for the agricultural applications of radioisotopes be established at the Atomic Energy Establishment at Inshas and that in the meantime this work be carried out at, or through, the Radioisotope Centre at Cairo.

Professor Tavčar's report also contains an outline of the instruction to be given to the assistants assigned to work on the application of radiation genetics and radiation cytology in plant breeding.

PRACTICAL APPLICATIONS OF SHORT-LIVED RADIOISOTOPES

The use of radioisotopes as tracers is well established all over the world. Up to now the great majority of isotopes used in this work have been those with comparatively long half-lives, that is the time taken for the radioactivity of these isotopes to decay to half its initial value is several days, weeks or even years. For example, the half-life of iodine-131, one of the most commonly used isotopes, is eight days.

While a long half-life is in some respects an advantage, in other important ways it is a distinct disadvantage. Thus, if a radioisotope is used for investigating or checking a process in industry or agriculture, it is obviously undesirable that any residual radioactivity be left in the product, which may have to be handled, or eaten, by the consumer. This means that sufficient time must be allowed for the radioisotopes in the article to lose their activity by natural decay, and the shorter the half-life the more quickly will this stage be reached. Again, when radioisotopes are used in medicine for diagnostic tests, it is desirable to reduce to a minimum the radiation dose delivered to the patient during the test. It may also be required to repeat the test at intervals without having to worry about the activity remaining in the body from the previous test. On both accounts, a short-lived radioisotope is preferable to a long-lived one, although naturally other factors besides half-life have to be considered in choosing an isotope for a particular test.

A short-lived radioisotope is usually defined as one whose half-life is reckoned in seconds, minutes or hours. By their very nature, these isotopes must be used at or near the site of production, unless it is possible to produce and ship many times the activity actually required by the user. In the past, this limitation has restricted the use of these isotopes to institutes located reasonably close to a major producer; inevitably, these have been in advanced countries.

Isotopes from Small Research Reactors

A new factor has now entered the situation. Numerous small research reactors have been built and are now coming into operation in various parts of the world, many of them in developing countries. These reactors can serve several purposes, of which the production of isotopes is one of the most important. Furthermore, it has been shown that it is more economic to produce short-lived than long-lived radioisotopes in such small reactors.

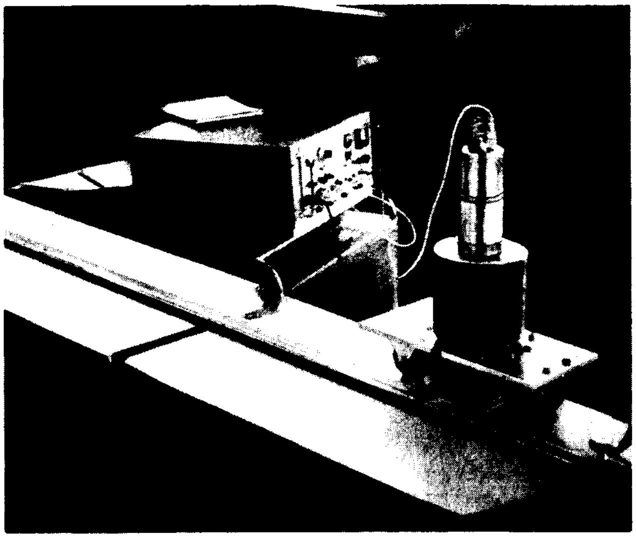
In order that maximum advantage can be gained from the isotope production facilities provided by these research reactors, it is essential, first of all, to exchange and disseminate information on the production and separation of short-lived radioisotopes and on the varied uses to which they can be put. With this objective in view, the International Atomic Energy Agency held a seminar in Vienna last November on the practical applications of short-lived radioisotopes produced in small research reactors. Some 170 scientists from 29 countries attended the seminar.

The seminar opened with two review papers, presented by L. G. Stang Jr. and P. C. Aebersold (both from the USA), which covered the whole field of production and preparation. These were followed by about a dozen reports from institutes in a number of countries, dealing with the different techniques of radioisotope production.

A large part of the seminar's discussions was devoted to the use of short-lived radioisotopes as tracers, which, in fact, is their main application at present.

Industrial Uses

L. G. Erwall (Sweden) dealt extensively with their use in industry, with special reference to the industry in his own country. "When choosing a ra-



Apparatus for investigating convection currents within large steel ingots as they solidify. A small amount of radioactive gold-198 is introduced at various times after pouring and subsequent mixing is observed by external counting. (From paper by A. Kohn, Institut de Recherches de la Sidérurgie, France)

dioactive tracer for a certain application", he said, "the general rule is that the tracer should be as short-lived as possible; one of the reasons for this is, of course, the necessity of avoiding long-lasting contamination of products, which could not only create a hazard from the radiation point of view, but also be disadvantageous if the produced material is to be used in, e.g., cassettes for photographic film, or housings or shields for nuclear radiation detectors." Speaking of the use of tracers for the study and control of the transport of solids, Mr. Erwall explained that "the two major advantages of radioactive tracers as compared with other possible tracers are: the extremely small amounts of matter necessary and the penetrability of the gamma radiation. The first of these advantages makes it possible to perform an investigation by adding a tracer in so small amounts that no concentration will occur which could interfere with the normal process. The second makes it possible to carry out the measurement of activity, i.e. the concentration of the tracer, completely from outside, without introducing into the process any measuring device which could disturb the flow of material."

As an example, Mr. Erwall mentioned rotary kilns in the cement industry where a small amount of labelled material was introduced at the inlet and the time of arrival of the tracer at various points was determined by detectors mounted outside the kiln. In one case, the raw material contained a certain percentage of potassium and the main aim of the investigation was to study its behaviour. For this reason some kilograms of raw material were labelled by the addition of a water solution of potassium-42 salt. Similarly, tagged pieces had been introduced in blast furnaces and in cellulose digesters and the transport rate of these pieces had been measured by registering the radioactivity at the inlets and outlets.

