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## PROGRESS IN PEACEFUL APPLICATIONS OF NUCLEAR ENERGY DURING THE YEAR 1967/68

### Statements by Member States

Note by the Director General

1. By 10 August 1968 11 Governments had responded to the Director General's invitation of 30 May<sup>1/</sup> to communicate statements for the information of the General Conference on the progress made in their respective countries during the year 1967/68 in peaceful applications of nuclear energy<sup>2/</sup>. The statements in question are reproduced below.

2. It is planned to consolidate these statements, together with such further statements as may subsequently be communicated, into a booklet<sup>3/</sup> to be published later in the year, at which stage it will be possible to incorporate any emendations that may prove desirable.

<sup>1/</sup> Circular Letter O/412-12th GEN.

<sup>2/</sup> The Government of the Netherlands has informed the Director General that it would propose to communicate a statement next year in respect of the period 1968/69.

<sup>3/</sup> Compare the booklet containing similar statements in respect of 1966/67 (GC(XI)/INF/97/Rev.1).

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## AUSTRIA

### The Reactor Centre at Seibersdorf in 1967

1. As in previous years, some 30 million Austrian schillings were available in 1967 for the purpose of modernizing and supplementing the scientific facilities of the Austrian Research and Reactor Centre at Seibersdorf. The total of investments has thus reached the 300 million schilling line. This remarkable amount, however, is still only a small part of what has so far been made available, for instance, in Switzerland or Sweden. By restricting activities to a few vital research tasks it was possible to achieve results that live up to the international standard, though the running costs did not exceed those of the previous year.

2. What is often considered a remarkable success is the combination of basic and applied research as it is being exercised at Seibersdorf. One hundred and two of the most outstanding students of Austrian universities majoring in the fields of technology and science use the facilities at the Centre for work on their diplomas and Doctor of Philosophy theses. On the other hand, income from contract research - in particular from isotope application in industry - amounted to over eight million Austrian schillings in the past year.

3. The quality of a research organization may be judged by two yardsticks. The first is the number and the value of its publications. So far the scientists of the Centre have published the notable total of 899 papers, mainly in German, English and French. Nearly all of these have appeared in well-known scientific books or journals. The second yardstick is the volume of research for which payment has been duly made. The patent and licence situation, too, may give a hint as to the research and development activities. It is to be noted in this connection that the utilization of patents and licences is specifically provided for in the charter of the Österreichische Studiengesellschaft für Atomenergie Ges.m.b.H. (SGAE), which operates the Centre.

4. We have now reached the stage of utilizing results from research. By now SGAE holds a total of 112 Austrian patents in force, mainly in the fields of isotope application and power reactors, and 67 applications are pending. Furthermore, 59 patents have been awarded in foreign countries and 70 are pending, mainly in the United States of America, the United Kingdom of Great Britain and Northern Ireland, the Federal Republic of Germany and France. This guarantees that interested foreign parties that have a large sphere of influence may become active in Austria only if an agreement can be reached, as well as a co-operation and sharing of work acceptable to Austrian industry. The number of patents granted is telling evidence of the fact that the long-range and methodical help which Austrian industry has given to SGAE is now beginning to bear fruit, to be harvested by the member organizations of SGAE as well as by industry as a whole.

5. Due to the fact that SGAE holds such a remarkable number of domestic patents, it has been possible to create a basis for obtaining the right to use the techniques and patents of other countries by way of exchange. In the following paragraphs a few examples are given of the utilization of domestic patents and other "know-how".

6. The Centre's Institute of Electronics has developed new amplifiers and single-channel discriminators. Since no Austrian enterprise seemed to be interested in producing these devices, licence contracts for three types were concluded with a German firm in Munich. Further licences are about to be granted. The German firm plans to manufacture a complete range of nuclear measuring devices following the Seibersdorf prototypes. Generally, the Centre offers the total "know-how" and a prototype device with all the diagrams and lists of components, and the licensee pays a non-recurring sum as well as a licence fee of about 3-5% of the selling price for all devices sold. The licensee usually assumes a liability to sell a certain minimum number of devices each year.

7. The Institute of Health Physics and the Institute of Chemistry have joined forces with the result that Austrian patent number 257.858 entitled "Procedure for the Manufacture of an Argentiferous Glass which is Sensitive to both Radioactive Radiation and X-rays" has been granted. This invention will replace the film dosimeters used so far. In this matter negotiations with an Austrian firm concerning the acquisition of the patent and the manufacture of the phosphate glass dosimeter are near completion. Regarding the production of a read-out device belonging to it, which is also protected by patent, there have been negotiations with four Austrian and two German firms which have finally culminated in a preliminary contract. This example illustrates clearly that new and economically interesting achievements can be produced by employing even small funds, as long as good ideas are forthcoming.

8. The frequently cited Compton spectrometer is the patent that is the most interesting scientifically and internationally speaking. In the economic field, too, it is likely to achieve a full success. The apparatus was recently tested with power reactor fuel at Windscale, England, and has proved very efficient. The device was also on exhibit in the Austrian Pavilion at the World Fair in Montreal.

9. Utilization of the "know-how" is also guaranteed in the case of the Seibersdorf mass separator, since an American firm has submitted a letter of intent with a view to a purchase order. The production of two such devices at a total cost amounting to 15 million Austrian schillings is under discussion. The final placing of the order, however, is connected with guarantees which have yet to be discussed. In case of the actual utilization of these products, several member organizations of SGAE would take part.

10. The Industrial Advice and Isotope Application Section is making steady headway. In one way or another this Section of the Centre has been of some help to almost every one of the 53 industrial member organizations. This rather small Section has obtained five Austrian

and nine foreign patents. Even beyond the Austrian border the examination of rim lubrication of the wheels of train coaches with the help of radioactive gold has found recognition. The Agency has found this application of considerable interest, and many European railway companies have introduced the technique, benefiting from Austrian experience of its use.

11. The ASTRA-Reactor Institute has been able to exploit several developments internationally. These include in particular a high-temperature irradiation capsule developed for testing coated particle reactor fuel. The development of the capsule was carried out mainly at Seibersdorf in co-operation with a member organization. Besides other industrial irradiation facilities, a unit for the irradiation of biological material with fast neutrons has found international recognition. Co-operating initially with the Agency, SGAE designed the irradiation unit which was finally built by an Austrian firm. Copies of this unit have in the meantime been built for India, the Philippines, Thailand and the United States. There are also orders from Bulgaria and China.

12. Of equal importance are the Institute of Chemistry and the Institute of Metallurgy which have made great achievements in the development of new nuclear fuels since the very start-up of the Centre. Originally participants in the international Dragon High-Temperature Reactor Project, these Institutes now co-operate mainly with the Federal Republic of Germany and the United Kingdom. Four Austrian patents, and nine patent applications which are at the publishing stage, have brought us the Dragon, the German and the American orders. The resulting research contracts have led to further applications for patents; these will, however, belong to the authorities awarding the contracts, though in all cases SGAE will hold the full rights for Austria. By the end of 1967 the two Institutes had received almost 20 million Austrian schillings as income from successful research work.

13. In the field of isotope production the Institute of Chemistry holds two patents, one of which covers an important procedure for the manufacture of iodine-131 from telluric acid. In Austria this isotope is often used for medical as well as industrial purposes. Research results from the Institute may be vital for future activities of the Austrian wood and synthetics industries, since it is now possible to produce technically interesting combinations of wood and synthetics.

14. The Institute of Reactor Technology has, in the short period of its existence, followed a particularly industry-minded line of development. Two major projects in co-operation with a member organization involving expenditures of several million Austrian schillings testify to this fact. The sodium loop and the development of a plant for the disposal of radioactive waste water are perfect examples of passing on "know-how" by the Centre to one of SGAE's industrial member organizations.

## BELGIUM

### Developments in the field of nuclear energy in 1967-68

#### RESEARCH AND SUPPORT PROGRAMMES

1. In 1967 the Belgian Government drew up a five-year programme covering the period 1968-1972. This programme follows on the 1965-67 three-year plan and relates to the following main subjects:

- (a) Fast reactors;
- (b) Dry reprocessing of fuel;
- (c) Proven reactors;
- (d) Basic research;
- (e) Other research programmes;
- (f) Operation of the high-flux materials testing reactor (BR-2).

