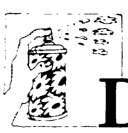

To Ban or Not to Ban: Data for the Ozone Question

A helium-filled Mylar balloon 50 times larger than the Goodyear blimp will carry instruments to the stratosphere next week—just in time to make perhaps the most critical measurement in the "ozone question."

The theory that chlorofluorocarbons might destroy the ultraviolet light-absorbing ozone in the earth's atmosphere touched off a spate of chemical and atmospheric studies such as the upcoming balloon flight. Those studies, in the 21 months since the scholarly proposal first appeared in NATURE, have gained considerable manpower, money and momentum. While there is no formal deadline for answers to the ozone question, some researchers are keeping in mind an informal deadline—this spring's long-awaited recommendation by the National Academy of Sciences on the fate of fluorocarbons. And finish-line data such as the balloon measurements can still make an impact on the final stages of that decision.

Atmospheric chemists from the University of Michigan at Ann Arbor will launch their giant research balloon from the National Scientific Balloon Facility at Palestine, Tex., Monday. The balloon will carry instruments to the upper stratosphere (45 kilometers up), then release them. The instruments and attached parachutes will fall through the 30 miles or so of stratosphere and relay measurements of chlorine oxide (ClO) concentrations at various altitudes.

Finding increased concentrations of ClO would tend to confirm the ozone destruction theory, balloon project leader James Anderson told SCIENCE NEWS. According to that theory, first published in NATURE by F. Sherwood Rowland and Mario Molina of the University of California at Irvine, aerosol propellants and refrigerants such as fluorocarbons 11 ($CFCl_3$) and 12 (CF_2Cl_2) are borne up to the stratosphere by air currents. At about 30 to 35 kilometers, they are struck by strong ultraviolet light (1,750 to 2,200 angstroms) and break apart, releasing reactive chlorine atoms. These, in turn, destroy ozone (O_3) molecules in a repeating cycle:

$$\text{Fluorocarbon} \xrightarrow{\text{uv}} Cl \qquad (1)$$
$$Cl + O_3 \longrightarrow ClO + O_2 \qquad (2)$$
$$ClO + O \longrightarrow Cl + O_2 \qquad (3)$$

Measuring the concentrations of ClO molecules should thus indicate whether or not this breakdown cycle is occurring and to what extent.

Anderson, Donald Stedman and coworkers B. P. Elero, Hines Grassl and Jim J. Margitan equipped the balloon with resonance fluorescence instruments and will analyze the data as it is relayed from the free-falling laboratory. "If all goes well," Anderson says, "we should have data within two weeks, and the National Academy of Sciences will certainly take interest."

Confirming that the ozone destruction cycle indeed occurs will not complete the case against fluorocarbons, however. There is a chance that another series of reactions might tie up the reactive chlorine shortly after it is generated rather than allowing it to knock out O_3 in a continuous cycle as feared. Researchers are therefore studying possible "sinks" for chlorine molecules. Al Lazrus of the National Center for Atmospheric Research is measuring the concentrations of hydrogen chloride (HCl), a confirmed stratospheric sink, with a cellulose filter device born by balloons and high-flying airplanes. He reported at a National Aeronautics and Space Administration advisory meeting in Los Angeles last week that HCl concentrations fluctuate according to season.

This finding is significant in light of another potential chlorine sink, chlorine nitrate, $ClONO_2$, which may also be seasonal, and increase when HCl decreases. Rowland, Molina and John E. Spencer of the University of California at Irvine predicted in January that ClO molecules might link with NO_2 molecules and remove reactive chlorine from the ozone destruction cycle. If this is true, the ozone problem might be only 75 percent as bad as predicted. But, on the other hand, Rowland says, $ClONO_2$ might react with HCl, removing both potential sinks. This would release *more* chlorine and make the problem 25 percent *worse.* Lazrus will make more test flights shortly to measure HCl concentrations and to try to resolve what atmospheric physicist Ralph Cicerone of the University of Michigan calls "the biggest uncertainty in the field right now."

The prospect of banning some or all uses of the fluorocarbons creates uncertainties of its own. While most aerosol packaging is clearly nonessential, refrigeration and air conditioning is not. Are there compounds that could replace the fluorocarbons for these essential functions if the chemicals are banned? Not really, University of Illinois chemists John W. Birks and Thomas J. Leck found out. They have surveyed 80 compounds—"Every compound known to man that boils between −15°C and −45°C," Birks says—looking for substitutes. The perfluorocarbons, such as perfluorocyclopropane, might work in place of fluorocarbon 12, but "we would need 250 million pounds per year," Birks says, "and we can only make a few grams at a time now." And switching to existing refrigerants such as fluorocarbon 22 would require complete redesign of refrigeration equipment. "Any decision to ban the use of R-12 (fluorocarbon 12) should take into account these facts," Birks and Leck state in the March 4 NATURE.

No one is saying anything official at this point, but refrigeration will certainly be spared by the upcoming National Academy of Sciences recommendation. The NAS Committee on the Impact of Stratospheric Change will issue a two-part report (a scientific overview and impacts and recommendations) this spring. The Federal Interagency Task Force on Inadvertant Modification of the Stratosphere (IMOS) has already recommended a ban on aerosol propellants beginning in January 1978 if the NAS report concurs (6/21/75, p. 396). And, Cicerone told SCIENCE NEWS, there has been nothing but minor quantitative adjustments and confirmatory evidence since research began in 1974. "The theory is as good as gold after two years, and we can't wait forever to control fluorocarbons. We must, however, separate the frivolous uses from the essential ones. This will remove 75 percent of them, and give us more time to study essential applications."

While this approach might sound reasonable to proponents like Cicerone, fluorocarbon producers aren't buying it. In a technical report submitted this month to IMOS and NAS, the Manufacturing Chemists Association (which represents 99 percent of the fluorocarbon producers) came to three very different conclusions: 1) there are research gaps that will take years to fill, 2) ozone decreases during a continued few years of production would be minimal, and 3) research should continue "with vigor" through 1978, at least, without regulation on the production or use of fluorocarbons.

A highly respected, industry-funded researcher, R. A. Rasmussen of Washington State University at Pullman, emphasizes that there are still considerable uncertainties in the model and theories, that sufficient momentum and a "critical mass of investigators" has only just been reached in the research, and that the stratosphere with its highly complex chemical cycles is not as sensitive to man-made perturbations as previously thought. "Do you know the postmortems on most environmental 'threats' postulated during the '60s?" he asks. "After the emotions were turned down, it was clear just how uncertain many of these really are."

But uncertainty can go in both directions, Cicerone says, and "when there is the *potential* for disruption or harm, it is the scientist's responsibility to fight for an end to unnecessary risks until those uncertainties can be cleared up." □