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Atomic Energy Research

AUSTRALIAN ATOMIC
ENERGY COMMISSION

*“To follow knowledge, like a sinking star,
Beyond the utmost bound of human thought.”*

ULYSSES
ALFRED, LORD TENNYSON



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FOREWORD

The Australian Atomic Energy Commission, created by Act of Parliament in 1953, is included in the portfolio of the Minister for National Development, Senator the Hon. W. H. Spooner, M.M. It has the functions of developing the practical uses of atomic energy, discovery and production of uranium, etc., scientific research, and training personnel to meet the needs of Australian nuclear technology. The Commission's plan for the development of Lucas Heights as an atomic research centre, submitted in September, 1954, and accepted by the Commonwealth Government, paved the way for construction of the present Research Establishment, as illustrated in the cross-sectional view seen in the following pages.



SENATOR W. H. SPOONER

**DIRECTION**

- 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.
- Members:** 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.
- Deputy of the Executive Member:** M. C. Timbs, B.Ec., A.A.S.A.
- Director, Research Establishment:** K. F. Alder, M.Sc., F.I.M., A.M.A.I.M.M., A.M.I.R.E. (Aust.).

RESEARCH

The Australian Atomic Energy Commission's Lucas Heights Establishment is the major Australian centre for atomic energy research and information. It has a programme of research in the development of nuclear power, the utilisation of radio-isotopes, and in other associated fields, directed towards the long-term development of the resources of the country.

The main feature of this programme is the development of a type of nuclear power reactor suited to Australian needs. A high temperature gas cooled reactor has been selected for study. By comparison with the nuclear power stations in existence or being planned at the present day, this is an advanced system. It is expected to be capable of competing on a cost basis with new coal-burning power stations in many parts of Australia.

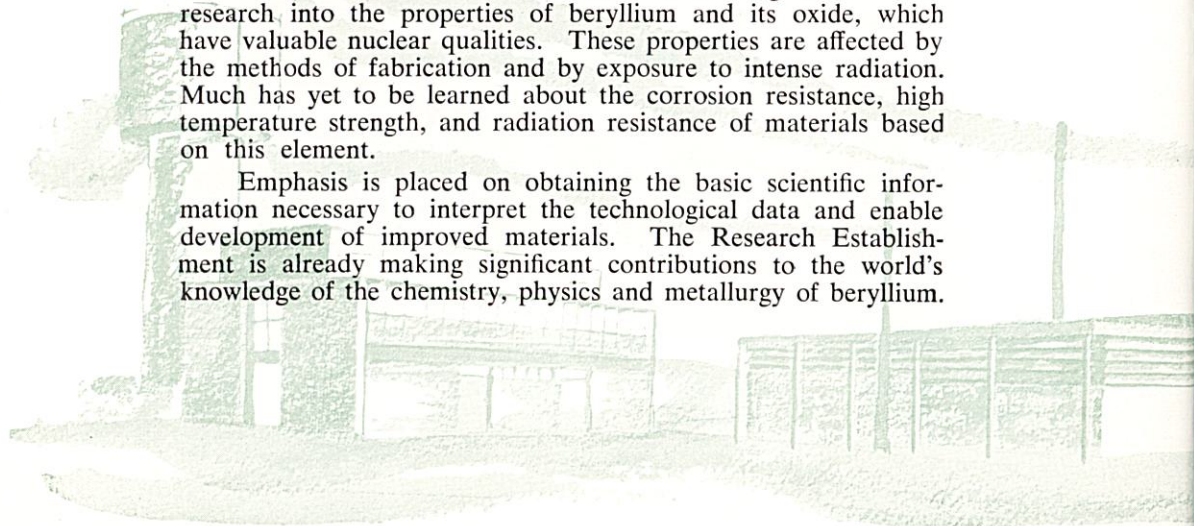
It is hoped to make this a "breeder" system whereby new fuel is bred from thorium at about the same rate as the original uranium reactor fuel is consumed, thus prolonging fuel life.

Developing of this system is essentially a long-range project and in the initial stages an extremely precise and careful study must be made of the basic physics and engineering of the system, and of the materials involved in its construction.

It is necessary to develop nuclear materials which can be fabricated to the required shape and form and can withstand the severe chemical and nuclear conditions within the proposed reactor. The physics of various configurations and proportions of these materials has to be analysed in detail, and the engineering of the core and associated structures has to achieve optimum conditions for highest output with minimum cost, commensurate with safety.

The Research Establishment is now doing considerable research into the properties of beryllium and its oxide, which have valuable nuclear qualities. These properties are affected by the methods of fabrication and by exposure to intense radiation. Much has yet to be learned about the corrosion resistance, high temperature strength, and radiation resistance of materials based on this element.

Emphasis is placed on obtaining the basic scientific information necessary to interpret the technological data and enable development of improved materials. The Research Establishment is already making significant contributions to the world's knowledge of the chemistry, physics and metallurgy of beryllium.



PROGRAMME

As the research programme goes forward the way is being prepared for the introduction of nuclear power in Australia, not necessarily through the HTGC reactor alone, but also for other reactor systems and for other applications of atomic energy.

These activities are building up a body of knowledge and local skill which will be needed when it is decided that nuclear power stations should be built in this country. On present indications the first such station could be in operation in the early 1970's.

Close contact is maintained with State power authorities, and when the time comes for such an authority to build a nuclear power station the Commission will be able to offer technical advice and assist in design, siting and other aspects.

The Commission is also seeking to extend the use of radioisotopes in Australia in scientific research and development, in the treatment of disease, raising production and lowering costs in agriculture and in manufacturing industry. There is a vast field for fruitful applications, and new ones are being continually devised. In Australia these new processes are being used only in a small fraction of the possible fields.

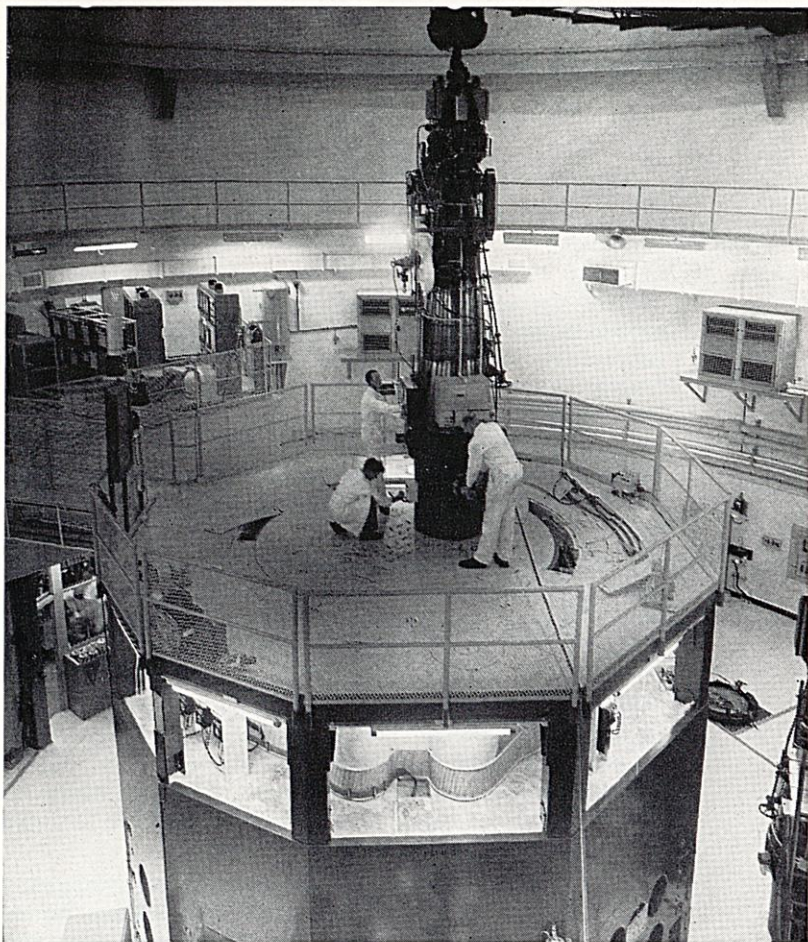
The use of isotopes is fostered by providing an advisory service which is a ready source of information on established uses, and by investigation of other projected applications. Isotopes, including short-lived isotopes which cannot be economically imported, are being produced in the HIFAR reactor.

Research and development work on technical and scientific applications of radiation is also being carried out. The possibilities of radiation for such purposes as industrial sterilisation, food preservation, and the control of insect pests are being investigated.

Scientists at Lucas Heights are also studying biological effects and questions of health and safety involved in the use of radioactive materials.

Lucas Heights, then, is a centre of specialised equipment and information. In addition to the high flux research reactor HIFAR, used for testing materials and producing radioisotopes, there is much other equipment unique in Australia. All these facilities are available to Universities and other institutions under suitable conditions.





