TUBE INVESTMENTS RESEARCH LABORATORIES

NEW HIGH-ENERGY RADIATION DEPARTMENT

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IN recent years, interest in the civil aspects of the atomic energy programme has been mainly centred in the use of atomic energy for power production; radioisotopes produced in atomic plants have also found widespread application as tracers in industry, medicine and agriculture. A new and rapidly developing subject concerns the use of high-energy radiation to promote chemical changes, such radiation being available in atomic reactors.

Although the effects on materials of ionizing radiation in the form of alpha-, beta- and X-rays have been studied for a number of decades, the subject has received a sudden impetus in the past few years and considerable scientific and technical effort is now being devoted to it in a number of countries. This greatly increased interest arises from two main causes—the availability of powerful sources of radiation in the form of atomic piles or high-voltage generators, and the discovery of important applications of the knowledge gained from such studies. Information on the effect of atomic radiation on potential pile materials is essential in the design of high-power reactors. Moreover, recent research has shown that some of the changes induced by radiation, particularly in organic materials, may be of considerable industrial value.

The fields of potential application are extremely varied and include such diverse subjects as the sterilization of pharmaceuticals and foodstuffs, the production of mutations in plants, the initiation of chemical reactions as, for example, in the petroleum industry, and the production and modification of plastic materials. It is a measure of the rapid rate of progress in this field that although some of the basic discoveries were published only a few years ago, processes based on these have already reached the industrial stage. The field of application will undoubtedly extend with further research. Eventually, high-energy radiation may indeed supersede certain chemical treatments involving heat or chemical reagents. It has already been found that some processes which cannot at present be carried out by conventional chemical techniques become feasible by the use of high-energy radiation which can be applied in solids, liquids or gases at any desirable temperature.

Although the development of the subject is closely bound up with atomic energy, it should perhaps be emphasized that this relationship is largely of a historical character. The observed changes in physical and chemical properties arise from disturbances in the electronic structure and not from any changes in the nucleus. Of the sources available to produce such modifications, only a certain number rely directly or indirectly on nuclear transformations. These include the atomic pile itself, radioactive uranium rods withdrawn from atomic piles after use, or fission products which would otherwise be wasted. Naturally occurring radioactive elements or radioactive isotopes produced in the pile, such as cobalt or caesium, may also be used for producing the required radiations. Chemical changes may be caused by alpha-, beta- or gamma-rays produced by such

sources, either alone or together with the slow and fast neutrons present in atomic piles.

For most applications of radiation, beta- and gamma-rays appear to be most useful and convenient. Alternative sources of radiation are, however, available which do not rely in any way on nuclear changes, but instead depend on electrical high-voltage equipment, including linear accelerators, Van de Graaff machines, cyclotrons and X-ray equipment. It has been found that many of the effects obtained depend only on the energy absorbed within the material being irradiated and not on the type of radiation or its energy, which determines the penetration within the specimen. Thus, results obtained under certain experimental procedures can often be readily translated into those for very different radiation conditions. Experiments carried out with low-intensity fission products can be used for determining the feasibility of using radiations from high-power accelerators and, conversely, information obtained from the use of such accelerators can eventually be applied when fission products of high intensity become available with the growth of the atomic energy programme.

Until recently, work on the changes which can be produced by radiation have been largely confined to the use of low-intensity sources in universities and atomic energy laboratories; but the stage has now been reached where British industry is entering into the field. The equipment installed at the Tube Investments Research Laboratories, Hinxton Hall, Cambridge, is the first industrial installation designed specifically to pursue this work on a larger scale and with a greater degree of control of radiation conditions. To permit treatment with various types of radiation of different penetration and ionizing power, a number of radiation sources are available; these comprise a high-voltage accelerator giving 2 million volts, several X-ray machines and a large radioactive cobalt source.

