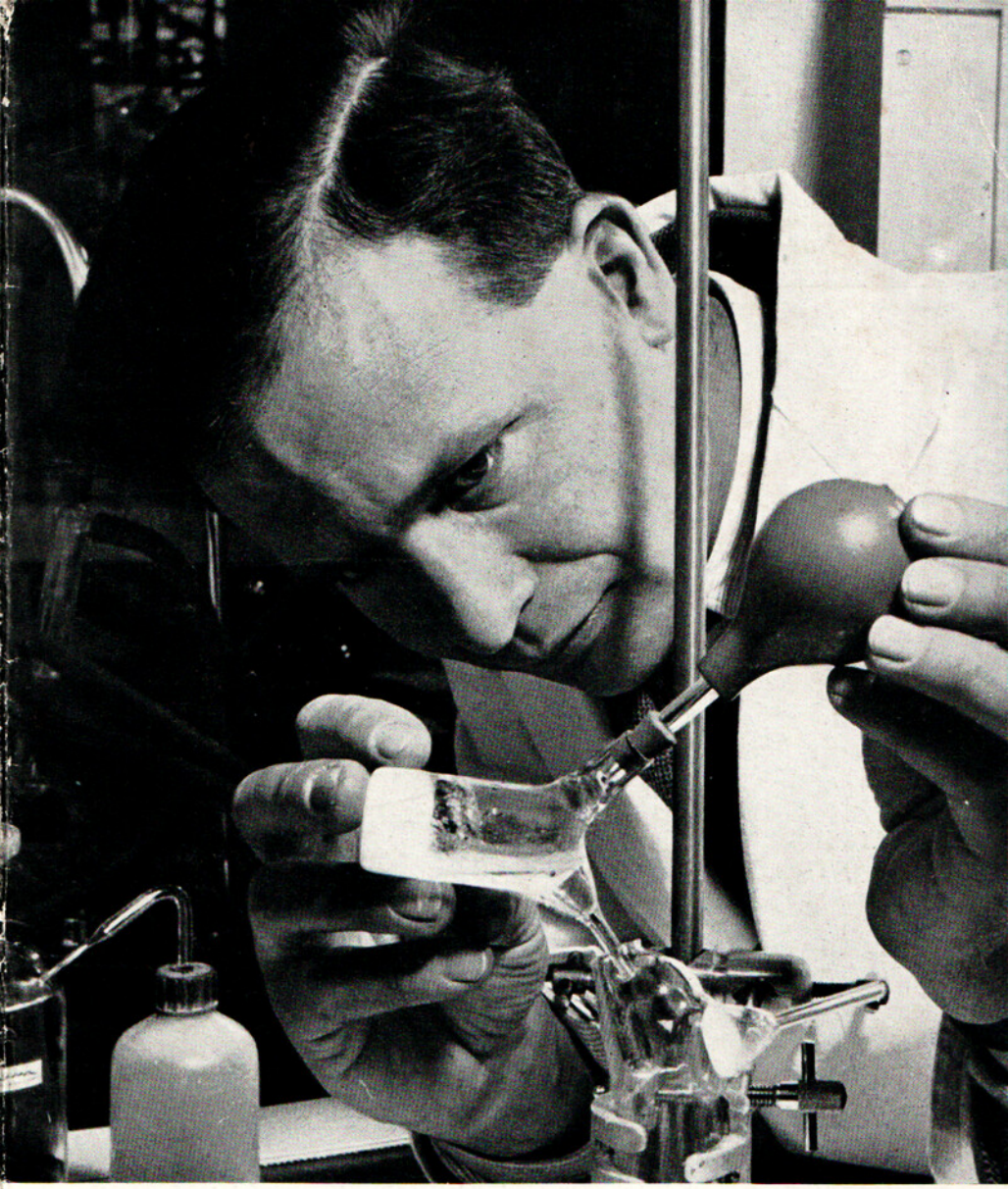


Crystallization of radioactive C-14 compounds.

