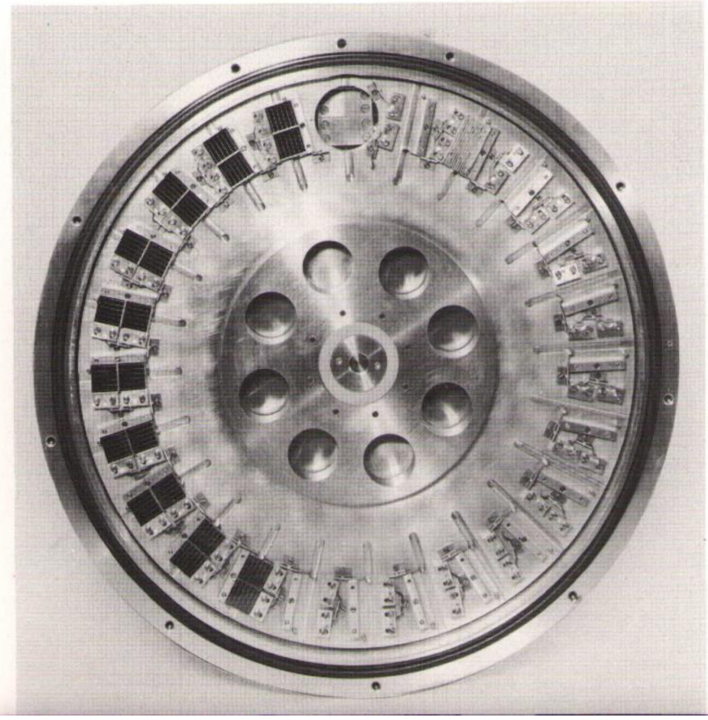
Industrial applications

There are five major fields of use:-

1. Accelerated radiation-damage testing of materials.
2. Elemental analysis at very low concentrations or over very small areas.
3. Detailed study of the fine structure of specimens.
4. Industrial 'tracer' studies.
5. Radiation processing technology.

Solar Cells on multiple rotating specimen holder, for testing by ion-beam irradiation to simulate damage by van Allen belt radiation.

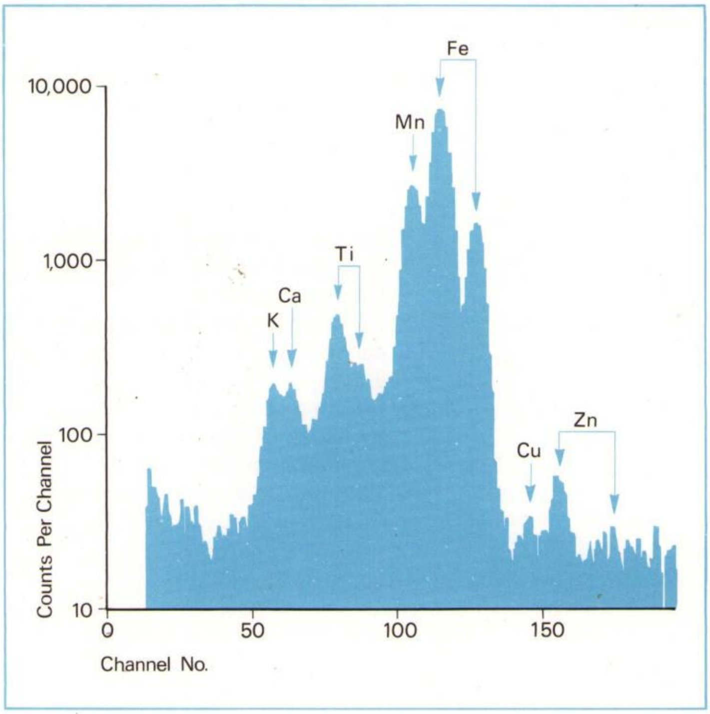


Radiation-damage testing

Materials that are subjected in use to high-energy radiations — cosmic rays, X-rays, nuclear radiations, etc. — may in course of time become so changed that their useful lives are substantially reduced. Rapid assessment of the radiation resistance of these materials can therefore be important. Charged-particle beams can be used to produce similar radiation damage effects to the proposed environmental radiation, but much more rapidly. Studies of both the micro-structure and the gross properties of accelerator-irradiated specimens can therefore provide valuable information on long-term environmental radiation effects rapidly and at a relatively low cost. The Rutherford back-scattering technique coupled with ion channelling offers a very direct method of assessing the degree of radiation damage in single-crystal specimens. Tests can be carried out on materials, components and assemblies for use in space and in high-altitude aircraft, or in other high radiation fields such as irradiation plant, high energy X-ray machines and nuclear installations. Energetic electron beams can be used to simulate the electronic behaviour of devices exposed to extremely high gamma radiation.