The radiation building has been designed primarily to provide accommodation for the radiation sources and operating personnel; the preparation of specimens and the subsequent studying of the changes produced will normally be carried out in a separate laboratory building now under construction. The radiation building itself comprises a tower flanked by two small wings, one of which houses the smaller sources and the control gear for the main 2-million volt accelerator. This is installed in the upper of the two stories of the central tower and projects vertically downwards into the radiation treatment room on the lower story. The second wing of the building is used at present as a test laboratory, but is arranged for conversion to accommodate longer specimens which can be fed from one wing to the other through the radiation chamber. To protect personnel in the two wings against the intense radiation present in the radiation chamber, the walls consist of 3 ft. of concrete, while the heavy steel door is lined with lead. The radiation-level in the control room is constantly monitored and recorded. Specimens are

Fig. 1. General layout of the conveyor system within the irradiation chamber. The output tube for 2-MeV. electrons, showing the electromagnetic beam scanner, Faraday cage and viewing window, can also be seen

led into the radiation chamber by a conveyor system passing through a labyrinth. A glass viewing-window approximately 1 ft. across allows specimens to be observed during treatment. This window consists of forty-one sheets of $\frac{3}{4}$ -in. glass separated by medicinal paraffin oil to prevent multiple reflexions which would otherwise make direct vision impossible. A separate chamber houses the necessary ventilation and heating equipment.

The Van de Graaff electro-static generator supplied by the High Voltage Corporation, of Cambridge, Mass., is capable of producing an electron or ion beam of 2 million volts and of high intensity. By operating under a gas pressure of some thirty atmospheres, the total size of the installation has been considerably reduced. Under normal operation, it can generate 500 watts of electron-beam power, equivalent to the total radiation power available from many tens of thousands of curies of radioactive cobalt. By using an electron beam, the equivalent radiation intensity is even greater, since substantially all the energy emitted can be directed on to and absorbed within the specimen. Although most efficiently used for electrons, the generator can be converted to produce gamma radiation, fast protons or neutron radiation should these be required for special purposes.

Articles for radiation can either be placed immediately under the beam or fed from the control room

by means of a flexible system of conveyor belts. The electron beam is scanned across each specimen by electromagnetic means controlled externally by the operator. The speed of the conveyor belt under the beam can also be varied over a wide range, and reversing mechanisms are available in the control room to enable specimens to be passed back and forth across the beam. Thus, a very wide range of radiation conditions can be readily obtained. After radiation, specimens may be taken out of the radiation chamber on the conveyor system and can then be handled immediately, since no induced radioactivity is produced with electron beams or gamma radiation of this energy-level.

In addition to the high-voltage accelerator, an X-ray machine operating at about 200,000 volts is available; this produces a radiation flux of higher penetration than from the 2-million volt electron beam, but the intensity is much lower. A second X-ray machine produces an intense beam of X-rays of up to 50,000 volts. Penetration of this radiation is very low and the equipment is mainly intended for surface treatment.

A high-intensity radioactive cobalt source gives highly penetrating gamma radiation of 1.3 million volts. This equipment has been designed to allow specimens to be irradiated at varying dosage-rates and at different temperatures. During the loading process, the cobalt source sinks into the base. To

protect personnel during this operation, a number of interlocking devices are incorporated so that the container cannot be opened until the source is retracted into the safe position.

The programme of work envisaged with the radiation equipment includes both research and development. In the first instance, the effects of irradiating plastic materials are being studied in detail because it has already been shown that very useful changes can be produced in materials such as polyethylene, rubber and silicones.

At the same time, fundamental research is being undertaken into the mechanism by which radiation interacts with matter, and includes such problems as the irradiation of solutions, effects of inhibitors or

protective agents, and the dependence on temperature of radiation-induced chemical changes. The investigation of radiation effects in materials may be considered as a new branch of scientific study involving close collaboration between chemists, physicists and biologists. Many of the effects observed are very novel, and their elucidation should provide not only a basis for further advances in radiation techniques and applications but also may well throw light on basic chemical reactions. The number of problems open for investigation is embarrassingly large, and collaboration with other organizations and research associations interested in the study or application of radiation methods is essential if rapid advances are to be made in this exciting new field.