#### Fast reactors

2. The development of fast reactors is given top priority in the coming five-year plan. The work is to be carried out under a tripartite collaboration programme approved by the Federal German, Netherlands, and Belgian Governments during 1967. This programme provides, first, for the joint construction of a 300 MW(e) prototype facility which is to be operational by 1974, and, second, for continued co-operation on the industrial level with a view to the manufacture and sale of commercial fast-breeder reactors.

3. Construction of the planned prototype facility will be accompanied by a research and development programme designed to make it possible to apply the characteristics of the prototype by extrapolation to industrial power plants and thereby improve their performance. This programme, the major part of which will be carried out by the Nuclear Energy Research Centre (CEN), deals particularly with sodium technology, the development of new cladding materials, the production of advanced oxide and carbide fuels, reactor physics, and the design of new equipment. It will also involve a large number of irradiation experiments in the BR-2 as well as in other reactors manufactured abroad.

#### Dry reprocessing of fuel

4. In addition to conventional reprocessing techniques using organic solvents, a number of countries have been interested for some years in an original processing method which entails separating the uranium, plutonium and fission products by means of halogen reagents, in particular chlorine and fluorine trifluoride.

5. This method, which has been tried out by the CEN with industrial backing, appears particularly suitable for fast-reactor fuels that need to be reprocessed at very high burnup rates, for which reprocessing facilities of other types are not very suitable.

6. The coming five-year period will be chiefly spent on further investigation of the conditions in which existing facilities can be operated, continuation of basic research, the development of certain equipment and the conceptual study of a commercial pilot plant. Detailed study and construction of the pilot plant are scheduled for around 1974.

#### Proven reactors

7. The research planned by Belgium in this field primarily concerns the improvement of pressurized water reactors and the development of more advanced fuels. The research involves the design of new equipment, the study and calculation of reactor cores, and also the improvement of techniques for industrial fuel fabrication, particularly for the case of fuels intended for the first big Belgian power stations. In addition, efforts will be concentrated on plutonium fuels with a view to their possible recycling in thermal reactors.

8. An important part of this programme is the design and construction of improved cores for the BR-3 reactor at Mol (the first Belgian nuclear power station equipped with an 11.5 MW(e) pressurized water reactor). The intention is that these cores should make it possible to test the techniques for fabricating Zircaloy-clad fuels and to make statistical assessments of pins containing plutonium or burnable poisons.

#### Basic research

9. This research is being undertaken within the framework of international bodies, such as the European Organization for Nuclear Research (CERN), at the same time as by university laboratories and the CEN. It concerns high-energy physics (in conjunction with the experiments conducted by CERN

in Geneva), low-energy physics, nuclear chemistry, solid-state physics, neutron physics and radiation biology. Those studies which require special equipment such as large accelerators, reactors or safety equipment are carried out either by the CEN at Mol or in collaboration with CERN. As for the universities, they play an important part in theoretical physics, low-energy physics and nuclear chemistry.

#### Other research programmes

10. These programmes relate to research in the field of safety and waste disposal, exploratory studies on chemical metallurgy and reactor physics and work on the use of radioisotopes. For the most part, they are carried out by the CEN at Mol.

#### Operation of the BR-2 reactor

11. Until the end of 1967 the BR-2 test reactor was operated jointly by the CEN and EURATOM. It has already been used for a large number of irradiation experiments commissioned by Belgian and foreign clients on fissionable and structural materials.

12. In future the reactor will be jointly operated by the German research centre Gesellschaft für Kernforschung, and the CEN, primarily for irradiation experiments under the fast reactor programme. This provides for the construction of several large-size loops that will make it possible to irradiate sodium-cooled reactor fuels under simulated conditions.

#### Budgetary matters

13. In 1968 the nuclear energy budget for Belgium will be about B.Fr. 1400 million, or more than an 11% increase against 1967. Of this total 37% pertains to Belgian participation in international bodies and 63% to the financing of activities on a national level.

14. In the programme as a whole, basic research accounts for 25%, technological research 50%, and public services and support activities 25%. On the national level the CEN absorbs close to 60% of the funds available, with industry receiving 28% and university laboratories 12%.

## NUCLEAR POWER STATIONS

### BR-3/Vulcan Power Station

15. The CEN's 11.5 MW(e) BR-3 pilot power station was operating commercially with a Vulcan core over virtually the whole of 1967. The overall load factor on 31 December 1967 was 93.5%, while the availability of the reactor had risen to 98.2% by the same date; this can be considered a remarkable achievement.

16. In 1967 the net output of electricity supplied to the network rose to 85 million kWh. In March and July of the same year a series of physical measurements was undertaken, which included, first and foremost, analysis of the dynamic behaviour of the plant during unloading at various power levels.

17. Full-power operation of the reactor was continued in 1968 until 22 April, with a break for a few days while a third series of experiments was undertaken. By the end of April some of the fuel passed the maximum scheduled burnup rate of 40 000 MWd/t U; the objective of the first phase in the BR-3/Vulcan experiments was thereby attained.

18. Since that time, the core has been used for an endurance test programme involving cycling of the reactor power. On 13 June 1968, the mean and maximum burnup rates for the fuel were 20 000 and 44 000 MWd/t U respectively.

19. The objective of the second experimental phase now in progress, which is to reach a maximum burnup of about 50 000 MWd/t U, will, it is expected, be attained round about September 1968.

### Ardennes Nuclear Power Station at Chooz

20. The contract between the Société d'énergie nucléaire franco-belge des Ardennes (SENA) and the AFW building consortium for construction of the Ardennes Nuclear Power Station at Chooz in France was signed on 25 September 1961. The AFW consortium is composed of the Charleroi Electrical Engineering Works (ACEC), the Cockerill Ougrée-Providence Company, and the Nuclear Metallurgy and Mechanical Engineering Company (MMN) on the Belgian side, the FRAMATOME Company on the French side and the Westinghouse Electric Corporation on behalf of the United States of America. Except for the first reactor core, manufacture of all equipment was shared equally between Belgium and France.

21. The Ardennes Nuclear Power Station, which has a capacity of 288 MW(e) when coupled to the turbine (gross output) stands on the river Meuse, in direct proximity to the French-Belgian border. It is fitted with a pressurized water reactor using slightly enriched uranium as fuel and pressurized light water ( $140 \text{ kg/cm}^2$ ) as moderator and coolant.

22. SENA selected a duplex type of installation for the Ardennes power station, which means that the nuclear steam generator is located underground, while the turbo-alternator unit and its ancillaries are housed in a conventional-style building at ground level.

23. The decision to build the power station fulfilled two purposes. The first was to provide the Belgian and French building consortium with an opportunity of adjusting to a completely new technique, and the second was to enable electric utilities to familiarize themselves with the operation of high-power nuclear power stations and to train operating personnel.

24. Assembly of the reactor was completed during 1966 and the reactor first went critical on 18 October of the same year.

25. The reactor then underwent nuclear tests accompanied by a series of routine tests on the conventional section of the power station. The latter was connected to the French and Belgian power networks on 3 April 1967. It had generated more than 630 million kWh by the end of January 1968, when an incident affecting the parts inside the reactor tank occurred. The dismantling of the reactor, removal of the fuel elements and inspection of the area where the incident occurred lasted several weeks. The heat exchangers in particular will have to undergo certain repairs. The exact cause of the incident, as well as the remedial action needed, are still under investigation. Resumption of operations at the power station is not expected until the end of 1968.

#### Doel and Tihange Power Stations

26. Belgian and French electric utilities have decided to continue their collaboration and to build a power station with a 750 MW(e) pressurized water reactor at Tihange in Belgium, due to be put into operation in 1974/75. The Belgian utilities also plan to erect a twin-reactor power station fitted with two pressurized water reactors, each with an output

of 375 MW(e), at Doel near Antwerp. The first of these two reactors will be started up in 1972-73, and the second in 1975-76. To undertake this work Belgian engineers have decided to form a Belgian consortium comprising ACEC, Belgonucléaire, Cockerill Ougrée-Providence and MMN. The final order for the two stations is expected to be placed before the end of 1968.

## CHILE

### Advances in the Peaceful Uses of Nuclear Energy

#### GENERAL ACTIVITIES

##### Nuclear policy and plans for development

1. The Chilean Nuclear Energy Commission commenced its activities in May 1966, and at the end of one year in office its Governing Board approved and submitted for consideration by the Chilean Government a report entitled "Nuclear policy and plans for development", which sets forth a line of action regarding all the principal aspects of the peaceful uses of nuclear energy.

