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PROGRESS IN PEACEFUL APPLICATIONS OF NUCLEAR ENERGY DURING THE YEAR 1967/1968

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BRAZIL

Advances in the peaceful uses of nuclear energy in 1967/68

1. The Government of Brazil, in order to influence the direction of nuclear energy development in the country, has issued guidelines on national nuclear energy policy in which it defines the responsibilities of various bodies in the Federal Administration.

2. As a result of the efforts of the Ministry of Mines and Power, an agreement was reached between the National Nuclear Energy Commission (CNEN) and Electrobrás concerning the design and utilization of nuclear plants for the production of electric power. These two bodies have already started work on implementing the Government's decision to build a 500-MW(e) power reactor in the Central South Region. This represents the first step in a programme which provides for the construction and operation of other nuclear power plants as well.

3. CNEN's budget for 1968 rose by 84% from 13 215 700 to 27 267 000 cruzeiros, thereby affording an opportunity, as fas as physical facilities are concerned, for the concentration of all of CNEN's sections in a building of its own, and also for the construction of the chemical engineering buildings of the Atomic Energy Institute of São Paulo, the administration building and auditorium of the Nuclear Engineering Institute on Fundão Island and a building for the Thorium Group of the Belo Horizonte Institute of Research on Radioactivity. It is also worth mentioning that CNEN's budget for 1969 will be more than twice as large as that approved for 1968.

4. With these financial resources at its disposal, CNEN can, as part of its many activities relating to exploration for uranium, contract for aerial prospection services along the western edge of the Piauí-Maranhão basin, covering an area of 37 000 km^2 and including part of the States of Goiás, Maranhão and Pará. It will also be able to set up a North-East District, with headquarters at Fortalieza, for the purpose of carrying on prospection for uranium in the Piauí-Maranhão basin, and to start work on opening up a mine gallery in Poços de Caldas. This will be the first such gallery in Brazil and is intended for use in the extraction of ore on a pilot scale. The purpose of this work is to use Brazilian technical resources in the exploration of the uranium ore found.

5. This upsurge in and expansion of CNEN's activities have not been limited to first priority activities: the work of the Centre for Nuclear Energy Applications in Agriculture (which is part of the Luiz de Queiróz Advanced School of Agriculture) has now been integrated with the national nuclear energy programme. Preparations have nearly been completed for a similar arrangement with the Biophysics Institute of the Federal University of Rio de Janeiro, in the interest of an intensification of health physics work.

6. CNEN is organizing a joint corporation, known as COMAMBRA, for the purpose of exploring the country's nuclear ore resources. This organization will combine the present Monazite Production Administration and the existing Brazilian plants engaged in the extraction and working of monazite sands.

7. A research programme which is now being developed involves an expansion of work on nuclear physics, reactor physics, nuclear chemistry, nuclear materials, nuclear medicine and radioisotope applications.

8. As a result of the unremitting efforts of the Brazilian Government in dealing with problems of nuclear energy development, Brazil has won international recognition, as evidenced not only by the mutual assistance agreements which it has concluded with other countries, but also by the assistance which it has received for research and training. In 1967, it was a major recipient of Agency assistance, representing a value of US $185 000. Among the projects benefiting from the Agency's technical assistance, mention should be made of the work of a group of experts selected by the Agency who, in collaboration with engineers from Electrobrás and CNEN, have carried out studies relating to the incorporation of nuclear power plants into the country's electrical power systems, especially in the Central South Region.

GERMANY, FEDERAL REPUBLIC OF

Progress Report on the Applications of Nuclear Energy in 1967/68

THIRD GERMAN ATOMIC ENERGY PROGRAMME

1. The period covered by the Second German Atomic Energy Programme (1963 to 1967) ended in 1967. After detailed discussions the responsible government authorities, German scientists and industry jointly worked out the follow-up programme covering the years 1968 to 1972. On 13 December 1967 the Federal Cabinet approved the Third German Atomic Energy Programme. Thus, for the first time and in contrast to its predecessors, this is a government programme. It is attuned to the Government's medium-term financial planning and provides funds totalling DM 5000 million. About 50% of these funds are to be allocated for nuclear research and about 50% for nuclear development.

2. In the Third German Atomic Energy Programme the main emphasis is placed on high-energy physics and nuclear solid-state research in the field of fundamental research, on gas-cooled high-temperature reactors and fast breeder reactors in the field of nuclear engineering and on mastering of the technology of the fuel cycle. The work of the large nuclear research centres and international co-operation are of special importance for the realization of the programme.