HIFAR

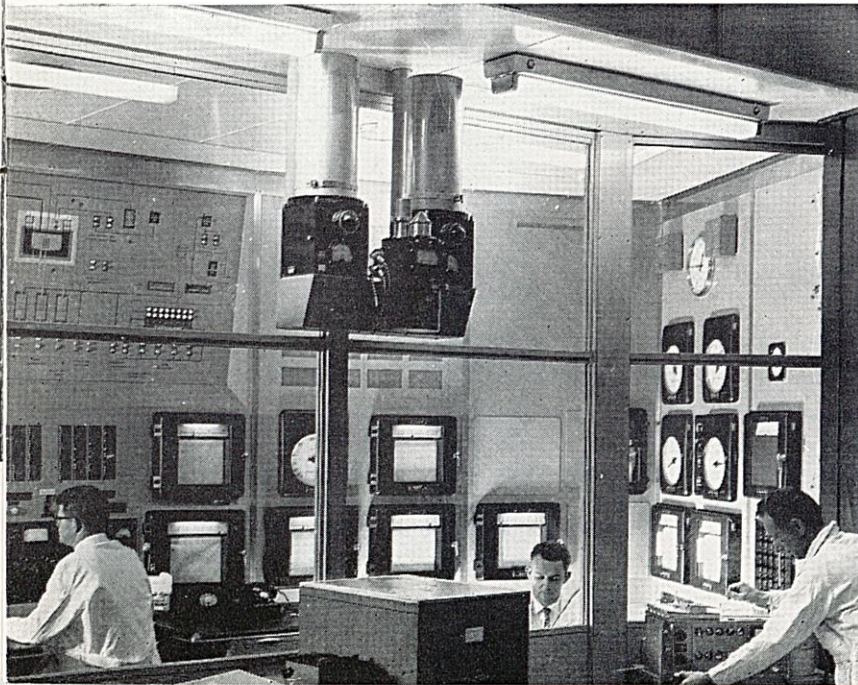
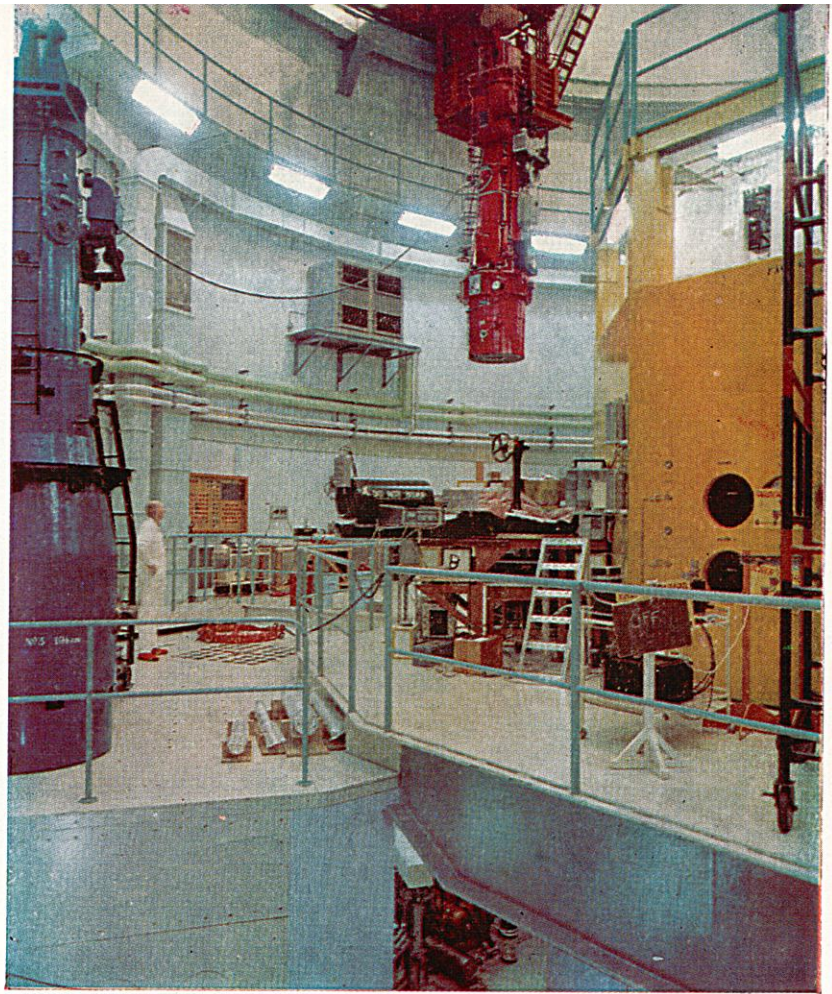
HIFAR — seen above from the cat-walk inside the reactor shell — is a materials testing and isotope production reactor, moderated by heavy water. It has a maximum output of 10 million watts of heat. HIFAR was taken critical in early 1958. It is powered by 25 fuel elements of highly enriched uranium metal alloy clad in aluminium and has a maximum flux of 1.8×10^{14} neutrons (180,000,000,000,000) per square centimetre per second.

HIFAR is now being used for testing materials for future power reactors. It is also equipped with special “self service” irradiation apparatus for production of a wide range of isotopes and is making cobalt 60 for medical use.

The nuclear properties of reactor materials are being closely studied to examine the best way to use them in the HTGC reactor system.

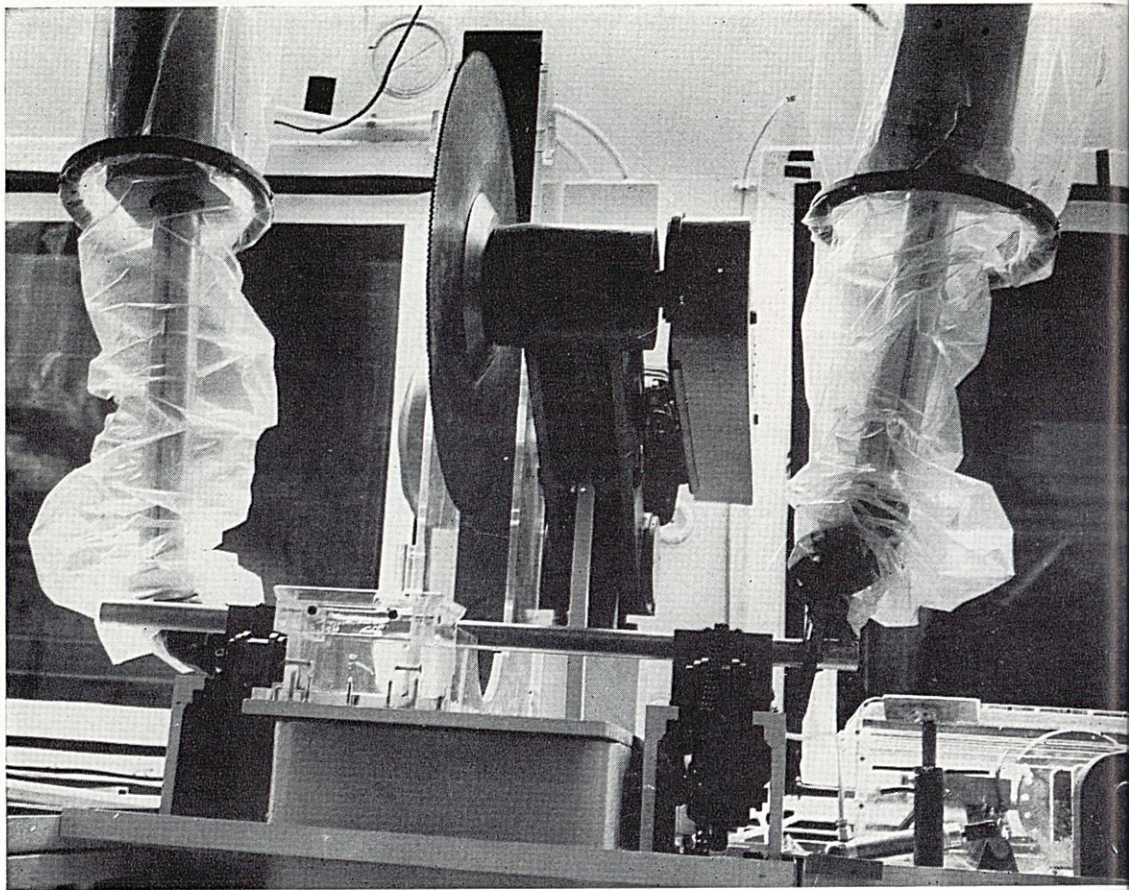
Loading or unloading active materials from HIFAR is carried out using 19-ton heavily shielded flasks for transporting highly radioactive materials.

The flask seen here is being lifted from the top of the reactor by the circular crane for transport by trolley to the remote handling cells.



Reactor control room — instruments linked to recorders and illuminated panels provide a clear picture of conditions in the reactor. Power level, position of control arms, condition of flow of the heavy water moderator and secondary cooling circuit can be seen at a glance by operating staff.