2. These aspects are:

- (a) Training, particularly in the basic sciences;
- (b) Partial concentration of personnel, operations and equipment for training and research through the creation of a National Centre for Nuclear Studies;
- (c) Prospection of Chilean soil for radioactive ores;
- (d) Promotion of nuclear energy applications in agriculture and other spheres;
- (e) Plans for the future development of nuclear power and possible applications in water desalination;
- (f) Safeguarding the health of the population, with particular reference to persons handling radiation equipment and radioactive material.

##### Projects

3. In order to attain these objectives, the Commission has formulated the following principal projects:

- (a) Establishment of a National Centre for Nuclear Studies, which is designed to concentrate manpower and material resources available to the country in different branches of sciences and nuclear engineering, to co-ordinate basic

and applied research, to provide academic training for university students and instruction in the handling and use of radioisotopes, and to make available the technical advice and services needed as a result of the growing interest in the use of radioisotopes and various irradiation techniques in medicine, agriculture, engineering, and so on;

- (b) Establishment of a Radiological Protection and Control Centre. Act No. 16319 makes the Commission and the National Health Service responsible for the surveillance of users' installations and for the adoption of measures to protect the population from potentially hazardous ionizing radiations, for which purpose this programme has been drawn up;
- (c) Prospection for radioactive ores. This project provides for resumption of prospection on the basis of agreements between the Commission and other organizations, such as the Geological Research Institute (Instituto de Investigaciones Geológicas) and the National Mining Organization (Empresa Nacional de Minería), for which the assistance of the Chilean Air Force and Army is also available.

4. The Commission's newly formulated programme, as summarized in the "Nuclear policy and plans for development" report, was submitted to the President of the Republic and to the Ministers and Bodies concerned and was favourably received. At the express wish of the President, the period for completion of the programme, originally set at five years, was reduced to three years, starting from 1968. As a result, the Commission's efforts in 1967 were chiefly devoted to the preparation and implementation of these specific plans, though without neglecting the other activities incumbent upon it, which are also summarized in this report.

### Technical assistance

5. Considerable technical assistance was rendered by the International Atomic Energy Agency (IAEA), as well as by other organizations, including the United States Atomic Energy Commission (USAEC) and the French Atomic Energy Commission (CEA).

6. An event of particular importance was the visit made by Dr. Dragoslav Popović, an IAEA planning expert. After six months' work in collaboration with the Commission, Dr. Popović submitted reports on the following topics:

- (a) Uses of nuclear radiation;
- (b) Exploitation of the cyclotron for making radioisotopes;
- (c) Significance of the construction of a research reactor for the development of nuclear power;
- (d) Prospection for radioactive ores;
- (e) Nuclear power generation in Chile;
- (f) Research reactors;
- (g) Radioisotopes and nuclear radiation in Chile.

7. In addition, assistance was rendered by the following experts:

- (a) Dr. Robson of the USAEC, expert in entomology;
- (b) Mr. Peter Schwartz of the IAEA, expert in hydrology;
- (c) Dr. D.A. Lindquist of the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture, expert in entomology;
- (d) Mr. K. Shea of the USAEC, expert in food irradiation;
- (e) Mr. J-M. Huc and Mr. J. Hamard of the CEA, experts in the measurement of environmental radioactivity.

### Agreement with France

8. Purchase of a 5-MW nuclear reactor. The Commission signed a basic agreement and various annexes with the CEA in April 1967. The principal purpose of this agreement is co-operation in the establishment of the National Centre for Nuclear Studies, the basis of whose activities is to be a research reactor. Among the main provisions of the agreement are

those providing for an exchange of experts and the award of fellowships by the CEA. Later on, following negotiations in which the Minister for Foreign Affairs, Don Gabriel Valdés, made personal representations to the French Government and the Commission acted in an advisory capacity, a long-term credit was granted on favourable terms for the purchase of a 5-MW nuclear reactor.

#### Visit by the Chairman of the United States Atomic Energy Commission

9. Gamma radiation unit for research purposes. The Commission received a visit by Mr. G.T. Seaborg, Chairman of the USAEC, who was accompanied by a large group of representatives from the United States Department of State and the USAEC. A joint statement was issued in which the United States Representative announced the offer of an experimental gamma irradiation unit for food preservation research, as well as several fellowships for Chilean scientists and engineers.

#### Measurement of environmental radioactivity

10. The Commission drew up and published a complete report on measurements made during the previous year as a result of the French nuclear explosions. At the same time, the Commission specially appointed for these measurements continued its work throughout the year, using an improved system for the purpose. A technical specialist was sent to Easter Island to deliver replacements for the equipment already set up there. The French Government rendered assistance in this work through the services of Mr. Hamard and Mr. Huc<sup>4/</sup>.

#### Information services

11. The Commission took a number of steps to publicize work on the peaceful uses of nuclear energy, such as the issue of scientific information bulletins to the Press, the showing of films at the Chilean-French Cultural Institute, and the organization of a stand at the Industrial and Electrical Engineering Exhibition at the University of Chile.

12. A significant stimulus was given to the Commission's library, in the form of the acquisition, over the course of the year, of 2800 books on specialized subjects, the bulk of which were donated by international

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<sup>4/</sup> See para. 7(e) above.

organizations. Over this period the library compiled a catalogue of authors, titles and subjects. It has circulated a detailed list of the various services available and published its first bibliographical bulletin, which provides both readers and other libraries with information on the collections available.

#### OTHER ACTIVITIES

13. Regional course on nuclear power. This course was given in Santiago under the sponsorship of the Agency.

14. Participation in the meeting of the Study Group on Research Reactor Utilization held at Bogotá, Colombia, and a visit to the Venezuelan reactor.

15. The following courses were attended by Chilean doctors and biologists:

- (a) IAEA Regional Advanced Training Course on Medical Applications of Radioisotopes, Montevideo, November-December 1967;
- (b) Symposium on Radiosterilization of Medical Products, Budapest, June 1967;
- (c) Regional Training Course in Radiation Immunology, Buenos Aires, September-October 1967;
- (d) International Training Course in Radiation Biology, Tel Aviv, May-June 1967.

16. Medical and biological aspects of the application of irradiation techniques. The Commission participated in the study of programmes on food preservation, sterilization of medical products, and irradiation of transplanted organs.

17. Meeting on the use of nuclear energy to improve agricultural productivity. This meeting, which was sponsored by the Inter-American Nuclear Energy Commission and the Organization of American States, was organized by the Chilean Commission. It was attended by 33 delegates from Argentina, Austria, Bolivia, Brazil, Colombia, Costa Rica, Mexico, Peru, and the United States of America, and also by 28 delegates from Chile. The topics dealt with were water research, plant research, soils and fertilizers, food irradiation and animal and insect studies.

18. Agreement with the Institute of Plant and Animal Research (Instituto de Investigaciones Agropecuarias). The Commission drew up a draft agreement, the chief aim of which is to supply the "La Platina" Experimental Station with the experimental laboratory equipment required to study the applications of nuclear energy in agriculture.

19. Irradiation of food. The Commission collaborated in studies on the feasibility of a food irradiation facility. To this end it held consultations with the Economic Co-operation Administration (ECA), requested the technical co-operation service of the Development Corporation (Corporación de Fomento) to make a study of the problem, and enlisted the support of the USAEC, as mentioned in the first part of this report.

20. The Latin American School of Physics (Escuela Latinoamericana de Física) held a session at Santiago in July 1967. This session, which was organized by the Commission, was attended by leading international specialists in solid-state physics, particle physics and nuclear physics.

21. The cyclotron was inaugurated in the middle of the year. The Commission played an important part in procuring financial aid for its construction.

COLOMBIA

Summary of technical operations carried out by  
the Institute of Nuclear Affairs  
August 1967 to July 1968

RADIOLOGICAL SAFETY

1. This is an operation of a permanent nature that continues to be carried out by a section of the same name. Studies have been made in the fields listed below.

2. Personnel dosimetry:

- (a) Using film, to detect beta and gamma radiation, on a monthly basis;
- (b) Using film, to detect neutrons, on a fortnightly basis;
- (c) Using pocket monitors and direct-reading dosimeters, on a monthly basis.

