Peaceful Uses of Atomic Energy

These four volumes—**Research, U.S.A.: Knowledge for the Future** (229 pp.); **Nuclear Power, U.S.A.** (214 pp.); **Radioisotopes and Radiation: Recent Advances in Medicine, Agriculture, and Industry** (143 pp.); and **Education and the Atom: An Evaluation of Government's Role in Science Education and Information, Especially as Applied to Nuclear Energy** (166 pp.) (McGraw-Hill, New York, 1964. $18 each; $62.50 set)—are dedicated by the United States Atomic Energy Commission to the memory of President John F. Kennedy and are preceded by a foreword by President Lyndon Johnson. The volumes provide a very good conspectus of the programs of the Commission on the Peaceful Uses of Atomic Energy. They are written at a *Scientific American* level. They are well printed and illustrated by a very large number of photographs and diagrams.

In the volume *Research U.S.A.* Albert V. Crewe and Joseph J. Katz describe a representative selection of the experiments supported by the Commission. The volume opens with a chapter entitled "New particles of physics." There are excellent photographs of the high-energy nuclear accelerators and the associated experimental laboratories and equipment such as bubble chambers and spark chambers. The diagram of subnuclear objects is up to date insofar as they include the far-famed Ω^-, and there is a description of the "eight fold way" and its more recent extensions. The experiments on neutrinos are described, with spark-chamber photographs of the creation of μ mesons by neutrinos. The second chapter is devoted to neutron physics, including neutron diffraction, and gives a list of its successes in unraveling molecular structures including sucrose and predicts the determination of structures of biological interest in the future. After this there are chapters on the nucleus, the new periodic table, ionizing radiations and matter, radiation and light, isotopes in research, and fusion research. In the section on radiation genetics, the authors remark that "laboratory directed transformations of microorganisms are now a commonplace, and that there is much reason to believe that the world may shortly be faced with a scientific revolution that will make previous ones retreat into insignificance." There are interesting photographs showing the effects of radiation in producing chromosome abnormalities. Work in Britain has shown that these abnormalities can be produced by doses as low as 25 rads, although the clinical implications of these abnormalities are still uncertain. The chapter on fusion research has photographs of the principal United States projects, and the authors remark that "so capricious are the winds of progress that it is difficult to know which approach, if any, is likely to be the first to reach thermo-nuclear conditions." The recent work on "magnetic wells" is not reported.

The volume on nuclear power is by Walter H. Zinn, Frank K. Pittman, and John F. Haggerty. The main chapter, on central-station electric-power generation, describes the evolution of the United States power program from which the pressurized-water reactor and the boiling-water reactor emerged as the main contenders for large-scale installation in the United States in this decade. An interesting diagram shows the rapid fall of power costs as the design output increases from 200 to 600 megawatts, the lowest costs from present designs being quoted as between 4.5 and 5.2 mils per kilowatt hour for fixed charge rates varying from 11 to 14 percent per annum. It is not clear from the text what load factors and station lifetimes have been assumed. Since the volume was written, the Jersey Central Power and Light Company has estimated the cost of power from their 500- to 600-megawatt boiling-water reactor as 3.8 mils initially, falling to 3.4 mils after the first 5 years, assuming an 88 percent load factor and a 30 year life. This contributes to the general opinion that nuclear power is now entering the strictly competitive stage in many parts of the U.S. and abroad. Nuclear plant output will probably increase to 1000 megawatts from a single reactor requiring a 750-ton pressure vessel with walls that are 18 inches thick. This would limit the location to sites accessible by water. Because steam conditions of current boiling-water reactors are poor, with thermal-conversion efficiencies of only 31.5 percent, considerable development potential is still available by using nuclear superheating. A brief account is also given of power stations using heavy-water moderator reactors, sodium graphite reactors, and fast-breeder reactors. The Argonne-designed Experimental Breeder Reactor 2 is now approaching the design output of 60 megawatts thermal and uses unconventional fuel elements of enriched uranium and an equilibrium mixture of fission products known as *fissium*. The reactor has its own recycling plant in which a large part of the fission products are removed by pyrometallurgical processes. This unconventional fuel cycle seems likely to remain uncommercial. The Enrico Fermi Fast Breeder Reactor, dogged by legal, trade union, and economical troubles, was operating at only 1 megawatt at the time of writing. The United States effort in fast reactors, after leading with Experimental Breeder Reactor 1, has fallen several years behind that of Britain and Russia.

Power stations using gas cooling are represented in the program by the Oak Ridge Experimental Gas Cooled Reactor (EGCR) and the Peach Bottom High Temperature Gas Cooled Reactor being constructed by General Dynamics. This is similar to the European Nuclear Energy Agency's DRAGON Reactor at Winfrith in Dorset, especially in using fuel particles with triple pyrolitic coatings to contain the fission products. Design studies of a 500-megawatt station predict thermal efficiencies of 43 percent and fuel burn-ups of up to 100,000 megawatt-days per ton, about five times higher than that of the boiling-water reactors.

The chapter on commercial nuclear ship propulsion describes the uncommercial *Savannah*, with its 20,000 shaft horsepower plant, and the paper designs of propulsion reactors that require only a third as much space as the

Savannah reactor, no doubt with corresponding reduction in costs.

