Swedish Atomic Energy Company (AB Atomenergi, Stockholm).

Until his appointment as Director General of the IAEA, Dr. Eklund was Deputy to the Managing Director of AB Atomenergi (since 1950) and also Director of the Reactor Development Division at AB Atomenergi (since 1957).

His publications include papers on atomic energy as well as on nuclear physics and instrumentation.

Dr. Eklund has also served on a number of international assignments, as listed below:

Member of the Working Group of the European Atomic Energy Society	1953 -
Chairman of the Study Group of Experimental Reactors in OEEC	1956 -
Member of the Halden Committee	1958 -
Member of the General Purposes Committee (Dragon)	1959 -
Member of the Board of Management (Dragon)	1959 -
Chairman of the Board of Management (Dragon)	1959 - 1960
Conference Secretary General for the Second International United Nations Conference on the Peaceful Uses of Atomic Energy	1957 - 1958
Chairman of an Information Mission on Nuclear Ship Propulsion (OEEC)	Spring, 1960

Dr. Eklund is a Member of the Royal Swedish Academy of Engineering Sciences.

UTILIZATION OF RESEARCH REACTORS

About 200 research reactors are now in operation in different parts of the world, and at least 70 such facilities, which are in advanced stages of planning and construction, should be critical within the next two or three years. In the process of this development a multitude of problems are being encountered in formulating and carrying out programs for the proper utilization of these facilities, especially in countries which have just begun or are starting their atomic energy work.

The subject came up at the last session of the IAEA General Conference which adopted a resolution urging early consideration of "steps to be taken to promote international co-operation in order to ensure full and effective utilization of the research reactors in such Member States as may request assistance towards that end".

An opportunity for scientific personnel from different Member States to discuss research reactor problems was given at an international symposium on the Programing and Utilization of Research Reactors organized by the Agency almost immediately after the General Conference session. Two hundred scientists from 35 countries, as well as from the European Nuclear Energy Agency and EURATOM, attended the meeting which was held in Vienna from 16 to 21 October 1961.

The discussion was based on 69 papers orally presented at the symposium. These covered such subjects as problems of organization and training, the experience gained so far, useful fields of research with reactors, and possibilities of international co-operation.

Problems of Establishment and Training

In a survey of major problems in establishing a research reactor center, R. G. Bradley (USA) stressed the importance of evaluation and determination of research and training programs prior to the building of research reactors. He said that once it was decided that the program justified a reactor, the feasibility of such an undertaking should be evaluated on the basis of the availability of resources, especially the availability of trained personnel and funds. Mr. Bradley added that the problem of developing plans that would assure adequate technical staff for the safe operation, maintenance and utilization of a research reactor was often a major stumbling block, particularly for countries with a relatively new nuclear energy program. He pointed out that some organizations had experienced serious problems not from completing their training programs at too late a date, but rather from the graduates returning home at too early a date to find equipment or programs on which to apply their new knowledge and techniques. Of necessity, they turned to non-nuclear jobs and some were ultimately lost to the nuclear program.

The problem, said Mr. Bradley, might be accentuated by the choice of reactor site. The univer-

sity faculties were the principal source of scientists and it was therefore understandable that many reactor projects were conducted by universities. Serious problems were likely to be created if a reactor project divorced itself from the universities by greater salaries, more up-to-date equipment, etc. While the nuclear facility might succeed in this recruiting venture, other equally important scientific endeavors might be sacrificed in the process. This would also result in a deterioration of the universities in those fields of engineering and the physical sciences which provided most of the junior scientists for a reactor project.

Mr. Bradley felt that reactor facilities in areas remote from other nuclear centers might be used effectively to provide on-the-job experience to neighboring scientific communities attempting to initiate reactor projects. The visiting scientists would thus gain first-hand knowledge that would be useful for their own reactor project and the host facility would benefit from the services of additional scientists.

Mr. Bradley suggested that IAEA should periodically review and comment on reactor operating procedures, and provide a personnel employment service which, in addition to helping interested organizations to find staff members, might assist those graduates who were not able to find jobs at home for which they had been trained. The Agency might also publish a series of brief working manuals or reports consisting largely of the information needed daily in the operation and utilization of research reactors. It was also advisable to publish and distribute progress reports on the research reactor programs in member countries in order to avoid duplication of effort and identify the organizations with similar interests.

Discussing organization of reactor centers, S. Andrzejewski (Poland) said that nuclear research centers should not become too large and that a regional distribution of these centers provided for a healthy scientific competition and contributed to acceleration of research activities.

