"Yes, I can attend your meeting," Sherry Rowland is saying into the phone. "But not the week after that. The Salzburg Festival begins then, and we're not going to miss it."

We're in Rowland's cluttered fifth-floor office in the physical sciences building of the University of California at Irvine. Some of the decor is standard for any scientist: the bookcases crammed with reference volumes, the desk piled with reports, the computer blinking off to one side. But a lot of it is pure Sherry Rowland: One end wall adorned with sports trophies, including a red banner celebrating an impromptu basketball game in Siberia ("The Russians wanted to play soccer, but I talked them into basketball."); the other solid with opera posters—*Eugene Onegin* at the Bolshoi Theater, *Simon Boccanegra* at the Straatsoper.

Lots of people have been coming to see Rowland, but not to talk about basketball or opera. For Sherry Rowland is the man who saved our planet—maybe. He did it toward the end of 1973, out of pure intellectual curiosity. In a few months of pencil-and-pad calculations and simple tabletop experiments, Rowland and a postdoctoral associate, Mario Molina, established that apparently innocuous industrial chemicals called chlorofluorocarbons (CFCs) were eating away at the upper-atmosphere ozone layer that shields us from harmful ultraviolet radiation. That discovery has led to some unprecedented actions: a pledge by Du Pont to stop production of CFCs, an international agreement to limit output of the chemicals, and a major scientific effort to understand what's happening to the ozone layer and how much its thinning could hurt us.

The "maybe" is because Rowland and other scientists think that what's

The man who knew too much

More than 14 years ago Sherry Rowland blew the whistle on the ozone-destroying potential of chlorofluorocarbons used in aerosol sprays, refrigerators, and automobile air conditioners. It took the discovery of an ominous hole in the ozone half the size of Antarctica to make people listen.

By EDWARD EDELSON
Drawings by Mitchell Albala

been done so far probably isn't enough. The discovery of an ozone hole over the Antarctic has shown that under special conditions the ozone layer can be destroyed with frightening rapidity. Chemical calculations show that the same sort of reactions can happen elsewhere in the stratosphere. Biologists say an overdose of ultraviolet radiation could not only cause an epidemic of skin cancer, but also destroy the base of the marine food chain.

The CFCs we sprayed under our arms and pumped into our car air conditioners 20 years ago are still drifting up to the stratosphere to increase the rate of ozone destruction. But at least we know what we're up against and have started to do something about it. And that's mainly because of F. Sherwood (everyone calls him Sherry) Rowland. "You can speculate as to how long it would have taken someone else to catch on to the CFCs, but that's totally moot," says Ralph Cicerone of the National Center for Atmospheric Research. "What created the tremendous surge in interest was the Molina and Rowland work."

When you chat with Sherry Rowland it's hard to believe that for some-

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Gas collectors like the one Sherry Rowland is holding helped explain the ozone hole discovered over Antarctica. A Southern Hemisphere plot of ozone distribution (above) for Oct. 5, 1987, showed a value of less than 125 Dobson Units (DU), a measure of ozone, for the black area. A reading of 109 DU, taken the same day, was the lowest ozone value ever observed. The plot shows that the ozone hole covers approximately seven million square kilometers, or nearly half the area of the Antarctic continent. The data were gathered using the Total Ozone Mapping Spectrometer instrument on NASA's Nimbus-7 satellite, which is managed by the Goddard Space Flight Center. The values of the colors in DU of total ozone are shown in the color bar.

thing like a decade he was the focal point of immense pressures—from a powerful industry suddenly threatened by his theoretical calculations, and from atmospheric scientists probing to find weaknesses in his conclusions. A few minutes with him is enough to tell you that his wry calmness in the days of his vindication can't be much different from his attitude when the controversy was at full boil.

You could describe Rowland as a slightly shorter look-alike of John Kenneth Galbraith. (Galbraith is six foot seven inches; Rowland, six foot five.) Now in his 60s, Rowland still has the frame of an athlete. He plays in intramural softball and basketball games at Irvine and bodysurfs when he can.

Born in Ohio, he served briefly in the Navy at the end of World War II, got his doctorate under the renowned chemist Willard Libby at the University of Chicago, played semipro baseball while in graduate school, and came in 1964 to Irvine to start the chemistry department.

Making headlines is nothing new for Rowland. In 1971, when the world was agitated by reports of high mercury levels in tuna and swordfish, he and several colleagues obtained century-old fish from museums. They tested them with neutron activation analysis and found essentially the same mercury levels that were causing alarm. The scare died quickly after that.