FURTHER INCREASE IN THE FEDERAL REPUBLIC'S FUNDS FOR THE ADVANCEMENT OF THE NUCLEAR ENERGY SECTOR IN 1968

3. In 1968 the Federal Government will allocate approximately DM 860 million for the advancement of nuclear research and development; this means an increase of 11% as compared to the previous year. These funds will be spent as follows:

(a) 32% on nuclear development, including the construction and operation of large experimental nuclear facilities, outside the nuclear research centres;

(b) 28% on the nuclear research centres;

(c) 28% on international co-operation;

(d) 10% on nuclear research at the universities and at institutes outside the universities; and

(e) 2% on radiation protection and reactor safety.

4. Of the DM 860 million, DM 660 million i.e. more than three quarters of the Federal Funds, will come from the budget of the Federal Ministry for Scientific Research. In addition to the Federal Funds, another DM 200 million will be made available by the Laender. Thus in 1968 government funds amounting to approximately DM 1060 million will be allocated for the advancement of nuclear research and development.

INCREASED EXPERIENCE AND ACHIEVEMENTS OF THE REACTOR INDUSTRY IN THE FEDERAL REPUBLIC

5. On 1 July 1968 nuclear power stations with a net electrical output of altogether 2200 MW(e) were in operation or under construction in the Federal Republic. In 1967 electric power generation from nuclear energy reached a total of 1200 million kWh, which was five times as much as the amount generated in 1966.

6. At the beginning of 1968 the Argentine National Nuclear Energy Commission placed an order with a German firm for the construction of a nuclear power station with a natural uranium pressurized heavy-water reactor of an electric output of 320 MW(e). The site chosen for the station is Atucha, approximately 100 km north-west of Buenos Aires. This is the first export order for a nuclear power station constructed in the Federal Republic. The plant will be the first nuclear power station in South America.

7. At Würgassen and Stade in North-West Germany, construction work has started on the two large commercial light-water nuclear power stations, the building of which was decided on in 1967.

8. Of the three nuclear power demonstration plants of the light-water type at Gundremmingen, Lingen and Obrigheim respectively, the reactor at Gundremmingen, on the Donau, has been in operation since 1967. The second plant at Lingen, on the Ems, went critical early in 1968 and reached its full electric power output on 13 July. The third demonstration plant at Obrigheim, on the Neckar, is to reach criticality for the first time before the end of this year.

9. Since the construction orders for the two large nuclear power stations in North-West Germany were issued, the preparations of the German utility companies for ordering additional plants have made good progress. In mid-1968 the largest German power supply company announced that within the foreseeable future it intended to start on the construction of a light-water nuclear power station, with a power output of more than 1000 MW(e), to be situated in South-West Germany. In addition to generating electricity, the plant is to produce process steam for the chemical industry. A similar project to be located in the Ruhr district is under discussion.

10. Progress has also been made in the field of gas-cooled high-temperature reactors; the AVR reactor at Jülich, near Köln, has gone into full operation. It has spherical fuel elements and reaches an electric power output of 15 MW(e).

11. The development and designing of the THTR thorium high-temperature reactor of the pebble-bed type, with an electrical output of 300 MW(e), conducted co-operatively by the European Atomic Energy Community (EURATOM), a German industrial firm and the Jülich nuclear research establishment, was completed with the presentation of the designers' plans as approved. It is expected that, with Government support, German utility companies will decide within a few months to build this prototype plant.

12. Early in 1968 a decision was taken for the construction of a 25 MW(e) experimental nuclear power station with a high-temperature reactor containing prismatic fuel elements, and a helium turbine in a direct cycle. The plant is to be located near Geesthacht in Schleswig-Holstein. The final objective of German high-temperature reactor development is the construction of commercial nuclear power stations with helium turbines.

13. In the field of fast breeder reactors, the Karlsruhe nuclear research centre and German industrial firms continue their joint research and development work on a 300 MW(e) prototype plant.

14. The building for the KNK compact sodium-cooled nuclear power station at Karlsruhe, which is to serve as a test bed for breeder reactor elements and for testing sodium technology, has been completed, and assembly of the

reactor plant is progressing. The plant is scheduled to go into operation in 1969. The construction of the HDR superheated-steam reactor at Grosswelzheim on the Main is nearing completion, so that this plant too can go into operation next year.

15. At the end of 1967 the nuclear ship "Otto Hahn" went on her first trial cruise using a conventional auxiliary propulsion system. On land, the reactor, which is to be built into this bulk carrier reached criticality for the first time. At present the reactor is being installed. The first "nuclear cruise" of the "Otto Hahn" is scheduled for the end of 1968.

16. In early 1968 the Federal Ministry for Scientific Research placed an order with German industrial firms for the development and design of an in-core thermionic reactor with an approximate output of 50 kW(e). The reactor is intended to supply electric power for satellites.

ADDITIONAL ACTIVITIES CONNECTED WITH THE SUPPLY OF NATURAL URANIUM AND WITH MASTERING THE TECHNOLOGY OF THE FUEL CYCLE

17. During the period under report, firms of the metal and mining industry founded the Urangesellschaft mbH & Co. KG at Frankfurt on the Main and the Uranerzbergbaugesellschaft at Bentheim. The two companies will engage in the prospection, mining and refining of uranium ores. Business connections with foreign countries have been established.

