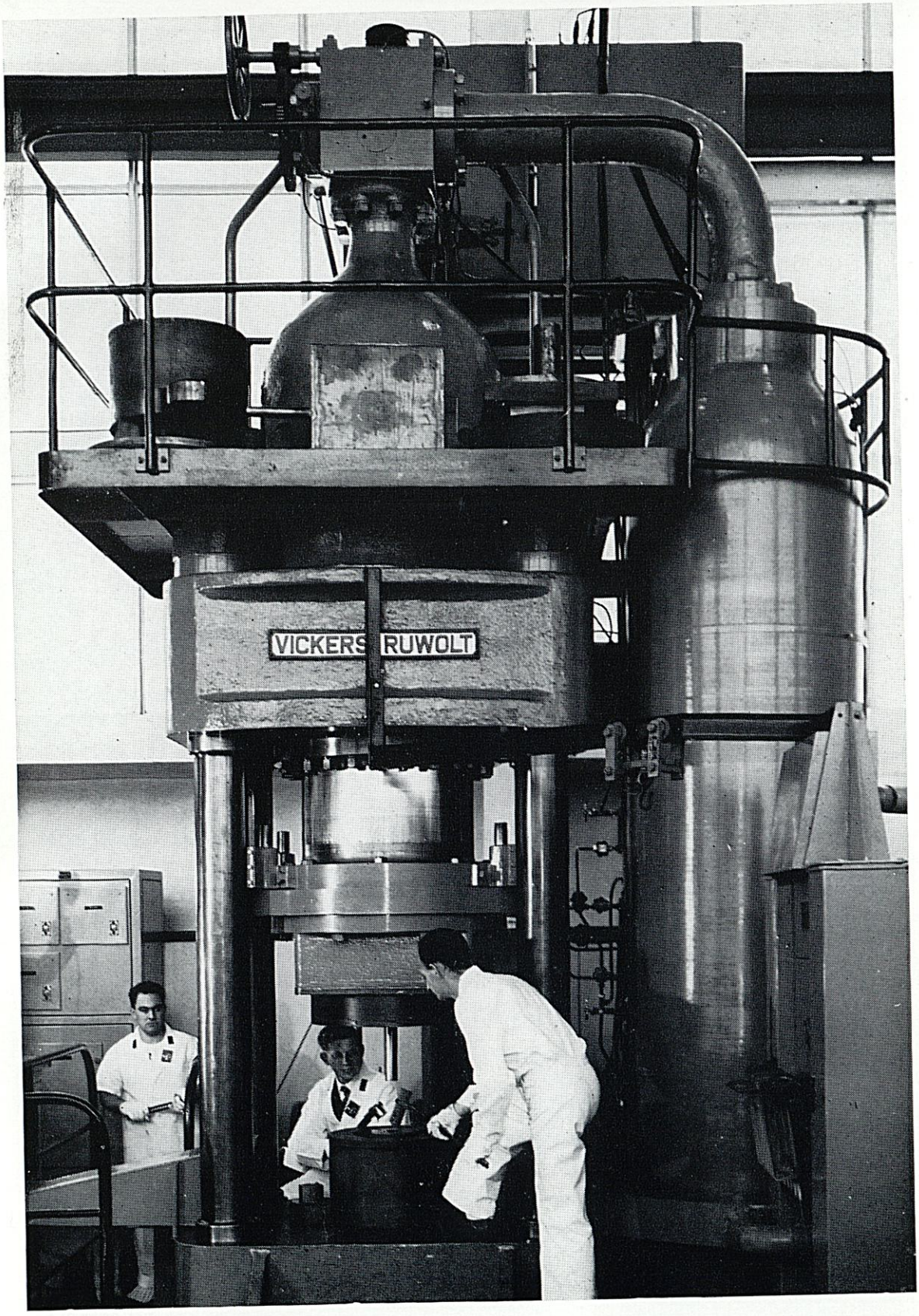
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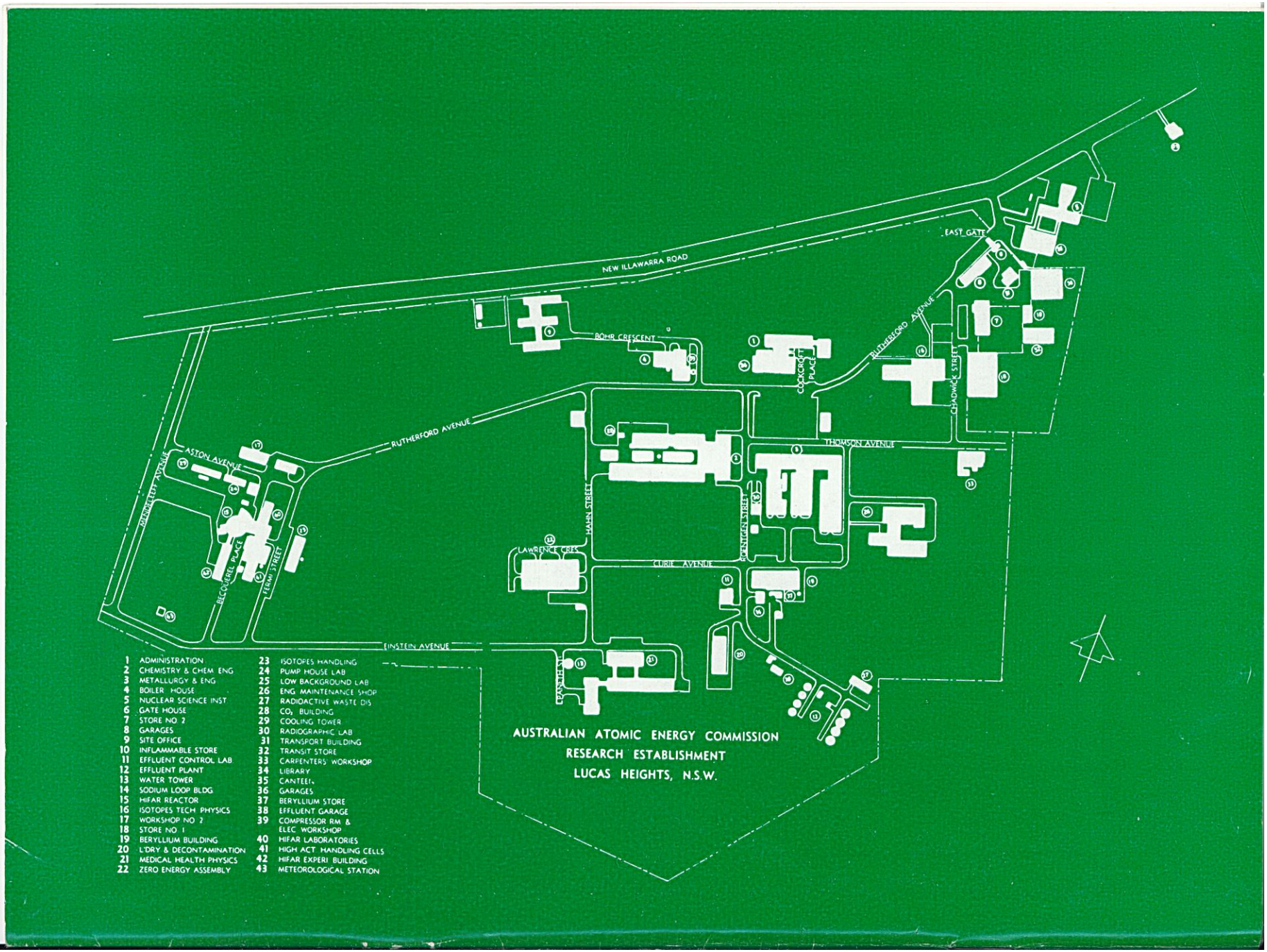

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8 GARAGES
9 SITE OFFICE
10 INFLAMMABLE STORE
11 EFFLUENT CONTROL LAB
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