Experience Gained

Four sessions of the symposium were devoted to experience in utilizing research reactors.

F. de Hoffmann (USA) presented a paper on research programs with TRIGA reactors, 24 of which are in use or under construction in 14 countries of Asia, Africa, North and South America and in Europe. Among the research programs he described were the use of neutron activation analysis in determining the organic chloride content of milk products and in studies which might help in extending the storage life of blood held in blood banks, as well as the use of reactor radiation in medical diagnosis and the treatment of tumors. Radiation environments which might be encountered by the crews of space ships, in the vicinity of solar flares or in the Van Allen radiation belts, were also being studied with research reactors.

H. Maier-Leibnitz and M. Pollermann, from the Federal Republic of Germany, told the symposium of the experience gained in utilizing a 1 000 kW swimming pool reactor of conventional design constructed at the Technical High School, Munich. They said that the reactor was part of a university and not of a research center and that its aim was to train students, during their last university years, mostly by letting them do the research work themselves.

E. L. Andronikashvili (USSR) said that the nuclear research center of the Georgian SSR Academy of Sciences Institute of Physics was built around a 2 000 kW(th) reactor equipped with, among other things, a cobalt unit and a radioisotope laboratory. Special premises for the production of short-lived radioisotopes were at present under construction. The center provided services and facilities for 25 scientific and other institutions in the Georgian Republic, including nuclear physics, radiation chemistry, radiobiology and medical institutions. Alongside its purely scientific activities, the center carried out projects designed to increase the productive capacity of Georgia. This involved work in such fields as viticulture, wine making, horticulture, and the food, textile, manganese, metallurgical and tire industries. The center also collaborated with scientific institutes in Moscow and the Azerbaijan SSR, active in the field of radiation effects on oil, and the reactor at the center had acquired new assemblies for research in radiation cracking of oil.

J. C. Bugher (USA), who described the Puerto Rico Nuclear Center, said that the choice of its program was guided by two sets of considerations; first, that the research activities of the center should be those most profitably carried out in the tropics; and,

The Austrian research reactor center at Seibersdorf, near Vienna. The reactor (in the background) is of the swimming pool type, with an output of 5 MW

second, that they should be in harmony with the center's goals of strengthening graduate education in nuclear science and technology in Latin America.

H. Kouts (USA), presenting a paper on the use of small reactors for reactor physics, said that the objectives of reactor physics programs in the United States were the same as those motivating a similar program in any country. These aims were to acquire information needed for the design and use of large reactors, to train the necessary operational staff, and to educate competent technical people needed for the scientific and technical advance of the country. The reactor systems employed in such programs varied from simple low power machines which needed no cooling systems to large reactors generating heat in the megawatt range. The low power reactors were of two kinds: small reactors for demonstration and training, and zero power critical assemblies used for these purposes and also for research. The higher power reactor systems were usually multi-purpose devices which, among other functions, served to supply neutrons for the activation of subcritical reactor assemblies.

Research and Practical Utilization

H. Maier-Leibnitz (Federal Republic of Germany), who presented a paper on nuclear physics research with reactors, pointed out that investigations with the help of reactors formed only a small part of research in nuclear physics compared with the contribution from accelerators. However, reactors were unique in providing a high flux of slow neutrons, and these were used in most experiments; a reactor was also a source of fast neutrons, gamma rays, fission products, beta rays and neutrinos, and experiments had been done with all these.

M. Tomlinson (United Kingdom) said that a research reactor was most suitable for basic research work in radiation chemistry (and in many other fields) because of the ability, in using the reactor, to mount and dismantle experiments quickly and simply, and because the reactor itself and the conditions at the irradiation position were capable of precise control. However, when doing research with reactors one thought immediately of the difficulties associated with precise dosimetry, the complications caused by induced radioactivity, and the complex equipment often required for the irradiation. In his paper, which was devoted to radiation chemical studies in research reactors, Mr. Tomlinson showed how these difficulties and complications could be reduced by suitable choice of equipment and techniques and stated that special characteristics of reactor radiation provided a unique role for the research reactor as a source for radiation chemical studies.

Discussing the role of reactors in research in plant sciences and agriculture, H. Smith (USA) said that a research reactor might be used as a tool in radiobiological studies to explore the basis for responses induced in plants by neutrons compared with other kinds of irradiation, for the induction by neutrons of gene mutations and chromosomal alterations, and for the production and use of short-lived radioisotopes to study certain problems in the uptake, transport and metabolism of plants. To this might be added the convenience of replenishing radiation sources, such as cobalt-60, for experiments utilizing gamma radiation. Also, reactor-produced neutron irradiation could be used to sterilize and preserve agricultural products. Mr. Smith said that while the uses of a research reactor for experimentation in plant sciences and agriculture were not sufficiently unique or critically important to justify the construction of a reactor for these purposes alone, a small multi-purpose research reactor could be utilized to advantage for basic botanical investigations and certain practical problems in agriculture.