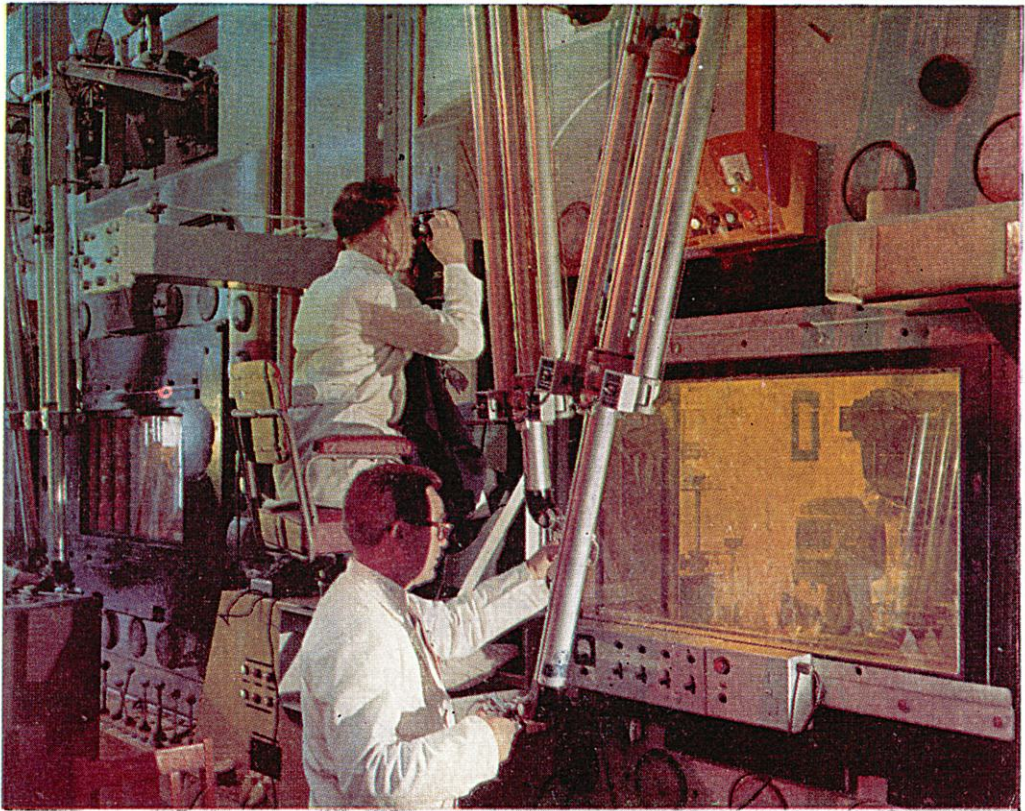
HIFAR is operated by Operations Division and all procedures and reactor experiments are rigorously scrutinised by a Safety Committee.



REMOTE HANDLING CELLS

The "fingers" of the master slave manipulators are shown (above) at work inside a high activity cell in the remote handling laboratories.

The manipulators are used in handling radioactive experimental "rigs" (assemblies containing material samples), in the servicing of reactor components and in handling intensely radioactive isotopes such as cobalt 60.



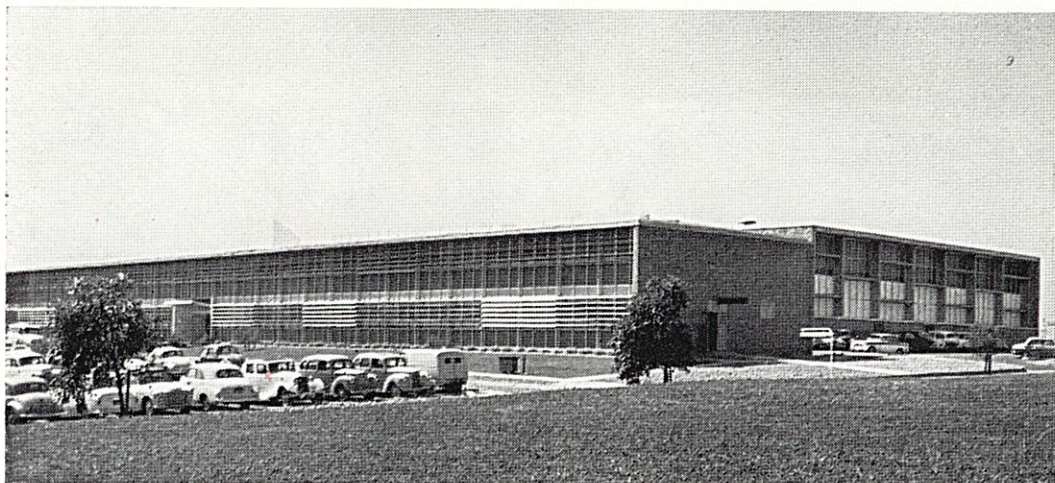
At the working face of the "hot cells" where operators of the master slave manipulators can reproduce almost all the motions of human hands inside the cells.

Shielded by 3'6" walls of steel aggregate concrete and 3'8" thick high-density lead-glass windows, the scientists carry out post-irradiation studies by the remote use of machinery and instruments, including a metallurgical microscope, closed circuit television, photographic equipment, a stereoviewer and a hardness testing machine.

Extensive use is made of hydraulics and pneumatics for operating lathes, cutting wheels and machining inside the cells.

Special pressurised suits are necessary when servicing equipment in the cells or preparing them for new studies.

When the cells are sealed the air pressure inside the cells is reduced to prevent leakage outwards and all exhaust air is passed through three filters before being discharged.



The Metallurgy/Engineering Research building is a key centre in the research programme. The wall of the physical metallurgy research laboratory can be seen on the right of the picture. The building also houses the Engineering Services workshop.

REACTOR ENGINEERING

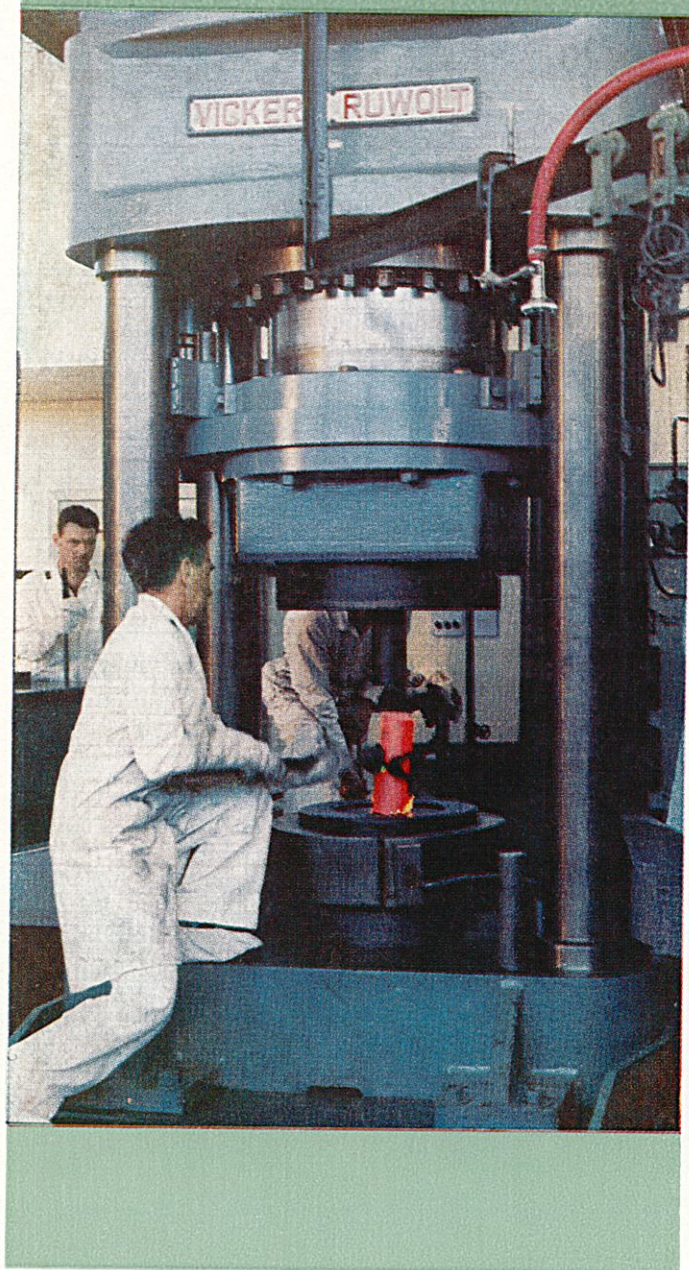
The information coming from other Sections on material properties and behaviour, and on fundamental neutron data is integrated into a complete reactor and power conversion system by the Engineering Research Section within Reactor Engineering Division.

