HIGH-VOLTAGE ACCELERATORS

AS attendance at international conferences tends to become larger and the programmes more congested, there is an unfortunate tendency for papers to become shorter and more specialized, so that the proceedings of such conferences are largely unintelligible to workers outside a narrow field. In fact, many of the short papers contributed to such meetings present detailed experimental data which arouse little discussion and would be more adequately dealt with by straight publication in journals of the learned societies. An entirely different situation occurs in meetings where the number of papers is limited, and adequate time is available for experts in neighbouring fields to present a more general review of present status, tendencies and difficulties in their respective subjects. With adequate time for discussion, attendance at such meetings can be very profitable not only by allowing informal interchanges between specialists but also by providing others with a feeling for the prevailing current of thinking in each subject, which cannot be obtained by reading the specialist literature.

The advantages of this second type of conference were brought out very clearly at the second Accelerator Conference which was held during October 4–6 at the Krasnapolsky Hotel, Amsterdam. Sponsored by the High Voltage Engineering Co., this meeting brought together more than three hundred scientists from twenty-four countries, either designing or using high-voltage accelerators for a variety of scientific purposes. A total of twenty-two lectures was given, and these brought out strongly the wide range of studies in which such accelerators have become essential. The session on the first day was devoted to applications in nuclear physics; the second to the new tandem accelerators and the types of experiments on which these are now used. Separate sessions on the morning of the third day were devoted to varied topics in neutron physics, isotopes separation, activation analysis, solid state research. The concluding session in the afternoon of the third day outlined contributions in radiobiology, industrial and medical applications and future accelerators for high-power applications.

A major feature of many of the lectures and ensuing informal discussions was the interchange of views on future applications and requirements for high-voltage accelerators. In many nuclear physics problems, highly monochromatic beams of very short duration are needed, whereas for industrial applications lower voltages and less-uniform beams are quite acceptable if the cost per kW.hr. could be reduced. In this connexion the forecasts of accelerator designers are most encouraging. Already the cost has sunk to between 2 and 10 dollars per kilowatt for a 10-kW. machine. With re-design, longer life of components and higher output ratings, we may expect to obtain high-voltage radiation at a total cost of less than 1 dollar per kW.hr., and 5,000 dollars per kW. installed. Although these figures are high compared with electrical energy from 240-V. mains supply, they are very favourable when related to the costs from electrical accelerators at present installed, or the present cost of radioactive isotopes such as cobalt-60. A single accelerator producing 20 kW. of high-energy radiation has the same energy output as several million curies of cæsium-137, which is far greater than the total world production from fission products. Since one kW.hr. of high-energy radiation, if fully absorbed, can give a sterilizing dose of 2·5 megarads to 300 lb. of material, the cost of radiation is no longer an economic handicap in a number of industrial processes. Attempts to discover industrial applications for high-energy radiation have been carried out in a number of industrial laboratories. It is unfortunate that for commercial reasons the more successful applications have not so far received much publicity. The paper contributed by S. H. Pinner and W. H. T. Davison gives an interesting compilation of patents involving radiation which have already been published. These indicate clearly the considerable interest in the polymer field, where a large change can be obtained with a relatively modest radiation dose.

On the nuclear physics side, Prof. P. M. Endt (Utrecht) discussed the use of proton- and gamma-rays in the study of nuclear resonance-levels, and Dr. T. Huus (Copenhagen) summarized work on Coulomb excitation. Prof. L. Katz (Saskatchewan) diverged from his original script to outline his requirement for a research linear accelerator. On the premise that he was only allowed one such equipment for research he laid down the very stringent specification required. The scientists and designers concerned with accelerator design were prepared to meet this technical challenge if the physicists undertake responsibility for finding the necessary money. It was not clear how the many earnest seekers after scientific truth could all congregate at the feet of this valuable, but extremely expensive, oracle.

By using ultra-fast microwave pulse techniques, life-time measurements of the order of 7×10^{-11} sec. were determined in some odd argon rare earth nuclei by Dr. G. Goldring (Rehovoth). Dr. E. Cotton (Saclay) also gave a short review on nuclear widths and life-times and Dr. A. Schoch (CERN, Geneva) discussed colliding beam techniques.

Electrostatic machines have considerable advantage in the production of continuous beams, and the voltage can be readily adjusted, but there is a limit of roughly 5 MeV. beyond which they cannot operate satisfactorily. This limit had been overcome by the use of tandem generators in which negative ions are accelerated from earth potential to about this voltage, then stripped to give positive ions which continue their path in the same direction. By this means the energy of the beam is doubled. The first of these new tandem generators was installed at Chalk River in February 1959, and Dr. H. Gove (Atomic Energy of Canada, Ltd.) gave details of experiments with this new equipment. In spite of its novel character 80 per cent operational time has been attained with a two-shift programme. The problems studied include proton cross-sections, giant resonance in carbon-14 and silicon-28, and thresholds and yields, departures from Rutherford scattering and narrow resonance structure. Dr. K. W. Allen (Atomic Weapons Research Establishment) also dealt with the advantage of a tandem generator as compared with the linear accelerator or the betatron for their nuclear work, which involves bombardment with p, d, t and ^3He ions in the energy-range of up to 10–12 MeV. and direct measurement of nuclear life-times of 10^{-11}–10^{-14} sec.