His involvement with CFCs and the atmosphere stemmed from his view that "as a research scientist you ought to try something new every few years." In 1970 he was faring well as the chairman of the chemistry department at Irvine, specializing in radiochemistry and doing work for agencies like the International Atomic Energy Administration and the U.S. Atomic Energy Commission. On a visit to Austria for an IAEA meeting he met William Marlowe, an AEC executive who was organizing a series of workshops to bring together chemists and meteorologists. He invited Rowland, who showed up at a meeting in Fort Lauderdale, Fla., in January 1972.

What intrigued Rowland was a paper written by James Lovelock, a brilliant British scientist who had invented an instrument called an electron capture gas chromatograph that allows detection of small amounts of trace gases in the atmosphere. Another scientist, Les Machta, told those gathered at the meeting that wherever Lovelock had set up his instrument he had detected a CFC called Freon-11.

"This particular CFC was everywhere," Rowland says. "That gave me a new problem to think about: Did we know enough in the laboratory to predict what would happen to it?"

A safer alternative?

CFC-11 is a member of a family of synthetic chemicals whose properties—especially their combination of high volatility and low chemical reactivity—make them an answer to industrial dreams. They were developed in 1930 by Thomas Midgley, a research engineer working for a joint Du Pont-General Motors operation, as a safer alternative to the refrigerants then in use—sulfur dioxide and ammonia, which are corrosive and toxic. As their name indicates, chlorofluorocarbons contain chlorine, fluorine, and carbon, bound tightly to form inert molecules. Midgley cheerfully demonstrated the harmlessness of CFC-12 at a 1930 American Chemical Society meeting by inhaling a lungful and blowing out a candle.

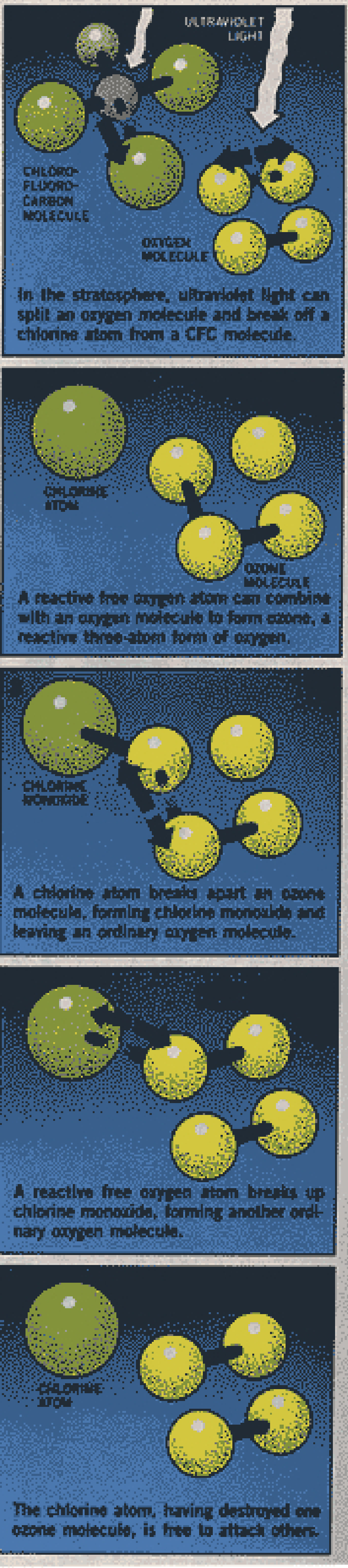
The Freons, as Du Pont trade-named them, were quickly adopted by industry. Freon- (or CFC-) 11 and 12 went into refrigerators and air conditioners, then later were used to make aerosol propellants and plastic foams found in everything from mattresses to fast-food cartons. CFC-113 was used as a solvent, especially invaluable in the semiconductor industry. By 1973 world production of CFCs was approaching a megaton a year, much of it blown directly into the air through aerosol nozzles, more leaking out from refrigerators and air conditioners. But no one was worried because the CFCs were so marvelously nontoxic and inert.

It was in 1973 that Rowland asked the AEC, which funded his research, if he could study CFCs. They agreed, as long as he didn't spend any extra money. Mario Molina, a Mexican chemist educated in Europe and the United States, had just arrived at Irvine. Rowland offered him his choice of research projects, and Molina picked the CFCs. They began work in the fall of 1973 and knew Earth was in big trouble before the year was over.

