ISOTOPES IN RESEARCH AND INDUSTRY

A comprehensive review of the present state of the use of radioisotopes in the physical sciences and industry was made at a major international conference in Copenhagen from 6 to 16 September 1960. The conference, organized by the International Atomic Energy Agency in co-operation with UNESCO, was attended by some 500 scientists from 40 countries and 11 international organizations.

The papers presented and discussions held at the conference showed that radioisotope applications are not only growing in variety but also rapidly emerging from the stage of officially sponsored research and experiment to that of standard industrial practice. The resulting change is of more than purely technical interest: in some of the advanced countries it has already benefited industry to the extent of millions of dollars. Recognition of this change was reflected not only in the results reported at the conference but also in its composition. Unlike at previous meetings of this kind, many of the delegates came from technical and industrial groups and a large number of the 150 papers related to or had some possible bearing on industrial application.

Referring to the wide participation in the conference by scientists from many countries, the Prime Minister of Denmark, Mr. Viggo Kampmann, in an address to the opening session, said: "The number of participants indicates that this particular branch of nuclear science is considered to be perhaps the one which is able to grant to humanity the greatest immediate practical results of atomic energy." The Agency's Director General, Mr. Sterling Cole, recalled that it had been said that radioisotopes might, at least for the time being, be of greater importance than even the generation of nuclear power. This, he said, was particularly true of the less-developed areas of the world.

Growth of Isotope Research

The opening session was also addressed by the world-renowned scientist, Professor Niels Bohr, in his capacity as Chairman of the Danish Atomic Energy Commission. He recalled how nuclear research, undertaken with the sole purpose of developing knowledge and understanding, had had "such large consequences in offering unsuspected possibilities for practical applications for the benefit of human society." Referring to the early days of radioisotope research, he pointed out that the investigations at that time were limited by the restricted number of radioisotopes available. "However, with the progress of experimental physics, it proved possible to produce artificially an increasing number of new radioactive isotopes, and this together with ever more refined methods of measurement greatly extended the scope of radioisotope research. Eventually the discovery of uranium fission and the releasing of energy, stored in atomic nuclei, by chain reactions, made it possible to produce radioisotopes in almost unlimited amount and thereby opened the prospect of their use even for industrial purposes."

Since then, said Professor Bohr, the radioisotope tracer method had become an indispensable tool in practically every field of the physical sciences; its applications in biology, which had led to immense progress in the study of living organisms, had even offered new tools in archaeological investigations. Because of the vastness of the whole field, he pointed out, the Agency had wisely planned the conference in Copenhagen mainly to cover the use of radioisotopes in the physical sciences and industry.

Mr. Viggo Kampmann, Prime Minister of Denmark, who opened the IAEA's Copenhagen conference on the Use of Radioisotopes in the Physical Sciences and Industry is shown in conversation with Professor Niels Bohr, Chairman, Danish Atomic Energy Commission, left, and Mr. Sterling Cole, IAEA Director General

The first few sessions of the conference were concerned with the use of radioisotopes in geophysics, metallurgy, solid state physics and nuclear physics. The conference then took up the industrial applications of radioisotopes, which were divided into two groups, namely applications based on the tracer function of isotopes and those based on the penetration, absorption or scattering of radiation. The second week of the conference was concerned with the use of isotopes in various branches of chemistry - from analysis to determine extremely small amounts of material to a study of the mechanism of various chemical reactions.

In Geophysics and Meteorology

In the field of geophysics, novel methods of prospecting for ore and coal deposits with the help of isotopes were described by three Soviet scientists. They explained how the use of a radioactive source in bore-hole logging and the measurement of the radiation reflected back to a detector indicated the depth of the occurrence and the thickness and structure of coal seams. This technique can also be employed for distinguishing the different elements in ore deposits in the bore-hole section and providing an estimate of the useful content.

Another Soviet paper dealt with methods of determining the age of geological and archaeological objects with the help of radioactive carbon (carbon 14). The radioactive carbon released chiefly in the stratosphere as a result of nuclear weapon tests can be used for investigating how carbon dioxide is transported from the stratosphere to the troposphere, and this was the subject of a paper presented by a Danish scientist. He explained how a study of the increase in the radiocarbon content in Danish cereals had shown latitudinal variations in this transport and consequently in radiocarbon contamination. He disclosed that carbon 14 measurements in Denmark on cereals had shown that during 1958 and 1959 the increase in the radiocarbon content was several per cent higher in Denmark than the average increase for the hemisphere.

Two papers - one by three United States scientists and the other by two experts from the European Organization for Nuclear Research (CERN) - described how radioisotope techniques could be used for the study of meteorites and explanation of cosmic phenomena. During their travel through space the meteorites are subjected to cosmic rays producing radioactive isotopes in the meteorite material. Since the radioactive life of an isotope is specific and characteristic for that isotope, an analysis of the radioisotopes in meteorites can yield valuable data about the age of the meteorites through space. As the meteorites are our only source of extra-terrestrial matter, their study can also furnish clues as to conditions in other parts of the solar system. Analysis of radioisotopes in meteorite material can indicate the variations in the intensity of cosmic rays in space and this, in turn, is significant in understanding the source of cosmic radiation.