This dosimetry covers the entire staff of the Institute of Nuclear Affairs (IAN) and occasional outside visitors, i.e. a total of roughly 80 persons. The results are recorded on appropriate personal record cards.

3. Calibration of sources and equipment. Using available equipment, ionization chambers, Geiger counters, dosimeters and scintillation counters were periodically calibrated with standards of attested activity. Other work carried out in this field includes personnel and area monitoring, decontamination, disposal of radioactive waste, checking on permits for the handling of sources, and listing and inspection of all IAN sources.

RADIOMETRIC STUDY OF ENVIRONMENT (ERA)

4. This programme involves continuous measurement of radioactivity in the environment (e.g., in samples of air, rain water, fresh water, vegetables, milk and fish). The findings are listed in monthly reports, a summary of which is published every six months and widely circulated.

5. During 1967 samples were taken at the following stations:

- (a) Bogotá (IAN). Determination of total beta activity in samples of air, rain water, fresh water, milk, vegetables, and fish from the Pacific Ocean. Fission products were also determined in these samples, by means of gamma ray spectrometry.
- (b) Medellín (ERA-1), Quibdó (ERA-2), Cali (ERA-3) and Leticia (ERA-4). These stations determined the total beta radioactivity and made a gamma spectrometer analysis of rain water and air samples.

6. This year new sampling stations have been set up at Pasto (ERA-5), Buenaventura (ERA-6), Bucaramanga (ERA-7). Furthermore, the programme has been further expanded to include the submission of biological samples by all stations, in addition to air and water. This monitoring system came into operation in June and will continue on an intensified scale. In addition, the stations are to begin determining the strontium and potassium content in the samples mentioned.

#### APPLICATION OF RADIOISOTOPES IN AGRICULTURE

7. Work accomplished in this field during 1967 can be summarized as follows:

- (a) Maize. This programme was carried out under a research contract concluded between the IAEA and the IAN. Its purpose is to study the efficient use of fertilizers for this crop, particularly the interaction between nitrogen and phosphorus and its influence on crop yield. The experiments were carried out at the Nataima agricultural station near the town of Espinal. The nutrient sources used were superphosphate with and without  $^{32}\text{P}$ -labelling, and ammonium nitrate and urea with and without  $^{15}\text{N}$ -labelling.
- (b) Rice. This programme was carried out at the Nataima experimental field and consisted in determining periods favourable for nitrogen application;  $^{15}\text{N}$ -labelled ammonium sulphate was used for the purpose.

- (c) Beans. This study was made in the IAN greenhouse and its purpose was to determine the proper time and dose for the application of phosphorus to beans via the leaves;
- (d) Sorghum. Preliminary studies of the fertilization in this crop were made in a greenhouse. This year the sorghum fertilization experiment has been continued with the object of determining suitable doses for field studies.

8. Research has continued on phosphorus fixation in the rice-growing soils of the Cauca Valley. There have also been experiments on the effect of continuous application of phosphorus on phosphorus uptake in rice-growing soil.

9. In each case the results of these programmes have been summarized and will be published at a later stage.

#### IAN-R1 REACTOR

10. Operations of the IAN reactor are the responsibility of the Reactor Division. The reactor has been used without interruption by the unit since February 1965.

11. The activities of the Division during 1967 can be summarized as follows:

- (a) Operations: 433 irradiations were carried out in the course of 305 irradiation periods, with an overall power consumption of 12 708 kWh for the year;
- (b) Research: Various parameters of the reactor, such as its reactivity coefficient with temperature and its sensitivity to neutron absorbers were determined. The calculation of epithermal and fast neutron fluxes was begun;
- (c) Publications: A variety of investigations were carried out and published as a paper under the title "Determination of various parameters of the IAN-R1 reactor". This paper was presented at the Third Colombian Congress on Physics and at the Study Group Meeting on Research Reactor Utilization held on December 11-15 1967 in Bogotá;

- (d) Other activities: Preventive maintenance of the reactor and training of operational personnel. A reactor physics course was given for final-year students of the Department of Physics at the National University. Students were given advice on degree theses dealing with various aspects of the reactor.

12. In the first half of 1968 the IAN continued to make its irradiation service available for different technical operations; gold seeds for medical purposes were irradiated and used at the Cancerology Institute. There has also been progress in work on calculation of the mean temperature of thermal neutrons. Various experiments relating to the design of neutron detectors based on beta-emitting radionuclides have been carried out with good results.

#### RADIOCHEMISTRY

13. The Radiochemistry Section carried out research in the following fields:

(a) Activation analysis:

- (i) Determination of selenium and tellurium in natural sulphur;
- (ii) Study of sensitivity in determining halogens with the IAN-R1 reactor;
- (iii) Calculation of potassium, chlorine and magnesium in wheat, maize and barley seeds;
- (iv) Calculation of iodine in urine specimens;
- (v) Calculation of uranium and thorium in the ores containing them, by the delayed neutron counting technique, using boron trifluoride detectors. The results of this research were presented at the Bogotá meeting on research reactor utilization.

(b) Radioisotope production:

- (i) Production of carrier-free  $^{32}\text{P}$ ;
- (ii) Production of  $^{32}\text{P}$ -labelled calcium superphosphate from commercial superphosphate, using the mechanism of exchange between the  $^{32}\text{P}$  solution and the commercial fertilizer;

(iii) Production of  $^{32}\text{P}$ -labelled potassium metaphosphate with properties similar to the commercial product. In the greenhouse experiments conducted by the Agricultural Section use was made of fertilizers labelled in the IAN-R1 reactor;

(c) Research in nuclear chemistry:

(i) Isolation of nuclear isomers (mercury-197m and mercury-197), by means of diethyl mercury and mercury dithizonate;

(ii) Development of new radioisotope generators utilizing recoil energy from a daughter nuclide when the parent nuclide is contained within a complex. The synthesis of various phthalocyanine complexes from phthalodinitrile by means of a variety of catalysts was studied. Fourteen different complexes were synthesized so as to study the possibilities of fixation in exchange resin or aluminium oxide columns;

(d) Radiation chemistry:

(i) Work was continued on improving the physical properties of wood (Cuangaré). The technique is based on impregnation of the wood with a monomer (methyl methacrylate) and inducing of polymerization by means of radiation, the IAN-R1 reactor being used for the purpose;

(ii) This year saw the continuation of activation analysis to determine the vanadium in crude oil and in the different fractions during refinement. Activation analysis of iodine in blood was also made and the search for new generators continued, more specifically, those of the palladium-rhodium type;

(iii)  $^{32}\text{P}$ -labelled fertilizers were supplied, as before, for greenhouse experiments and laboratory tests made by the Agricultural Section.

## APPLICATION OF RADIOISOTOPES IN INDUSTRY

14. During 1967 the main effort was oriented towards industrial scintigraphy.  $^{60}\text{Co}$  and  $^{192}\text{Ir}$  sources were used for making a series of inspections of weld seams in pressure tubes at the Rio Mayo Hydroelectric Station, and scintigraphs of two compressors were made for a soda plant in Cartagena.
15. Work was started on the fitting out of a laboratory which will provide an information service on the practical use of radioisotopes in industry.
16. The scintigraphy service continued to operate in the first half of this year.
17. Investigations were carried out to localize blockages in the oil pipeline owned by the Empresa Colombiana de Petróleos, for which use was made of a  $^{60}\text{Co}$  source of approximately 240 mCi secured to the back of the scraper. The section inspected covered approximately 200 km.

## PROSPECTION FOR RADIOACTIVE MINERALS

18. During the year 1967 prospection work was carried out by groups made up of IAN geologists:
  - (a) Group I in the Department of Santander (Bucaramanga, Pajuil, Matanza, Charta, Suratá, Cachirí, Vetas, California, Jordán, Mesa de los Santos, and the Bucaramanga-Puerto Wilches Railway);
  - (b) Group II in the north of Santander (Bochalema, Chinácota);
  - (c) Group III in the north of Santander (Pamplona-Cácota-Mutiscua);
  - (d) Group IV in Boyacá (Duitama, Surba River Valley).

The findings of these groups are published in the relevant reports. Generally speaking it can be stated that in the areas studied there were found deposits of lignitic coals, shales and uranium-bearing phosphates.

19. The following work has been carried out this year:
  - (a) Group I in the north of Santander (Durania - La Don Juana);
  - (b) Group II in the north of Santander (Arboledas);
  - (c) Group III in the north of Santander (Chitagá);
  - (d) Group IV in the north of Santander (Ceste de Arboledas).