"It was that quick," Rowland recalls. "I suppose if you look at it in retrospect, the key was asking the question."

As Rowland explains it, the problem was simple. Only three things can happen to a molecule in the atmosphere. It can be photodissociated—broken apart by solar radiation. It can dissolve in water and fall in rain. Or it can react with an oxidizing substance in the atmosphere—sometimes ozone, sometimes a hydroxyl.

A CFC is transparent, which means it doesn't absorb visible radiation. It doesn't rain out because it's insoluble in water. And its inertness means it



In the stratosphere, ultraviolet light can split an oxygen molecule and break off a chlorine atom from a CFC molecule.

A reactive free oxygen atom can combine with an oxygen molecule to form ozone, a reactive three-atom form of oxygen.

A chlorine atom breaks apart an ozone molecule, forming chlorine monoxide and leaving an ordinary oxygen molecule.

A reactive free oxygen atom breaks up chlorine monoxide, forming another ordinary oxygen molecule.

The chlorine atom, having destroyed one ozone molecule, is free to attack others.

NASA Langley Research Center scientist Edward V. Browell monitors the plotter readout of his "ozone and aerosol differential absorption laser detection and ranging system" experiment. The experiment uses laser beams to analyze the atmospheric chemistry overhead a DC-8 by measuring the reflectance from different layers of air. Browell is looking at the readout of stratospheric aerosols while the DC-8 is flying directly over the South Pole. On the left is the readout for ozone concentrations above the aircraft. The numbers on the side indicate latitude and longitude.

doesn't react with oxidants. A month of study was enough to show that "this molecule will last for quite a while," Rowland sums up.

In fact, it will live long enough to drift into the stratosphere, the upper part of the atmosphere, where it will encounter a different kind of solar radiation: the more energetic ultraviolet that is absorbed by the ozone layer. So Molina and Rowland began testing the interaction of CFCs and ultraviolet. It wasn't complicated, Molina recalls: They put some CFC into a container on a laboratory bench, exposed it to ultraviolet, and measured the absorption spectrum. The result: ultraviolet split some of the CFC molecules.

Factoring in the rate at which CFCs diffused into the stratosphere, Rowland and Molina came up with an interesting number: The average lifetime of a CFC-11 molecule in the stratosphere was between 40 and 80 years. A CFC-12 molecule would live 80 to 150 years, they estimated.

"We considered writing it up," Rowland remembers. "But just to be more complete, we decided to figure out what happens to the decomposition products.

"That's when the bottom fell out."

About 78 percent of the atmosphere is nitrogen, and another 21 percent is oxygen. Both normally exist as two-atom molecules. But ultraviolet radiation can break oxygen molecules apart (see drawings), giving very reactive atoms. Some of them combine to make a three-atom form of oxygen, which is ozone. Ozone is very reactive too. In the stratosphere it readily combines with nitrogen oxides (which are produced by living things and drift into the stratosphere). Normally ozone formation and destruction stay in balance, creating a tenuous but vital ozone layer in the upper atmosphere—vital because it prevents most ultraviolet radiation from penetrating to Earth's surface.

Cycle of destruction

Toward the end of 1973 Rowland and Molina began to study the changes that would occur if the fragments of CFC molecules penetrated the ozone layer. One obvious decomposition product of a CFC is the chlorine atom. "At thirty kilometers [above Earth], its reaction with ozone is tremendous," Rowland says. "You get chlorine oxide and then repeat the process. You suddenly find you're not getting rid of the chlorine, you're getting rid of the ozone."

Calculations showed that a lone chlorine atom would destroy one molecule of ozone every minute and would stay in the stratosphere for at least a year. Some chlorine atoms would combine with methane to form hydrogen chloride, but the hydrogen chloride would react almost immediately with the hydroxyl to release the chlorine atom once more. The cycle of ozone destruction would stop only when the chlorine diffused into the lower atmosphere.

It was about that time that Rowland came home one night and told his wife, Joan: "The work is going well, but it looks like the end of the world."

In December Rowland called Harold Johnston, an atmospheric scientist at the University of California at Berkeley, to tell him about the CFC work. Johnston had been active in studies about the possible effects of nitrogen oxides from the proposed U.S. supersonic transport on the ozone layer. But he told Rowland that the possibility of a chlorine chain reaction had already been established by Ralph Cicerone and Richard Stolarski, then at the University of Michigan.