Model theories of neutron behaviour are built up and modern high-speed computers used to calculate suitable reactor sizes, the amount of fuel which can be burnt and the amount of new fuel produced, safety factors and methods of control.

Studies are made of the best mechanical and thermal operating conditions, the cost of components and ways in which the cost of electricity from nuclear plant can be reduced. At the same time a long series of experiments, some fundamental and some on actual components, is carried out to prove the soundness of the design.

In addition to the high temperature gas cooled reactor system, many other types of power reactors are in various stages of construction and development throughout the world. The Reactor Engineering Division keeps close watch on these developments and evaluates and compares different systems.

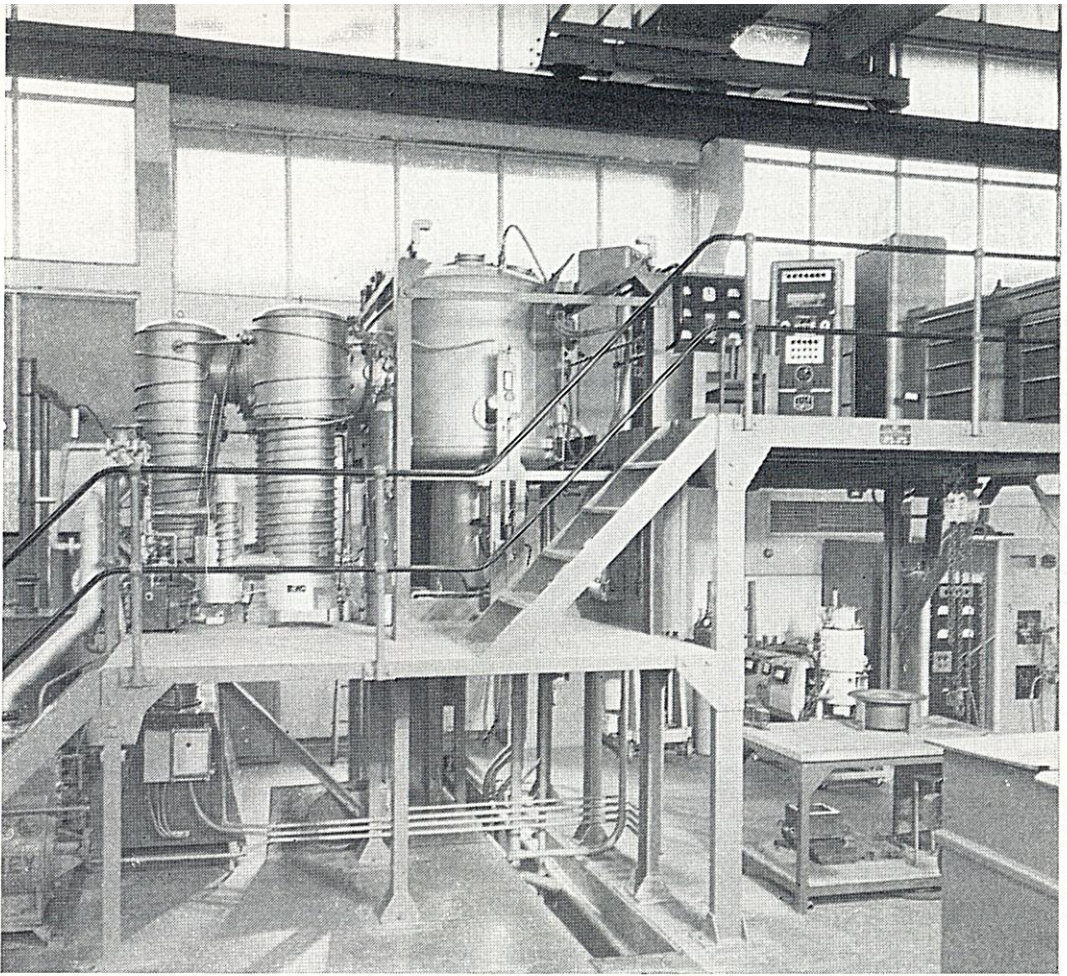
The Division is in touch with Australian power generating authorities and continually reviews the competitive position of nuclear power relative to conventional power. It also keeps watch on special applications of nuclear energy, such as ship propulsion, process steam generation, chemo-nuclear processes, and the U.S. Plowshare project.



This hydraulic press—in the fuel development laboratory of Materials Division—is a four-column, down-stroking press of 1,000 tons capacity.

It has the unique feature of high ram speed of up to 10 inches per second against 500 tons. Metals such as beryllium can be heated to high temperatures and extruded from a relatively cold container.

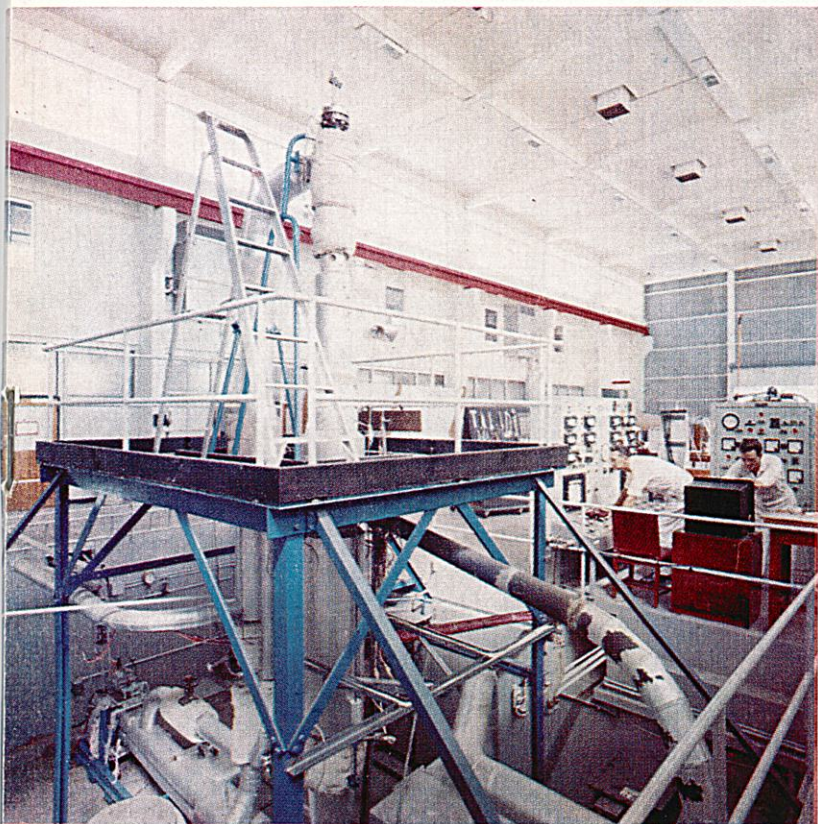
The press is also used at slow speeds for powder metallurgy operations.



The vacuum furnace in the fuel development laboratory of Materials Division is used for melting uranium and other metals; it may also be used for high temperature vacuum sintering operations.

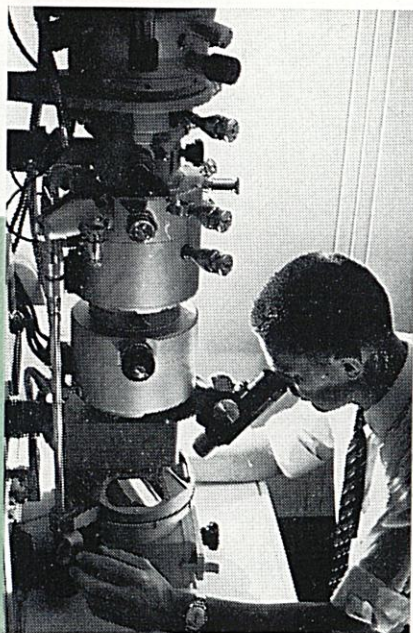
Operator at the console of the IBM 1620 Computer. Specifically designed for scientific and engineering calculations, the computer is being used to study reactor systems.

