Popperfoto/Reuter

The plume from Mount Pinatubo, seen here on 12 June 1991, rose over 10 km; volcanic aerosols reached well into the stratosphere.

heterogeneous reactions occurring on the surface of these particles, nitrogen oxides are transformed into nitric acid and, especially in the coldest regions of the lower stratosphere, the unreactive and most abundant forms of chlorine molecules (for example, $ClONO_2$) are partly converted into reactive radicals. Thus, under these circumstances, the atmosphere shifts from a situation where the ozone loss is controlled primarily by nitrogen oxides to a situation where it becomes more readily determined by the abundance of chlorine.

During non-volcanic periods, the aerosol load in the atmosphere remains relatively limited but after major volcanic eruptions, such as those of El Chichón in April 1982 and Mount Pinatubo in June 1991, it can be raised by one or two orders of magnitude[6], so that heterogeneous reactions occur at a much faster rate. Thus, as shown by models based on our current knowledge of the chemical kinetics involved, the ozone molecules of the lower stratosphere should become more vulnerable to atmospheric chlorine and so to man-made CFCs. The analysis by Grant *et al.*[1] of ozone profiles measured at Brazzaville, Congo (4° S), Ascension Island (8° S), and Natal, Brazil (6° N) after Pinatubo suggests that the ozone concentration in the 3–6 months following the eruption was reduced by as much as 15–20 per cent in the altitude range (approximately 24–25 km) where the largest volcanic aerosol loading was observed.

These significant reductions in ozone could potentially result from heterogeneous conversion of NO_x on the surface of sulphate aerosols. Alternatively, heating in the aerosol layer may have drawn ozone-poor, tropospheric air into the lower stratosphere[7] so that the change was associated with transport. Or perturbations of solar radiation fields by the aerosol layer[8] may have reduced the rate of photochemical production of ozone.

Although heterogeneous chemical mechanisms on sulphate aerosols are expected to be most efficient near the polar vortex, no convincing evidence of significant ozone depletion, at these high latitudes, associated with the eruption of Mount Pinatubo has yet been produced. The paper in this issue by Hofmann *et al.*[2] reports for the first time unusually high ozone reduction in Antarctica during September 1991 at altitudes where polar stratospheric clouds are usually not observed. Ozone reduction approaching 50 per cent was detected both in the 11–13 km and 25–30 km regions, resulting in an ozone column abundance 10–15 per cent lower than in previous years.

Different potential explanations are invoked by the authors, including meridional and vertical transport, and homogeneous chemical loss which is found to account for at most a 10 per cent reduction in ozone at 30 km compared with 1980. After careful analysis, Hofmann *et al.* conclude that the depletion below 12 km results from the presence of large quantities of sulphate aerosols produced from the sulphur injected during the eruption of Mount Hudson in Chile (46° S) in August 1991. The ozone depletion observed above 25 km altitude appears to be associated with transport of air from the Wedell Sea and the Palmer Peninsula area where polar stratospheric clouds seem to have been produced at relatively high altitude by mountain lee waves. □

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DAEDALUS

Sound moves

DAEDALUS is dissatisfied with existing loudspeakers. He wants to transduce electricity to sound directly by passing a modulated electric current through the air. This should heat and expand it at the sonic frequency. The problem, of course, is that air does not normally conduct electricity. One answer might be to pass sparks through it. If the sparks were passed at the 44.1 kilohertz digitization rate of a standard digital recording, each spark having the precise energy of the digital signal at that instant, the spark gap should radiate perfect high-fidelity digital sound.

To generate really loud sound in this manner would need worryingly intense sparks. It might be better to use a strong continuous electric current, such as a carbon arc or a silent electric discharge, and modulate it with an analogue sound signal. But Daedalus prefers the idea of building up a strong digital signal by many small additions of energy. This is the idea behind his new digital sonic travelling-wave tube.

It consists of a tube with a series of electrode pairs, spaced at 7.8-millimetre intervals down its length. At the instant of starting, the front electrode pair carries an electric discharge with intensity proportional to the first sample in the digital signal. The next electrode pair has a discharge reflecting the next sample in the signal, and so on down the tube. Then 22.7 microseconds later (that is, one digitization interval at 44.1 kHz), all the discharge intensities are stepped up the tube to the next electrode pair. The whole pattern moves 7.8 mm up the tube, while the last electrode pair acquires the next digital sample in the stream. Now sound travels 7.8 mm in 22.7 μs. So sound travelling up the tube keeps pace with its moving digital representation, and is reinforced at each step. The system acts as a sonic travelling-wave tube amplifier, and emits from its muzzle a beam of perfect, highly directional sound.

This elegant loudspeaker will transform sound reproduction. High-powered versions will direct targeted announcements at the platforms of railway stations and shout advice to sportsmen on the field. Smaller versions will grace our lecture halls and living rooms. On the smallest scale, little travelling-wave tubes may serve as the earpieces of deaf aids and personal tape players. As simple open tubes, they won't prevent the wearer hearing the sounds around him, and as unidirectional devices they won't radiate the wrong way out into the air. The only snag is that they have to be many multiples of 7.8 mm long. Some sort of horned 'Viking helmet' design seems indicated. David Jones