The results confirm the presence of uranium-bearing pegmatites detected in 1967.

#### ENTOMOLOGY

20. A programme has been worked out for co-operation between the Colombian Plant and Animal Institute (Instituto Colombiano Agropecuario) and the IAN in the study of ways of controlling Heliothis spp., Diatraea spp., and Dermatobia spp. by means of gamma radiation, and the findings will be reported to the United Nations.

21. The IAN has also assisted in the formulation of a nation-wide programme for integrated control of cotton pests, which will be submitted to the United Nations Food and Agriculture Organization together with a request for economic and technical assistance. Among other measures, preliminary arrangements have been made for the installation of facilities required to study the breeding of Diatraea spp. under laboratory conditions and the creation of artificial diets for this insect.

## CYPRUS

In reply to the Director General's invitation to communicate a statement, the Government of Cyprus has informed him "that except for the installation of a cobalt teletherapy unit, which has been operating since January 1966, no further progress has been made in Cyprus in the peaceful application of nuclear energy."

## GREECE

### Progress Report on Applications of Nuclear Energy - 1967/68

#### DEVELOPMENT AND UTILIZATION OF ATOMIC ENERGY

1. On 19 June 1968, Law No. 451 was passed to provide for the reorganization of the Greek Atomic Energy Commission (GAEC). All previous Laws and Legislative Decrees are now invalid. According to the new Law, the fostering, supervision and control of all kinds of applications of atomic energy in Greece are under the authority of GAEC.
2. As mentioned at the 11th regular session of the General Conference, Greece is not only interested in fundamental research but also in the application of nuclear energy,<sup>5/</sup> and in this light GAEC has taken the appropriate measures to encourage the introduction of nuclear power in this country. GAEC will provide the necessary training for some of the engineering staff of the Public Power Corporation, at its request, in reactor engineering work, in anticipation of the possible construction and operation of its first nuclear power plant.
3. In the field of hydrology the GAEC has been in contact with the Land and Reclamation Service of the Ministry of Agriculture and the Institute of Geology and Subsurface Research for the hydrological investigation of various parts of the country, after a proposal by the Agency to provide experts and certain laboratory facilities to assist in this project.

#### DEMOCRITUS NUCLEAR RESEARCH CENTRE

4. At the Democritus Nuclear Research Centre (DNRC) the production of radioisotopes and labelled compounds for medical, scientific and industrial applications continues to expand. The radioisotopes are distributed to various medical centres for clinical and diagnostic

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<sup>5/</sup> See document GC(XI)/OR.115, para. 80.

procedures, to industry for radiography and to the various laboratories for fundamental and applied research purposes. The reorganization of the Radioisotope Production Group, with the assistance of an Agency expert, is expected to increase the supply of radioisotopes. Greek industry is continually expanding the use of radioisotopes for various applications, and GAEC advises interested parties on the possibilities existing in this field.

5. A radiation damage project is being carried out in collaboration with the Garching Nuclear Research Centre at Munich. The programme in the field of nuclear chemistry and activation analysis, hot-atom chemistry in solids and liquids, radiation chemistry and physical chemistry are being successfully continued.

6. The Biological Sciences Group is contributing to protein chemistry, enzymology, photosynthesis, the study of lipids, physiology and genetics in fungi, marine biology and the control of the Dacus oleae fly.

7. The Soil Science and Plant Nutrition Groups are actively investigating problems of genetic classification, fertility and nutrition.

8. In the field of geology an investigation was carried out with the assistance of an Agency expert, the results of which were favourable, and continuation of the project on the evaluation of radioactive ores is under contemplation.

9. The Health Physics Group is continuing the programme of radiological surveys, environmental monitoring, waste disposal and dosimetry.

10. Reactor physics, delayed neutron research and reactor dosimetry are being developed in the Reactor Technology Division.

11. The High-Energy Physics Group is making good progress in on-line application of computer systems and in pattern generation and recognition. A Hough and Powell device to carry out programmes in high-energy physics in collaboration with the European Organization for Nuclear Research (CERN) is now nearing completion.

12. DNRC plans to increase the power of the reactor and to install a linear accelerator; this will assist the physicists to extend their research projects. The linear accelerator will especially assist expansion of solid-state research into radiation damage, studies of nuclear reactions and their cross-sections, and the examination of short lifetime, fission and stripping and pickup reactions. It will also make possible an expansion of programmes in radiation chemistry, especially by pulsed radiolysis, to study intermediate short-lived products, and nuclear chemistry in the fields of short-lived radio-isotopes, transuranic elements and hot-atom chemistry. The Biological Sciences Group will use the accelerator in basic and applied research, such as studies of the genetic effects of radiation and food preservation.

13. A programme to facilitate and broaden the distribution of scientific and technical information comprises the publication of reports. These reports are placed in the Library of DNRC and some 6000 volumes and 35 000 reports are available for all persons interested in the field of nuclear energy.

14. The inauguration of DNRC's School of Nuclear Science and Technology took place on 8 January 1968. Approximately 30 post-graduates, physicists, medical doctors, etc. have attended the school to further their studies of peaceful applications of nuclear energy.

#### SYMPOSIA AND MEETINGS

15. The first National Hellenic Congress of Oncology took place in Athens from 10 to 13 April 1968. This conference was organized under the joint auspices of the Hellenic Anti-Cancer Institute and GAEC. Some 200 scientists from all over the world attended.

16. An Agency study group meeting on health physics was held in Athens from 16 to 20 October 1967. Approximately 40 participants from Middle East countries attended the meeting and several representatives of world organizations.

#### TECHNICAL ASSISTANCE

17. A number of Agency fellowships were awarded to applicants from DNRC and other research institutes. Two scientific visits were arranged under the Agency's technical assistance programme to enable scientists to visit laboratories abroad which were specialized in the application of radioisotopes in industry and hydrology.
18. Numerous Greek scientists attended conferences, study group meetings and symposia and participated in study tours during the period covered by this report.
19. The valuable assistance of Agency experts enabled DNRC to evaluate its present and future programme.

#### AGENCY RESEARCH CONTRACTS

20. Renewals of Agency research contracts were awarded to DNRC to continue research on delayed neutron spectrum measurements and also to the Alexandra Hospital for the continuation of radioisotope studies on endemic anaemia.
21. Two new contracts were awarded, one to the Biology Division of DNRC in support of the project on the use of radiation and radioisotopes in a study of the physiology of fungi toxicity and of the development of fungicide resistance in pathogenic fungi, and the other to the University of Athens for a project concerning the effect of gamma-irradiation on the lipid metabolism of radiosensitive tissues.

#### INTERNATIONAL CO-OPERATION

22. During the period under review the laboratories of CERN at Geneva were used by several scientists for further studies and co-operation on high-energy physics and computing methods.
23. Under a bilateral agreement the United Kingdom Atomic Energy Authority will transfer a sub-critical nuclear assembly to the National Technical University of Athens to assist the staff and students to do practical work as part of their courses in nuclear physics and engineering.

## MADAGASCAR

### Progress in the Peaceful Uses of Atomic Energy - Work of the Radioisotopes Laboratory in 1967/68

1. The work of the Radioisotopes Laboratory covers two fields:
  - (a) Nuclear medicine, under Dr. Manambelona;
  - (b) Isotopes in agriculture, under M. Moutonnet, agricultural engineer from the Commisariat à l'Énergie atomique (French Atomic Energy Commission).

#### NUCLEAR MEDICINE

2. The year 1967/68 has been mainly notable for the use made of the results of the work that has been done since 1965 when the Laboratory was officially opened. On this basis the following activities have been undertaken:

#### In the field of thyroid pathology

3. Statistical assessment of goitres endemic to Madagascar and analysis of causative factors responsible. The study has been based on patients attending the Laboratory and on school children at various convent schools.

4. We ascribe its endemic nature to a conjunction of three factors: iodine deficiency, the family structure and the influence of high altitudes on human biology. Collective prevention measures are currently under study in co-operation with responsible departments of the Ministry of Health.

#### In the field of liver pathology

5. A study of tropical cirrroses has been initiated. We have drawn attention to the fundamental difference between the type of cirrhosis found in Madagascar and European cirrhosis.