Radioisotopes

Their uses in Medicine, Industry, Agriculture and Research

RADIO ISOTOPES

Every element contains atoms which are all chemically the same but which may differ from one another in weight. These different kinds of atoms are known as isotopes of the element. Some isotopes are radioactive; that is, the atoms are unstable and may change into other atoms by emitting high speed particles and sometimes electromagnetic radiation (gamma radiation).

The activity of a radioisotope decays as the number of unstable atoms becomes less. The rate of decay is unaffected by temperature, pressure and other conditions. Every radioactive isotope has a characteristic *half life*, that is, the time taken for half the unstable atoms originally present to disintegrate. The half life may be anything from a fraction of a second to millions of years, depending on the isotope.

Radiation is, in general, of three types.

ALPHA PARTICLES — High speed particles, roughly four times as heavy as a hydrogen atom, which are easily stopped by a thin shield, such as a piece of paper.

BETA PARTICLES — High speed electrons of almost negligible weight, (about 1/1837th of the weight of a hydrogen atom), stopped by a fraction of an inch of metal.

GAMMA RADIATION — A penetrating electromagnetic radiation of the same nature as X-rays. Gamma radiation cannot be stopped but it can be absorbed for the greater part by a considerable thickness of metal, brick or concrete.

Radioisotopes can be detected and measured in far smaller quantities than is possible by the most sensitive methods of chemical analysis.

USES OF RADIOISOTOPES

The sensitivity of detection and measurement of radioisotopes is many orders beyond that of chemical methods. It is possible to detect about 10^{-16} of a gram of phosphorus-32, a typical isotope of 14 days half-life.

The uses of radioisotopes can, in general, be divided into five categories which can be further sub-divided. These categories are:—

A Caesium Teletherapy Unit used in the treatment of cancers.

MEDICAL USES

Because radioisotopes emit penetrating radiations they can be used widely in medicine for diagnosis, therapy and research. The atoms of a radioactive isotope, being chemically indistinguishable from other atoms of the same element travelling round the body, are assimilated in the same way as normal materials, but their deposition in the various organs of the body is associated with a concentration of radioactivity at that point. They are of value in medicine, therefore, in the following ways :-

DIAGNOSIS

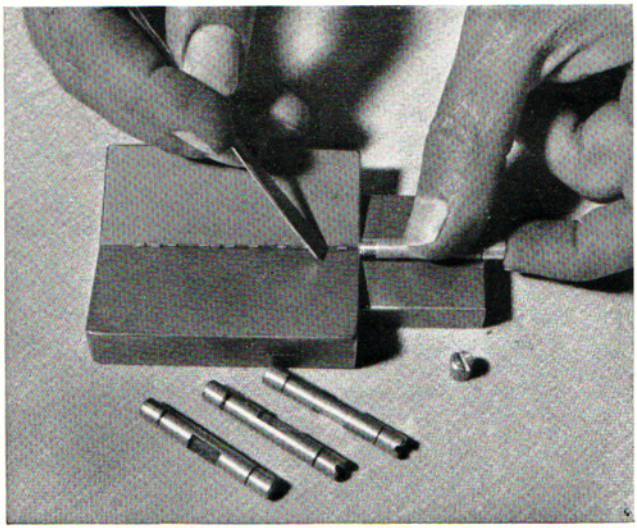
By administering radioactive isotopes, the rate of uptake of an element in an organ will be shown by the rate of rise of radioactivity. It is, therefore, possible, by applying a suitable counter to an organ which is associated with selective uptake, to show its state of health. For example, by administering radioactive iodine -131 or -132 and applying a counter to the thyroid gland, it is possible to diagnose quite a number of illnesses to which it is prone.

THERAPY

Rapidly dividing tissues are particularly sensitive to damage by radiation; for this reason growths can often be controlled and eliminated by treatment with X-rays or gamma rays from radium. Radioisotopes can be used for this purpose (a) by applying the radiation from an external closed isotope source, or (b) by implanting a source of radiation into the body. Artificial radioisotopes are cheaper than radium and can be selected with the energy of radiations best suited to any particular application, and can even be chosen with a half-life such that removal of implants after treatment is unnecessary.

