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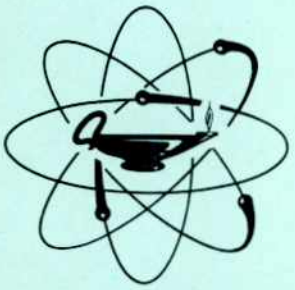

A TECHNICAL PROGRESS REVIEW

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Survey of Radioisotope Applications in Latin America*

By G. B. Baro and J. G. Flegenheimer†

Radioisotope applications in Latin America are summarized here, with special emphasis on Argentina because the authors are naturally most familiar with that country.

Perhaps the chief reason for building the first reactor in Argentina was to train reactor physicists. However, the radiochemistry group was already a strong one, having had the advantage of several years of training with radioisotopes produced by the Buenos Aires synchrocyclotron and by a Cockcroft–Walton accelerator. Therefore, as soon as the fun was over for the reactor physicists and the reactor had been tested, it was put on a routine operating basis for producing isotopes. It is still doing this, after several redesigns.

In our experience, the first step is to get the reactor going and producing some of the ordinary relatively short-lived radioisotopes. Soon, so many people wake up to what is going on that demands for these materials grow at an exponential rate. You are then obliged to produce other isotopes to supply the needs. Demands outstrip the reactor capacity, and you soon have to import most of the isotopes. At this point, the reactor physicist comes into the picture again, very willing, of course, to design a new and larger reactor that will satisfy demands for some years. Thus you end up with a reactor designed and operated mainly for radioisotope production. Argentina is now operating its RA-3 reactor, which has a 5-MW power level with a maximum thermal flux of about 2×10^{13} n/(cm^2)(sec). A new building of about 2 thousand m^2 for radioisotope production, adjacent to the reactor, is to be completed by the end of 1969. Except for the production of high-intensity radiation sources, Argentina hopes soon to supply all its own demands and to export radioisotopes to other Latin American countries.

Besides radioisotope production, it is interesting to note the consumption of radioisotopes. In Argentina, from 1954 until 1968, the consumption of radioisotopes increased about 10-fold, from about 8 Ci to about 85 Ci (Fig. 1). We do not have the figures for other Latin American countries, but we believe that the consumption in Brazil has been roughly the same. The consumption in Latin America can therefore be estimated approximately by multiplying the figures for Argentina by 4 or 5. The long-lived radioisotopes were all imported, but the short-lived—less than a month—were at least partially produced in those Latin America countries which have reactors. We can safely assume that, with larger research reactors operating, most of the short-lived radioisotopes will be produced domestically. Perhaps consideration should be given to joining efforts among our countries and establishing large regional production centers to supply the demands of all Latin America.

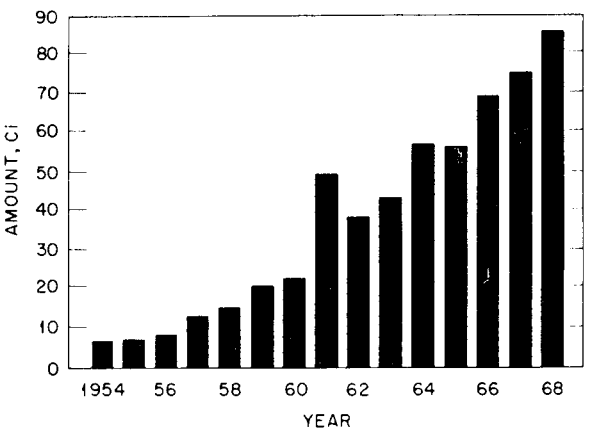

Fig. 1 Consumption of radioisotopes in Argentina exclusive of radiation sources.

USES

The main question, of course, is not how much of something is produced or consumed but what is done with it. How radioisotopes have been used in Argentina is shown in Table 1. Large variations may occur from year to year, depending on how much long-lived source material is imported for use, for example, in irradiators for medical therapy, for agricultural seed or plant treatment, or for industrial purposes. In Argentina, there are now some 35 thousand Ci of ^{60}Co, 7 thousand Ci of ^{137}Cs, and about 2 hundred Ci of several

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other source materials—e.g., ^{226}Ra and ^{90}Sr—being used in medicine.