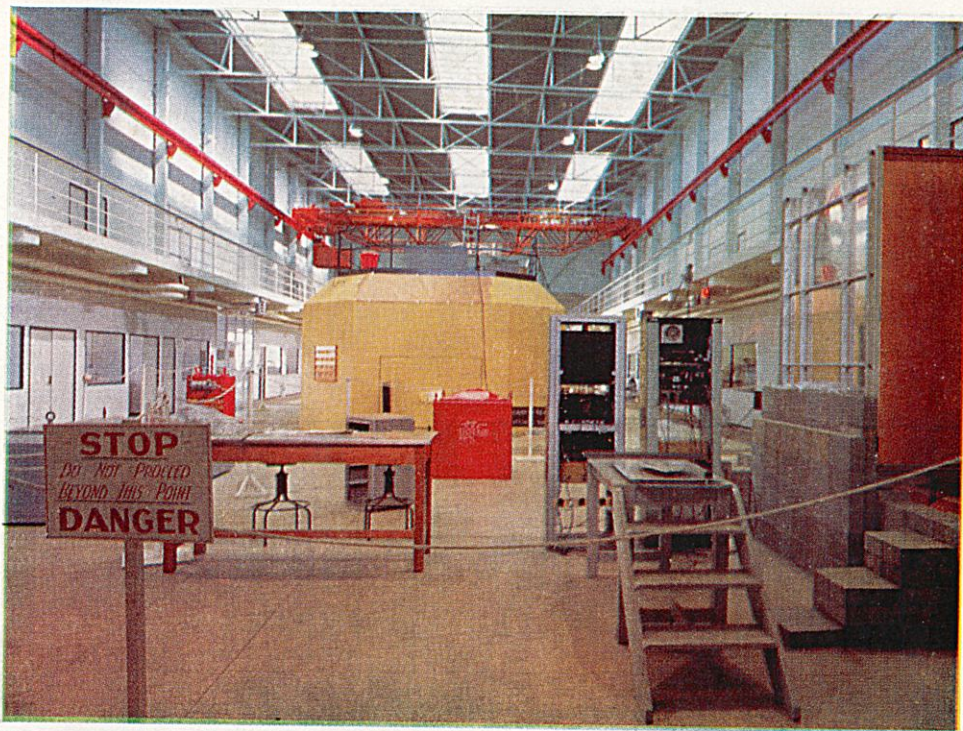




View of an experimental, pressurised gas-loop in the Engineering Research Bay of the metallurgy and engineering research building. The loop is designed to operate at a pressure of 300 lb. per sq. inch and a coolant temperature of 650°C. Under such conditions the behaviour of specimens of various fuel element materials in circulating carbon dioxide is studied.

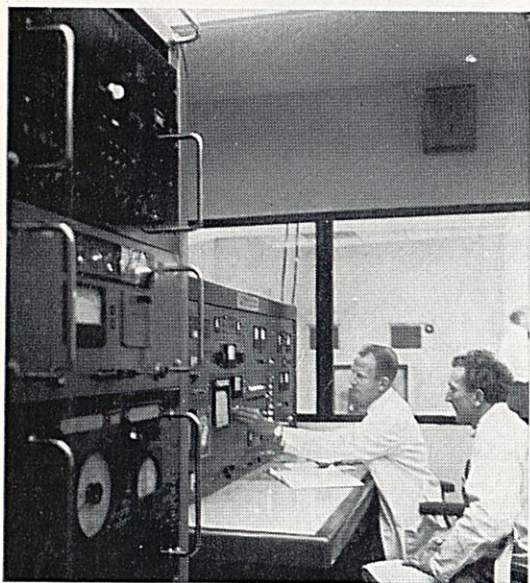
A high-resolution electron microscope which is finding extensive application in the Materials Division and has been applied also to a wide range of research projects in the Establishment.





A view of the Reactor Physics Building bay. MOATA reactor is the yellow structure in the centre of the picture.

PHYSICS DIVISION

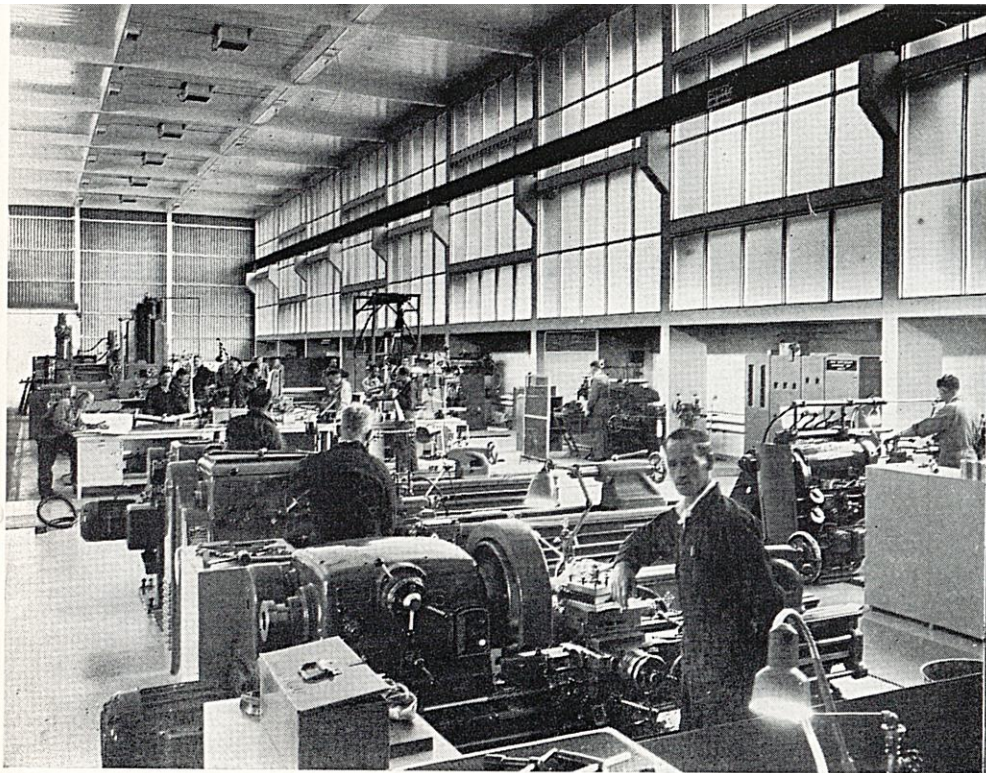


Control console of MOATA

Nuclear and reactor physics information on the behaviour of neutrons in reactor systems is obtained from experiment, theory and results of overseas work. These data are collated by the Physics Division and supplied to the Reactor Engineering Division for detailed calculations on particular reactors under study or design.

To further the experimental work associated with the reactor research programme of the AAEC, a 10 kilowatt reactor, MOATA, has been installed in the Reactor Physics building. This light water cooled, graphite moderated reactor is fuelled by twelve highly enriched uranium alloy plate-type fuel elements and has a maximum flux of 10^{11} neutrons per square centimetre per second. Using MOATA as a source of neutrons, the nuclear properties of the reactor materials for an HTGC reactor system will be studied to assist in achieving the best reactor design.

Provision of space is made for a 3 million volt Van de Graaf accelerator in the same building.



ENGINEERING SERVICES

The main machine shop (above) is one of the engineering services groups within Operations Division. Experimental equipment is fabricated here, including complex rigs and assemblies for insertion into HIFAR. Much of the work done in this shop supports irradiation tests.

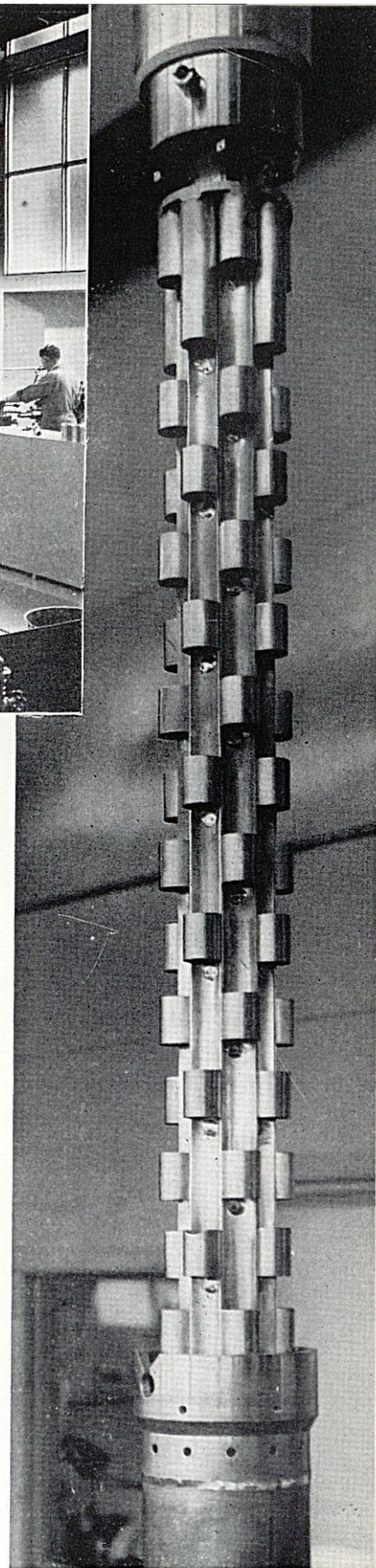
Other groups in the Division cover reactor operation, engineering design, site services, and building design and construction.