STUDIES OF NUTRITION AND UPTAKE

The importance of different elements in food in the nourishment and development of various organs can be studied, by feeding a patient or an animal on food containing a radioactive isotope. It is also possible to measure with radioisotopes (a) the rate of elimination of certain substances from the body (b) the total blood volume and (c) the rate of retention from respiration and many other physiological factors determination of which has been difficult in the past.

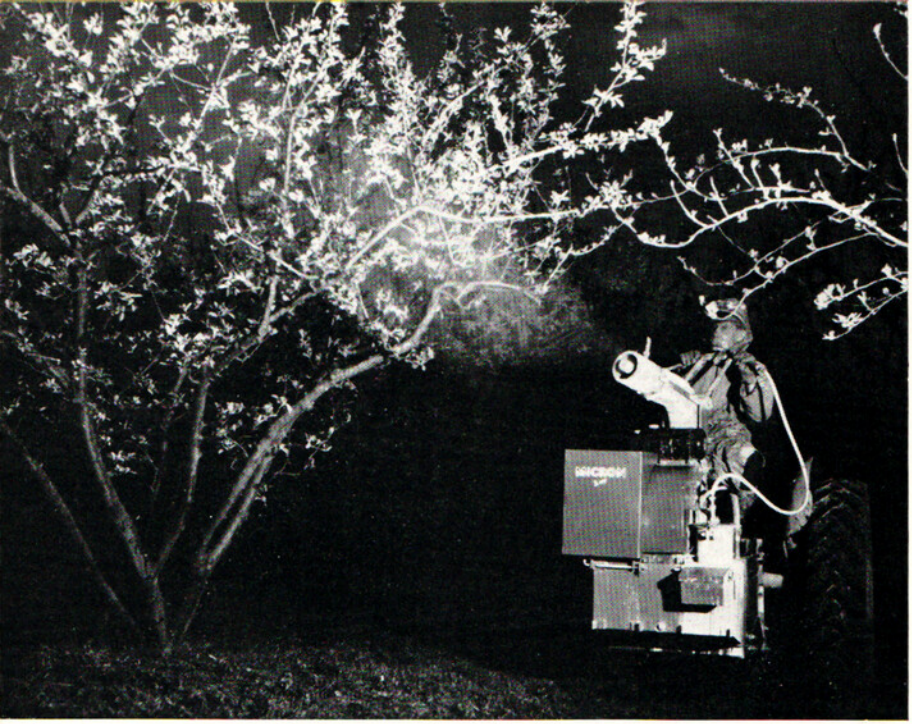


Loading gold seeds into a magazine for use in the treatment of cancer.

AGRICULTURAL APPLICATIONS

PLANT BREEDING

Radiation can cause an increase in the natural genetic mutation rate in plants and animals. High doses of radiation can increase the natural mutation rate many times and this can put many new characteristics into the hands of crop

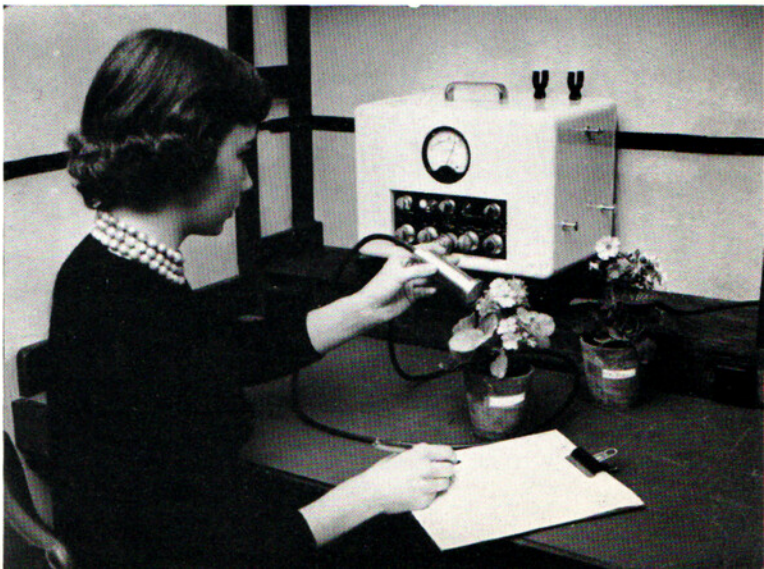


Spraying systemic insecticides containing radioisotopes. The use of radioactive compounds in this way can show where the insecticide is deposited and how quickly it is absorbed.

breeders for breeding improved stocks. Wheats with a shorter straw length and strains of oats with special resistance to disease have been developed.

