reliably, but also at the minimum cost computed over the total life of the station. The history of the commissioning of the Berkeley and Bradwell stations is reviewed by C. D. Heath and D. J. Silverlead, and in their assessment they direct attention to the need for greater flexibility in the timing of the various tests and measurements, improvements in the planning of construction and plant installation, and some simpler form of commissioning organization.

Two papers deal with the performance of reactor cores and materials and of power station plant, and a third with power station maintenance. Of the nine civil nuclear stations, Berkeley and Bradwell have had more than two years' full-power operation and Hunterston one year. Serious defects have been experienced at all three stations and the extra fuel costs have amounted to about six and a half million pounds. The major defects were in the fuelling routes, turbines and boilers. Experience suggests that more reliable operation in the future will occur. With

regard to maintenance, it is emphasized that health physics requirements are an important factor in maintenance planning and that future stations should be better planned and equipped for the maintenance of radioactive equipment.

The final paper in the symposium, by P. H. G. Holbrook and A. C. Horne, deals with some of the special problems, not necessarily technical, which arise in the operation of a nuclear power station. The provisions of the Nuclear Installations Licensing and Insurance Act, 1959, the Radioactive Substances Act, 1960, and the Generating Board's safety regulations have to be enforced and accordingly appropriate inspectorates and organizations have to be established. The increased automation of future stations, with centralized control and computational operation, may lead to a change in the pattern of station organization with economies in technical man-power and less risk to personnel.

S. WEINTROUB

PHYSICS EDUCATION

IDEALISM and iconoclasm were offered in equal proportions by speakers at the International Conference on the Education of Professional Physicists, held in London during July 15–21. The meeting was arranged by the Institute of Physics and the Physical Society for the International Union of Pure and Applied Physics, and attracted participants from twenty-five countries.

Lord Beeching (Imperial Chemical Industries, Ltd.), in a forthright introductory speech, deplored the attitude of university departments which, while disclaiming interest in vocational training, were in fact preparing students exclusively for the vocation of fundamental research. It was, he asserted, not in the public interest that academic research should be presented as the best career for physicists at a time when the industrial, economic and political problems of the community were increasingly dependent on the widespread use of science and technology. Though the Government had great responsibilities in the deployment of scientific and technical resources, only a handful of Junior Ministers had any scientific training. The cause of this deficiency was in the attitude which asked: "Why should we train a good physicist, only to have him wasted as a politician?"

Students of physics must learn that they were not going to be employed exclusively in the narrow practice of their specialty, Lord Beeching continued. Many graduates would find careers in which knowledge of physics was only a small part of the requirement. His own company employed 290 physicists, of whom half held posts not necessarily filled by physicists and about 10 per cent were doing work for which scientific qualifications were not essential. The object of the Government and the universities should be to create an apparent surplus of scientists, many of whom would move into management, administration and politics.

Most of the subsequent contributors were concerned with the scope and content of the undergraduate curriculum, but there was lively discussion also on the extent to which industry's needs were fulfilled by the products of the universities.

A discussion of the young physicist's training and progress in industry, offered by G. S. Bosworth (English Electric Co., Ltd.), was strongly criticized by A. B. Pippard (Cavendish Laboratory, Cambridge) as showing how second- or third-class people could be turned into useful members of an industrial team, while offering nothing to attract the first-class scientists who were badly needed in British industry but were repelled by the Philistine attitude of prospective employers.

Extreme differences of opinion such as this were infrequent. It was generally recognized that the primary

purpose of a university was the advancement of learning and that an industrial concern would fail unless it was conducted to make a profit. Efforts to secure closer collaboration between the university and the industrial community in undergraduate and postgraduate work were reported from several parts of the world; it was agreed that physicists were somewhat better prepared for a practical career in countries such as Holland, where industrial scientists and engineers had a substantial role in academic research and teaching.

Discussion of the content of the curriculum embraced three main topics: (a) mathematics, (b) laboratory work, and (c) lectures. Commenting on the importance of adequate mathematical training, M. Y. Bernard (Conservatoire National des Arts et Métiers, Paris) proposed, not entirely in jest, that special courses should be provided for university teachers of physics, who might otherwise be embarrassed by the superior mathematical ability of their students. The consensus of opinion in France, he reported, called for three kinds of instruction. Professional mathematicians should be responsible for about 25 per cent of the undergraduate's course, dealing with topics where a rigidly logical approach was valid. A physicist should have about 40 per cent of the available time, to cover inductive methods and the development of general laws. The rest of the course should be devoted to exercise classes.

More radical views were asserted by Bernard Friedman (University of California), who condemned the "pernicious influence of sound old-fashioned courses in classical mathematical physics". Up to the end of the nineteenth century, he said, important problems giving insight into the physical world were tackled and solved by the use of special functions, separation of variables and often complicated techniques of integration. These methods were now out of date, partly because of the increasing mathematical sophistication of modern physics and partly because of the rapid advance in electronic computing. When numerical results were required, the computer would generally give more accurate results with less effort. If, on the other hand, a qualitative approach was attempted, mathematical techniques of a more abstract kind were now available.

To understand the mathematical content of present-day physics, the student must be trained in linear algebra, probability and Markoff processes, functional analysis, group representations and Lie algebras. Time does not allow the prospective physicist to follow the standard mathematical courses on these topics, but a briefer curriculum must not be allowed to degenerate into a collection of recipes for solving standard types of problem. Emphasis

should be put on the teaching of abstract concepts such as linear spaces, linear operators, convergence in metric spaces and group invariances and symmetries, even if the immediate practical applications were not fully described.