The differences can be shown schematically:

(a) Difference in scintigrams obtained using radioactive colloidal gold:

| <u>European cirrhosis</u>         | <u>Tropical cirrhosis</u>         |
|-----------------------------------|-----------------------------------|
| Moderate distension of the spleen | Enormous distension of the spleen |
| Frequent osseous fixation         | No osseous fixation               |

(b) Aetiological difference:

|                            |  |
|----------------------------|--|
| Generally alcoholic origin | Parasitic origin (malaria, bilharzia, intestinal worms). |
|----------------------------|--|

Mineral analysis of water used for consumption

6. A mineral analysis of water samples taken in the dry season from different points in the island has been undertaken at the Laboratory with a view to finding factors correlating with certain endemic diseases (deficiency diseases of various kinds, endemic bilharzia).

7. It will soon be possible to draw up a map showing the distribution of elements playing an important part in biology, e.g. calcium. It should then be possible to see whether or not there exists a correlation between the map and biological indications of diet deficiency in the element under examination (e.g. for calcium, dental decay or possible tendency to convulsions). The results already obtained seem to account for the endemic nature of spasmophilia (tendency to convulsions) in the Fianarantsoa and Ambositra zone.

8. Finally, to facilitate the exchange of views and co-operation with provincial hospitals we have organized in certain important centres like Tuléar and Fianarantsoa lectures illustrated by slides and films obtained from the Commissariat à l'énergie atomique. These lectures were for members of the medical profession. In the lectures we particularly emphasized the important results of work undertaken at the Laboratory on certain diseases native to Madagascar. The lectures have generally been followed with much interest.

Research contract concluded with the Agency

9. Our study on the life span of erythrocytes in patients suffering from glucose-6-phosphate-dehydrogenase (G.6.P.D.) deficiency will be completed this year.

## ISOTOPE IN AGRICULTURE

10. The Laboratory's activity in this field is carried on along two lines: study of water content in soil using neutron probes (our main activity) and our own contribution to agricultural entomology. It is divided into laboratory and field work; field work is carried out at many different points on the island, particularly close to the west and north west coasts.

### Laboratory work

11. The Laboratory has set up further sampling points for testing the water content of soil and has initiated a comparative study of neutron measurements of real evapotranspiration and the values obtained by the Prescott formula, as well as beginning work on the calibration of surface probes.

12. Study of ignition losses in soils and kinetic study of the desaturation profile based on the soil at the Laboratory.

13. Calibration of neutron moisture meters on the basis of soils from the Mangoky delta; volumetric calibration of depth probes, on the basis of four soils of differing density.

14. Agricultural entomology. Labelling the larvae of sugar cane locusts by  $^{32}\text{P}$  injection in the cane shoots; labelling of adult earias by  $^{32}\text{P}$  and  $^{35}\text{S}$  injection.

### Field work

15. At Tafaina (a catchment area selected for study by the French Office for Overseas Scientific and Technical Research). Developing a surface probe with scaled-down head for measuring soil water content during rainfall and studying how it varies as a function of run-off. Installing a new tube, 6 m long, in a second run-off test plot with a steep slope. Water profile, recorded twice monthly.

16. At Manankazo. Installation of four tubes, on-the-spot calibration. Water profile recorded (every 15 days during the rainy season). Measurements taken during the dry season; initial tests for determining root activity in pine trees by localized application of  $^{32}\text{P}$  and measurements of leaf radioactivity.

17. In the Mangoky delta (where cotton growing has been introduced on a large scale). Installation of between 50 and 60 tubes completed in December. Analysis of results to obtain partial and total volumetric humidity. Water profiles recorded every 10 days: before irrigation and 48 hours after. Neutron measurements programme during irrigation season.

At Tanandava. Installation of a 310 probe has been set up to study cotton boll shedding as a function of soil water content. The study had to be broken off, as the results were distorted by severe weather.

At Ambilobe (sugar cane cultivations). Installation of a probe. Dry-season measurements on a group of six tubes.

SAUDI ARABIA

In reply to the Director General's invitation to communicate a statement, the Government of Saudi Arabia has informed him that "we are still in the planning stage of atomic energy and we have not yet done any application in this field."

## SWITZERLAND

### Progress Report on the Use of Nuclear Energy in 1967/68

#### ELECTRIC POWER GENERATION

1. Over the year under consideration the Swiss utilities have added a third nuclear power plant to their construction programme, which now stands as follows:

| Power station | Type of reactor   | Electrical capacity (MW) | Start of construction | To be put into operation |
|---------------|-------------------|--------------------------|-----------------------|--------------------------|
| Beznau I      | Pressurized water | 350                      | 1965                  | 1969                     |
| Beznau II     | Pressurized water | 350                      | 1968                  | 1972                     |
| Mühleberg     | Boiling water     | 306                      | 1967                  | 1971                     |

In 1972, these three reactors, which are of the light-water variant, will be able to cover approximately 20% of Swiss electricity consumption.

2. Taking into account four other major projects under study, two of which involve foreign partnership, it can be stated that the Swiss utilities plan to meet future electric power requirements mainly on the basis of nuclear energy. In order to use this to the maximum advantage, they will also embark at a future stage on the construction of hydraulic pumping stations.

#### INDUSTRIAL ACTIVITIES

3. The industrial group which was interested in the development of a heavy-water moderated pressure-tube reactor successfully completed start-up tests on the experimental nuclear power plant at Lucens, and the latter was handed over to one of the electrical companies for operation on 9 May 1968. The operational programme, which is restricted to two years, is aimed at testing the performance of plant components and also provides for some experimental research.

4. The speed-up in plans for nuclear power generation in Switzerland has led this industrial group to discontinue its efforts to develop a heavy-water reactor and to concentrate on the design and manufacture of components for nuclear power plants, the demand for which on both Swiss and international markets is constantly growing. Swiss industry has thus been called upon to furnish an increasingly large part of the equipment for the three nuclear power stations being constructed in Switzerland, in addition to supplying a variety of important components for nuclear power plants abroad, as well as equipment for nuclear research centres. Furthermore, the first orders relating to the design and construction of such plants have been placed with Swiss engineering companies both by Swiss and foreign clients.

5. The project that was being worked on by a large Swiss industrial company for a 400 MW(e) nuclear power station based on a high-temperature reactor is being continued in close collaboration with the joint programme operated by the European Nuclear Energy Agency (ENEA) at Winfrith (Great Britain) under the code-name "Dragon". This project will make it possible to decide within one or two years whether this system offers any clear-cut industrial or commercial advantages and, if so, will provide a basis for plans to build a prototype large power station.

#### REACTOR RESEARCH

6. Pursuant to the decisions previously adopted in the light of the new trend in power generation and industry, a long-term study programme geared towards the development of fast breeder reactors is now under consideration by the Swiss Federal Government; this programme could form part of a programme of international collaboration. As the first phase, a programme of work on a gas-cooled fast reactor has been undertaken by the Federal Institute for Reactor Research at Würenlingen in close collaboration with a large American firm. The results of this study, which also concern the possibility of converting the Lucens reactor into a fast-neutron fuel element irradiation rig, have been passed on to ENEA, which is currently seeking to determine what interest the European countries have in initiating another joint programme. The Institute has also drawn up a research

programme on the possible use of plutonium as a fast reactor fuel, the first stage of which relates to the development and irradiation testing of plutonium carbide fuel.

7. During the past year the Federal Institute for Reactor Research celebrated the tenth anniversary of the start-up of its first facility, the Saphir swimming-pool reactor, and also began operation of a new experimental zero-power reactor designed to measure the reactivity of core components. The Institute's facilities have continued to provide services for research and university teaching, the production of isotopes for medical use, and a variety of other industrial purposes.

#### USE OF RADIATION

8. With regard to the industrial use of radiation, certain progress has again been noted over the period in question, thanks largely to the efforts made by the Swiss Association for Atomic Energy in publicizing information on the matter; establishment, within the private sector of the economy, of a Swiss Centre for Radioisotope and Radiation Technique, with a range of activities covering all aspects of this field, has also been helpful in this respect. With a view to participating in an international programme organized by ENEA, a number of Swiss clock-making, chemical and mechanical-engineering firms interested in the study of nuclear batteries, have joined in an association for this purpose. With regard to the irradiation of food, the federal commission responsible for this matter has endeavoured to implement the research programme that it worked out earlier.