18. The building for the first German reprocessing plant for irradiated nuclear fuel elements at Karlsruhe has been completed and its equipment is at present being installed. The plant is scheduled for operation in 1969.

19. In co-operation with the Karlsruhe nuclear research centre, German industry has taken up development work for an industrial plant which is to manufacture fuel elements containing plutonium, especially for fast breeder reactors.

20. In the Asse salt mine near Wolfenbüttel in North-West Germany another batch of low-activity radioactive wastes has been given trial storage by the Gesellschaft für Strahlenforschung mbH.

FURTHER INSTALLATIONS FOR NUCLEAR RESEARCH

21. For the extension of the German electron synchrotron DESY at Hamburg, having a maximum energy output of 6.5 GeV, the installation of a new injection linear accelerator was begun. To supplement this installation, electron-positron storage rings (3 GeV) are being planned.

22. At the Jülich nuclear research centre an isochron cyclotron for the acceleration of deuterons with variable energies (45 and 90 MeV) was put into service. Another accelerator of the same type but with lower energy is at present being erected at Bonn University.

23. For the preparation of research work using heavy ions in the fields of low-energy nuclear physics and of nuclear chemistry, a working group at Heidelberg University is continuing the development of a heavy-ion accelerator.

24. On 30 June 1968, 17 research reactors and 10 small training reactors were in operation in the Federal Republic. As for the larger research reactors, it was possible to increase the power output of the DIDO research reactor in the Jülich nuclear research establishment by 50% to 15 MW(th), and that of the FRG 1 reactor at Geesthacht near Hamburg from 5 to 15 MW(th).

25. The measuring reactor of the Physikalisch-Technische Bundesanstalt at Braunschweig reached criticality for the first time in the second half of 1967. Two impulse reactors have been ordered for medical and radiobiological research activities.

USE OF LARGE-SCALE RADIATION SOURCES

26. In order to carry out radiochemical research activities, the Technical University at München has been equipped with a ^{60}Co large-scale radiation source with an activity of 10 kilocuries (kCi).

27. As an experiment an industrial firm has started to use a new ^{60}Co large-scale radiation source, with an activity of 90 kCi, for the sterilization of medical instruments.

INTERNATIONAL CO-OPERATION

28. The close scientific and technological co-operation within EURATOM has been continued. The intensive co-operation in the field of high-energy physics within the European Organization for Nuclear Research (CERN) has also been pursued.

29. Following the agreements for co-operation in the development of sodium-cooled fast breeder reactors concluded between the Governments of the Federal Republic, Belgium and the Netherlands, a contract for collaboration in the construction of a 300 MW(e) prototype nuclear power station has now been signed by the participating industrial companies of the three countries. The power utility companies of the three countries have started discussions concerning the selection of a site.

30. Preliminary planning for the bilateral German-French Max von Laue - Paul Langevin-Institute at Grenoble, which is to be equipped with a very-high-flux reactor for research work, has been concluded. The preliminary project comprises all the results obtained so far with respect to planning and development for the construction of the reactor. It will serve as a working document for the invitations to tender which will now be issued to German and French industrial firms.

NEW ZEALAND

Peaceful Applications of Nuclear Energy: 1967/1968

NUCLEAR POWER

1. The planned introduction of nuclear power into New Zealand is still envisaged for about 1977. A unit rating of approximately 250 MW is considered to be appropriate for the New Zealand system as it will be at that time, with three similar units following at yearly intervals. Larger units will be acceptable for later stations, thus giving the acknowledged advantages of scale.

2. The report of the Planning Committee on Electric Power Development in New Zealand, which incorporates the above statement, points out also that if present investigations prove that large-scale reserves of natural gas are present in or around New Zealand, this could have an effect on the programme for the introduction of nuclear power. In the meantime, however, preparations for nuclear power generation are continuing as planned.

3. Site investigations in the Kaipara Harbour area in the upper North Island are continuing, adequate cooling water is available and the results of foundation investigations appear reasonable. This is the most favoured site, near the load centre of Auckland City, where there is a high demand.

4. Other aspects of the introduction of nuclear power which have been receiving attention are the establishment of safety criteria and consideration of licensing arrangements.

CENTRAL AUTHORITY

5. The New Zealand Atomic Energy Committee, responsible for advising the Government on these matters, has completed and presented to the Government its recommendations on the future organization and role of a central authority, to deal with nuclear matters in general and licensing and inspection of power reactors in particular.

6. Training programmes for specialized personnel continue, though difficulties are still being encountered in obtaining the type of personnel with the required background and experience.