The use of radioisotopes in meteorological research was also discussed in two evening lectures.

Study of Metals

Isotope applications in metallurgy were reviewed by scientists from a number of countries. Isotopes are now being widely used in studying the behavior of metals under different conditions, and it is expected that the results of these studies will not only add to knowledge of the properties of metals but also help in metallurgical processes for industrial purposes. For example, a British scientist explained how radioactive isotopes could be used in the study of metal deformation during tube-making processes. The radioactive substance, inserted in the tube, is able to reveal any deformation of the material in the process of manufacture.

Another subject discussed was the application of radioisotopes in research in the field of semiconductors, i.e. materials such as silicon and germanium which are used in transistors. Semiconductors are essentially based on the presence of an extremely minute amount of impurity in a metal of very high purity, and radioactive substances can be used not only in investigating but also in manipulating semiconducting metals. As is well known, transistors are replacing the orthodox radio valves in many branches of the electronic industry, and it is expected that radioisotope techniques will help in producing transistors of better quality and with more precise effect.

As indicated earlier, the industrial applications of radioisotopes fall into two broad categories. The first covers those applications in which small amounts of radioactive substances are used as tracers, while the second comprises those in which the penetration, absorption or scattering of radiation is used for the measurement or inspection of materials and systems. The first is based on studying the location or course of a radioisotope through a process which it may not be possible to investigate by other means, while the second is based on measuring the radiation during its interaction with the material or system under study.

Tracer Methods

Discussions at the Copenhagen conference underlined the growing importance of radioactive "tracers" in the study and measurement of wear in engines and machine parts. Measurements of wear by conventional means can be carried out only after long periods

Nearly 600 scientists from 42 countries attended the IAEA's conference in Copenhagen on the Use of Radioisotopes in the Physical Sciences and Industry

of running, while the application of radioisotope techniques enables wear to be measured within a fairly short time and with considerable accuracy. Studies on metal wear are now carried out on a routine basis with the help of radioisotopes and the results help in developing materials which are more resistant to wear. This has already brought immense benefit to industry.

By making a machine component radioactive, the rate of its wear can be measured by the deposition of *radioactivity in the lubricating oil*. A paper by three American scientists described a method of studying the wear of diesel engines by measuring the amount of radioactivity both in the oil and in the exhaust gas.

Under certain circumstances, wear is associated with the transfer of metal from one component to another. If one of the rubbing surfaces is made radioactive, the transfer of metal particles to the inactive surface can be determined by measuring the radioactivity on the latter as a result of the rubbing. This and other radioactive tracer techniques in lubrication and wear research were explained in a paper presented by four British scientists.

Two Soviet scientists described how radioactive methods could be employed in studying the operative properties of lubricating oils and thus helping in the production of high-grade lubricants. A Czechoslovak contribution dealt with the radioisotopic control of wear on the suspension bearings of large turbogenerators.

A paper by two Canadian scientists explained how radioactive tracers could be used to mark grinding balls to obtain information on their life under different conditions so as to enable a comparison of cast balls of different types or composition. A batch of steel balls marked with radioactive iron or radioactive cobalt is followed through a milling operation over several weeks and studies are then made of their wear and loss of weight.

Among other industrial applications of radioisotopes discussed at the conference was the use of radioactive gases in the detection of leaks in hermetically sealed components, which is often considerably more sensitive than conventional methods of leak detection. The component can be immersed in a radioactive gas under pressure and the radiation transmitted into the component can then be measured, or some radioactive gas can be inserted before sealing and any subsequent loss of activity inside the component can be monitored as a measure of the leak rate.

Two scientists from the Wantage Research Laboratory, United Kingdom, also described a method for the continuous measurement of gas flow in a pipe by using a hinged gate and a radioactive source. A radiation detector outside the pipe, in conjunction with a radioactive source attached to a valve-like device inside the pipe, which moves under the influence of the flow, can constitute a self-contained instrument for the continuous monitoring of the flow. By attaching the radioactive source to the lower edge of the gate, the radiation intensity at a point outside the pipe can be made to increase with flow velocity and consequent deflection of the gate. This method is particularly useful where it is difficult to introduce the more conventional measuring systems because of extreme operating conditions, such as high gas pressure or inaccessibility.

Further Industrial Uses

Two scientists from a British petroleum research group reported on methods of using radioisotopes for *the continuous measurement of sulphur in a refinery*. As the sulphur content of refinery streams has to be kept below certain levels to give satisfactory products, a system of continuous measurement would be of great value. At present the refineries are usually dependent on relatively slow measurements in the laboratory; the introduction of radioisotope techniques for continuous measurement would offer considerable financial reward. Since a particular type of radiation is absorbed more by sulphur atoms than by carbon or hydrogen atoms, even small changes in the sulphur content of hydrocarbons (such as petroleum) can be measured by this technique.

