carries away most of the energy as kinetic energy and only $\sqrt{2\gamma} m_0 c^2$ is accessible. the large values of γ now available, it seems that future high energy accelerators must operate in the colliding beam mode. The large electron–positron (LEP) storage rings now under construction at CERN near Geneva represent the most advanced enterprise of this type. The tunnel to house the rings is 27 km in length, and the planned energy is ultimately expected to exceed 100 GeV per beam ($\gamma = 2x10^5$). An even larger machine, for protons of energy 10-20 TeV per beam, is being considered in the United States. These machines are near the limits of acceptable cost and sheer physical size. In the case of electrons, the energy loss by synchrotron radiation in the magnet fields also represents a technical limit; further progress will require 'linear colliders', in which two linear accelerators fire very dense bunches of electrons at one another. An experiment to test the principle of this method, and to learn how to generate and control the very dense bunches that will be needed, is underway at the Stanford Linear Accelerator Center (SLAC).

Two questions were asked at Frascati: first, what is the minimum performance specification for an 'interesting' accelerator beyond the range of established techniques; second, what approaches might ultimately be capable of achieving the necessary specification? Appropriately, Carlo Rubbia (CERN) opened the discussion by attempting to define not only what energies are required, but what minimum rate of worthwhile events would need to be achieved.

The ratio of event rate to cross section is known as the luminosity, which for pairs of bunches each containing N particles colliding head-on is given by the expression $L = N^2f/A$, where f is the repetition rate and A the bunch area. For linear colliders the bunches are used once only, so that the beam power is $P = Nf\gamma m_0c^2$. L is determined by the minimum acceptable event rate for experimentation, and P by the power supplied to the accelerator times the efficiency of acceleration of the beam. Since cross sections for interesting events involving point-like particles decrease with energy, both L and P must increase, and Rubbia made a plea for $L = 10^{34}\ cm^{-2}\ sec^{-1}$ for a 5 + 5 TeV electron machine. Inserting affordable values for P and technically-credible values for f and N in the above formulae yields sub-micron diameter bunches with an optical beam quality that is better than has so far been achieved. This challenge was quantified by L. Hand (Cornell University) and J. Rees (SLAC), who indicated the need for high efficiency and optical precision in the beams. High fields are also essential, and it was this aspect that was emphasized at the meeting. Recent experiments at SLAC suggest that extrapolation to above 100 MeV/metre should be possible by development of conventional techniques; this implies not more than 50 kM for a 5 TeV machine, a large but not incredible value. Any new approach must either enable such fields to be obtained more economically than at present or promise higher fields.

Progress was reported on two other linear accelerator concepts, the 'wake field' accelerator of G. Voss and T. Weiland (DESY) and the 'two beam' concept of A. Sessler (Lawrence Berkeley Laboratory). In the former, converging wake fields from a ring of electrons moving through a suitable structure produce intense fields on the axis which can then be used for acceleration. Experiments to test the idea are under way at DESY in Hamburg, FRG and, with a different geometry, at Osaka in Japan. In the two beam accelerator power is provided not by an array of klystrons, but from a single low energy electron beam that runs parallel to the accelerator structure. This passes alternately through magnetic undulators, which generate the required microwave power by free electron laser action, and induction sections that restore the beam energy. An experiment at Livermore has produced 100 MW of radiation at 34 GHz with 5 per cent efficiency. Both these ideas aim at high fields, but their potential still needs to be established.

As at the previous meeting, the 'beat-wave' concept of T. Tajima (University of Texas) and J. Dawson (University of California, Los Angeles), excited considerable interest. It promises the most spectacular accelerating fields, generated by beating together two laser beams in a plasma, where the difference of the laser frequencies is equal to the plasma frequency. Despite tantalizing figures for the field gradient, the detailed physics of the process is still not clear and it is too early to see how one might design such an accelerator. In the United States, experiments are planned to try setting up and detecting a beat wave, and there are hopes that a experiment will be approved in the United Kingdom. There is plenty of scope for further theory and simulations, and for ideas on how to use the concept to build an accelerator. The stringent requirements for efficiency and good beam quality make this task difficult, but there was plenty of enthusiasm for further exploratory work.

An idea much discussed in earlier meetings is the acceleration of particles over a grating carrying an evanescent surface wave, excited by an incident laser beam. At its simplest this would not be efficient, but basic experimental studies on the coupling of waves and grating structures are being planned in Ottawa. A development due to R. Palmer (Brookhaven) is to replace the grating by two rows of tiny spheres spaced about three to a wavelength. The idea is to squirt these from an ink jet printer and, when they have arrived at the correct position, to subject them sequentially to a travelling pulse of laser light. This should render the spheres conducting and, on the short time scale required, capable of sustaining the enormous fields required for rapid acceleration to high energies of a beam of injected particles. The spheres act as a sort of receiving antenna that transfers energy from the laser light to the particles.

Everyone will have their own views about how credible these new concepts really are, but there was considerable enthusiasm at the meeting and no doubt that the future is going to bring increasing activity in this fascinating and potentially important field. □

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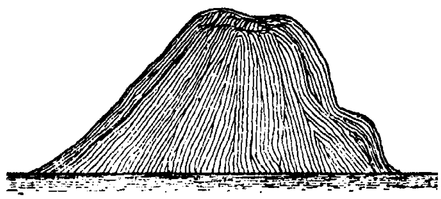
100 years ago

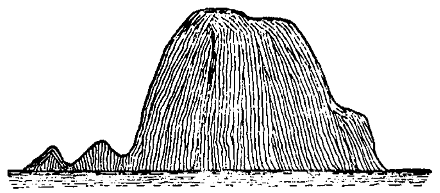
THE NEW VOLCANIC ISLAND OFF ICELAND

AT the end of July this year the light-keeper at Cape Reykjanes, the south-west point of Iceland, reported that a volcanic island had risen in the sea a few miles off the cape. Reykjanes has long been noted as a centre of volcanic activity, and from time to time islands have arisen and submarine eruptions have occurred in its neighbourhood. In the year of the great Skaptárfell eruption, which proved so fatal to Iceland, 1783, an island appeared off Reykjanes, only to disappear again after a very brief existence. Only a year or two ago an eruption of considerable violence occured in the sea, not far from the spot where the new island appeared. Columns of stream and clouds of dust, mingled with occasional glowing masses of fused rock, were seen to rise out of the sea, and large quantities of pumice were thrown up and drifted ashore on the neighbouring coast.

When first seen, on July 29, its shape was that of a truncated cone with a slight depression on the top, and a considerable hollow half way down the slope on the north side. On August 5 and 6 a series of violent earthquake shocks occurred, which shook and split the masonry of the lighthouse and damaged the lamps. The island's shape was considerably altered: a large part of the slope on the south side had slipped down into the sea, where it now lies, forming two little hillocks close to the foot of the main mass, and leaving a steep face nearly perpendicular towards the bottom.



The island as when first seen.



The island as it now appears.

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