HEALTH AND SAFETY CRITERIA

7. The Department of Health, through its National Radiation Laboratory, has spent a considerable time in the period under review assisting with the preparation of safety criteria for the siting of power reactors. This Laboratory has also statutory obligations in relation to the importation, distribution, installation, operation or use of radioactive substances or radiation producing devices. It issues required licences to specific personnel, whether they be employed within industry, government departments or the hospitals and medical profession. The Laboratory provides a free film badge service for the whole country, and it is the agency through which all radioactive sources are imported into the country. It maintains a register of the location and usage of such substances and radiation producing devices, also carrying out inspections at regular intervals.

8. The monitoring by the Laboratory staff of occupational radiation exposures of workers in the field totals 3091, of which 1262 are continuously monitored and 1829 workers are periodically monitored. As well as the supply of therapeutic applicators, primary X-ray standards are maintained, calibrations made, advisory services provided, educational and specialized training courses given and a research and development programme undertaken. Environmental radioactivity measurements, involving the measurement of radioactivity in air, rain and milk, is undertaken on a continuous basis and the results published in a quarterly report. Nuclear testing in the Pacific has added considerably to this work.

CENTRAL NUCLEAR LABORATORIES

9. The Institute of Nuclear Sciences in the Department of Scientific and Industrial Research has extended its programme of work in a number of fields, but principally in the use of the 3-MeV Van de Graaff accelerator and in radiation chemistry.

10. More effort is to be put into the application of radioisotopes and radiation in the industrial field. The demand for this type of work is growing and in most cases the requirement is beyond the facilities available in industry itself.

11. A recent development produced excellent results as a particle and fibre abrasion tester. A radioactive stainless-steel Waring Blender blade has been used to develop a reliable abrasion test method. This has been used on wood fibre and clay fillers used in paper making. A good correlation has been obtained between abrasion values using this method and experimental paper cutting tests. The method has been shown to be more reliable and of wider application than the Valley Abrasion tests at present used in the paper industry.

12. As well as the normal nuclear physics experiments and studies, the accelerator has also been used to produce neutrons via the (d,t) reaction, the resultant neutrons being used to study neutron-induced reactions. In this way the reaction $^{82}Se(n,p)\ ^{82}As$ has been used to study some of the properties of ^{82}As. The $^{12}C(d,n)\ ^{13}N$ reaction was successfully used to produce sufficient amounts of ^{13}N. This isotope has been used by plant physiologists for investigating the uptake of nitrogen by trees.

13. Radiation chemistry work, both basic and applied, is beginning to open up in new avenues. Work on the reactions of peroxy radicals has continued. Several methods of identifying the acid formed during the gamma-radiolysis of oxygen-saturated solutions of methanol in water are being tried. The most promising method appears to be isotope dilution using ^{14}C-labelled methanol.

14. Experiments with a crosslinking agent and tallow, gamma irradiated, have produced a product which does not melt at 200°C (normal melting point 40°C). The mechanism of this reaction is at present under study.

15. Irradiation studies have commenced in an endeavour to extend the shelf life of Tamarillos (a New Zealand fruit). Various seeds for growth rate experiments and commercial preparations of enzyme catalase have been irradiated to inactivate viruses. Methyl methacrylate has been irradiated, testing its suitability as a stable dosimeter for electron beam irradiations in the megarad range.

16. Hydrology studies continue. Rain water samples from Malaysia and Thailand are being measured for tritium content. This is being undertaken at the request of the Agency. Ocean circulation studies are being maintained and measurements of ^{14}C in atmospheric CO_2 and in sea water bicarbonate continue.

FORESTRY RESEARCH

17. The Forest Research Institute is actively using radioisotopes in tree nutrition studies, tree physiology, forest pathology and for the study of weed control in forest nurseries.

DAIRY RESEARCH

18. The New Zealand Dairy Research Institute in the main uses ^{14}C for research on the metabolic activities of micro-organisms or the biosynthesis of milk components. Being on the same campus as Massey University and the Veterinary School, with the Plant Chemistry and Grasslands Division of the Department of Scientific and Industrial Research nearby, enables the various organizations and departments to assist each other in the maximum utilization of new knowledge and facilities available.

AGRICULTURAL RESEARCH

19. The Department of Agriculture and the Scientific and Industrial Research Laboratories are calling into use more radioisotopes as tracers in various animal studies and to solve nutritional and soil problems.

20. Nutritional studies in fruit research, plant chemistry, nitrogen fixation in soil, the use of radioisotopes in entomology and similar problems which affect New Zealand's primary industries are receiving more attention.

21. Special courses on radiation biology have been commenced for veterinary science students, and there is a stonger tendency for co-operative research between organizations that are in the position of being able to interchange limited manpower and equipment to greater advantage.

22. Cell biology is receiving more attention at the universities. Radiophysics and radiochemistry are being strengthened.