The Agriculture and Veterinary Department of Buenos Aires University has an 11 thousand Ci ^{60}Co gamma source for seed and plant irradiation; the Argentina Atomic Energy Commission has a 10 thousand Ci ^{60}Co and a 1 hundred Ci ^{60}Sr source for irradiating liquids and is building an irradiation plant in Ezeiza, near Buenos Aires, with a 10^6-Ci ^{60}Co source and a capacity of 1 ton/hr for 1-Mrad irradiations of material with a specific gravity of 1. It will initially operate with 250 thousand Ci of ^{60}Co.

labeled molecules prepared on request are all used in medicine or other life sciences.

The wide use in medicine has been stimulated by the Argentina Atomic Energy Commission in two ways. First, the Commission holds regular training courses on the use of radioisotopes, at which 87% of the attendants are medical doctors. Second, the Commission contributes to the support of a Nuclear Medical Center in Buenos Aires, where medical students can complete their training in nuclear medicine and medical doctors are developing radioisotopic techniques. The Commission supports work in hospitals

Table 1 Use of Radioisotope Products in Argentina: Distribution by Field

4-Year Average, 1963 to 1966

Field	Amount, % of total			No. of institutions authorized to use radioactive materials
	Radio-isotopes	Labeled compounds	Sealed sources	
Medicine	70.8	70.0	20.8	223
Industry	1.0	0.1	70.9	64
Research (mainly biology)	28.0	29.5	6.9	45
Agriculture	0.2	0.4	1.4	19

A number of irradiators in Latin America can be used by all CIEN (Comisión Interamericana de Energía Nuclear) member countries. Mexico has two Van de Graaff accelerators, 0.6 and 2 MeV, respectively; two ^{60}Co irradiators, 3700 and 2000 Ci, respectively; and one Dynamitron electron accelerator, 12 mA and 5 MeV. Ecuador has a Gammacell-200, and Brazil, in Bello Horizonte, has 4000- and 1600-Ci ^{60}Co facilities. In Central America, there is a 2400-Ci ^{60}Co source, and in Puerto Rico, an 8000-Ci ^{60}Co source and a 10,000-Ci ^{137}Cs source. Venezuela, Peru, Uruguay, and other countries also have irradiators, and Chile is obtaining a 50,000-Ci ^{60}Co source from the IAEA.

Medicine

In Argentina, radioisotopes have been used mostly in the biomedical field, as is true also for the other Latin America countries. There are 3749 authorizations for using radioactive materials in our country, and more than 90% of them are for medical and biological work. The 38 radioactive compounds now produced routinely and a similar number of special

and other institutions on biological application of radioactive materials, in many cases supplying the materials on a no-charge basis or at prices as low as 10% of catalog prices. About 150 papers on biological experiments using radioactive isotopes are published in Argentina annually.

A regional center of reference for secondary standards in dosimetry has been established at the Ezeiza Atomic Center for calibrating dosimetry equipment used in radiotherapy, for personnel training, and for advisory service to all countries in the region.

Industry

Industrial applications have developed somewhat less rapidly than medical, but they have made an impact, as shown by an inquiry carried out by the IAEA in 1963. Industrial radiography has come of age in Argentina, with more than 90 commercial firms and private specialists authorized in this field (Fig. 2). Originally, all such work was done by the Commission. With the new reactor at Ezeiza, ^{192}Ir sources will be produced.

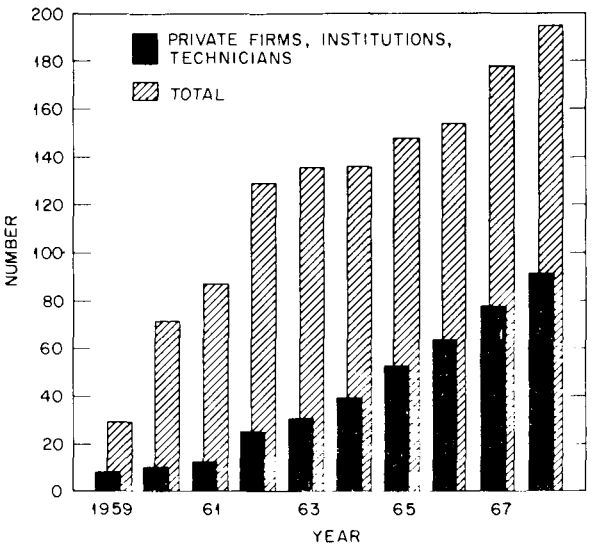

Fig. 2 Users of industrial gamma radiography in Argentina.