The National Aeronautics and Space Administration had asked Cicerone to study the space shuttle and the atmosphere. Because shuttle exhaust contains chlorine, Cicerone and Stolarski had worked out chlorine's reaction with ozone. "As soon as we heard about Rowland and Molina's work, it was clear that the CFCs were more important than what we had studied," Cicerone recalls. Rowland and Molina had spotted the key ingredient for trouble: a major source of chlorine in the upper atmosphere. Cicerone immediately began studies to confirm the findings.

Rowland and Molina sent a paper in January 1974 to the journal *Nature*. Through a series of mishaps, including

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the sudden decampment of an editor, it didn't appear until June. Rowland delivered essentially the same report at a San Diego meeting in July. In September, he and Molina estimated that if CFC production continued at the 1972 rate, between 7 and 13 percent of the ozone layer would eventually be destroyed.

Nothing happened at first. It wasn't until the American Chemical Society held a press conference for Rowland at its annual meeting in September, and the University of Michigan publicized Cicerone's work, that the press picked up the story.

"This is not my planet: The atmosphere is different, and the climate is going to be very different"

Environmental do-gooder

The National Academy of Sciences appointed an ad hoc five-member panel (including Rowland) to find out whether the ozone problem was serious. Du Pont asked Rowland to give a talk; he did, and was listened to politely. Later, two Du Pont executives came to Rowland's office for a visit. "I had the impression they were casing the joint," he says. In parting, one of the visitors remarked that Rowland seemed to be an "environmental do-gooder," a phrase that he remembers. "I suppose if one has a binary view of the world, I probably am more comfortable with the do-gooders than with the polluters," he says now.

Industry skepticism was understandable. CFC production was a $2-billion-a-year business. And here was this professor saying it should be brought to a halt because of some theoretical calculations. Measurements to confirm or refute the theory were difficult to perform because they required dealing with small concentrations of molecules in an atmosphere so thin it would be regarded as a vacuum on Earth's surface.

But as the measurements began to come in, the CFC-ozone problem became less theoretical. The National Academy of Sciences ad hoc committee decided the issue was worth a full-scale investigation and report, so a second NAS panel, with a dozen members (Rowland was not among them), was formed. A new interagency government committee on the Inadvertent Modification of the Stratosphere (IMOS) wrote a strong report in mid-1975, supporting the seven-percent ozone-depletion prediction (and rushed it into print a month early out of fear that the White House might stifle it).

Rowland remembers his first sight of the report. He was working in Vienna, Austria, walking home one evening to meet his wife. He saw her at a coffeehouse table, reading an *International Herald Tribune*. "There it was, in the headlines," he recollects. "The IMOS report was out."

The evidence continued to pile up. Measurements taken by the National Oceanic and Atmospheric Administration showed a shrinkage of the ozone shield in the 1970s. And in 1975 a government task force said use of CFCs in aerosol spray cans should be banned by the beginning of 1978.

Du Pont called the recommendation premature and said at least three more years of study were needed, but the threat of a ban sent most companies in the aerosol-spray industry scrambling for substitutes—generally in the form of hydrocarbons such as propane. (By the time the ban went into effect, the spray-can industry found it could get along without CFCs.)

But then came an industry counterattack—one that at first seemed to derail the ozone threat entirely. It was rooted, oddly enough, in work done by Rowland and Molina to explain one of the new atmospheric measurements.

Balloon-borne samplers showed a substantial drop-off in hydrogen-chloride concentration above 20 kilometers, something out of line with the Rowland-Molina theory. Originally they had thought that chlorine nitrate, a chemical that's also present at 20 kilometers, would be destroyed quickly, releasing chlorine atoms. Their new studies of the ultraviolet-driven chemistry of the upper atmosphere came to a different conclusion.

"In the lab, we found that the chlorine nitrate ultraviolet absorption cross section was not as large as previously hypothesized," Rowland says. "So chlorine nitrate would not go away in a matter of minutes but rather in a matter of hours. It is an important reservoir for chlorine atoms. Chlorine nitrate ties up chlorine, so it's not able to attack ozone. Chlorine nitrate also ties up nitrogen oxides, keeping them away from the ozone too. Chlorine would still remove ozone at forty kilometers, but at twenty kilometers it would reduce ozone depletion by nitrogen oxides. There would be less ozone up above and more below."