STUDIES IN GROWTH AND NUTRITION

By using fertilizers containing radioactive isotopes it is possible to observe in experiments the uptake mechanism of plants and their rate of growth and to study the importance of certain elements in the soil in securing healthy and reproducible crops. Thus new and more effective fertilizers can be developed and marketed; similar techniques can be used for the development of insecticides and selective weed-killers.



Checking radiation emitted from a plant fed with a solution containing radioisotopes.

INDUSTRIAL APPLICATIONS

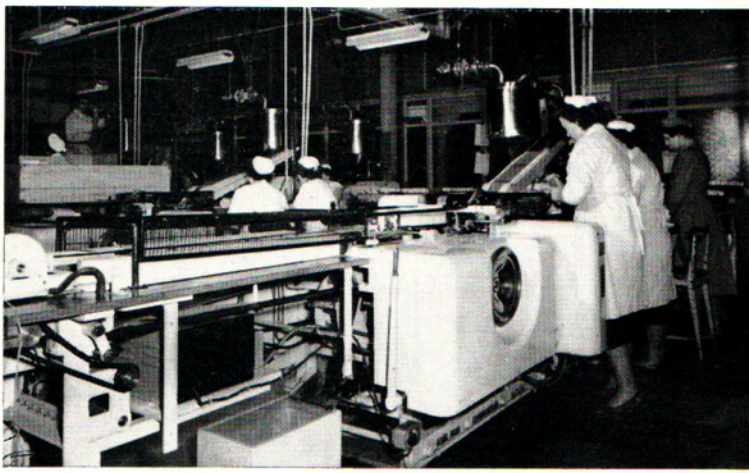
Radioisotopes are of considerable value in industry. Some of the applications for which they can be used are given under the following headings.—

THICKNESS MEASUREMENTS

The thickness of a material can be found from the attenuation of radiation passing through it. The thickness measurement does not require any physical contact with the material being produced and so can be carried out continuously on moving material. By employing a reflection technique, it is possible to measure the thickness of a coating of tin, zinc, paint or other material on the surface of a sheet, or to detect corrosion pitting in a closed metal pipe or tank from the outside.