Scientists from the Netherlands and the Soviet Union gave an account of methods for using radioactive hydrogen (tritium) for determining the flow of water in an oil field. An idea of this flow in quantitative terms is extremely useful for petroleum extraction processes.

Some possible uses of isotopes in the rubber industry were discussed by four scientists from Czechoslovakia. They showed how the wearing quality of rubber tyres could be gauged more rapidly and more accurately during road tests by using radioisotope techniques.

At present, the largest financial savings in industry through the use of radioisotopes come from their application for measuring the thickness of various materials, and two papers by French scientists gave an account of recent developments in this field. Isotope thickness gauges are usually based on measuring the penetration of radiation through the materials under study. To give a simple example, the thickness of fine metal plates as they are turned out in a factory in quick succession can be gauged (and their uniformity ensured) by making each of them pass between a radioactive substance on the one side and a radiation measuring instrument on the other. Since the amount of radiation passing through a plate would depend on its thickness, this method can be employed as a means of extremely quick, accurate and continuous measurement.

Applications in Chemistry

Separate sessions were devoted to discussions on the uses of isotopes in analytical chemistry, organic chemistry and physical chemistry. Keen interest was expressed in the unique value of isotopes for the analysis of materials, and a number of papers by British, American and French scientists gave an account of recent developments in isotopic analytical techniques. The experiments and results reported at the conference showed that isotope techniques have become indispensable for a variety of important investigations which cannot be carried out by other means.

If the sample to be analyzed is made radioactive, the elements constituting the sample can be easily detected because the radiation from a particular radioactive isotope is characteristic for the isotope. By measuring and studying the radiations emitted from the sample, it is thus possible to determine the nature and quantities of all the various elements present.

One of the major advantages of this technique is that the analysis does not interfere with the physical structure or composition of the material. It is also particularly useful for determining the presence of trace amounts of an element that are too small for detection by other means. One important practical application of this technique, as indicated earlier, is in the field of transistors. The technique can also be employed in metallurgical investigations of a more general nature, for example in determining the amount of hydrogen in metals.

Problems connected with the production of radioisotopes and radioactive compounds were also discussed in separate sessions.

Two papers, one from Britain and the other from Poland, showed that isotopes are proving useful also in domains which have little apparent connection to science and technology. Two Oxford scientists told the conference how the analysis of 500 Greek silver coins of the 5th century B.C. had yielded interesting evidence about trading connections of that period and of deliberate debasement of the coinage. The Polish paper contained an account of the use of nuclear radiation for determining the techniques employed in making a large bronze door 800 years ago at the Royal Cathedral at Gniezno, Poland, and thus obtaining valuable data about the technology of mediaeval art.

Steady Expansion

Commenting on the results of the Conference many of the participants noted the steady expansion of isotope applications, not only in new fields of research and industry but also in many new countries. Dr. Paul C. Aebersold, Director, Office of Isotope Development, United States Atomic Energy Commission, said that since the first atoms for peace conference in Geneva in 1955 there had evidently been a growing interest in many countries in the immediate practical benefits that atomic energy could yield through the use of radioisotopes. While the advent of economic nuclear power was taking longer than had been envisaged at one time, an immediate practical benefit from the research and training reactors now in operation in many countries could be derived from the use of radioisotopes produced by them.

Dr. John Putman, of the Wantage Research Laboratory, United Kingdom, said that while the basic principles or procedures relating to isotope applications were no longer novel, the conference had shown how methods proposed several years ago had now been developed and in many cases put to practical use. In several of the participating countries, the use of radioisotope techniques had now spread to fields other than the laboratories directly interested. Dr. Putman emphasized that among the most valuable results that came from conferences of this kind was an informal exchange of ideas between scientists from different countries.

The importance of such exchanges was also noted by the chief Soviet delegate, Professor V. Botchkarev, Head of the Isotope Laboratory, Central Atomic Energy Board of the USSR. Further, he said the conference had shown that during the last few years new and interesting results had been obtained in the production and uses of isotopes. He drew attention to the interest shown by the participants in isotope applications in industrial processes and in the prospecting for minerals.

The following scientists acted as Chairmen at different sessions of the conference: J. Koch (Denmark), M. Rollier (Italy), A. Tscherban (USSR), P. C. Aebersold (USA), J. N. Gregory (Australia), Henry Seligman (IAEA), Ch. Fisher (France), C. Burckhardt (Switzerland), J. L. Putman (UK), J. Hoste (Belgium), K. Kimura (Japan), W. Herr (Germany), K. Wilzbach (USA), V. Botchkarev (USSR), J. Fuksa (Czechoslovakia), C.C. Evans (UK), F. Strassmann (Germany), L. Jurkiewicz (Poland), P. Albert (France) and A. H. W. Aten (Netherlands).

The proceedings of the conference will be published by the International Atomic Energy Agency.