TRAINING

23. Most New Zealand universities provide seminars, training and research in nuclear physics, isotope or radiation chemistry and engineering. The Electrical Engineering Department of the Canterbury University has, as part of its equipment, a sub-critical nuclear assembly, which is used for the training of students studying various nuclear topics.

24. Although the nuclear laboratory of the Department is not equipped to support research, equipment is assembled to aid research where this does not interfere with the primary training role of the laboratory.

25. A current research project is aimed at the full simulation of various types of reactor on the Department's hybrid (analogue plus digital) computer, to permit investigations into instrumentation and control of these various reactor types.

MEDICAL

26. Our Medical School, in addition to training research students in isotope techniques and providing experience in the handling of radioactive substances, concentrates, in the Department of Bio-chemistry, on three main fields of work: the mechanism and replication of deoxyribonucleic acid (DNA) in micro-organisms and in bacteriophage; studies of the nucleotide sequences in the DNA of bacteriophage; and studies of the metabolism of carbohydrates and sugar alcohols by micro-organisms.

27. More therapy units have been installed or replaced in the major hospitals in New Zealand. In general the medical diagnosis and therapy facilities are of a very high standard.

28. Because of the geographical location, some of our hospitals are probably the most distant users of radioisotopes in the world, considered in relation to their distance from the usual commercial suppliers. All our hospitals, laboratory research workers and the industrial application field suffer from the lack of easily obtained short-lived radioisotopes. If current proposals for a research reactor are proceeded with, this will help overcome the situation felt, in the main, most severely in the medical field.

PAKISTAN

INTRODUCTION

1. The Pakistan Atomic Energy Commission is charged with the development of the nuclear power programme and the application of radioisotopes and radiation in medicine, agriculture and industry. It has pioneered the application of newly developed techniques of nuclear radiation and radioactive isotopes in medicine, agriculture, industry and research. The highlights of PAEC achievements in different fields are given below.

NUCLEAR POWER

2. Construction is under way of a 137-MW(e) nuclear power station at Karachi. Work is on schedule and the plant is expected to become operative in 1970.

3. The establishment of another nuclear power plant at Rooppur in East Pakistan is also being planned. It is proposed to have two units of 200 MW each, with the first expected to go into operation in 1974 and the second during the Fifth Plan period 1975-80.

AGRICULTURE

4. Important development work in agriculture is being carried out at the Atomic Energy Agricultural Research Centre, Tandojam, and at the Atomic Energy Centre, Dacca. Improved varieties of certain food and cash crops have been evolved. Efficiency of fertilizer applications has also been studied and practical recommendations made.

5. Two institutes for work on pest control and preservation of food by the use of radiation are being planned for the two wings of the country. These institutes (named IPCORI) are being established for disinfestation of stored food grains, pasteurization of fresh fruits and perishable foods and sterilization of medical supplies.

6. On the basis of encouraging results obtained by PAEC scientists in the evolution of new and better strains of jute, cotton, wheat and rice by gamma irradiation, it has been decided to establish two institutes

exclusively for work on genetics and plant breeding, one at Lyallpur in West Pakistan and the other at Mymensingh in East Pakistan. The Lyallpur Institute is almost complete, while the Mymensingh unit is rapidly coming up.

HEALTH

7. Atomic Energy Medical Centres using radioisotopes and radiation in diagnosis and therapy are in operation at Karachi, Dacca, Lahore and Jamshoro. The Centre at Multan is expected to go into operation very shortly. Two more Centres are under construction at Chittagong and Rajshahi.

8. The Medical Centres have proved of great help in the effective diagnosis and treatment of a number of malignant diseases like cancer and leukaemia. So far more than 14 000 patients have received radioisotope treatment at these Centres.

INDUSTRY

9. Many useful gadgets and instruments for scientific and general use have been designed and fabricated on a laboratory scale in the Atomic Energy Centres at Lahore and Dacca. The instruments have wide application in research, while some of the gadgets, consisting of electronic traffic-flow analyser controls of traffic signals, seed counting machines, etc., can be of great practical use.

10. Application of radioisotope techniques to hydrology and industrial problems is also under development. PAEC is collaborating with the Karachi Port Trust in undertaking a systematic survey of the silt movement near the harbour using radioisotope tracers. In East Pakistan, the Water and Power Development Authority has been assisted in investigations on underground water movement.

11. The Lahore Atomic Energy Centre has also initiated work on harnessing solar energy for such small-scale but important uses as rural lighting, running low-power irrigation pumps in villages and small, family-size solar stills to convert brackish or saline water into fresh water.

RESEARCH AND DEVELOPMENT

12. In order to support the practical applications of atomic energy, considerable research effort is also necessary. Accordingly, a national multi-discipline institute for advanced studies is nearing completion in Islamabad. This is the Pakistan Institute of Nuclear Science and Technology (PINSTECH) whose principal facility is a 5-MW swimming-pool type reactor. Apart from being the first and only research complex of its kind in the country, PINSTECH has also started production of certain short-lived radioisotopes for consumption in the country.