As an example of the use of tracers with fluids, Mr. Erwall described how the flow and dilution of waste water from cellulose factories had been followed with the help of radioactive ammonium bromide and how other tracers had served to detect and locate leaks in water pipes and the seepage of water under a dam structure.

A Korean scientist, Chong Kuk Kim, told the seminar how the short-lived sodium-24, produced in Korea's recently installed TRIGA MARK II reactor, had served to locate a leak in an irrigation reservoir. J. Guizerix (France) and E. Gaspar (Romania) also dealt with leak detection.

Applications in Medicine and Agriculture

Among the papers on the application of short-lived radioisotopes in medicine, two dealt with the use of yttrium-90 as a radiation source for the treatment of cancer. According to M. H. Duggan (UK), the implantation of yttrium-90 sources in the pituitary, which has been used extensively in the past for the treatment of certain types of breast cancer, has recently shown promise in arresting blindness resulting from diabetes.

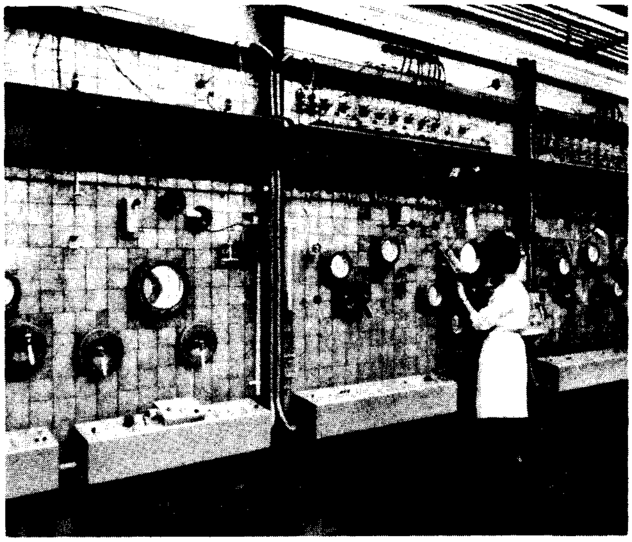
Experimental results which might have a bearing on agriculture were contained in a paper read by J. C. Arthur (USA) who had used the radioactive isotope copper-64 to investigate the reaction mechanism of enzymes considered responsible for the browning and discolouration of fruit and vegetables during food processing.

Other Uses

E. Somer (Denmark) described studies carried out with bromine-82 to determine the flow and distribution of waste water as a pre-condition for protecting recreation and fishing areas along the Danish coast against ever-increasing pollution.

In Australia, where attempts are being made to increase rainfall in certain areas by "seeding" clouds with silver iodide particles dropped from aircraft, radioactive copper-64 was used as a tracer to study the movement and dispersion of the seeding substance. J. S. Watt, who gave an account of these experiments, said that it was of particular interest to study how much of the seeding substance reaches the sub-freezing temperature levels where it may act as an ice nucleating agent leading to the formation of large ice crystals and subsequently rain. Mr. Watt stated that the solution of this problem could materially affect the seeding procedure at present being employed.

Another example of the use of short-lived radioisotopes was described by C. C. Thomas (USA). This was the measurement of the amounts of carbon paper



Installation for chemical processing of short-lived radioisotopes by remote control. The three working "cells" shown are fully shielded and are linked by a conveyor. (From paper by M. Douis and M. Valade, Centre d'Etudes Nucléaires de Saclay, France)

ink transferred in data processing machines, which, if too high, might impair their functioning.

Activation Analysis

Applications of radioisotopes very different from the tracer experiments are those based on "activation", serving mainly analytical purposes and for which very short-lived radioisotopes with half-lives of fractions of minutes can be employed. Activation analysis is a method of establishing quantitatively or qualitatively the presence of very small amounts of certain elements by submitting them to radiation from a cyclotron or to irradiation within a reactor. This irradiation leads to the formation of radioisotopes. Since every radioisotope emits in turn a characteristic kind of radiation, very small amounts of the elements in question can thus be detected, identified and measured. described "loops" which enable solutions to be pumped into and out of a reactor for activation analysis. Examples were cited of how this analytical method can serve to determine impurities in metals, for the detection and measurement of strontium in bone, and even for crime detection. V. P. Guinn (USA), who gave various examples of the use of activation analysis, said that commercial automobile greases contain impurities which are characteristic of their origin and traces of such greases, identified by activation analysis, could be used to detect hit-and-run drivers.

Production Methods

Not all the short-lived radioisotopes need, however, be produced in local reactors. In certain cases, as P. C. Aebersold (USA) pointed out, it might be more convenient to produce isotopes with half-lives longer than 12 hours in large reactors at high specific activity and allow them to decay during transit, provided that the shielding requirements were not excessive.

Considerable attention was given during the discussions to the problems of placing samples for irradiation within the reactor and of retrieving and processing them after irradiation. The modern trend is towards pneumatic transfer systems, the sample container, or "rabbit" as it is called, being transferred by compressed air or a vacuum system. C. Taylor (UK), however, pointed out that it was also possible to have efficient sample transfer systems operating on a belt principle.

Another method of obtaining short-lived radioisotopes, mentioned by L. G. Stang (USA), consists in the so-called parent-daughter milking system. Under this system, the product obtained from the reactor is not the short-lived radioisotope which the user requires but a long-lived "parent" isotope which subsequently decays and gives rise to a short-lived "daughter" product. The user receives a container holding both the "parent" and the "daughter" in a state of equilibrium which restores itself after the extraction of the "daughter" product.