#### PROSPECTION FOR URANIUM DEPOSITS

9. In pursuance of a work programme drawn up by a committee of experts on Swiss uranium deposits, the major indications discovered so far have been subjected to renewed study. In the two mineralization zones examined, detailed surface, geological and radiometric analyses have shown that continued prospection at these two sites by sinking and drilling operations is justified.

## BASIC RESEARCH

10. The Federal Institute of Technology and the cantonal universities continue to contribute actively to basic research in nuclear physics, in conjunction with the Swiss accelerators, and in particle physics, with the CERN accelerators, and also in fields related to nuclear energy. As regards the meson production unit, construction of which was agreed on last year, work on design of the resonance cavities and magnets for the 500 MeV high-intensity proton ring accelerator has produced very encouraging results, on the basis of which it is possible to go ahead with construction of the unit.

## INTERNATIONAL RELATIONS

11. In addition to the bilateral agreements on co-operation between Switzerland and the United States of America, France, Canada and the United Kingdom of Great Britain and Northern Ireland, Switzerland now has agreements with the United States of Brazil and Sweden, although in the case of the latter ratification is still pending.

## VIET-NAM

### Progress in the Peaceful Uses of Atomic Energy

1. The escalation of the war during the past year directly affected our scientific and technical potential. In the nuclear research field, budget and staff reductions seriously curtailed the activities of the Viet-Nameese Atomic Energy Bureau. In spite of that, the Dalat Nuclear Research Centre has been able to carry out a number of research projects of practical value.
2. The Radiobiology Department has concentrated its efforts on studying the radiation sensitivity of rice and the muong bean and investigating soil fertility by means of radioisotopes.
3. The technical and economic aspects of rice preservation by gamma irradiation have been considered, and with the acquisition of a sufficiently powerful gamma radiation source, Viet-Nam hopes to be able to set up a pilot centre in the near future.
4. In the animal biology field, study of the effect of low gamma-radiation doses upon the incubation period of hens' eggs has produced interesting results.
5. With the assistance of the Dalat Pasteur Institute and the Isotopes Laboratory at the Cho Ray Hospital, biological tests have been performed on samples of medically applied iodine-131 and colloidal gold-198, prepared by the Dalat Nuclear Research Centre.
6. Apart from producing these two radioisotopes used for diagnosing thyroid gland and liver diseases, the Radiochemistry Department regularly supplies the Radiobiology Department and the Radioisotopes Laboratory of the Ministry of Agriculture with phosphorus-32 for agricultural research. Methods for preparing sulphur-35, fluorine-18, copper-64 and technetium-99m have also been developed.

7. Activation analysis forms no less an important part of the activities of the Nuclear Research Centre. In 1967 various neutron activation analyses were carried out, such as determining traces of copper and zinc in hevea leaves, arsenic in locally produced soya sauce and so on.
8. In the field of nuclear physics, the question of radionuclide standardization has been of particular interest to the physicists of the Dalat Centre. In collaboration with the Electronics Department, the Physics Department has constructed a Rossi coincidence circuit with a resolving time of 3  $\mu$ sec. The availability of a beta-gamma and gamma-gamma coincidence circuit has made it possible to measure the radioactivity of a number of radionuclides with a simple decay diagram ( $^{198}\text{Au}$ ,  $^{60}\text{Co}$ , etc.).
9. The bibliographical study of nuclear spectroscopy, initially prompted by Dr. Y.Y. Chu, an expert of the IAEA, is progressing satisfactorily, but the intended project for calibrating and standardizing short-lived radionuclides has not yet got under way, for lack of equipment.
10. The mechanism of nuclear reactions has also been studied and certain problems of mathematical physics have been resolved by the Fortran method, using the IBM-1401 computer of the Ministry of Finance, Saigon.
11. In the radiation protection field, apart from the routine monitoring of environmental radioactivity, a dosimetry service using films has been set up for the benefit of all people in the country using atomic radiation sources. Systematic inspection of all public and private bodies using sources of this type was started at the beginning of 1967, and so far 50 institutions have been surveyed and placed under the supervision of the National Commission for Protection against Atomic Radiation.
12. Two booklets written in Viet-Nameese and entitled "The Safe Use of Radioisotopes" and "Recommendations on the Use of X-rays" have been widely distributed by the Atomic Energy Bureau.

13. A two-week course was organized in 1967 to initiate X-ray equipment operators in radiological protection techniques.
14. In the field of nuclear science education, the Atomic Energy Bureau, in collaboration with the Agricultural Research Commission, has organized a training course on the application of radioisotopes and radiation in agriculture.
15. In order to facilitate the spread of nuclear information and education in nuclear sciences, the Atomic Energy Bureau has published a vocabulary of nuclear terms in Viet-Nameese. Furthermore, a French-Viet-Nameese nuclear dictionary is being prepared. These documents will certainly be useful for students intending to read for the Certificate of Nuclear Physics which was recently instituted at the Faculty of Sciences, Saigon.
16. Finally, the popularization of nuclear sciences and techniques continues to hold an important place in our work programme. The Atomic Energy Bureau has continued to publish a large number of popular booklets. Public lectures have been held. In particular, two important lectures followed by the showing of the film "The Nuclear Challenge", kindly placed at our disposal by the IAEA, were given by two IAEA experts; one on International Co-operation in the Peaceful Applications of the Atom (Dr. Ha Vinh Phuong), and the other on Use of Radioisotopes and Radiation in Agricultural Research (Dr. I.G. Valencia).

## YUGOSLAVIA

### Progress in Scientific Research on and Peaceful Applications of Nuclear Energy in 1967/68

#### INTRODUCTION

1. Scientific research in the field of nuclear energy is pursued in six specialized nuclear institutes and in other research laboratories set up at University centres and industrial enterprises. It is being conducted in the fundamental, applied and development branches.
2. Fundamental research embraces physics, chemistry, radiobiology and electronics.
3. Applied research covers the production of radioisotopes and labelled compounds and their application in industry, hydrology, agriculture, forestry, veterinary and human medicine, and in other fields of research.
4. Development research is being pursued on the prospection and exploitation of nuclear raw materials, and the technology of their processing; on problems close to nuclear power, i.e. problems associated with the technology and metallurgy of fuel and fuel elements, reactor heat transfer, reactor physics and electronic equipment for the operation, control and exploitation of nuclear reactors; further, on problems concerning the design, siting and safety of nuclear power stations, the industrial manufacture of some nuclear power plant components and physical and medical protection against ionizing radiations.
5. These scientific activities absorb today 1000 scientists and engineers, of whom 240 have the title of Doctor of Science.

#### FUNDAMENTAL RESEARCH

6. In nuclear physics theoretical and experimental investigations are being conducted in the field of low-energy physics, solid-state physics, physics of ionized gases and quantum electronics. In high-energy physics only theoretical work is being done. In low-energy physics activities are centred around the development of antilinear algebra and the three-body interaction. In beta-gamma spectroscopy past work has enabled commencement of investigations into electrostatic fields and the influence

of the chemical nature of compounds upon the binding energy of electrons, while the study of the technique of perturbed gamma correlations has opened up investigations into the inner structure of garnet-type material and intermetal compounds.

7. In research into nuclear reactions it is worthwhile to point out the results obtained in the understanding of the reactions obtained by bombarding neutron-rich helium isotopes, and the technique of the measurement of short lived isotopes obtained by 14 MeV neutron activation. Further, work has been done on nuclear models; on electromagnetic and beta radiation; on the study of systems with small numbers of nucleons; and on nuclear-nuclear interactions; and in fast neutron physics, particularly on nuclear spectroscopy of the reaction mechanism.

8. In solid-state physics experimental and theoretical investigations have been carried out into the magnetic, ferroelectric, optic, semi-conducting and structural properties of solid bodies (uranium oxides and sulphides, pyrolytic graphite, substances of the  $\text{KH}_2\text{PO}_4$  type). Research has also been done into the diffusion of copper and sodium in germanium and silicon microcrystals, the resonant scattering of gamma radiation, gamma-gamma correlation and Compton scattering.

9. In ion physics research has been done in atomic collision processes in the gaseous and solid stage, and in the dynamics of electric gaseous discharges. An apparatus has been developed for the testing of the process in the 5-50 keV range.

10. In quantum electronics work has been done on laser beams in various environments.

11. Research in nuclear chemistry covered basic research of interest for nuclear technology; study of reactions interesting for the safe handling of nuclear fuels; development of methods for the reprocessing of fuel (including a further advancement of the Purex process); study of the physico-chemical changes under the action of radiation; the fundamental aspects of liquid-liquid extraction; and development of analytical methods of control.

