Suggestions are made regarding the training of personnel to operate a nuclear plant. Finally, the types of assistance which might be obtained from the IAEA are listed as follows:

(a) detailed analysis of alternative reactor systems suitable for the conditions in the Philippines; (b) health and safety measures; (c) preparation of atomic legislation and regulations; (d) preparation of specifications for the nuclear plant; (e) evaluation of bids; (f) site selection; (g) training of personnel; and (h) obtaining fuel and outside financing.

FAST REACTOR PROGRAMS

Scientists from 22 countries and two international organizations discussed the physics of fast and intermediate reactors at a seminar held by IAEA in Vienna last August.

Fast reactors are those in which the neutrons emitted in the fission process are not "moderated" or slowed down, while in intermediate reactors they are moderated to a limited extent. When the neutrons are not slowed down, they are particularly effective in converting the abundant uranium isotope, U-238, which accounts for more than 99 per cent of natural uranium but which itself is not fissionable, into plutonium-239, which is readily fissionable, like uranium-235. It is, therefore, possible to "breed" fresh nuclear fuel in a fast reactor even in larger quantities than the fuel consumed.

This advantage of fast reactors, which may become the ultimate means of economic power generation from nuclear fission, has led to large programs of research and development in many countries. Some of these national programs were reviewed during the closing stages of the IAEA seminar. (The main part of the meeting, however, was concerned with the physics aspects of such reactors.) The highlights of this review are presented in the following paragraphs.

France

Dr. G. Vendryes (France) said that his country's program was initiated four years ago in the hope that within the decade 1970-1980 fast breeder reactors would become competitive as a source of cheap nuclear power, the more so as conditions in France lend themselves particularly to this development. The construction of graphite reactors by Electricité de France would provide France with ample supplies of plutonium.

The first step taken by the French Atomic Energy Commissariat was to begin construction of the experimental reactor "Rapsodie" at Cadarache. Plutonium, probably in the form of a plutonium-uranium-molybdenum alloy, will be used in the very first loading of "Rapsodie". When the reactor becomes operational by the end of 1964, one of its main purposes will be the carrying out of experiments on irradiation of fuel elements.

A laboratory complex has been built at Cadarache and at present various items of equipment are being installed there. A team to measure nuclear constants will also be transferred to Cadarache, which now has all the facilities and means for research and development in the fast reactor field.

As a second step in the French program it is planned to design and build a 250 MW (thermal) reactor towards the end of the present decade, which would help in designing a true electrical plant prototype.

Stress will continue to be laid on plutonium fuel studies and on solving problems in such fields as physics, electronics, control and safety, mechanics and engineering.

The larger part of the French fast reactor program will be carried out in close co-operation with EURATOM.

Soviet Union

Describing the program of the USSR, Dr. Ivan Bondarenko said that the problem of basing the production of electrical power on nuclear energy was not acute in his country, in view of its large reserves of fossil fuels. Nevertheless, power needs constantly grow, making it necessary to open up new sources of energy. Interest in fast reactors, Dr. Bondarenko pointed out, was linked to the hope of obtaining cheap electrical power in the relatively near future.

The USSR program in the fast reactor field, which started in 1948, might be divided into a theoretical and a practical stage. During the first stage, research on various physical aspects was carried out, which confirmed the original assumptions and strengthened confidence in fast reactors. The transition to the practical stage began with the construction and operation of a 5 MW plutonium oxide reactor called BR-5. At the same time work started on the BN-50 project, a fast power reactor with an electrical output of 50 MW and a thermal power of 250 MW. Work on this project helped in solving many problems but was later dropped, since it was considered that a reactor with a thermal output of 250 MW was still not the facility from which the real advantages of the fast reactor could be obtained.

At present Soviet scientists and engineers are thinking of designing a larger reactor of 800 MW or possibly more.

At the same time, work on fast reactor fuels and on various technological and engineering problems continues, with the BR-5 reactor providing the necessary experience.

United Kingdom

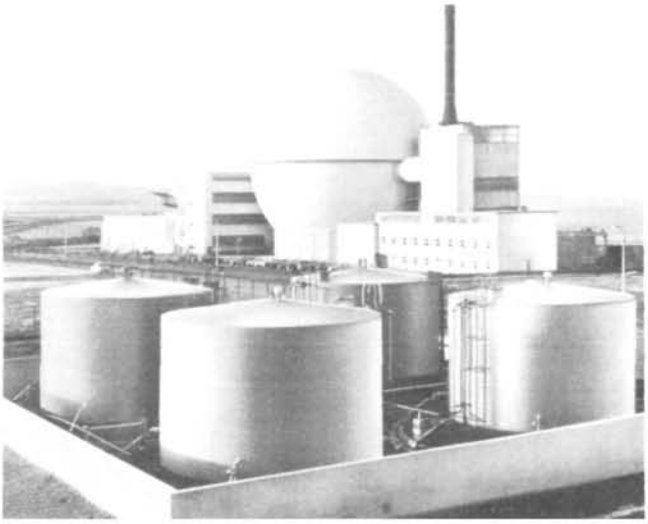
As was pointed out at the seminar, interest in fast reactors in the United Kingdom is based very much on the belief that they have the possibility of being both low capital and low fuel cost power producers. It is also heightened by the prospects of abundant supplies of plutonium from the natural uranium power stations now being built in that country.

According to Dr. Derek Smith, who described the United Kingdom's fast reactor program, designs of fast reactor power stations for use in the 1970's are at present under study, since it is likely that at that time electricity generating boards will be looking for power stations with outputs of the order of 1 000 to 2 000 MW (electrical) with two or more reactors per station. Reactors of the 1 000 MW size have been studied and development programs to study engineering problems, including the design of fuel elements, initiated.

