Fluorocarbons and ozone: New predictions ominous

A third major prediction about the effects of fluorocarbons on the stratospheric ozone layer, this one more ominous than the previous two, will soon be released. Harvard University atmospheric scientists Michael B. McElroy, Steven C. Wofsy and Nien Dak Sze have submitted to the journal SCIENCE computer calculations based on atmospheric data and a proposed model of fluorocarbon breakdown and ozone destruction in the upper atmosphere. The three predictions have caused sufficient concern in the scientific community that the National Academy of Sciences has formed a special study committee.

The first prediction was made in July by physical chemists Frank S. Rowland and Mario J. Molina from the University of California at Irvine. In the July 28 NATURE, they proposed a chemical model for the breakdown of ozone in the upper atmosphere by fluorocarbons. Fluorocarbons are used widely as propellants in aerosol spray cans. When inert propellants such as fluorocarbon 11 ($CFCl_3$) and fluorocarbon 12 (CF_2Cl_2) float up past the troposphere (the lower seven miles of atmosphere) into the stratosphere, they absorb ultraviolet light in the 1,750 to 2,200 angstrom range. In the proposed sequence of events, chlorine atoms liberated by the light energy interact with ozone (O_3) in a chain reaction that changes thousands of ozone molecules into molecular oxygen (O_2).

They predicted that increased worldwide production and use of fluorocarbon aerosol propellants and refrigerants might result in a 10 percent decrease in the stratospheric ozone layer within 50 to 80 years. This decrease, they warned, would allow more of the sun's harmful ultraviolet rays to reach the earth's surface and could cause an increase in the occurrence of human skin cancers.

Using the Rowland and Molina chemical model, Ralph J. Cicerone and Richard S. Stolarski of the University of Michigan published computer calculations in the Sept. 27 SCIENCE that predicted a 10 percent decrease by 1985 or 1990 (SN: 9/21/74, p. 181).

Now, the Harvard team has completed its own computer calculations and is making more ominous predictions. McElroy, Wofsy, and Sze studied six conceptual models for future world production of fluorocarbons. Unlike the earlier works, they considered the factors of vertical mixing of fluorocarbons and ozone between atmospheric layers and the effects of fluorocarbons on the slow but finite regeneration of ozone by the action of ultraviolet light on oxygen. The same approach, used in an earlier study on the effects of SST exhaust on the ozone layer, showed "excellent agreement" with atmospheric observations.

All of the six models assume that the ozone layer has already been diminished by 1 percent.

The first model (see diagram, line A) assumes that production of fluorocarbons continues indefinitely at 1972 levels, approximately 500,000 metric tons of fluorocarbons 11 and 12 per year. The atmospheric buildup of fluorocarbons over that period and the subsequent breakdown and attack on ozone would result in a five percent decrease in the protective ozone layer by the year 2000. But, McElroy points out, fluorocarbon production has been growing, and this static model is not realistic. Production increased about 22 percent per year from 1960 to 1972. Ray McCarthy, the technical products manager of Dupont's Freon products division, suggests that a 10 percent growth rate would be a reasonable projection for continued worldwide production and use; some skeptics doubt that growth will slow that much.

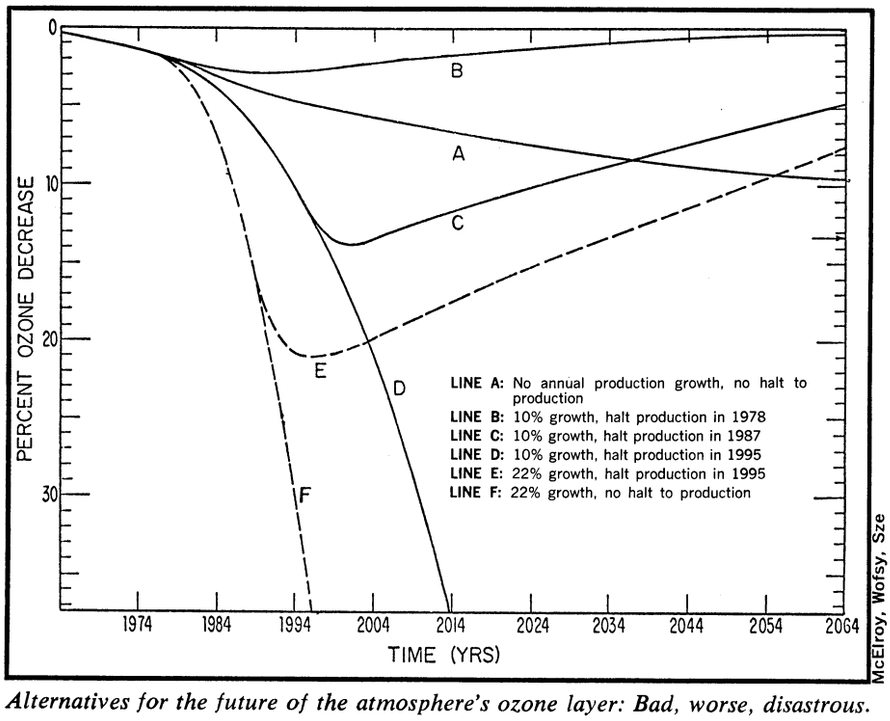
In models B, C and D, a 10 percent growth rate was assumed. In model B, production is terminated in 1978. Nevertheless a three percent decrease in ozone occurs by 1990. (Effects are delayed by years due to the slow upward drift fluorocarbons.) Full ozone layer regeneration would require more than 100 years, McElroy says.

