detailed consideration. For example, it may be necessary for the State to assume certain obligations in connexion with the requisite financial security, and the exact nature of such obligations must be settled by agreement.

Whether a comprehensive convention should be established or there should be agreement only on certain basic norms is a question to be decided by the Member States of the Agency. But both in regard to land-based installations and nuclear ships, a beginning towards the elaboration, adoption and international harmonization of liability rules is a task of the highest priority. Efforts must be simultaneously directed to the establishment of safety and to adequate financial protection in the event of a possible failure of safety. The growth of the atomic industry will depend in a large measure on the success of these efforts on both fronts.

STUDIES ON REACTOR PHYSICS

Most of the peaceful applications of atomic energy are inherently dependent on advances in the science and technology of nuclear reactors, and aspects of this development are part of a major programme of the International Atomic Energy Agency. Independent research and experiment are, of course, being vigorously pursued in several countries and the most useful role that the Agency can play is as a co-ordinating body or central forum where the trends can be reviewed and the results assessed. The pooling of information and the exchange of ideas are to the common advantage of all concerned, and progress is thereby made quicker and more balanced. The results of these studies, to which all Member States of the Agency have easy access, can be put to particularly good use by countries where atomic work is just being planned or begun.

Some of the basic studies are carried out by members of the Agency's own scientific staff. While this is a continuous activity, the Agency also convenes groups of experts from different countries to examine a particular problem in detail and make any necessary recommendations. Furthermore, some of the important subjects are discussed at international scientific meetings held by the Agency, where scientists from many countries can compare their experience and correlate the results.

Reactor Computations

One of the subjects covered by such studies is the physics of nuclear reactors and a specific topic recently discussed was Codes for Reactor Computations, on which a seminar was held in Vienna in April this year. The seminar, which was attended by 100 participants from 20 countries, lasted five days during which 37 papers were presented.

Discussions at the seminar indicated how electronic computing machines could be used more widely and effectively for calculations during the design and operation of reactors. Many types of computing machines have lately come into use and high speed machines are now installed in business establishments and statistical organizations in all parts of the world. Since these machines are seldom fully occupied, some of the computing time could be obtained for reactor calculations at a very reasonable cost. The pooling and evaluation of experience and ideas that took place at the Agency meeting laid the first international foundation for the full utilization of electronic computing techniques in reactor physics studies. These techniques, which can now be employed with equipment within easy reach, could prevent considerable waste of time and effort involved in cumbersome methods of calculation.

Until recently there was little need for international co-operation in this field because almost all generalized computing codes were designed for the machines of two or three large manufacturers. With the introduction of new types of machines however, it has become desirable to establish a universal machine language to facilitate coding as well as to achieve interchangeability of codes and avoid duplication of work.

Codes were divided into two classes: compiler codes and machine codes. Compiler codes are designed to be used directly by the engineer or physicist who expresses his problems in mathematical terms. The machine accepts the codes in these terms and then translates them into fundamental machine operations. Machine codes, on the other hand, are written directly in the fundamental language of the machine. They can be properly assembled only by experts who understand in detail the particular machine to be used. Compiler codes can be easily transferred from one type of machine to another if the machines are designed to accept them, whereas machine codes must be rewritten for each machine.

Many participants in the seminar were strongly in favour of establishing a universal language for compiler codes. The compiler language which is most widely in use today is primarily designed for one type of machine. Steps towards the establishment of a universal machine language have been taken with the formulation of what is known as the ALGOL system. This and other possible systems were considered by the experts and the basic technical requirements examined.

The mathematical and statistical methods were also discussed in detail. Several scientists gave accounts of existing facilities for reactor computations in different countries, and a census of such facilities was taken at the meeting.

Certain proposals were also made as to how the International Agency could assist in the better utilization of computing machines for reactor calculations. For example, it was suggested that the Agency should consider the setting up of a code library and of a group of experts for the co-ordination and control of present and future codes.

Heavy Water Reactors

The meeting on reactor computations was the second to be called by the Agency to study problems of reactor physics. The first was a meeting of a Panel of Experts on Heavy Water Lattices which met in Vienna in August 1959, while the next will be a seminar in 1961 on the physics of fast reactors.

The Panel on Heavy Water Lattices was composed of six leading specialists from laboratories which have been working on heavy water reactors for a number of years. They were: Dr. Edward Critoph (Chalk River, Canada), Dr. Viking Olver Eriksen (Kjeller, Norway), Dr. Roger Naudet (Saclay, France), Dr. B. Pershagen (A. B. Atomenergi, Sweden), Dr. Daniel S. St. John (Savannah River, USA) and Dr. John J. Syrett (Harwell, UK). The Chairman of the Panel was Dr. George G. Laurence of Canada. Four other scientists attended the meeting as observers.

A co-ordinated study of the physics of heavy water lattices had been recommended by a number of scientists participating in the 1958 Geneva Conference where it was felt that since a great deal of information on this subject had already been accumulated an attempt should be made to correlate the data and the research programmes on an international basis. The Agency agreed with this suggestion and gave it priority in view of the special interest shown by many of its Member States in this type of reactors.

The term "lattice" describes the pattern in which the fuel elements and the moderator are arranged in a reactor. Heavy water is a particularly useful moderator for reactors fuelled by natural uranium, and there is at present a widespread interest in the use of natural uranium as reactor fuel. This has inevitably focussed considerable attention on the design of heavy water moderated reactors. A great deal of work has already been done independently in different countries, and if the data obtained from this work were co-ordinated and made generally available, duplication of effort could be avoided and the outstanding problems attacked more effectively. This is the purpose served by the study made by the IAEA Panel of Experts, the results of which have recently been compiled by the Agency's scientific staff and published in the form of a handy book of reference.* It is hoped that this publication will enable the designer of a heavy water reactor to check his calculations even if he has no means of performing the necessary experiments with his own facilities. He should be able to place his proposed design within the family of lattices examined elsewhere and to interpolate between the results.

The members of the Panel described the development of heavy water reactors, the equipment and methods of research currently used, and plans for further development in their respective countries, and these status reports are summarized in the opening section of the book. Other topics covered include fundamental concepts and definitions, accuracy and correlation of data and several specific technical problems such as burn-up, fuel element exchange and temperature co-efficients. A number of scientific papers prepared for the meeting are also reproduced in the book.

After discussing the experimental and theoretical techniques employed in the different laboratories, the experts made a few suggestions for future research. These include an extension of experiments to more fuel elements shapes and spacings and investigation of the effects of high temperatures and high irradiations. To support this programme, they stressed the need for obtaining more data on certain specific points. The expense involved in such work to ensure greater accuracy of data can be easily justified in terms of the costs of the power reactors which will be designed on the basis of these experiments.

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* Heavy Water Lattices, *International Atomic Energy Agency, 1960. Price US$1.50.*