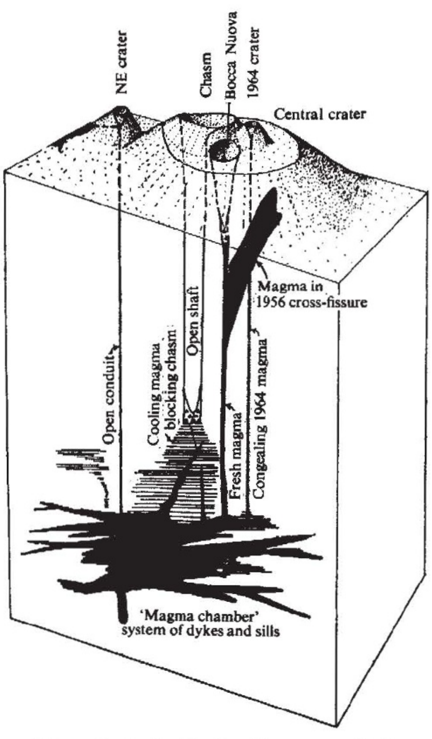
experiments carried out at the Intersecting Storage Rings by groups from Italy and the United States and members of the CERN staff; these are to be published shortly in *Physics Letters*. What these experiments have shown is that the proton-proton cross-section increases between equivalent incident proton energies of about 70 GeV and about 1,500 GeV. A year or so ago it was confidently expected that the cross-section would remain constant in this energy range. But it now seems that the total cross-section goes up from 38 mb (38×10^{-27} cm^2) at 70 GeV, to 39 mb at 300 GeV, 40.5 mb at 500 GeV and 43.2 mb at 1,500 GeV.

The total cross-section for protons interacting with antiprotons, on the other hand, is known to be more than 50 mb at 10 GeV but only 43 mb at 50 GeV. If this downward drift continues—and a definitive statement about this will have to await the results of experiments at the large accelerator at Batavia, Illinois, and at the 200/400 GeV synchroton now being built at CERN or the availability of stored antiproton beams at the CERN Intersecting Storage Rings—the Pomeranchuk theory will have to be re-examined.

VOLCANOES

Model of Etna

THE eruption of Mount Etna in 1971 is the subject of a recent issue of the *Philosophical Transactions of the Royal Society*. The diagram shows the probable distribution of magma within the summit cone in 1971 and provides an explanation of how the eruption came about.



Hypothetical block diagram of the summit cone during 1971. Vertical distances are not necessarily to scale. (From Guest, *Phil. Trans. Roy. Soc. Lond.*, A274, 75; 1973.)

The Bocca Nuova opened up in 1968 as a small gas vent and Guest (*Phil. Trans. Roy. Soc., A274*, 63; 1973) suggests that it was the collapse of the Bocca in 1970 which gave rise to the 1971 eruption. The magma column below the Bocca may have burst into a fracture created during the 1956 eruption, which may then have been enlarged as a prelude to the escape of lava from the far side of the summit cone at the start of the 1971 eruption.

SEMICONDUCTORS

Low Light Levels

from a Correspondent

BECAUSE the eye, an instrument weighing 20 g and parallel-connected to an adaptive computer and several servo-systems, can detect 10^{-16} W in unit bandwidth (noise equivalent power, NEP), it might be claimed that there is nothing left to do. But in an introductory review at a meeting of the Electronics Group of the Institute of Physics at Imperial College, London, on February 23, Dr T. S. Moss (Royal Aircraft Establishment, Farnborough) pointed out many deficiencies in this line of reasoning. There is, for example, ten times more radiation at 1 μm on a clear moonless night than at 0.5 μm, where the eye's response peaks, and a hundred times more (10^{-8} W cm^{-2} sr^{-1} μm^{-1}) at 1.6 μm; also the eye has a slow response and gives little range and velocity information. Furthermore, when external sources of illumination cannot be used, imaging can be accomplished in the 8 to 14 μm atmospheric window by making use of the heat of objects at ordinary temperatures, generally using cooled detectors. The need to know range and velocity has led to the development of yttrium–aluminium–garnet (YAG) lasers at 1.06 μm, carbon dioxide lasers at 10.6 μm and fast sensitive detectors.

Unequalled detectivity at 10.6 μm (the figure of merit $D^* = 10^{11}$ in a 60° field of view, twice the limit imposed by illumination from an unrestricted room temperature background) was claimed for liquid nitrogen-cooled photovoltaic diodes made from the alloy lead–tin–telluride, by Dr T. J. Waterfield (The Plessey Co. Ltd). Noise sources in these detectors and their associated amplifiers were discussed, and it was revealed that integrated arrays of detectors give uniform spectral response when used with current amplifiers. Almost as high a detectivity ($D^* = 7.3 \times 10^{10}$ in a 30° field of view) has been found in photodiodes in cadmium–mercury–telluride at 10.6 μm and this work was described by Dr J. Marine (French Atomic Energy Commission, Grenoble) in a joint paper with Dr Motte (Société Anonyme de Telecommunications). The diodes are produced by the implantation of 250 keV aluminium ions and their subsequent annealing to give donors: the abrupt junctions have a higher quantum efficiency (50 per cent) than diffused diodes and give cut-off frequencies of 300 MHz.

Both these kinds of diode had been used by Drs C. T. Elliott and D. J. Wilson (Royal Radar Establishment, Malvern) to detect CO_2 laser radiation in a heterodyne (or strictly homodyne) system. The use of a local oscillator removes the noise from the incoherent background radiation and with a lead–tin–telluride detector a record 5×10^{-20} W, only 2.5 times the theoretical limit set by photon noise, was needed to give unity signal-to-noise in unit bandwidth (NEP); the photovoltaic cadmium–mercury–telluride detector is only a factor of two worse but holds greatest promise for the largest bandwidths. Both photovoltaic and photoconductive cadmium–mercury–telluride detectors (from Mullard) show serious non-linearities but the latter have yielded an NEP of 10^{-18} W at 193 K, thus avoiding nitrogen cooling.

Advances in photocathodes using single crystal semiconductors were described in papers from Services Electronics Research Laboratory (SERL) and Mullard. Dr G. A. Allen described how the devices depend on obtaining a p-type semiconductor in which the bottom of the conduction band lies above the vacuum level, that is with negative electron affinity. This is achieved by coating the semiconductor surface with caesium and oxygen, which provides a thin positive space charge through which minority carriers tunnel into vacuum. In a transmission photocathode light must penetrate through a transparent medium, which forms the wall of the vacuum chamber, into an active region, usually p-type gallium arsenide a few microns thick. In order to avoid loss of minority carriers at dislocations the transparent substrate must be a crystal of matching lattice parameter. The growth of both substrate and layer by liquid phase epitaxy was described by Dr M. C. Rowlands. Their much higher quantum efficiency will probably make such photocathodes standard devices for the near infrared.

Three of the contributors dealt with detectors based on silicon technology; Dr J. M. Shannon (Mullard) described arrays based on photosensitivity junction field-effect transistors, Dr J. Dickson (Plessey) discussed limitations of arrays in general, and Dr R. Webber (SERL) discussed the theory of photodiodes operating under avalanche conditions.