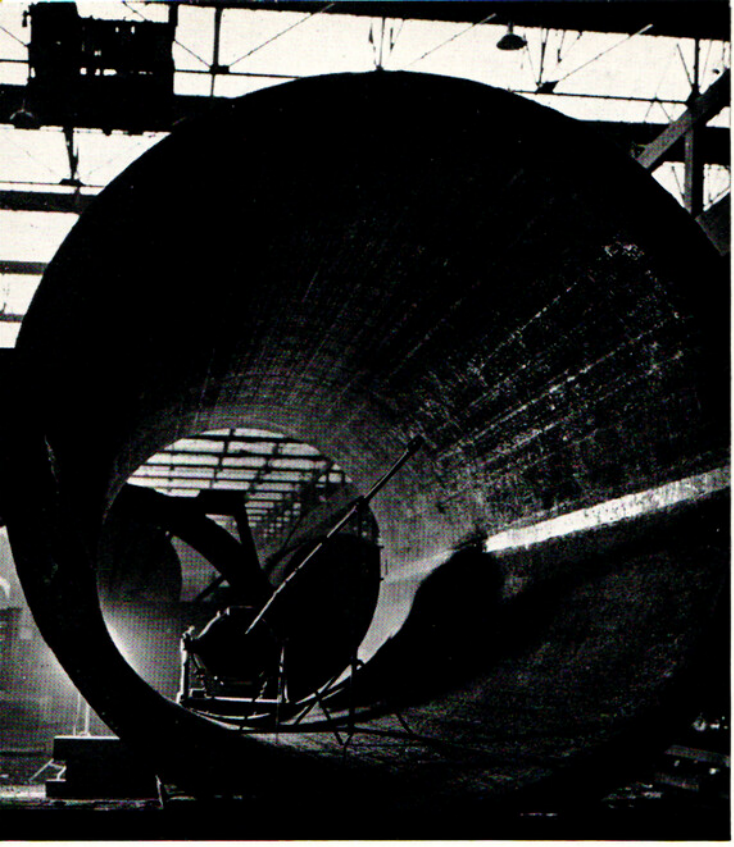
STATIC ELIMINATION

In many processes involving the weaving of synthetic fibres, the fibres become electrified during their passage through the loom.



Checking the filling of toothpaste tubes by means of a radioisotope device.

At night, when the loom is not working, dust is attracted by the static charge on the textiles, producing dirty marks. A small source of beta radiation, exposed when the loom is shut down, removes the electric charge by ionising the surrounding air, giving cleaner products. A similar technique can be used with slowly moving materials. The method is applicable to the handling of very thin sheets of synthetic material used for covering foodstuffs, etc., and celluloid and other plastic materials used in the manufacture of laminated glass. Such materials acquire a static charge during polishing and it is very difficult to prevent the adhesion of dirt.



Using a radioisotope (contained in the axial tube) as a source of gamma rays to radiograph a joint. Photo— G. A. Harvey Ltd., Greenwich.

WEAR STUDIES

By making rubbing surfaces radioactive in an atomic pile the rate of wear of the surfaces can be measured by the rate of growth of radio-activity in the lubricant. This makes it possible to determine the rate of wear of engine parts accurately, avoiding the misalignments which often follow dismantling. Further, the sensitivity of measurement is such that accurate results can be obtained in less than one-tenth of the running time required for orthodox methods.

This in turn permits measurement of the same component at different stages of its working life and under different conditions of wear and lubrication. The technique is also applied to measure the wear of machine tools and by studying the distribution of wear debris in the swarf, much can be learned about the mechanism of wear.

PIPE LINE SURVEILLANCE

Leakage from oil and water pipe lines is readily detected by filling the pipe with a solution of a radioactive isotope under pressure. The pipe is then flushed and the concentration of radioisotope that has leaked out is measured in the surrounding earth, either by a geiger counter in a probe forced into the ground or by passing suitable counters with a recording mechanism through the pipe. Frequent surveillance of pipe

lines is thus possible, preventing the situation which has often occurred, when large areas of pasture land have been polluted from seepage of oil before leakage was discovered.

LIQUID LEVEL INDICATION

The liquid level in closed containers can be measured by using the tank contents to attenuate a beam of gamma rays. Fixed or continuous level indication is provided and the output of the gauge can be fed back to control the level. The arrangement is particularly useful for highly corrosive fluids and those under extremes of temperature or pressure.

RADIOGRAPHY

By using gamma radiation to expose a photosensitive material, radiographs of welds and internal mechanisms may be obtained, with a radioisotope acting as a substitute for an X-ray plant. A wide range of energies is available to suit different thicknesses of material and the small size of the radioisotope source enables it to be placed in vessels or pipes inaccessible to X-ray equipment. Its independence of electric or water supplies makes it suitable for field or site work.

LEAKAGE OF VOLATILE LIQUIDS

When a radioactive compound is dissolved in a volatile liquid, the radioactive compound is deposited where the liquid evaporates. Thus spillage and leakage can be studied with a counter; this application has been used to study the spillage of aircraft fuel in flight and its possible connection with fires.

MIXING TECHNIQUES

Radioactive isotopes can be used to trace the effectiveness of the mixing of a few ounces of additives with tons of bulk material. Small additions of radioactive tracers can also be used to measure bulk flow in large industrial plant; this has been found valuable in studying the characteristics of recycling processes. If an isotope of short half-life is used, the product will, by the time it reaches the hands of the consumer, be free from measurable activity.

BULK IRRADIATION

The introduction of large atomic power programmes means that large quantities of fission products will be available, many of which are gamma emitters. These may be used in the following typical applications.