Elemental analysis

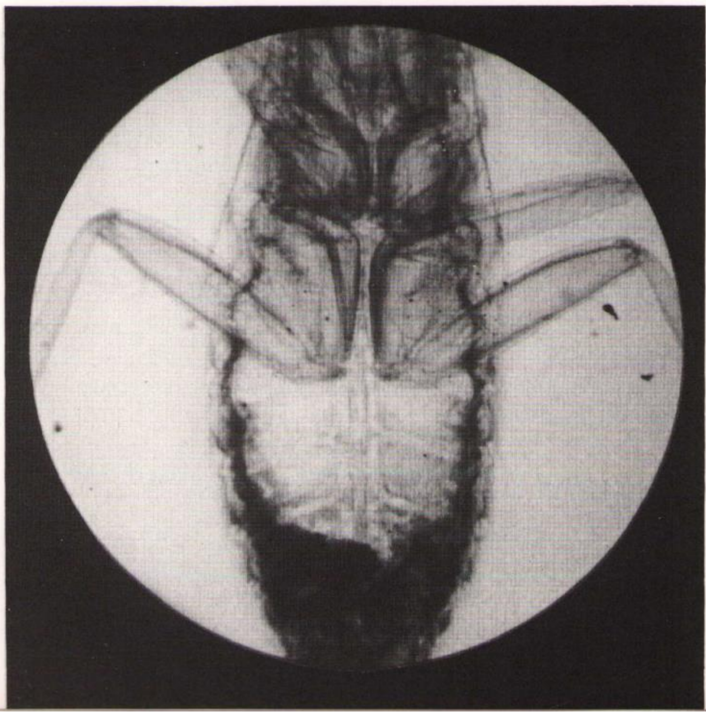
Charged-particle beams, and the secondary radiations produced with their aid, provide very useful excitation sources for stimulating the emission of characteristic X-rays, γ-rays, or scattered particles from specimens under analysis. They are often applicable where other methods of excitation are unsuitable, e.g. where the concentration in the specimen is too low, where neighbouring elements interfere, or where the element in question is of very low atomic number. Micro-probe analysis of surfaces can be carried out with proton beams having a focal spot less than 4 μm in diameter. Charged-particle beams can sometimes be used to activate elements that are not satisfactorily activated by neutrons, e.g. Silicon, Aluminium, etc. or where other elements in the specimen would interfere.



Graph showing elemental composition of material dredged from the bottom of Lake Windermere, using charged-particle activation analysis.

Fine-structure studies

The behaviour of a beam of particles on encountering a target can provide valuable information about the fine structure of the target material from the microscopic to the atomic scale (e.g. porosity, local density variations, crystal structure). Beam energy can be closely controlled so as to penetrate to a pre-determined depth only, providing information about