The authors state that "one promising use is a new class of 30-knot 'express' cargo vessel. Two such vessels could be built and operated at a lower cost than four conventional 21-knot cargo vessels of the MARINER type and could produce the same or greater cargo-carrying capacity."

The volume *Radioisotopes and Radiation* is by John Lawrence, Bernard Manowski, and Benjamin S. Loeb. The United States Atomic Energy Commission is now spending $80 million per annum on biological and medical research, with a doubling time of about 6 years. Examples are given of metabolic studies with carbon-14 compounds using a breath analyzer enabling vitamin B-12 and folic acid deficiencies to be determined. Iron-59 is used as a diagnostic tool in studying obscure anemias and other blood diseases, and for studying the movement of iron within the body. Tritium-labeled thymidine has been of great help in proving the replication processes of DNA and in studying genetic coding. Radioisotopes enable researchers to study cardiac output, kidney function, and liver function.

A wide variety of scanners is used in locating the distribution of isotopes such as iodine-131 to study thyroid disorders or carcinoma, positron-emitting isotopes to detect brain tumors, and strontium-85 to locate bone lesions. Liver scanners and spleen scanners are clinical tools. Whole-body counters are being used to measure the loss of iron-59, which is characteristic of different diseases, or of whole-body potassium-40 in studies of muscular dystrophy.

An interesting account is given of the elimination of the screwworm from various areas by irradiating male flies, and of successful work on the melon fruit fly in Hawaii.

Radiation-induced mutations in plants have produced certain important commercial varieties: Sanilec bean, seaway bean, gratoit bean, florad oats, Alamo X oats, NC4 x peanuts, and Penrad barley.

Radiation sterilization of food has been a success, with bacon sterilized by 4.5 megarads without change of flavor after 2 years. Radiation sterilization of fish is now nearing commercial application with the construction of a pilot plant at Gloucester which is capable of irradiating a ton of fish per hour with 250,000-curie cobalt-60 source. The radiation sterilization of hospital supplies such as sutures, scalpels, syringes, gloves, and surgical dressings is now a well-established process.

Great hopes were entertained a few years ago that radiation could be used as a catalyst in many commercial chemical processes. So far the number of successes is few. The manufacture, by the Dow Chemical Company, of ethyl bromide by use of an 1800-curie cobalt-60 source was a first example. Cross-linked polyethylene film has been successfully produced by radiation, and more than 1000 tons per annum are now being produced. The Esso Research and Engineering Company has developed a foamless detergent, SAS, to the stage of pilot-plant operation.

The volume *Education and the Atom* is by Glenn Seaborg and Daniel M. Wilkes. Seaborg gives an account of the philosophy behind the Atomic Energy Commission's support of fundamental science, which provides 1200 contracts in the physical and life sciences, engineering, and mathematics, from which 4000 graduate students are supported. One of the problems is to increase the 15 to 20 strong centers of science by a greater spreading of federal support. One of the techniques is for several agencies to join forces in supporting one institution. Thus, the Institute of Molecular Biophysics at Florida State University has received support from the Atomic Energy Commission, the National Science Foundation, the National Institutes of Health, and the Air Force. One of the new developments, common to both sides of the Atlantic, has been to provide "General Research and Training Grants" of the order of 5 percent of the total grants to universities and colleges engaged in project research. The Research Councils in Britain now make a grant to the institution of £200 per annum for each graduate student receiving a research and training grant. Seaborg considers that "serious coordinated studies of the present support structure and a possible supplement and alternatives are necessary, and are being undertaken by both Congress and the Executive Branch."

Very interesting figures are given for the present faculty and student structure of eight national laboratories, showing that the number of postdoctoral workers is now more than half the numbers of candidates for graduate degrees. The authors reiterate the advice of the present Scientific Advisory Committee that when new federal research centers are built they should whenever possible be located near and identified with universities. There is some discussion of relative priorities—$1.5 billion a year for basic research out of a total of $15 billion per annum for research and development—suggesting that "it is the intuitive assessment of many authorities that the expenditure on basic research is too low in the light of our goals in development."

The authors discuss the difficult question of priorities within the budget for research and development. "What kind of machinery can be developed to evolve systems of priorities? Shall we have some system of representative government for science?" We have the same problems in Britain, perhaps even more acutely. There is fairly general agreement that we ought, without straining our resources, to be able to satisfy the needs of important, small-scale, fundamental science. The remainder of the funds available might then be distributed among the contenders for big science and adjusted to resources by adjustment of a scale—the number of space probes or satellites to be launched a year, the energy of the next generation of nuclear accelerators, the diameter of the next generation of radio telescopes.

An account is given of the Atoms for Peace Program, as part of which 26 research reactors have been provided for overseas countries. No critical evaluation of their use is given.

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Source Book on Mathematics

Mathematics: Its Contents, Methods, and Meaning. vols. 1–3. A. D. Aleksandrov, A. N. Kolmogorov, and M. A. Lavrent'ev. Translated from the Russian edition (Moscow, 1956) by S. H. Gould, T. Bartha, and K. Hirsch. M.I.T. Press, Cambridge, Mass., 1964. 1126 pp. Illus. $30.

It seems most appropriate to have a book like *Mathematics: Its Content, Methods, and Meaning* reviewed in *Science*, for the book was, in fact, especially designed for the readers of such a journal. As one well-known American mathematician recently said, "Whether a physicist wishes to know