In model C, production growth continues at 10 percent until 1987, at which time production is halted. Maximum effects would be felt 10 years later, with a 14 percent ozone decrease. Seventy years later, the ozone layer still would be decreased by 5 percent. In model D, production growth continues at 10 percent indefinitely. By the year 2014, the team predicts a disastrous 40 percent decrease in ozone.

Models E and F assume continuation of the present 22 percent industry growth rate. If production is halted in 1995 (line E), they predict a total ozone layer decrease of about 22 percent by the year 2000. If production increases at 22 percent per year and is not halted, a 40 percent decrease in ozone will be realized by about 1995.

Although the precise consequences of ozone layer destruction are unknown, it is known, McElroy says, that life is in a precarious balance with ozone. The ozone layer shields the earth's surface from ultraviolet radiation.

A 1973 National Academy of Sciences study on the biological impact of increased ultraviolet radiation, conducted during the debate over the environmental safety of SST's, found that a five percent decrease in ozone could produce at least 8,000 extra cases of skin cancers per year in the U.S. white population. (Skin pigmentation shields



Alternatives for the future of the atmosphere's ozone layer: Bad, worse, disastrous.

many of the harmful rays.) Skin aging in general also would be accelerated by increased ultraviolet exposure. Changes in solar radiation levels could harm phytoplankton in the oceans, which produce much of the earth's oxygen. Insects see in a portion of the ultraviolet spectrum and light intensity changes in this region could affect insects' perception of skylight, flower colors and sexual markings. And many plants, particularly agricultural species, are damaged by ultraviolet light.

The growing concern over fluorocarbons and the ozone layer has led to the formation of a special NAS study committee. The members include McElroy and Rowland; atmospheric chemist Donald M. Hunten of Kitt Peak National Observatory, chairman; Francis S. Johnson, executive director of the Center for Advanced Studies at the University of Texas at Dallas, and chemist Harold S. Johnston of the University of California at Berkeley. The group will meet later this month to consider the reports and decide whether to recommend the formation of a permanent study group to the governing board of the National Research Council. Another NAS group, the climatic impact committee, is already studying the climatic effects of SST exhaust, fluorocarbons, and other man-made pollutants.

