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PRESS RELEASE

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

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CYCLOTRON FOR ISOTOPE PRODUCTION

The U.K.A.E.A. are to install a cyclotron at the Radiochemical Centre at Amersham to meet the growing demand for certain radioactive isotopes that are important aids to scientific and medical research.

Most of the 120 radioisotopes supplied by the Centre are derived from Nuclear reactors, but about thirty of them can only be made with a cyclotron or similar particle accelerator. At present the supply is limited because it depends on part-time use of cyclotrons that are intended for research rather than production.

These isotopes have qualities that make them specially valuable in medicine and in research in the life sciences, and the Authority have been advised by the Medical Research Council and other institutions that a good supply of them is in the country's general scientific interest. Accordingly the new machine is to be designed and operated exclusively for isotope production and will ensure an ample and reliable supply. It should commence operation in 1965.

The total cost of the project will be £500,000. The machine, which is being manufactured by Philips Gloellampenfabrieken of Eindhoven, Holland, is of the azimuthally variable field type, and will accelerate protons to 25 MeV and deuterons to 15 MeV and alpha particles to 30 MeV. The chemical processing of the isotopes will be done in the existing laboratories at Amersham and the products marketed by the Centre at home and abroad in the usual way.

TECHNICAL NOTE

Scientific and medical applications of cyclotron produced radioisotopes

A radioactive isotope of an element differs from the naturally occurring stable isotope (or isotopes) of that element in having a different number of neutrons in its nucleus. If this number of neutrons is greater than in the stable isotope we speak of the radioactive isotope as being neutron rich: if less, neutron deficient. In a nuclear reactor, stable isotopes can be irradiated with neutrons to give neutron rich isotopes: these account for rather more than 50% of the known radioisotopes. The remainder, the neutron deficient isotopes, cannot in general be produced in the nuclear reactor, but must be produced by bombardments with charged particles, e.g. protons, deuterons, and alpha particles, in a cyclotron.

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Reactor produced radicisopes have been readily available for over 15 years. They are widely used in the physical sciences and industry, and in the biological sciences and medicine. Because of their relative cheapness and availability in large quantities, they will always account for the major usage of radioisotopes. But as the uses of radioisotopes has diversified, and as the requirements of experimentalists have become more critical, gaps in the range of radioisotopes available in this way have become apparent. For this reason there has grown over the last 5 years or so a significant demand for cyclotron produced radioisotopes.

The usefulness of a radioisotope is determined by its half-life, the properties of its radiation, and its specific activity (that is, the amount of radioactivity associated with a given weight of the element). The optimum combination of these properties depends very much on the particular application for which the radioisotope is required. Often a cyclotron produced isotope can be found which has properties more suitable for a particular purpose than can be obtained with the reactor produced radioisotopes of the same element. For example there are some cases in which, from considerations of half-life alone the most suitable, or indeed the only practicable, radioisotope for a particular application is a cyclotron produced one. Examples of such radioisotopes are beryllium-7 and vanadium-48, which are the only radioisotopes of these elements with half lives long enough for tracer experiments on beryllium and vanadium, and sodium-22 which, with its long half-life (2.6 years), is suitable for long term experiments that are impracticable with the short-lived reactor produced sodium-24 (15 hours).

In addition to the differences in half lives between different radioisotopes of an element, there are certain systematic differences between the types of radiation emitted by cyclotron produced radioisotopes as a group and those emitted by reactor produced radioisotopes. Neutron rich (reactor produced) radioisotopes decay by emission of beta particles (negative electrons) whereas neutron deficient (cyclotron produced) radioisotopes decay by emission of positrons (positive electrons) or by the capture of orbital electrons by the nucleus. Thus many cyclotron produced radioisotopes are important as sources of positrons, or of the X-rays resulting from the electron capture process. The positron emitting isotopes are of particular importance in the medical field, where considerable emphasis has been placed on body scanning techniques with radioisotopes. The functioning of parts of the body, e.g. liver, kidneys and bone, and the existence of tumours, especially in the brain, may be observed by administering to the patient a suitable radioisotope preparation and studying its movement and distribution in the body by external detection equipment. Positron emitting isotopes permit more precise location of the sites of concentration of radioactivity, and thus have special advantages for scanning techniques. The positron emitter arsenic-74, for example, has been extensively used for brain tumour location.

A further significant advantage of cyclotron produced isotopes in many fields of research is that they can often be produced at much higher specific activities than the reactor produced radioisotopes of the same element. This is because in the majority of cases neutron bombardment in a reactor gives a radioisotope of the same element as the target material, and chemical separation is therefore not possible. Cyclotron reactions, however, in which charged particles are the bombarding agents, invariably produce radioisotopes of an element different from that of the target material. The radioisotope can then be separated chemically at a very high specific activity. There are a few cases where the same radioisotope can be produced either in a reactor or a cyclotron and for these the superiority of the cyclotron product

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as regards specific activity is usually quite marked. An example is zinc-65, which is required as a tracer in biological experiments. Zinc-65 may be produced by the irradiation of metallic zinc in a nuclear reactor, but the product consists of a tiny amount of radioactive zinc-65 and a very large amount of unchanged stable zinc. The product is not very suitable for biological experiments since the amount of zinc in a living organism is very small. In the cyclotron, zinc-65 may be prepared by bombarding a copper target with deuterons, and the zinc-65 may be chemically separated practically free from stable zinc.

In many medical applications a radioisotope of short half-life is desirable so that, after the measurement has been carried out, the total radiation dose to the patient will be as low as possible. Many cyclotron produced isotopes are superior in this respect to reactor produced radioisotopes of the same element. Another advantage of a short half-life is that measurements may be repeated at short intervals if required. The short-lived cyclotron produced radioisotope, iron-52, has been used for serial measurements on the production of red blood cells.

In the physical sciences the cyclotron produced isotope cobalt-57 is of particular importance, since it is the most suitable isotope for use in many applications of the Mössbauer effect, a tool of wide application and extreme precision in nuclear physics and solid state physics.

Over the last few years the supply of cyclotron produced radioisotopes by the Radiochemical Centre has been made possible by the generous co-operation of several cyclotron groups, notably the Nuffield cyclotron at Birmingham University, the Medical Research Council cyclotron at Hammersmith Hospital (each of these cyclotrons being used for bombardments with deuterons and alpha particles) and the 86 inch cyclotron at the Oak Ridge National Laboratory in the United States (employed for bombardments with protons). Recent developments in cyclotron engineering have made possible the construction of a machine giving useful beams of all three of the important bombarding particles, protons, deuterons, and alpha particles, and such a machine is to be installed at Amersham. It will make possible the further development of the existing service, in particular the production of short-lived radioisotopes and the development of special sources and labelled compounds based upon them.