There is an obvious need for accelerators going to even higher voltages, and Dr. P. Rose (High Voltage Engineering Co.) described plans for three-stage accelerators giving 15 MeV. He also foresaw accelerators furnishing 30-MeV. beams of 10 m.amp. within ten years. Other potential improvements in high-voltage accelerators include millimicrosecond pulsing as compared with the 2-μsec. pulse at present available (R. Connor, High Voltage Engineering Co.) and more powerful generators using the 'Amplitron' instead of the klystron or magnetron (J. C. Nygard, High-Voltage Engineering Co., and R. F. Post, California).

Ion sources of high efficiency, capable of separating μgm. quantities of rare materials, were described by Prof. J. Kistemaker (Amsterdam), while Prof. R. Fleischmann (Erlangen) discussed polarized ion beams, and Dr. K. Beckurts (Karlsruhe) dealt with pulsed neutron sources and neutron life-time in moderators.

In radiation research, high-voltage beams are valuable in solid-state investigations, as outlined by Dr. P. Baruch (Paris) and have also been used in chemical analysis, either by gamma or neutron activation (J. W. Otvos, Emeryville). Radiation effects in biological systems, as presented by Dr. W. Huber (Stanford), particularly emphasized aspects of interest to radiation physicists and chemists dealing with radiation damage in much simpler systems.

The time-scale permitted adequate time for private discussions on many specific aspects which could not be raised at the formal sessions. Social activities included a banquet given by the High Voltage Engineering Co., at which Prof. H. B. G. Casimir of the Philips Research Laboratories delivered a witty speech and a reception was held by the Mayor and Aldermen of Amsterdam. This included a Van Gogh exhibition which was very much appreciated. Scientific education is sometimes described as narrow and non-cultural. Perhaps we may hope that students of the humanities who hold this view also relax from their learned meetings by attending exhibitions of classical scientific experiments and reading or discussing recent developments in atomic structure, relativity and quantum theory, the basic concepts of which have an increasingly important influence on the outlook of the modern thinking man.

The full proceedings of the conference will be published at the end of the year in *Nuclear Instruments and Methods*.

A. CHARLESBY

FLOW MEASUREMENT IN CLOSED CONDUITS

FLOW measurement is one of the less-spectacular aspects of fluid dynamics, and perhaps for this reason it has not received the attention it deserves. Nevertheless, flow-metering is as old as the engineering applications of fluid dynamics, since in almost every application it is desirable or important to know the volume or mass flow per unit time passing through the system. For example, the distribution of water in a water grid, the flow of air in an air-conditioning plant, the supply of steam to a turbine, the regulation of the flows in the continuous production of chemical engineering products. The fluids may be gases or liquids and the latter may be corrosive or contain solid suspensions as in sewage or wood pulp. The rate of flow may be small as in a blood vessel or great as in large hydraulic turbine installations and in gas turbines. The nature of the fluid, the size of installation, the speed of flow and the accuracy required, all influence the choice of meter.

Of the more common types of flow-meter, the simplest and most accurate for measurements in liquids consists of a large vessel on a weighbridge into which a given mass of liquid is timed. The National Engineering Laboratory, East Kilbride, possesses a 30-ton weighing tank. Alternatively, a somewhat less accurate but more convenient method is that which uses a vessel designed on the pipette principle, into which a definite volume of liquid is timed. These two methods are generally used as standards against which more compact and convenient flow-meters may be calibrated. The pitot-static pressure head has been widely investigated, and used by aerodynamicists for measuring the velocity at a point in air flows, and is regarded by them as a fundamental instrument. By traversing the instrument across a duct the velocity distribution and hence the flux can be found. Small rotating vanes coupled to counting devices and known as current meters can also be used to find the velocity at a point after calibration, and hence the volume flow can be found by integration. A great many meters in practical use utilize a pressure difference brought about by a change of cross-sectional area of the duct. In nozzles and venturi meters this change of area is smooth and gradual, and such meters introduce little loss into the duct system, but they are fairly sensitive to upstream disturbances. In the orifice-plate type of meter the change of section is sudden, and a large resistance is offered to the flow, which gives rise to a large pressure difference. Another method, used in hydraulic power installations, involves the steady injection of a solution of salt at a known rate. Samples are then taken downstream where the mixing is complete, and from the dilution the mass flow can be found. A variant of this makes use of radioactive isotopes. Some methods attempt to measure the mass or volume flow directly without introducing any obstruction into the duct. An interesting example is the magnetic flow-meter, in which a magnetic flux is set up at right angles to the flow of a conducting liquid, and a current flows between two electrodes in the pipe wall which can be related to the volume rate-of-flow. The meter is of particular value in water-borne sludges. Another example of considerable practical importance is the Gibson method. In this the fairly rapid closure of a valve, or of the inlet guide vanes of a hydraulic turbine, causes a pressure variation with time between two stations in the pipe line. The integral of this over the time of closure is related closely to the