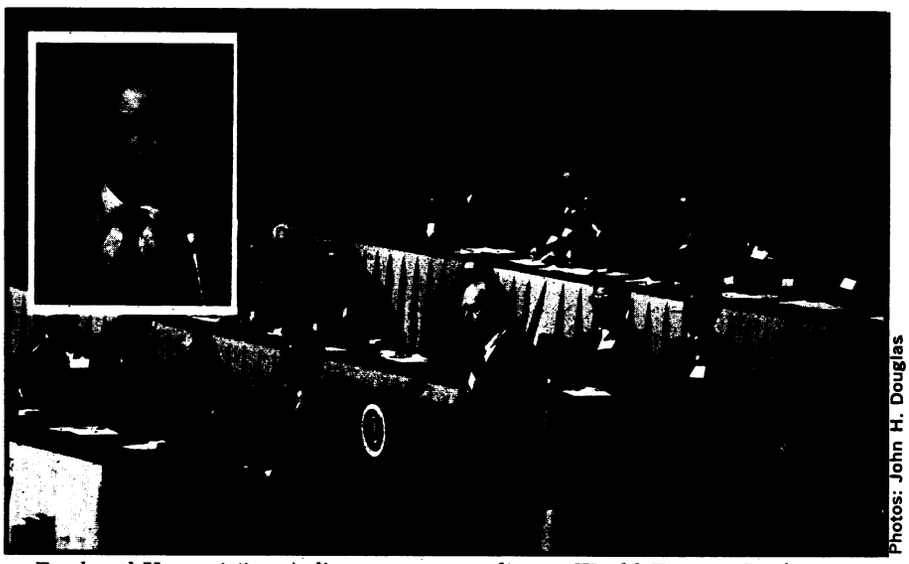
The Manufacturing Chemists Association, a trade group representing members in North America, Europe, Australia and Japan, is currently funding several studies on the environmental effects of fluorocarbons. James E. Lovelock, atmospheric scientist at the University of Reading in England, is making direct measurements on the concentrations of fluorocarbon 11 in the stratosphere. James N. Pitts and O. C. Taylor from the University of California at Riverside are studying the reactivities of fluorocarbons at various altitudes. And Camille Sandorfy from the University of Montreal is making the first experimental measurements of reaction rates under simulated stratospheric conditions.

Although the predictions are strong, industrial spokesmen are quick to point out that little experimental data exists and judgment should be suspended until more information is available. McElroy says he does not recommend taking immediate action to terminate fluorocarbon production or use. "All of these models are just that—models. Although they are based on what we believe to be good work, atmospheric chemistry is very difficult and it is easy to miss something. Direct measurements on a vastly accelerated scale must take place" to test the theoretical models, he says.

But he emphasizes that expanded research on the subject is urgently needed. This situation is different from most kinds of science, he says, where a theoretical paper will "sit on the shelf" until it is confirmed. "We can't afford to wait the normal 10 years." McElroy says, "because if the theories are correct, by that time the effects will be pronounced." □

Energy: Inflation for some, disaster for others

The mountain may yet come to Mohammed, if the Arabs have their way. Though President Ford's address to the World Energy Conference in Detroit last week signaled a new, tougher stance in the face of continued high oil prices from the Organization of Petroleum Exporting Countries (OPEC), Sheikh Ahmad Zaki Yamani of Saudi Arabia responded by patiently explaining why oil producers will not be moved by threats and then lectured the United States on the evils of "economic imperialism." Meanwhile, several developing countries continue to slide toward famine and economic chaos.



Photos: John H. Douglas

Ford and Yamani (inset) dispute energy policy at World Energy Conference.

Ford's address spearheaded a carefully orchestrated diplomatic offensive to unite energy-importing countries for mutual protection while preparing the way for a tougher stance in bargaining with OPEC nations. Artificially high prices "run the risk of worldwide depression and threaten the breakdown of world order and safety," he told the conference delegates. This warning was echoed by Secretary of the Treasury William E. Simon, who likened OPEC policies to killing the goose that laid the golden egg. In New York, Secretary of State Kissinger pointedly endorsed a recent tentative agreement among petroleum importing nations to share their limited resources, calling it "an encouraging first step." And in Washington, Federal Energy Administration head John C. Sawhill used the toughest language of all: "There comes a point where the conditions under which oil is supplied lose their commercial character and become issues of national survival. At that point—and we have long since passed it—we must explore the full range of options at our disposal to protect the national interest."

An immediate response came from the chief conference spokesman for the OPEC nations, Saudi Arabia's oil minister, Yamani. With the cool logic and intonation of a Boston Brahmin (he studied international law at Harvard) Yamani said OPEC members were not subject to the forces that usually break up cartels—loss of market advantage when one member refuses to withhold his goods in order to drive up prices. "The rewards of conservation . . . are far greater than any immediate gain engendered by expansion of sales," he said in his prepared text, meaning that nations that leave their oil in the ground will eventually be able to sell it at even higher prices. The exporting countries take their newly found power very seriously, he said, and have no intention of bankrupting the West. Nevertheless, in his view, most of the world's economic problems are not caused by OPEC oil prices nearly so much as by the profligate use of energy built up in the days when oil was cheap.

Privately, some Western delegates agreed with him. One pointed to the convention city of Detroit as a symbol of energy waste in big cars; another responded to a question about the tougher Administration stance by asking sarcastically, "Just what are you going to threaten them with?" The managing director of Japan's petroleum association, H. Kumeda, told SCIENCE