13. The Atomic Energy Centres at Lahore and Dacca are also engaged in fundamental and applied research in atomic energy and allied fields.

SEARCH FOR NUCLEAR MINERALS

14. For making our nuclear power programme self-sufficient, it is essential to exploit local deposits of uranium and other nuclear minerals. The geologists of PAEC have discovered radioactive and heavy minerals in sizeable quantities in certain areas. The chemical and economic evaluation of the ores is in progress.

ADVANCED TRAINING

15. Realizing the importance of trained manpower for the success of any new development activity, PAEC had started its training programme from the very beginning. This foresight has paid rich dividends and PAEC has now on its rolls nearly five hundred qualified scientists, engineers and other technical persons whose services will be fully utilized in a number of new projects and plants under execution.

SOUTH AFRICA

Nuclear Activities in 1967/68

INTRODUCTION

1. The general theme of the South African nuclear research programme and the facilities established for its execution were set out in a similar document for the eleventh session of the General Conference in 1967[1]. What follows here is therefore a brief summary of advances and developments which have taken place during the past twelve months.

NUCLEAR POWER

2. After a study lasting some two-and-a-half years the report on the introduction of nuclear power in South Africa, prepared by the Atomic Energy Board working closely with the Electricity Supply Commission and various appropriate government departments, has been completed. The main conclusion reached was that nuclear power would be economically competitive in the Republic during the first years if a station with an output of between 200 and 350 MW were to be put into service in the Western Cape between 1978 and 1980.

3. The most suitable natural-uranium type for local conditions is at present considered to be one using heavy water as moderator and coolant. Since South Africa has no uranium enrichment plant, only those types of reactor fuelled with natural uranium were considered. South African industry should be able to supply up to two thirds of the material and equipment required for the first nuclear power station. The possible use of nuclear power for the desalination of seawater was also studied, but it was concluded that there was no region in South Africa where fresh water produced in this way could compete in price with natural water for many years to come.

1/ GC(XI)/INF/97/Rev.1, Statement H.

NUCLEAR MATERIALS

4. The Bufflex process for the production of high-grade concentrates from uranium ore, which was successfully developed a year or more ago and which is now being exploited on a commercial scale, entailed an ion-exchange step followed by solvent extraction. A further refinement known as the Purlex process is the elimination of the ion-exchange stage, and this is a project which has made great strides. The pilot plant is operating successfully and various operating conditions are being investigated, while an on-stream method of uranium analysis has been devised which, linked to a controller, provides fully automatic control of the extraction section.

5. The earlier studies of UO_2 and UF_4 production have had gratifying results and the latter project is now virtually at an end. Complete conversion of UO_2 and UF_4 at production rates of up to 40 lbs/hour has been obtained and the product has been shown to be suitable for conversion to UF_6 of nuclear grade with the possible exception of the molybdenum content. The pilot plant to study the Fluorox process for the manufacture of UF_6 from UF_4 using oxygen instead of fluorine as the reactant has now been completed.

6. The uranium metal plant - a pilot plant which has been on a production basis to produce fuel rods for a university sub-critical assembly - has also now completed its task. Various materials studies are in progress; they include the production of high-strength zirconium alloys and the development of ceramic fuels using relatively large sol-gel spheres and uranium carbide. The construction of a sodium mass-transfer loop is well advanced, and other work on sodium involves corrosion studies for which a high-temperature sodium facility incorporating the supply of ultra-high-purity argon is under construction. The local design, manufacture and commissioning of fuel capsule irradiation loops is a notable demonstration of the increasing sophistication of South African capabilities in relation to the nuclear industry.

7. The fascinating world of ultra-low-temperature metallurgy has now become accessible in South Africa with the construction of a liquid helium cryogenic loop, costing some $150 000, for the study of irradiation behaviour. Installation of the loop in the research reactor SAFARI 1, is currently being undertaken.

REACTOR PHYSICS

8. The critical assembly PELINDUNA-ZERO achieved criticality shortly before the end of 1967. As previously indicated this assembly will be used for reactor physics studies[2], and computer programmes have been written for the investigations being carried out with it and also with the sub-critical assembly which has now been modified and improved.

RADIATION STUDIES

9. A very much expanded field of research into gamma radiation effects has been opened up by the acquisition of an 18 000-curie radiation source. Hitherto work has been carried out with a 500-curie "hot spot".

RADIOISOTOPE PRODUCTION

10. The rate of radioisotope production has been doubled during recent months and it is now possible to undertake the chemical processing of certain isotopes, in addition to the production of a wide range of radio-elements in the reactor. A further improvement in efficiency is being achieved by the direct coupling of the production facility building to the reactor by rabbit tubes, thus eliminating the manual transfer of materials between buildings.