A fairly big irradiation program of fuel element materials is under way in the material testing reactors DIDO and PLUTO at Harwell and DMTR at Dounreay. A radiation program will shortly be started in the fast reactor at Dounreay, which has been modified for testing fuel elements as distinct from fuel materials.

Reactor physics studies are being carried out at Aldermaston and Harwell. The ZEBRA reactor, under construction at Winfrith and due to be operational in about a year's time, will produce plutonium and permit investigation of fuel assemblies.

Dr. Smith said that the Dounreay fast reactor was the central part of the UK program. It would help in acquiring experience and confidence in the operation of big sodium-cooled reactors. By radiation testing of fuel elements and materials, it was hoped to obtain as yet unknown data on the dynamic behavior of at least a bigger fast reactor. Experience would also be acquired in both the fabrication and processing of fast reactor fuels.



The fast breeder reactor at Dounreay, UK. This picture of the reactor sphere and diesel fuel storage tanks was taken soon after the reactor started operating at very low power on 14 November 1959 (Photo UKAEA)

Scientists and engineers in the United Kingdom are looking towards the construction of 1 000 MW commercial fast reactors in the 1970's. A prototype reactor will probably be constructed in the latter half of the present decade.

United States

Dr. Bernard Spinrad (USA) said that there were many institutions in the United States working on competing concepts, and he reviewed the activities of some of them.

(a) The fast reactor program at the Argonne National Laboratory is based on the EBR-2 reactor at present under construction there and on the EBR-1 reactor. This program provides for investigations into the use of metal fuel, reprocessing and fabrication of fuels with emphasis on remote fuel fabrication techniques. It also provides for the ultimate conversion of the EBR-2 reactor from uranium-235 fuel to plutonium. Safety and engineering problems of fast reactors are also being studied.

(b) The Los Alamos Scientific Laboratory is one of the first scientific institutions to start work on fast and intermediate reactors, and various measurements of basic properties and experiments in this field have been carried out there. At present this laboratory is active in a plutonium alloy chemistry program, fast reactor safety and in engineering and physical research. A core-test facility is being built at Los Alamos to be used in developing and testing advanced concepts of molten fuel fast reactors.

(c) The Atomic Power Development Association, which was the designer of the Enrico Fermi Reactor, carries out fast reactor economics analysis and works on fuel concepts.

(d) The Brookhaven National Laboratory is active in the intermediate reactor field.

Dr. Spinrad also said that General Electric Company was working on a fast oxide breeder program which included work on fuel, irradiation experiments, safety and conceptual work. Atomics International and the United Nuclear Corporation were working on fast reactor fuels and various aspects of safety.

According to a planning schedule, construction of an advanced power plant should start in 1964 and an economic fast reactor should operate in 1971. Dr. Spinrad, however, pointed out that this was not a firm decision.

MEASURING RADIOACTIVITY IN THE BODY

Techniques of measuring the total amount of radioactivity in the body of a living person as well as the principal applications of such measurements were reviewed at a Symposium on Whole Body Counting held in Vienna from 12 to 16 June 1961. Organized by IAEA, the meeting was attended by over 120 scientists from 27 countries and three international organizations. Thirty-three papers were presented and discussed.

The growing importance of whole body measurements was emphasized by the IAEA Director General, Mr. Sterling Cole, in his opening remarks at the symposium. He pointed out that historically the need for these measurements first arose in connection with studies to determine the degree of radioactive contamination of persons occupationally exposed to radioactive substances. With the development of atomic energy applications, this need has immensely grown and accurate measurements are now an integral part of health and safety measures in this field. A second important need for these measurements arises from the medical applications of radioactive tracers; when a radioisotope is administered to the body as a tracer it is often useful to determine how long the isotope is retained by the body.

Accordingly, whole body counters can be divided into two broad groups: (a) counters for the radiation protection surveillance of the general public and radiation workers, capable of detecting extremely low levels of radioactivity in the human body, and (b) counters for medical research and diagnosis, designed to check the retention and excretion of radioactive substances administered to patients for metabolic and pathological studies. In both cases, the primary requirement is that the counter must be able to measure the total activity in the body. To ensure this, the detector is so placed in relation to the subject that the measurements are not affected by variations in the distribution of the radioactive deposits in the body.

In recent years, there has been a remarkable development of the instruments and techniques for such measurements. One of the main purposes of the symposium in Vienna was to discuss how best to use these highly sophisticated instruments. It was hoped, as Mr. Cole said, the meeting would "produce, for the benefit of medical scientists and radiation protection workers throughout the world, an up-to-date survey of these instruments themselves and of the whole body counting applications to which they have been and will be effectively put".

Improvement in Methods

An indication of the progress in counting techniques was given by Professor F. W. Spiers, of the University of Leeds, UK, in an introductory review at the first scientific session of the symposium. He pointed out that the first attempts to measure total body burdens of radioactivity were made in 1929 with the object of determining the amounts of radium taken up by workers handling the substance. Accurate quantitative measurements, however, were not achieved until 1937, when Geiger-Mueller counters were applied and due consideration given to subject-detector geometry, i.e. their relative positions. The lowest body burden of radium that could be measured at that time was 0.1 microgram, which incidentally is just the maximum permissible burden of radium in occupationally exposed workers according to the recommendations of the International Commission on Radiological Protection. During the past two decades, the techniques have so improved that it is now possible to detect one-hundredth of this maximum permissible burden. Modern counters can also detect natural radioactive deposits in the body, such as potassium 40, and any additional intake from radioactive fallout due to nuclear weapon tests.

This improvement in the sensitivity of counting devices has been achieved mostly through the use of