THE MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

WILSON REPORT

IN December 1954 an independent Committee, that is, not an inter-departmental one, was set up to review the ex-Headquarters organization of the Ministry of Agriculture and Fisheries, to which has now been added the remnants of the Ministry of Food, making it the M.A.F.F. The report of this Committee has recently been published* and, from the name of its chairman, Sir Ayrton Wilson, is being referred to as the Wilson Report. Anyone desirous of forming a clear view of the multitudinous activities of this Ministry and how they impinge on the farmer cannot do better than read this report. Although conforming to the usual style of such reports, with short numbered paragraphs, it is extremely lucid and readable and displays throughout its hundred pages the extreme thoroughness with which the members of the Committee have carried out their difficult task.

The Committee was asked "to consider generally whether the organization is best adapted to secure efficient and economical performance of the functions of the Ministry", to which the Committee's reply is summarized as, "It could certainly be better adapted"; whether "there was undue complexity, over-specialization, or overlapping", to which the reply is, "Yes! there is"; and whether "there was duplication and unnecessary interference with the work of local authorities", to which the reply is, "Little or no evidence of this". In addition to these three questions, the Committee was asked to survey the remaining organizations of the Ministry of Food and also to examine carefully the methods for dealing with the acquisition, management and disposal of land by the Minister and with the preparation of cases for consideration under the Agricultural Act of 1947 and the Agricultural Holdings Act of 1948. Because these cases impinge so directly on the rights and livelihood of individual citizens, the Minister evidently felt it necessary, in view of public criticism, to have existing procedures reviewed by an independent body. Comparatively minor improvements are put forward.

The report concludes with no less than seventy-eight main recommendations which, if put into effect, would result in savings approaching a thousand in staff and £1,000,000 in salaries, travelling expenses

and general overheads. There would be additional savings on premises difficult to estimate accurately in advance. With the present Government committed to some reduction in national expenditure, it is evident that many of the recommendations of the Wilson Committee are likely to be implemented and they are now being considered by the County Agricultural Executive Committees as well as by the organizations concerned. Clearly it is not possible here to give an adequate summary of the voluminous report and its many findings; but an attempt will be made to select some of the major points.

Apart from its headquarters staff, the Ministry has no less than thirty-two organizations which can be divided into six major groups, with a staff of 8,500, and twenty-six smaller groups with about 1,500. The total annual cost is just under £10 million. The major groups are the County Agricultural Executive Committees, the National Agricultural Advisory Service, the Agricultural Land Service, the State Veterinary Service, Fatstock-Marketing, and the National Milk Testing Service. Examples of the minor groups are the Agricultural Lime Department, Land Drainage and Water Supply, the Rodent Inspectorate and the Insect Inspectorate. The organizations work within twenty-two different sets of boundaries—a fact which, in itself, indicates the probability of frequent lack of co-ordination.

Before planning some pruning, streamlining and regrouping of these numerous bodies the Committee first pointed to certain weaknesses, abnormalities and dangerous tendencies, and then laid down some desirable principles. Unlike most government departments, the Ministry of Agriculture and Fisheries has created its own local authority in the form of the County Agricultural Executive Committees and invested them with both advisory and executive duties. For the executive work, the Ministry has made much use of technical and professional staff instead of keeping to the usual practice of using administrative staff. The numerous separate organizations had the dangerous tendency of getting away from team-work altogether. "The Ministry's local organization is riddled with divided loyalties and dual control." The basic principles which, in the opinion of the Committee, ought to be followed are: first, the operations and methods of a Ministry should be supported by a broad body of public

* Report of the Committee appointed to review the Provincial and Local Organization and Procedures of the Ministry of Agriculture, Fisheries and Food. Pp. vi+108. (Cmd. 9732.) (London: H.M. Stationery Office, 1956.) 4s. 6d. net.