PRESERVATION OF FOOD

GRAIN. By irradiating grain with gamma rays, losses from insect infestation during storage may be eliminated. This may be achieved by sterilising the insects and their eggs, which requires a smaller dose of radiation than is necessary for their direct destruction.

POTATOES. The sprouting of potatoes in store may be inhibited by a light dose of gamma radiation which does not affect palatability.

MEAT. The storage life of meat may be increased by gamma irradiation through the reduction of bacteriological population. Complete sterilization is accompanied by some change of flavour. Exhaustive tests are being made in several countries to ensure that foods sterilized by irradiation are safe for human consumption on a large scale before they are released for public use.

CHEMICAL EFFECTS

Gamma radiation reduces the temperature and pressure required for many chemical reactions; it is particularly promising in polymerisation. In some instances the process results in a novel product which is unobtainable by any other means.

PHYSICAL EFFECTS

Cross-linking of organic molecules under the influence of radiation can in some cases result in improved physical properties. This is of special value in its application to synthetic plastics and acrylic resin.

STERILIZATION OF DRUGS

Gamma radiation can be used to sterilize penicillin and other antibiotics which must not be subjected to high temperatures. At present these drugs are prepared under aseptic conditions which are costly to set up and maintain. The rays can sterilize the antibiotics after they are safely packed in sealed containers. Radiation sterilization of surgical appliances, such as rubber catheters and plastic syringes, is already in limited use, with marked successes in reduction of infection.

RESEARCH

Research applications in general are so numerous that it is not possible to deal with them in full. A few examples are:—

ANALYTICAL CHEMISTRY

When a material to be analysed is activated in an atomic pile it is often possible to detect very small quantities of a wide range of elements. For example, elements such as arsenic develop characteristic radiations which may be detected and measured. The technique is so sensitive that far smaller quantities can be determined than was previously possible by the normal methods of chemical analysis. This technique, called activation analysis, also offers the advantages of high specificity and the elimination of corrections for reagent blanks. In certain favourable cases, a direct instrumental measurement on the irradiated material enables the amount of the impurity to be determined quickly and easily.

MEDICAL RESEARCH

One of the applications of radioactive tracer methods is in haematology through the use of iodinated human serum albumin. This can serve to determine the volume of the patient's blood or to investigate circulatory disorders.

In the highly complex research work on protein metabolism, labelling techniques using carbon-14 have been introduced. The labelled compounds are amino-acids produced by the micro-organism Chlorella—the green algae which grow on stagnant water. They are made by growing the algae in a medium having radioactive carbon dioxide as the source of carbon.

DETERMINATION OF AGE OF ARCHAEOLOGICAL SPECIMENS

The isotope carbon-14 present in small quantities in the air as CO_2 results from cosmic bombardment of nitrogen-14. All animal and vegetable carbon contains equilibrium amounts of carbon-14, derived directly or indirectly via plants, from the CO_2 in the air. Upon the death of the animal or plant, the carbon starts to decay with a half-life of 5,500 years. By measuring the C14 content of an archaeological specimen, it is possible to assign its age to within about 100 years.

ISOTOPES SUPPLY

To users at home and abroad, the U.K.A.E.A. offer a very wide range of radioisotopes, amply covering all the applications described in this pamphlet and many others besides. Their products include not only all the important primary isotopes, but also several hundred "labelled compounds" and a great variety of radiation sources for industrial and medical purposes. Altogether this is the world's most comprehensive supply.

For the production and distribution of all such materials which they offer for civil purposes, the Authority have a special establishment—The Radiochemical Centre. Its Head Office and principal laboratories are at Amersham in Buckinghamshire, and at Harwell it has an Isotope Production Unit which provides services based on the reactors there and at other Authority sites.

Radioisotopes

Enquiries for radioactive materials should be directed to:

THE RADIOCHEMICAL CENTRE,
AMERSHAM, BUCKINGHAMSHIRE, ENGLAND.

and for technical advice or information to:

ISOTOPE RESEARCH DIVISION (A.E.R.E.),
WANTAGE RADIATION LABORATORY,
WANTAGE, BERKSHIRE, ENGLAND.

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