Comments on practical work were remarkable for the diversity of ideas revealed. S. C. Brown (Massachusetts Institute of Technology) claimed that the main object was to teach what a physicist does. Systematic experiments and laboratory reports should therefore be abandoned in favour of project work, closely linked with the research programme of the department. It was suggested that only the 2,000 physics students at Massachusetts Institute of Technology could ever enjoy such lavish attention, but Brown reported that most of the forward-looking universities in the United States used the same method. Some speakers thought that practical physics could be taught in lectures, though manipulative skill could only be acquired by experience at the bench. E. Mendoza (University of Wales) and F. H. Read (University of Manchester) favoured seminars in which a class (of up to fifty students) conducted one experiment under the guidance of a lecturer.

However great the importance of mathematical and practical instruction, the core of the undergraduate cur-

riculum is in the systematic lectures by which the principles and applications of the subject are uncovered. The burdens laid on the undergraduate's knowledge and on his maturity of understanding are augmented every year. A. B. Pippard showed, from a study of examination papers, how to-day's student is expected to know just as much about electricity, thermodynamics and other long-established divisions of physics as his counterpart of 1940—and in addition, to be conversant with many newer topics of a substantial kind. His solution was to reduce the first-degree course to two years and to provide a more comprehensive training for a proportion of the student body.

The conference passed a number of resolutions of an unexciting character, but its real significance was based on divergence rather than unanimity. Physicists are produced with evident success in educational systems sufficiently varied to include strict Government control of priorities and syllabuses in the U.S.S.R., unfettered academic enterprise in the United States and the amalgam of tradition and innovation characteristic of both the older and newer British universities. The competence and enthusiasm of the finished products encourage the belief that the confusion over aims and methods is superficial.

J. M. A. LENIHAN

PLANT PHYSIOLOGY IN CANADA

THE annual scientific and business meeting of the Canadian Society of Plant Physiologists—La Société Canadienne de Physiologie Végétale—was held at the University of New Brunswick, Fredericton, during June 2–5.

The programme commenced with a symposium entitled "Problems in Marine Algal Physiology". J. S. Craigie (N.R.C., Halifax) discussed the problems of isolating and identifying marine algal excretory products from sea-water. Compounds excreted by several brown and red algae were identified as condensed polyphenolic substances with distinct growth-promoting properties. A brominated benzyl alcohol derivative excreted by *Polysiphonia lanosa* was isolated and crystallized. A pure crystalline extracellular chitin excreted by the diatom *Thalassiosira fluviatilis* was isolated and characterized and was claimed to be the first recorded evidence for the occurrence of poly-N-acetyl glucosamine in the algae. L. Provasoli (Haskins Laboratories, New York) discussed the nutritional requirements of marine algae grown aseptically. Unlike unicellular algae, seaweeds grown autotrophically require a range of vitamins in specific concentrations and ratios for normal morphological development. The growth of *Ulva* and *Monostroma* in aseptic culture was maintained only in the presence of plant hormones, phenolic compounds, and by the addition of supernatants containing active substances from a variety of red and brown seaweeds and from several unicellular algae grown aseptically on artificial media. These unidentified active substances are ethanol extractable and heat resistant and their ubiquitous production in the sea underlies the significance of external metabolites in the water environment. R. T. Wilce (Amherst, Massachusetts) discussed algal survival in the Arctic Sea. Reproductive activity at the end of the winter period and an abundant spring and summer growth were found to depths of 30 metres. The greatest concentration of algal biomass occurred at 15–20 metres, where extremely low light intensities were recorded. Survival under these conditions requires either the possession of a highly efficient photosynthetic apparatus or the facility to exist heterotrophically. Evidence for the heterotrophic growth of pigmented algae in deep lakes and unlit caves suggested

that these arctic populations also thrived by the heterotrophic utilization of organics from the sea.

Several scientific sessions followed the symposium. Continuing their work on plant photorespiration, G. Krotkov *et al.* (Queens, Kingston) showed a distinction in spruce tissue between photo- and dark-respiration with the latter inhibited by light. W. Turner and R. G. S. Bidwell (Toronto) presented evidence for the enhancement of assimilation of carbon dioxide by leaf blades with application of IAA. E. R. Waygood *et al.* (Manitoba), working with detached wheat leaves, showed that photophosphorylation could be both restored and enhanced by benzimidazole treatment and that the synthetic pathway of NAD and NADP from ¹⁴C-carbonyl-nicotinic acid was essentially the same as that reported for animal tissues and micro-organisms. The permanent bleaching of *Euglena gracilis* by nitrofurantoin derivatives was discussed by D. R. McCalla (McMaster, Hamilton). Other mutagens and radio-mimetic agents were used as bleaching agents, but only N-methyl-N-nitroso guanidine proved non-lethal. It was suggested that these bleaching agents damaged chloroplast DNA. Continued interest in the biosynthesis of aromatic compounds and phenolase enzyme systems was reported by A. C. Neish *et al.* from the Atlantic Regional Laboratory (N.R.C., Halifax). In particular the biosynthesis of the cinnamic acid derivatives as the C₆–C₃ intermediates in lignin formation was discussed. Other biochemical contributions of interest dealt with the *in vitro* synthesis of glycine and the metabolic utilization of ¹⁴C-ethanol (E. A. Cossins *et al.*, Alberta). N. E. Good (Michigan) discussed the preparation of several new H ion buffer systems. They were mostly substituted derivatives of *tris*(hydroxymethyl)amino methane covering the pH range from 6 to 8 and were claimed to be superior to both *tris* and phosphate buffers.

Several contributions described studies of the structure and the effects of environment on plant cells by electron microscope and light microscope. A. J. Mia and G. Setterfield (Carleton, Ottawa) reported the synthesis of cell wall material by apposition in *Rauwolfia* sclereids using ³H-glucose pulse labelling. In a session on translocation in the higher plants, contributions from the Biosciences Division (N.R.C., Ottawa) described the experimental