G. B. Cook (IAEA), who discussed isotope production in a research reactor, made some suggestions about the gradual development of an isotope production program with a reactor, since a certain amount of research was possible by obtaining isotopes produced elsewhere. If material was imported in bulk quantities and dispensed locally, appreciable savings could be made, as compared with the results of haphazard ordering. Such a dispensing laboratory could also be the first stage of development before a country had its own reactor. Mr. Cook said that the following three stages of development could be envisaged:

(a) dispensing center only, subdivision and dispensing being made according to the consumers' requirements;

(b) partial local production, with some isotopes being still imported but the more expensive and short-lived items being produced locally; and

(c) local production and dispensing of all radioisotopes.

Mr. Cook pointed out that although local production was relatively expensive, it had certain advantages, viz. development of scientific manpower and techniques, and encouragement of radioisotope methods in medicine, agriculture, science and industry; independence of foreign supplies; fuller utilization of a reactor; and access to short-lived isotopes.

Co-operation Between Advanced and Developing Countries

International co-operation between advanced and developing scientific communities and countries was discussed at the last session and at a round-table meeting held at the end of the symposium.

V. Goncharov (USSR) gave an account of the Soviet Government's assistance to other countries in the field of the peaceful uses of atomic energy. Pointing out that the Soviet Union had concluded 21 bilateral agreements and conventions with 14 countries, he said that some 500 Soviet experts had been sent to these countries to assist in the construction, erection, adjustment of equipment supplied, and start-up of 9 reactors, which had been built between 1957 and the present time. The Soviet Union had also been helping

these countries in the training of staff for the reactor research programs. Between 1956 and August 1961, training was provided in the USSR to a total of 1 170 persons. At present, equipment was being designed and manufactured for a number of research reactors, radiochemistry laboratories, sub-critical assemblies and various experimental physics units intended for the nuclear centers currently being built in various countries with the help of the Soviet Union. Mr. Goncharov also referred to collaboration between the countries participating in the Joint Institute of Nuclear Research (Dubna), which was being carried out through the Low-Energy Nuclear Physics Section of the Institute's Scientific Council. A permanent atomic energy utilization committee, which had been set up to promote multilateral co-operation between the Socialist States, considered problems in the production and standardization of various atomic equipment and materials.

C. E. Chauvez (France) said that since 1955 approximately 100 foreign students had been trained annually at nuclear energy centers in France. Besides, a series of lectures and courses directed by French nuclear specialists had been organized in a number of countries, particularly in the Middle East. France had bilateral nuclear energy agreements with a number of the French-speaking African countries as well as with some countries in South America and Asia.

During the round-table discussion, Mr. Goncharov suggested that IAEA should collect and disseminate information on research reactors which would help the developing countries to decide which type of reactor was best suited to their individual requirements. The Agency should also prepare a general program for research with such reactors from which developing countries might select appropriate areas for investigation.

M. El-Guebeily (United Arab Republic) suggested that the Agency should prepare a list containing information on the present production of radioisotopes in the world and put it at the disposal of the developing countries. The Agency should also prepare a set of recommendations on research reactor types most suitable for such countries. Further, it should encourage research on a regional basis and promote bilateral and multilateral co-operation.

J. F. Hill (United Kingdom) suggested that international exchange of reactor experience, either through bilateral agreements or through IAEA, should be promoted.

T. Thompson (USA) said that IAEA should disseminate information on work being carried out at various research reactor centers so that the developing countries could enter into bilateral or multilateral arrangements so as to benefit from the work already in progress.

Other speakers who participated in the discussion also urged a larger role for IAEA in promoting international co-operation in the research reactor field and suggested a number of practical steps that the Agency might take in that direction.

The following scientists served as chairmen at various sessions of the symposium: Dr. J. F. Hill (United Kingdom), Prof. P. T. Nowacki (Poland), Dr. F. T. Binford (United States); Dr. C. E. Chauvez (France); Prof. V. Goncharov (Soviet Union); Dr. T. Thompson (United States); Dr. J. Cosentino (Argentina); Dr. D. Stewart (Canada); Dr. M. El-Guebeily (United Arab Republic); and Prof. F. Juul (Denmark).