RADIOACTIVE WASTE DISPOSAL

Disposal of Radioactive Wastes into the Ground

(Proceedings of a Symposium jointly organized by the International Atomic Energy Agency and the European Nuclear Energy Agency, Vienna, May 29–June 2, 1967.) Pp. 666. (International Atomic Energy Agency: Vienna; HMSO: London, 1967.) 362 schillings; 98*s*. 10*d*.; $14.

RADIOACTIVE wastes are an unavoidable concomitant of the exploitation of nuclear energy, and countries with well established nuclear programmes have already had to make at least a preliminary choice of methods for their disposal. Other countries are as yet uncommitted and the main purpose of this symposium was to assist them by reviewing the practical experience which has already been acquired. The proceedings are confined to disposal into the ground and consist of forty-three papers, published in the languages in which they were presented (English, French, Russian and Spanish) together with verbatim discussion reports in English. The material is nominally divided into sections dealing with the uptake and migration of wastes below ground, site selection, operational experience, the burial of solidified wastes and disposal into deep geological formations. This classification has unavoidably led to considerable overlapping. Although several papers are devoted to laboratory and field studies of the sorption and migration of radionuclides in soils and rocks of different compositions, the emphasis is given to detailed descriptions of the disposal methods already adopted or under development and the problems of site selection and evaluation.

The largest volumes of waste are those with a relatively small radioactive content, and shallow burial commends itself as a convenient and economical disposal method for solid material. The most important safety consideration is the control of groundwater contamination. In some countries the policy is to seek to prevent such contamination completely by using, for example, watertight engineered underground containers. Because major nuclear establishments often produce these low-level wastes at a rate of thousands of tons annually, such measures may carry a heavy economic penalty in addition to leaving doubt as to the "permanence" of the containment provided. It has been clearly demonstrated in the United Kingdom, Canada and the United States that burial without containment can be practised while still conforming with the accepted standards of radiological protection for man and his environment. This may be achieved by the use of areas in which groundwater percolating through the wastes is either not utilized or is adequately diluted by water from uncontaminated sources. Advantage may be taken of the adsorption of radionuclides by soil constituents which effectively retards the migration of activity in relation to the movement of the groundwater itself and thus permits reduction of activity by radioactive decay. These principles have been applied not only to the shallow burial of solid wastes but also to the ground disposal of liquids by means of seepage basins or underground cribs. Disposal site selection and the evaluation of the capacity of a site to receive wastes safely are frequently complex and the roles of the geologist, hydrologist, soil chemist, engineer and health physicist are all brought out in the symposium papers.

As the amount of activity present in wastes increases there is a corresponding need for greater isolation from man's environment. In Czechoslovakia and Spain, for example, dry disused mineworkings are to be used. Disposal into characteristically dry salt formations appears to be the method of choice in West Germany, where a research programme is being undertaken in the Asse salt mine. In the United States the feasibility and safety of the method have already been demonstrated at Lyons, Kansas. One of the more interesting developments, pioneered by the Oak Ridge National Laboratory, is the adaptation of hydraulic rock fracturing to liquid radioactive waste disposal. The wastes are mixed with cements and additives and pumped at high pressure down a well and out into a horizontal fracture previously induced by pressurized water. The fracture is extended by pumping of the waste slurry, which is then allowed to harden under pressure into a thin horizontal grout. This procedure, carried out at depths down to about 1,000 feet in impermeable shale, probably provides as high a degree of isolation of activity as can reasonably be envisaged.

As an account of current knowledge and accumulated experience, these proceedings are undoubtedly comprehensive and the inclusion of cost data enhances their value to those who are concerned with the practice of ground disposal. The proceedings of this symposium, together with those of an earlier IAEA symposium in 1966 which covered disposal into freshwater, the seas and oceans, permit one general conclusion. Much of the apprehension which the subject occasionally generates would be dispelled if there were a more widespread appreciation of the intensive study devoted to radioactive waste disposal and the extreme caution of its practitioners. It is clear that a standard of responsible practice is developing which caters for the convenience and safety of both present and future generations rather than the immediate exigencies which have traditionally determined attitudes to industrial waste disposal.

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PHYSICIST'S VIEW OF PHYSICS

The Nature of Physics

A Physicist's Views on the History and Philosophy of his Science. By Robert Bruce Lindsay. Pp. vi+212. (Brown University Press: Providence, Rhode Island, 1968.) $7.50.

THIS is a very good book; one of several which looks hard at the foundations of physics. The method is by using a combination of the history and philosophy of the subject, which the author rightly regards as tightly interwoven. He is even a little apologetic, writing in America, for pressing home the need for a deliberate methodology. Thus he errs, if anything, on the side of modesty, because what he has done is to provide advanced students or an intelligent layman with a most readable discussion of the history of ideas. An example of this is the contrast between not only the traditional "why" and "how", but a third factor, namely, "how much". In this way, the near-obsession of the Victorians with models and measurements is faithfully recorded, but shown to be a limited prospect of human experience and curiosity. So far, so good.

Next comes the inevitable *fin de siècle*, with Wien, Rayleigh and Jeans all failing to cope successfully with black-body spectral distribution, and the victory, after great reluctance, of Max Planck and the quantum. The saga is well told, but in the telling the writer illustrates his own thesis, that the physicists managed very nicely with no philosophy (and little history), until they collided head-on with a situation which demanded philosophical attention before it could be accepted into any reasonable theory of knowledge. And the same applies to both theories of relativity. Sure enough, however, when one turns to the chapter dealing with the validification or falsification of hypotheses by brute tests, the reader is quite honestly told that the ultimate decision to accept A rather than B, or vice versa, is essentially an aesthetic judgment. That this has happened time and again is only to say that the greatest feats are akin to poetry. An example is the work of Eddington, methodologically a close parallel to that of Archimedes, when he used the axiomatics of Euclidean geometry to deduce the number π. The author keeps his readers at full stretch on