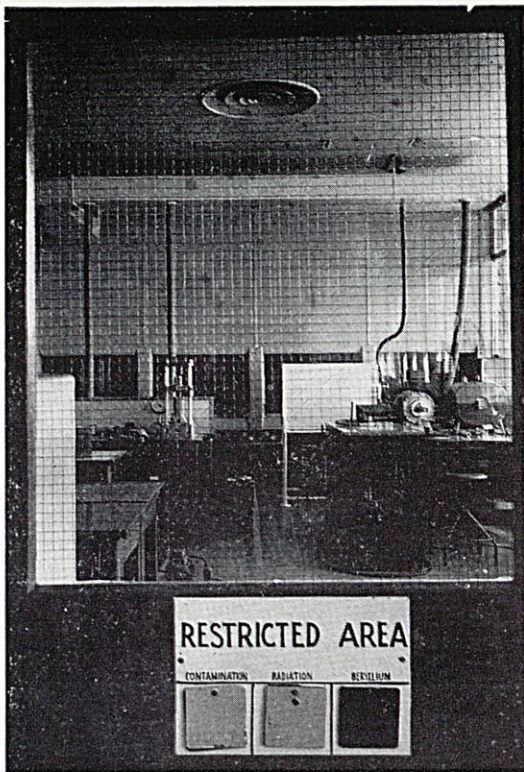
IRRADIATION EQUIPMENT

Right.—A “Cake-stand” rig combining 92 compartments for insertion into HIFAR of materials for producing isotopes. Rigs like this are contained in an outer tube or “thimble” and inserted into HIFAR.

This equipment is used for preparing a wide range of isotopes principally where long irradiation times are required.

Short term irradiations are being carried out in a “self service” isotope production unit. Other rigs are used for irradiating cobalt discs for production of cobalt 60. All these rigs were designed on the site.





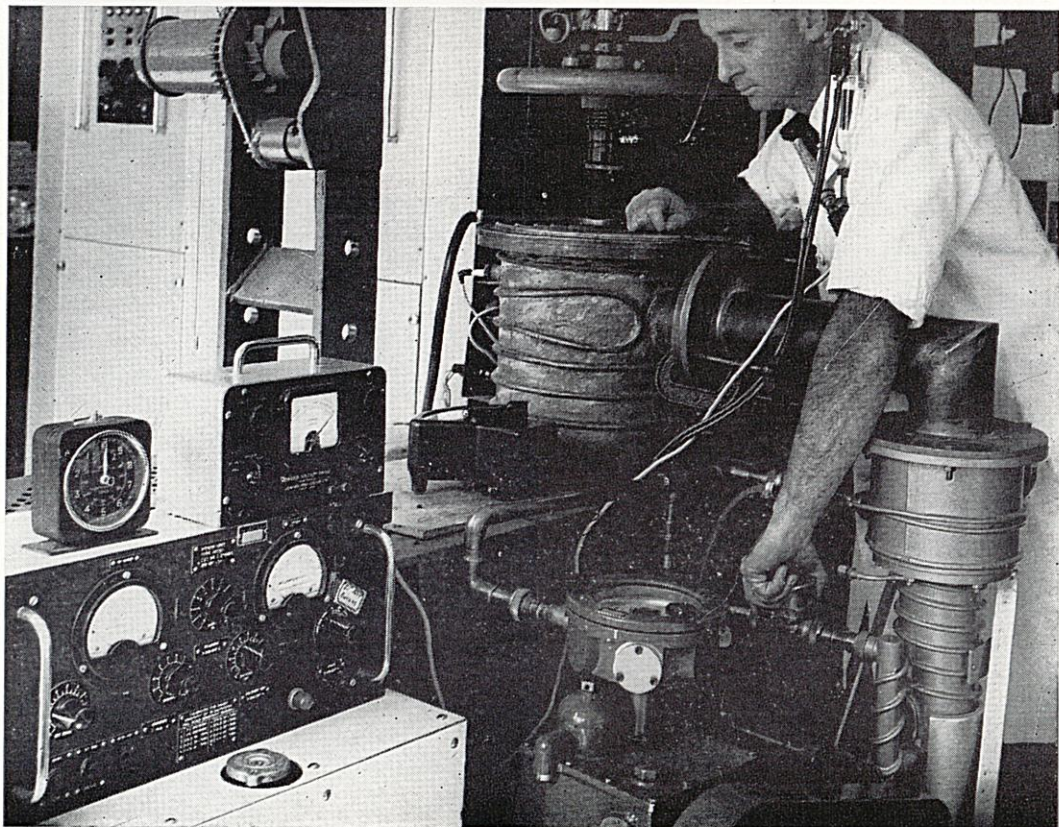
BERYLLIUM

Materials Division closely studies the use of beryllium oxide and beryllium metal as possible moderators and fuel carriers.

Entrance to the special laboratories where some of the studies are made is restricted and specially prescribed clothing has to be worn owing to the toxic nature of beryllium and its compounds.

Experiments on beryllium oxide and beryllium metal are being carried out in HIFAR to allow forecasts of the probable life-time of these materials in a high temperature gas cooled reactor.

A vacuum furnace (below) is used for consolidating beryllium metal powders.



The Health and Safety Division is concerned with the protection of personnel from radiation and toxic materials. Safety standards are set and continuous supervision of working conditions maintained in the Establishment.

Medical services are provided to determine the fitness of personnel to work with radioactive and toxic materials, and for emergency treatment. Health physics research is done on methods of measuring radiation. Environmental surveys check that no active or toxic materials escape. Radiation biology research is done on the effects of radiation on living material.



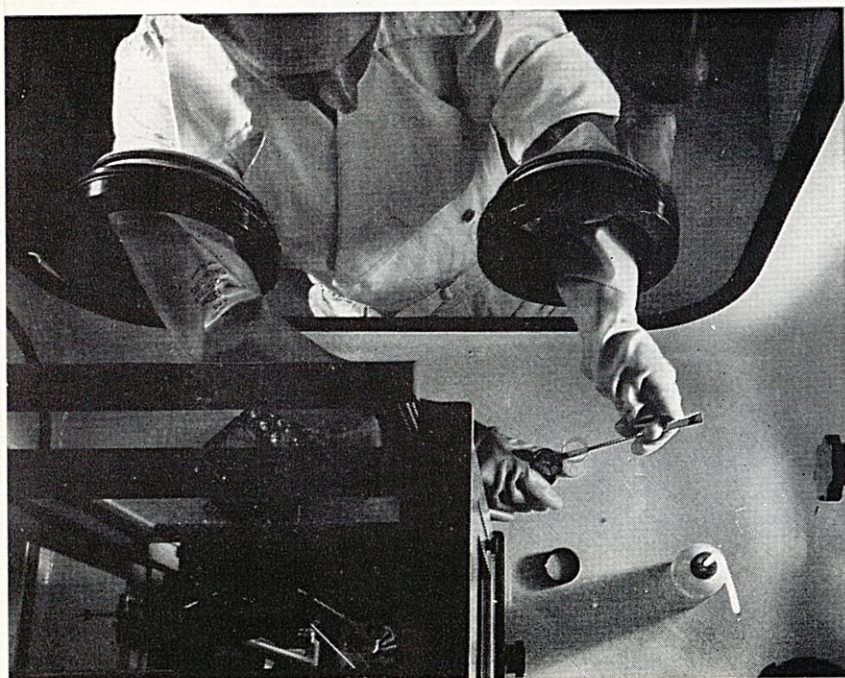
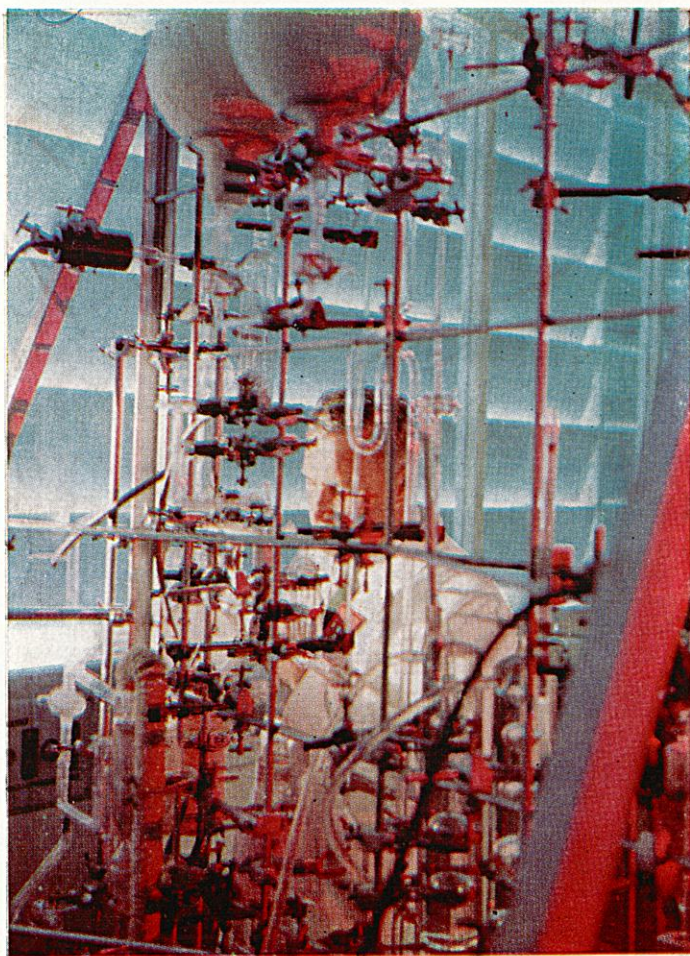
RADIATION BIOLOGY AND HEALTH PHYSICS



CHEMISTRY AND CHEMICAL ENGINEERING

Both Chemistry and Chemical Engineering sections of Materials Division are concerned in research on reactor materials whose chemical behaviour has to be studied in order to determine their suitability for use in future reactors.