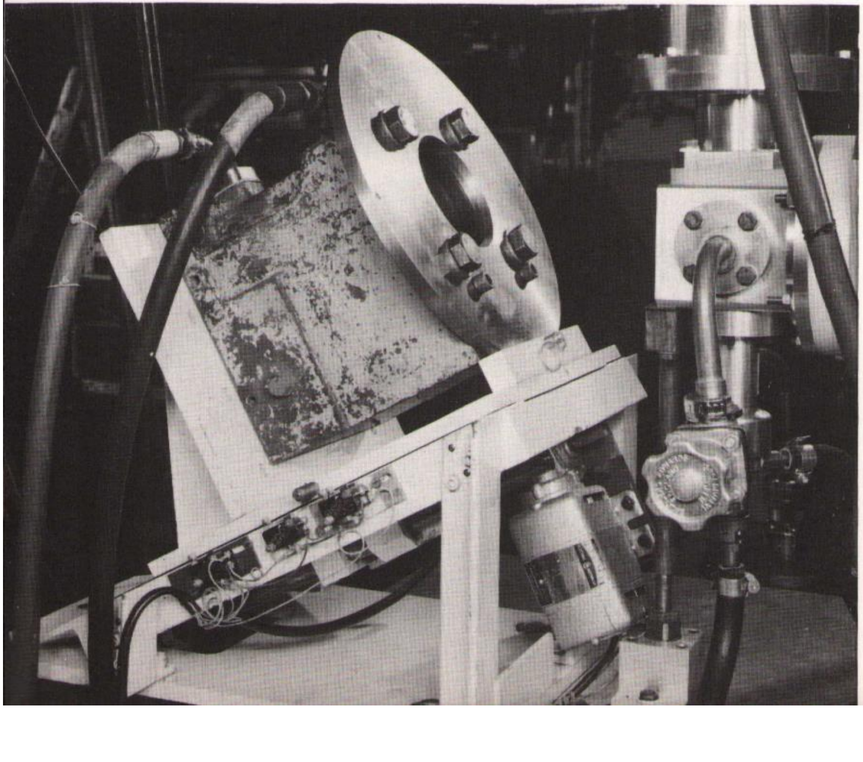


X-radiograph of the head and thorax of a beetle, magnified 3½X. The very small focal spot of the proton beam, and the close control of X-ray energy that it gives, provides much better resolution and contrast than conventional X-radiography.

surface layers or very thin films. The primary beam can be brought to a very fine focal spot so as to produce secondary X-rays suitable for radiography at high magnification or resolution. Proton beams impinging on suitable targets produce mono-energetic X-rays free from continuum radiation. These can be used to give X-radiographs which discriminate between materials of similar density and differing only slightly in atomic number.

Industrial 'tracer' studies

Accelerator beam irradiation is sometimes useful for inducing radioactivity in specimens or materials to be the subject of radioactive tracer investigations, especially if reactor irradiation does not produce suitable or sufficient activity, or if only a limited area of the specimen is to be treated. For example, in the study of lubrication and engine wear it is possible to use either a proton beam to activate appropriate elements in the metal of the engine, or an accelerator to implant ions such as radioactive ^{85}Kr gas. This sensitive test of wear can, for example, be combined with studies of the implanation of metal ions aimed at improving abrasion resistance.



The cylinder block of an internal combustion engine set up for irradiation with protons. By irradiating the liner with protons to produce ^{56}Co and the piston rings with neutrons to produce ^{55}Fe and ^{59}Fe it was possible to measure independently the detritus arising from the rings and from the liner. Both irradiations were undertaken at Harwell for Esso Research Centre, Abingdon.

Radiation processing technology

Accelerators producing beams of charged particles or secondary radiations are potentially useful as radiation sources for industrial processing. Most such applications are at present at the research or early development stage, but a few are well on their way to commercial exploitation. Harwell can offer beam facilities at all stages of process development from research to pilot-scale production.

Electron-beams of a few hundred kilovolts can be used for the very rapid curing of suitably-formulated industrial paints and lacquers, to give a fully hardened film in under a second. Other technologically interesting polymerization or co-polymerization reactions, e.g. in textile fibres and thin films and foils, can be studied and developed, as well as other radiation-induced reactions of potential importance.

Ions of suitable elements can be implanted into target materials at closely controlled depths and locations to give improved semiconductor devices, to modify the refractive index of glasses, or to bring about useful improvements in surface hardness, corrosion resistance, abrasion resistance and bonding ability of metals.

A wear measurement technique using thin layer activation is now in use.

Supporting microbiological services are available.

See also the companion brochure on Radiation Technology.

For further information, write or telephone:
Miss J. Lincoln,
AERE, Harwell, Oxfordshire,
OX11 0RA
Tel: Abingdon 4141 (STD 0235)
ext. 2506.

Harwell Design Studio 60/1974

A small ion implantation separator developed in association with Harwell and now available commercially from Messrs. Lintott Engineering Ltd. of Horsham, Sussex.