HEALTH AND SAFETY

11. Activities relating to the safe handling of radioactive substances have resulted in the complete revision of the previous regulations for the use of these materials and the issue of a new code which is more practical in the light of current knowledge and practice. Studies of nuclear weapons fall-out in human bone structure have been intensified on account of the observed increase in fall-out. Fuller international collaboration in the Southern Hemisphere in these studies is being actively promoted and the results are being made available to international organizations.

REACTOR POWER

12. The additional plant and equipment needed to raise the thermal power of the reactor SAFARI 1 from 6 2/3 MW to the design figure of 20 MW has been installed and commissioned. The much intensified neutron flux will contribute greatly to the materials testing programme and also further speed the production of radioisotopes.

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[2] Ibid., page 30, left-hand column.

NUCLEAR PHYSICS

13. Apart from the continuation of work on the inelastic scattering of neutrons (on which an increasing number of publications will shortly appear), a great deal of effort culminated in the successful completion and commissioning of the second new terminal for the 3-MeV Van de Graaff accelerator at Pelindaba. Now operating smoothly, this terminal utilizes a pulse of one nanosecond at the different repetitive frequencies of 1, 3 or 9 megacycles per second, and permits improved energy resolution or alternatively increased productivity at the same energy resolution.

14. 1968 is effectively the last year of South Africa's second five-year programme of nuclear research. During these ten years the flow of results of value and interest to research workers in other lands has become progressively greater, and with the Republic poised to introduce a nuclear power programme, the years ahead offer wide scope for mutually beneficial co-operation in the application of nuclear energy between South Africa and her neighbours, especially the developing nations on the African continent.

SPAIN

Programmes put into Effect in the Peaceful Uses of Nuclear Energy 1967/68

GENERAL

1. During the period under review, the Junta de Energía Nuclear (Nuclear Energy Board - JEN) has made major progress in research and development programmes on the peaceful uses of nuclear energy, and private undertakings have likewise continued their work, now at a very advanced stage, on installations relating to the operation of several nuclear power stations.

FUEL CYCLE

Prospecting

2. Intensive efforts have been made to assess the potential of sedimentary formations of continental origin, chiefly Tertiary, and, in addition to these, Permotriassic and Lower Cretaceous outcrops. Scintillation equipment for aerial prospecting has been developed, and technical personnel have had to be trained to operate it. This has been carried out in collaboration with the Argentine Atomic Energy Commission. The new technique will be used to make a preliminary selection of sites in regions of the sedimentary type, which extend over large areas.

Mining

3. The amount of uranium ore mined was 115 600 m^3. At the end of the period under review the uranium reserves were estimated to be as follows: at prices less than 10 \$/lb, 10 000 t of U_3O_8, classed as confirmed; in the price range 10-15 \$/lb, 3600 t of U_3O_8 classed as confirmed, together with 27 000 t of additional resources; in the price range 15-30 \$/lb, respectively 13 500 and 225 000 t of U_3O_8.

Ore processing

4. The study of bacterial leaching and uranium extraction using quaternary ammonium bases has continued, and the degradation of monazite sands for solubilizing uranium, thorium and rare earths has been investigated. Comparative tests have been made on a variety of leaching techniques and equipment, and there has been work on the chemistry of uranium extraction and re-extraction, recovery of uranium by ion exchange resins, and other related topics.

General Hernández Vidal uranium plant (Andújar)

5. This plant has continued to produce uranium concentrates at a rated output of 60 t of U_3O_8 per year, processing about 200 t of ore daily. The factory is situated in the province of Jaén, close to the ore deposits, and has been operating normally since 1959.

New uranium plant at Ciudad Rodrigo (Salamanca)

6. The Cabinet has recently given authorization for the establishment of this new plant, which will be able to process 1000 t of ore per day. The design, together with the preliminary technological trials, has been carried out by JEN at the Juan Vigon Centre in Madrid.

Fuel element fabrication

7. Prototypes of multiple-rod fuel elements based on natural UO_2 pellets, canned in aluminium and sintered aluminium powder (SAP), have been manufactured; the purpose of these fuels is to produce ^{239}Pu, which can then be used to start metallurgical studies of plutonium-bearing materials.

8. An investigation has also been carried out on the possibility of fabricating fuel elements from uranium recovered during reprocessing of depleted fuel from the JEN-1 reactor, so that an enrichment of approximately 15% can be maintained. There are now special welding techniques and instruments available for a precision study of deformation due to thermal recycling, radiation effects, or burn-up.

Irradiated fuel reprocessing

9. The M-1 plant, designed and built entirely by JEN engineers, has gone into service. It commenced operations with the reprocessing of JEN-1 reactor fuel, in which the ^{235}U is 20% depleted.