Radioisotopic gages for metal sheets, paper, and plastics were also developed originally by the Commission but are now produced commercially. About 50 radioisotopic gages—for measuring thickness, density, levels, and humidity—are in use in 27 factories. The Commission's policy has been to produce prototypes of the equipment and then to make the design available to private companies for manufacture. Latin American markets for such gages are still limited, but a much wider use is predicted.

Some radioisotopic techniques are carried out routinely in Argentina, but others have been developed for special purposes, e.g., for finding leaks in pipes, measuring flow rates in waterways, studying wear in motors, measuring snow thickness automatically in the Andes, studying sediment transport in the Rio de la Plata and along seashores, determining residence time in dryers, inventorying mercury in electrolytic cells, locating scrapers in large underground pipelines, and tracing materials in metallurgy.

Argentina has used delayed-neutron activation analysis for determining uranium in alloys. At the request of the Law Court, arsenic has been determined in human hair and nails and the results used in settling a lawsuit. The efficiency of motor lubricants has been measured, and recently a nondestructive method for determining arsenic and antimony in lead and tin alloys was developed. Biological samples of different origins are also being analyzed. With the RA-3 reactor and adjacent facilities now in operation, activation analysis will be used more and more in Argentina.

Other Latin American countries possessing reactors have also used modern activation-analysis methods. Brazil, for example, has determined hafnium in zirconium, sodium in demineralized reactor water and graphite, gold in minerals, and several other elements in a variety of materials. Work has also been done on activation analysis of hairs for identification. Venezuela, Colombia, and Uruguay are also interested in this field.

A very useful application of radioisotopes in Latin America is in hydrology. In Chile and in the Andean provinces of Argentina, it is very important to know in advance the amount of water that will be released to the rivers in the summer. This can be deduced from the amount of snow accumulated in the winter. Such information is useful in, for example, droughts, as occurred this year in Mendoza and San Juan. We hope that a more extensive use of radioisotopic snow thickness gages will help alleviate such problems in the future. Chile has used radioisotopes to establish the flow and direction of underground waters in Pampa del Tamarugal and in the Cantones and Salar Pintado regions in Tarapacá Province.

Latin America is also interested in applying nuclear techniques to prospecting and mining, and a recent IAEA symposium on this subject was held in Buenos Aires. Such methods have not yet been used extensively—apart from water, oil, and radioactive mineral explorations—but Latin America, with its ample natural resources, is a fertile ground for them.

Tracers have been used in agriculture and livestock studies. Colombia has used ^{32}P to study barley fertilizers; Brazil has studied fixation of carbon dioxide by nitrifying bacteria; Chile has used ^{32}P and ^{131}I to study the action of tetracycline on chicken growth. The work done at Turrialba, Costa Rica, on applying radioisotopes in tropical agriculture is known throughout America. Argentina has carried out studies on soils, lack of minerals in livestock, and labeling of insects and mice.

Large radiation sources in Latin America are used mainly for radiation therapy, but interest is growing in their application to food preservation, polymerization, chemical and biochemical effects of radiation with a practical objective, and industrial sterilization. Venezuela, Costa Rica, Peru, and some other countries have programs on sterilization of male insects to eliminate pests. Curaçao has eliminated the fruit fly in this way.

A semiindustrial irradiation plant soon to be operated in Argentina will be used mainly for industrial sterilization of pharmaceutical products and in cost studies on processes using high-intensity radiation

sources. When completed, this plant will be one of the largest in the world.

FUTURE

Latin America is mainly an exporter of raw materials, but this situation is changing. Rapid industrialization and population increases will call for greater power output, and nuclear power is an obvious solution to some of the problems. Argentina will have its first power reactor [316 MW(e)] operating in 1972, and advances in nuclear know-how will be accompanied by an expansion of radioisotope applications. With the production of fissile material in power reactors, the transuranium by-products—e.g., ^{237}Np and ^{241}Am—will become available, probably within 10 years. Nuclear batteries will certainly find very useful applications in Latin America, and costly installations and new technologies will be needed. Regional centers for nuclear work would be a great advantage, not only for favorable economics but also for exchange of ideas among groups with common interests. Pressures for results and getting things published is not yet so strong in Latin America as in some other parts of the world, and there is still time for sitting down and thinking originally and even for trying out methods which have a rather dim chance of success but which may provide useful shortcuts. Latin America is moving fast, and we are most optimistic about its future.

(MG)