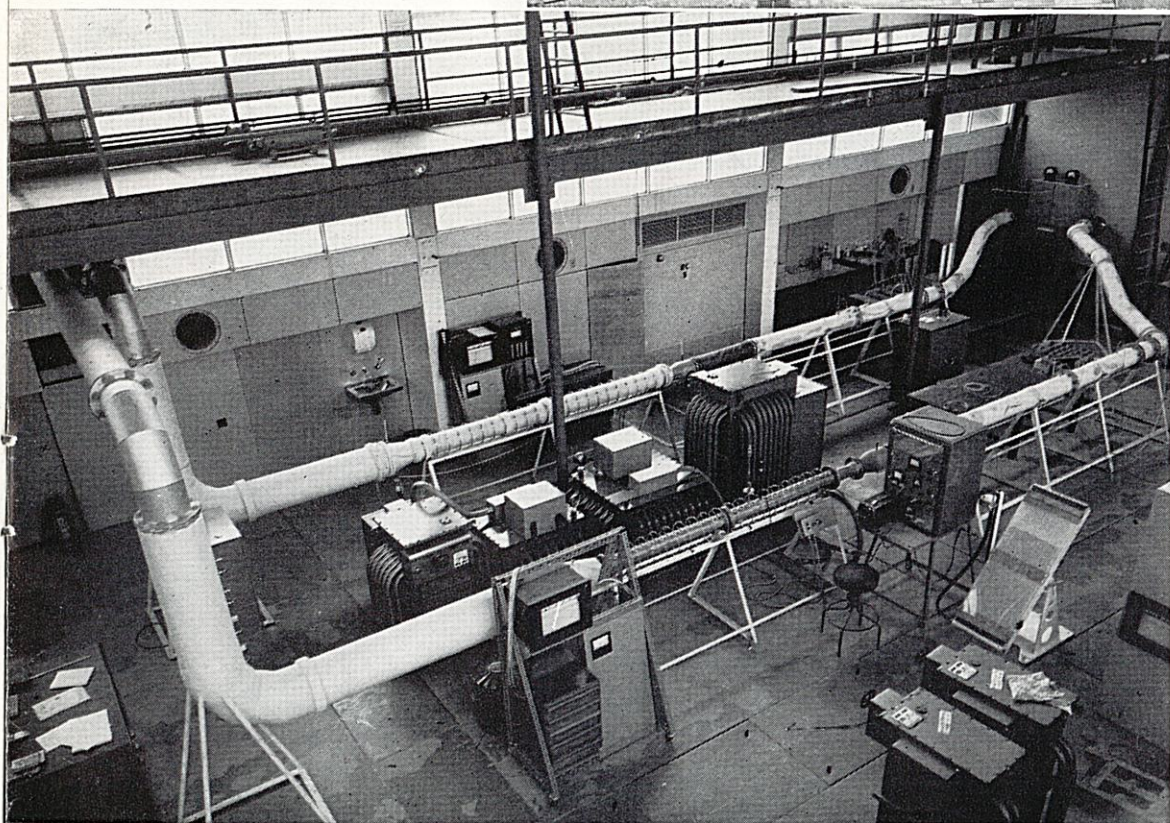
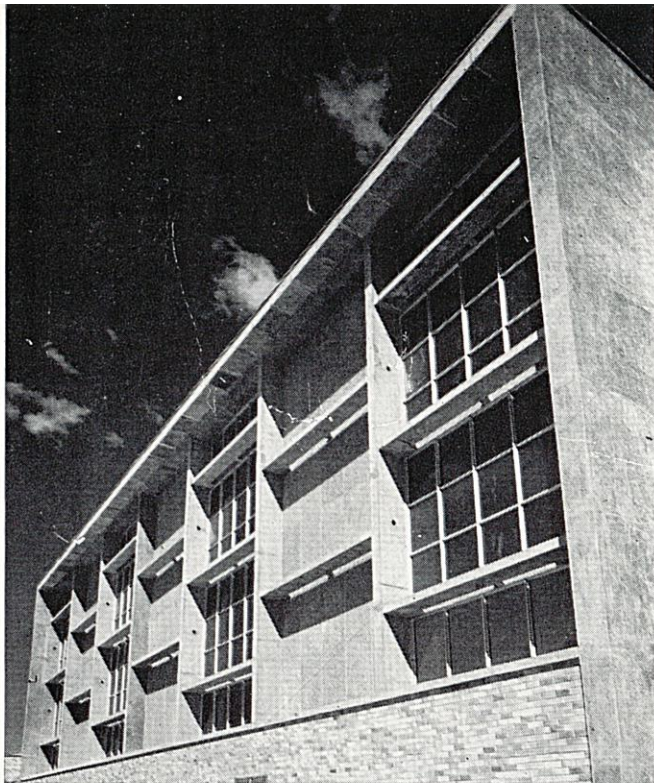
In the laboratory shown on the right, surface areas of powders are measured in a gas adsorption apparatus.



To protect the worker from contamination by some toxic or radioactive materials, many operations must be carried out in glove boxes with perspex windows. This glove box contains an accurate balance used in the preparation of mixtures of beryllium oxide, uranium oxide and thorium oxide.

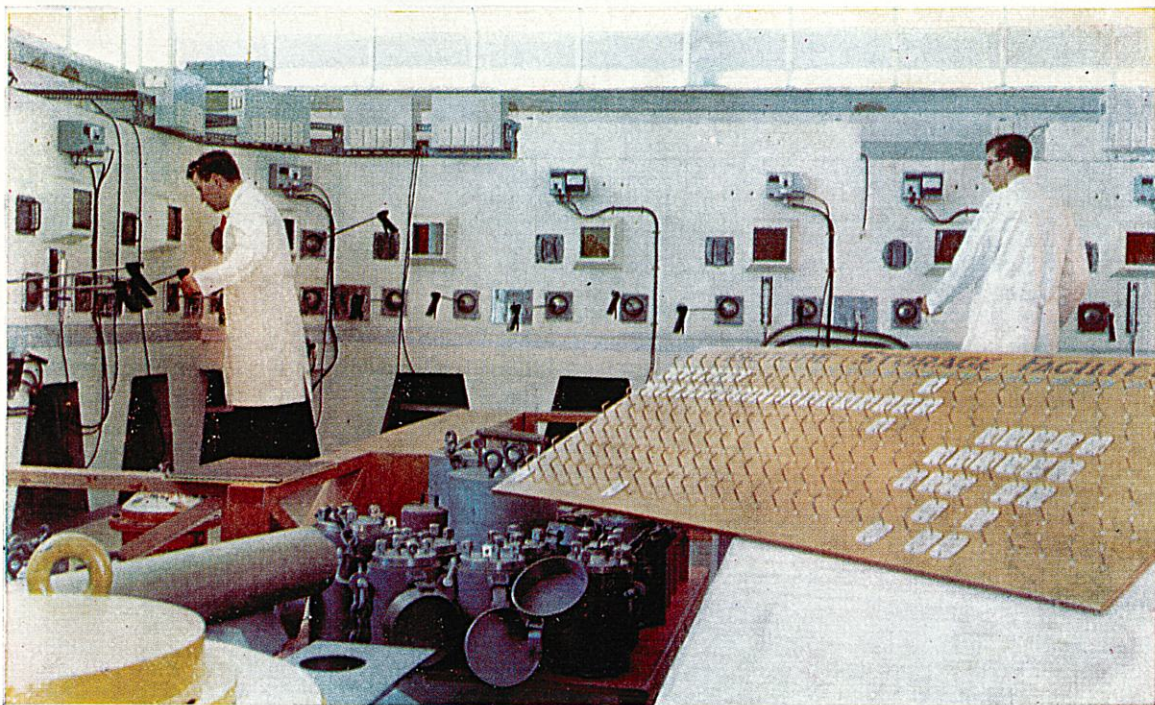
The Chemistry/Chemical Engineering Building is the only major radiochemical facility in Australia. A wide variety of different research programmes is carried out in this building, including studies of fuel re-processing, chemical studies of beryllium and beryllia, compatibility studies, etc. The building also houses the site analytical service which utilises a comprehensive range of modern physicochemical techniques.

Right — The Chemical Engineering Bay.