10. After the elements have been dismantled in the 1000-curie (Ci) hot cell, the can and fuel are dissolved in an acid medium; the solution is then put through an initial decontamination cycle with solvents, after which the uranium and plutonium are separated, and then repurified with further solvents. The maximum capacity of this reprocessing plant is 550 g of uranium per day.

Radioactive waste disposal plant

11. The CIES pilot plant for the decontamination and disposal of radioactive wastes is also now in service. The operations involved are ion exchange, evaporation and solidification. The plant contains a storage cell for high- and intermediate-level wastes, and the processing of the medium-level wastes includes evaporation and incorporation in asphalt for purposes of final disposal.

NUCLEAR REACTORS

JEN-1 and JEN-2 reactors

12. The JEN-1 reactor has been used for research in criticality, control rod calibration, neutron flux determination, raising the power, and so on. The relevant studies have also been made in connection with the proper functioning of the JEN-2 reactor. Reactor safety has been a subject of particular attention.

CORAL-1 experimental fast reactor

13. This zero-power reactor, the design, planning and instrumentation of which have been effected entirely by JEN, achieved criticality in March of this year. It consists of a core with 21 kg of uranium 93.5% enriched in ^{235}U, surrounded by a natural uranium reflector with no moderator. The core-reflector assembly is arranged in two halves, one of which lies on a moving carriage; the system is set in operation when the two halves are brought together.

14. The purpose of this reactor is to make a fast neutron source available for studying fast multiplicative structures, and also to gain experience in measuring fast neutrons.

RADIOACTIVE ISOTOPES

15. JEN has devoted considerable effort to the study of the production and use of radioisotopes and labelled compounds. In 1967, 2248 shipments were made, representing a total of 557.3 Ci, the bulk of which was produced by JEN. There are at present 446 users in Spain, and the number is on the increase.

16. Among the uses of isotopes promoted by JEN, mention should be made of the calculation of the flow rates of a number of rivers, the study of leakage from reservoirs, and research in plant physiology. JEN also operates the Náyade irradiation unit, which has a cobalt-60 source of 6900 Ci and is used to study the irradiation preservation of foodstuffs such as potatoes, lemons, and fruit juices.

MEDICINE AND RADIOLOGICAL PROTECTION

17. A great deal of experience has been gained in this field since the American air disaster at Palomares.

18. The JEN has acquired a whole-body counter and automatic batteries of counters for gross alpha measurements, with which it is possible to handle a large number of samples simultaneously.

19. In addition to routine monitoring activities, there has been research that will facilitate a more thorough understanding of environmental radioactivity and decontamination.

BASIC RESEARCH

20. JEN takes a keen interest in basic research, which it has performed to a large extent independently, but also on the basis of contracts with a number of Spanish universities; between 10 and 15% of the total budget is devoted to these activities.

21. In the field of physics, mention should be made of studies on elementary particle theory with particular emphasis on problems of higher symmetries and weak interactions; the propagation of pulsed neutrons in multiplicative and non-multiplicative systems; nuclear spectrometry of alpha, beta and gamma radiation; research on nuclear levels; absolute measurement of radioisotope activities; and experimental high-energy physics by analysis of bubble chamber photographs. A large part of this experimental work is being conducted in collaboration with CERN.

22. In the field of chemistry, mention should be made of radiochemical separation techniques, chemical behaviour of tracers, activation analysis with neutrons and charged particles, radiation chemistry, and the separation of stable isotopes by ion exchange chromatography.

23. In metallurgy, work has been done on the properties of solids at high temperatures and the effect of radiation on metals.

24. In biology, mention should be made of molecular changes in the replication of DNA in normal processes, the action of nucleic acids on DNA synthesis in higher organisms, and study of the biological effects of low and very low doses of natural radiation.

TRAINING

25. The Institute of Nuclear Studies, a subsidiary organization of JEN, has continued to give a regular course in nuclear engineering for advanced graduates. It has also organized courses on the application of isotopes in industry, medicine, veterinary science, agriculture, and other fields, as well as other courses on specialized techniques such as instrumental chemical analysis.

26. Some of the universities and higher technical schools have held regular courses in nuclear science and engineering.

NUCLEAR POWER STATIONS

27. At the present time private industry in Spain is constructing three nuclear power plants, the first of which, the José Cabrera station, will go into operation towards the middle of 1968.

28. The three power stations are the one mentioned above, which embodies a pressurized-water reactor and has a capacity of 153 MW(e), the Santa María de Garoña station, of the boiling water reactor type, with a capacity of 440 MW(e), and the Vandellós station, with a gas-cooled reactor and a capacity of 480 MW(e).

29. In all three cases JEN has advised the undertakings concerned at various stages of the projects, and has rendered technical assistance on various subjects, chiefly concerned with nuclear safety. As advisory body to the Government, JEN has issued a large number of reports both on the equipping of the power stations under construction, and on their subsequent operation.