12. In this field modern physico-chemical methods have been developed and work is being done on activation analysis, the chemistry of complex compounds and the development of electro-chemical reduction by the use of a rotating mercury electrode. Theoretical investigations are focused on the study of the electronic structure of complexes and organic systems, as well as on molecular spectroscopy.

13. Research in radiobiology and fundamental biology included the physiological and biochemical changes in the central nervous system under conditions of irradiation; radiation haematology; the effects of radiation upon the genetic regulatory systems; the genetic effects of radiation; the hypophysis-hypothalamus-gonad feed-back; metabolism of the build-up and function of nucleic acids and the effect of radiation on them; and radiation immunology. In addition, radioecological research has been done in the northern part of the Adriatic Sea and in the water-stream of the river Danube.

14. Research in electronics has been conducted to help solve the problems of electronic instruments for nuclear and other investigations, particularly for physics, chemistry and biology. The research has been in three directions:

- (a) Study of the development of equipment and systems using digital electronics for the processing of data obtained by measurements; theoretical and experimental development of digital electronic assemblies, logic and systems;
- (b) Study of the sensitivity of the measuring methods of electronic equipment, particularly in connection with the problems of the construction and operation of nuclear magnetic resonance spectrometers and analysers, problems of the identification of weak signals in the presence of noise, analogue digital conversion and oscillators; and
- (c) Research into measurement methods and the development of high resolution electronic assemblies. The programme includes theoretical and experimental work on assemblies for amplification, filtration, amplitude discrimination and the counting of pulses from the radiation detector, and on the primary processing of pulses for time analysis.

## APPLIED RESEARCH

15. Applied research is being conducted in the production and application of radioisotopes and labelled compounds. Apart from normal production of radioisotopes, which in 1967 amounted to 9400 curies (Ci), contained in 1480 items, work has been done on the further extension of the range produced and on improvement of the quality of the products. Mention may be made of the new products for medical applications - the iodine-labelled compounds hippuran, rose-bengal and serum albumin. The production continued of strong teletherapy radiation sources (2000 Ci Co).

16. The application of radioisotopes increasingly finds its place in industry, hydrology and medicine, while in agriculture radioisotopes are being used more for research purposes in the agricultural institutes.

17. At the Institute for the Application of Nuclear Energy in Agriculture, Veterinary Medicine and Forestry at Zemun, a United Nations Special Fund project (UNSF) entitled "Nuclear Research and Training in Agriculture" has been successfully accomplished. The aim of this project was the improvement of agricultural production by the introduction, development and general application of nuclear research techniques. The executing agencies were the Agency, on behalf of UNSF, and the Federal Nuclear Energy Commission, on behalf of the Yugoslav Government. At present, intensive work on current problems of Yugoslav agriculture is being carried out at the Institute. At the same time wide international collaboration is also being achieved.

## DEVELOPMENT RESEARCH

18. This research concerns problems associated with the development and preparations for the building of a nuclear power system, and with activities on radiation protection. In this field the research centres have developed methods and techniques enabling the direct development and manufacture of some parts of nuclear equipment, materials and power-plant fuel to be launched.

19. Work on the location of nuclear raw materials started in 1948, beginning with uranium prospection in certain types of terrain. Detailed studies have already been completed, as well as regional prospection of an area covering some 50 000 km<sup>2</sup> where investigations have shown that there exist favourable conditions for the occurrence of uranium and for mining exploration.

20. Investigations have revealed a vast number of radioactive anomalies, low-grade uranium deposits and two deposits with uranium concentrations of economic value. The results obtained and the identified amounts of uranium provide a basis for the further conduct of regional prospection over an area covering some 40 000 km<sup>2</sup>, where one can expect that an increase in the raw material resources of economic value will be discovered by further exploration.

21. In the processing of domestic nuclear raw materials research is being conducted on the selection and development of the necessary technological processes, as well as on the production of uranium concentrate, nuclear grade uranium oxide and nuclear grade uranium metal for reactor fuel. Besides, processes are being developed for the production of nuclear grade structural and alloying reactor materials, such as zirconium, niobium and molybdenum.

22. Research is being done on laboratory and pilot-plant scale. The technology of the production of uranium dioxide and uranium metal, the quality of which meets the required standards, has been mastered.

23. In hydrometallurgy good experience has been gained in the application of organic solvents and solid ion-exchangers, reduction and fluorination.

24. In the development of UO<sub>2</sub> fuel elements research has been conducted on powder characterization, elaboration of the method for the chemical activation of powders and sintering, which has enabled the problems associated with the production of these fuels to be solved. Results have been obtained in the field of nuclear, physical and heat transfer testing of fuel elements through the use of a high-pressure out-of-pile reactor loop. Work in this field covers also research on the development of a fuel element assembly and of new methods for the production of ceramic fuel by vibratory compaction. Arrangements have been made for the irradiation of fuel elements in the RA reactor<sup>6/</sup>, while further work on radiation damage will be handled through international co-operation.

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<sup>6/</sup> The 6.5 MW(e) research reactor at the Boris Kidrič Nuclear Institute, Vinča.

25. Research on the characteristics of boiling heavy-water reactors has led to the advancement of reactor calculation methods for use by the designers. Experimental research in heavy-water reactor physics develops under the NPY project<sup>7/</sup>. Experimental facilities have been developed for testing the thermal properties of concrete vessels for these reactors. Activities connected with the development of advanced reactor systems embrace research on heat transfer and nuclear-thermal reactor calculations with integral steam superheat, the development of uranium metal fuels and their use in heavy-water systems, and the development of prospective fuels of the  $UO_2$ - $PuO_2$  type.

26. Research on domestic production of ancillary systems for nuclear power plants has been concerned with liquid radioactive effluents and their decontamination, primary circuit water, radioactive gases and aerosols, and the disposal of radioactive effluents into river-streams.

27. Work on reactor electronics and instrumentation covers the development of the system and components of digital operation, data processing research in fast electronics and the application of unipolar transistors to the construction of isolated gates. Research in reactor electronics has resulted in the development of some specialized equipment for research activities and for use in industry and power development.

28. In connection with radiation protection and nuclear reactor safety the following have been developed: methods and instrumentation for radiation field dosimetry, individual dosimetry, the detection of radioactive gases and aerosols, measurement of the contamination of the biosphere and the processing of radioactive materials; methods for the decontamination of equipment and for internal and external human decontamination; studies of the mechanisms of the action of radiation upon living organisms, and analyses of potential accidents and their effects.

29. The Yugoslav industrial and design organizations carry on research activities to enable domestic industry to build nuclear power plants. Thus, in addition to studies concerning the most feasible power plant types and sizes, attention has been devoted to investigations of the technology

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<sup>7/</sup> This project is the subject of the agreements reproduced in documents INFCIRC/55 and Add.1.

for manufacturing large stainless steel and prestressed concrete reactor vessels, to the development of fuel loading machines, to the development of a control rod system of original design and to the testing of the corrosion of reactor vessels and piping materials. The electricity utility organizations are carrying on economic studies related to the integration of the first nuclear power plant of 400-500 MW(e) into the national grid.

30. The Yugoslav Nuclear Energy Commission maintains connections and co-operation with numerous national atomic energy commissions and the International Atomic Energy Agency, the European Organization for Nuclear Research, etc., and the nuclear institutes do the same with many nuclear centres and other scientific institutions in various countries. Besides, wide exchange of experience and co-operation is being maintained, through participation in numerous international symposia and seminars, the publication and exchange of published scientific papers, the placement of foreign trainees in the nuclear institutes and the joint work of groups of researchers. Joint programmes are being undertaken with some countries, the total cost being shared.

31. The nuclear institutes have the following research facilities and equipment: a 6.5 MW(th) heavy-water research reactor with a  $6.10^{13}$  n/cm<sup>2</sup> sec. neutron flux; a zero-power reactor; a 250-kW TRIGA reactor; a 1.5-MeV Cockcroft-Walton accelerator; a 16-MeV cyclotron; a 2-MeV Van de Graaff generator; a 31-MeV betatron; three neutron generators of 220 keV each; a <sup>60</sup>Co radiation unit of 3500, 100 and 300 Ci; digital and analogue computers and other important equipment.