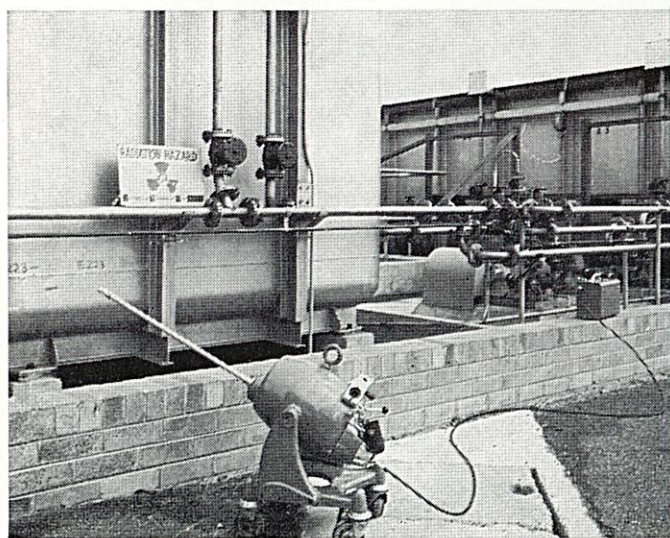


Above — Heat transfer and fluid flow characteristics of various fuel element assemblies are measured in this heat transfer rig to find the most efficient surface contour and arrangement of the fuel elements.

ISOTOPES

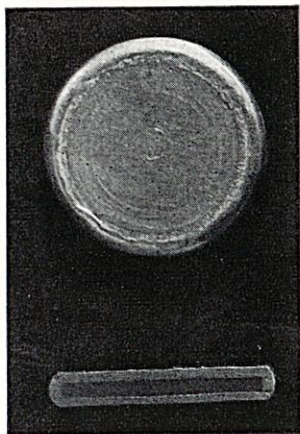


A range of radioisotopes is now being produced at Lucas Heights and special cells like those above are needed for handling and packaging.

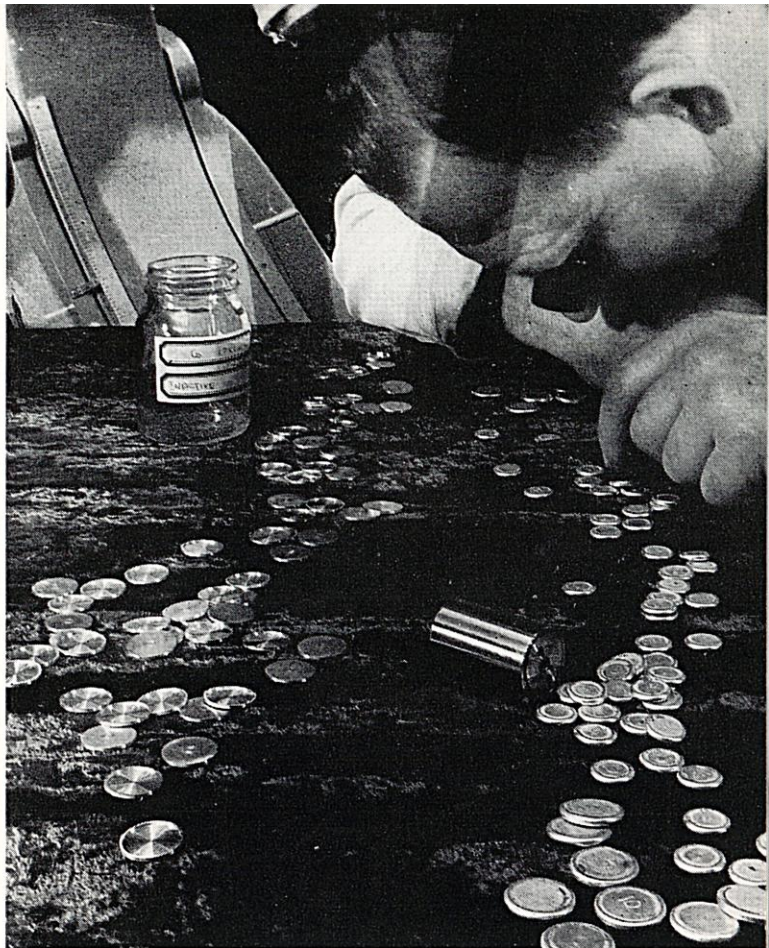


Industry is making greater use of isotopes. Illustrated is an application of radiography using isotopes to check welds in an effluent tank for flaws.

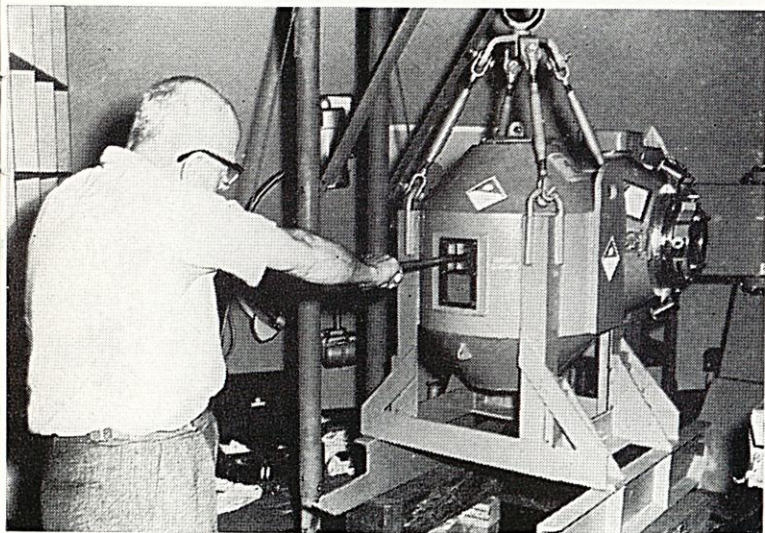
Isotope Division has an Advisory and Consulting Service and welcomes requests for assistance from industry.



A cross section of a canned cobalt disc.



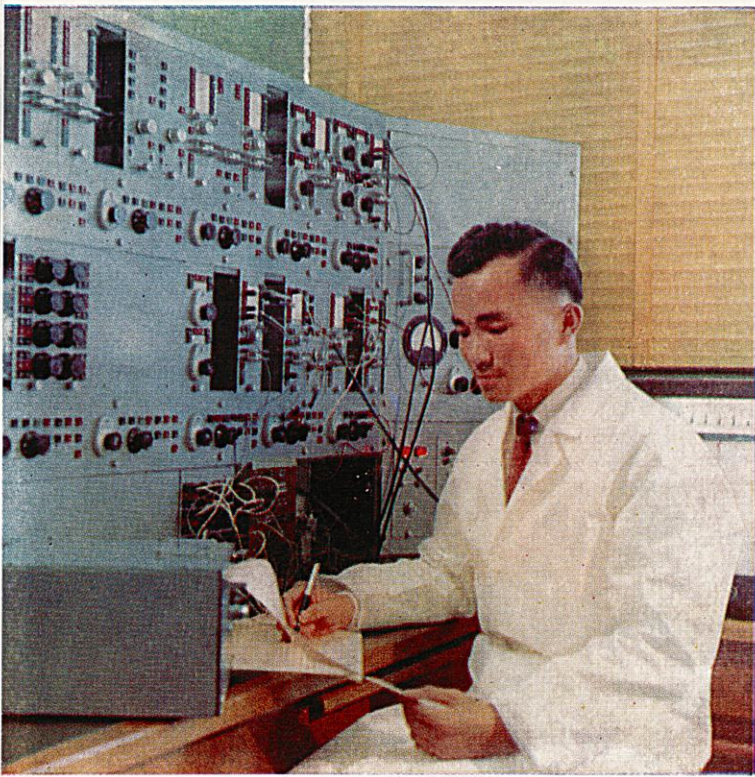
COBALT 60



Cobalt 60 is widely used in medical radiation therapy because of its suitable radiation, reasonably long half-life (5.25 years). It can be readily produced in a high flux reactor.

Several hundred discs were placed in HIFAR during the first year of operation at full power—1960—new canning techniques were devised to protect the discs from corrosion in the heavy water—and careful research on the best positions for irradiation during many months were made.

In October, 1961, the first Australian-produced cobalt 60 teletherapy source (2633 curies) was installed at St. Vincent's Hospital, Sydney. Left: Changing the cobalt 60 source at the hospital.



INSTRUMENTATION

An International Atomic Energy Agency fellow from Taiwan operating a small analogue computer set up to solve problems associated with the kinetic behaviour of the AAEC nuclear reactor HIFAR. The equipment was designed and constructed in the General Nucleonics Division and is typical of instruments developed at Lucas Heights.

MINING

The Commission is responsible for the operation of the Commonwealth-owned Rum Jungle uranium undertaking. A sample of ore from one of the mines in this area is illustrated at right.

In the past, the Commission has organised extensive uranium search surveys, but these activities have been curtailed in view of the present world-wide over-supply of uranium. Exploration and development is now confined to existing producers.