Plugged into different computer models of atmospheric chemistry, the chlorine-nitrate calculations produced wildly divergent results. Some models couldn't handle the problem at all. Others indicated that CFCs would have an almost negligible effect on atmospheric ozone. It was high uncertainty, and at the worst possible time. The National Academy of Sciences panel had essentially concluded its report; preliminary copies were circulating among the 12 members. Suddenly, publication of the report was put on hold. Rumors that it would be rewritten completely began to circulate. Friends recall the circles under Rowland's eyes in those days.

A fatal flaw?

"The industrial people had put a big stake on this report, saying they didn't want to issue any response about the seriousness of this problem until a credible group like the National Academy of Sciences had looked at it," Cicerone says. "What we had done was to raise the stakes, to put tremendous pressure on the academy group. Now here came this curve ball. Everybody was wondering whether this was going to be a fatal flaw in the Rowland and Molina theory."

The academy called an emergency weekend meeting of the modelers who had been running computer simulations of CFCs and the ozone. It was held in Boulder, Colo., at the National Center for Atmospheric Research, whose supercomputer was turned over to the modelers for the entire weekend. Ralph Cicerone remembers "staying up all night a couple of nights, doing calculations, talking to colleagues and competitors, saying, 'What in hell is going on? We're getting very different answers.' "

That Sunday night the modelers finally agreed on what was happening. When chlorine-nitrate reactions were factored in, the overall ozone depletion was within the 7-to-13-percent range Rowland and Molina had predicted, but the profile was different: almost no ozone in the upper stratosphere, more in the lower stratosphere. Knowing that ozone distribution could have a major effect on climate and temperature, Paul Crutzen, one of the most respected

COMMON CHLOROFLUOROCARBONS AND HALONS

COMPOUND (chemical formula)	OZONE DEPLETION POTENTIAL*	ATMOSPHERIC LIFETIME (Years)	AMOUNT USED IN U.S. (millions of kg)	AMOUNT USED WORLDWIDE (millions of kg)	MAJOR USES
CFC-11 ($CFCl_3$)	1.0	64	79.7	368.3	Rigid and flexible foams, refrigeration
CFC-12 (CF_2Cl_2)	1.0	108	136.9	455.0	Airconditioning, refrigeration, rigid foam
CFC-113 ($C_2F_3Cl_3$)	0.8	88	68.5	177.0	Solvent
Halon-1211 (CF_2BrCl)	3.0	25	2.8	7.1	Portable fire extinguishers
Halon-1301 (CF_3Br)	10.0	110	3.5	7.0	Total-flooding fire ext. systems
HCFC-22† ($HCClF_2$)	0.05	22	99.2	figures not available	Air conditioning

*Ozone-depleting potentials represent the destructiveness of each compound. They are measured relative to CFC-11, which is given a value of 1.0.
†Will not be limited by Montreal Protocol.
Consumption data based on 1985 figures.

SOURCE: EPA

atmospheric scientists in the world, looked at the results and said somberly, "This is not my planet: The atmosphere is different, and the climate is going to be very different."

During that weekend Cicerone and the others had ironed out the distorting effect of a couple of simplifications in the computer models. One was "so elementary that it makes people look foolish," Rowland says. Instead of a day-night cycle, modelers assumed a 24-hour day with sunlight at half intensity. Because chlorine nitrate is made only during the day, that simplification threw the model off by a factor of two. In addition, the modelers had not accounted for the fact that the ultraviolet radiation that breaks up chlorine nitrate is reflected from clouds and the ground, so that it goes through the atmosphere twice—another factor-of-two error. When the models were adjusted for both factors, they came back to the ozone depletion range originally predicted by Rowland and Molina.

But before the picture became clear, the CFC industry saw an opening to exploit. It called press conferences and sent out news releases questioning the ozone-CFC theory. One typical headline of the time: "Is the 'Threat' of Aerosols Going Pffft?"

The academy report, issued in the fall of 1976, upheld the basic thrust of the Rowland-Molina theory but gave the CFC industry a couple of talking points by estimating the range of ozone depletion as anywhere from 2 to 20 percent and saying a CFC ban wasn't needed for a year or two. The aerosol spray ban went through nonetheless.

And then—nothing happened.

The scientific studies continued, generally accumulating evidence to support the original Rowland-Molina numbers. But regulatory action came to a halt. Sweden, Norway, and Canada banned CFC aerosol spray use, but most other countries did nothing. In the United States CFC production for air conditioning and refrigeration proceeded in a business-as-usual fashion. The search for alternative chemicals petered out in a few years as industry cut spending. A second National Academy of Sciences report in 1979, which estimated ultimate ozone depletion at a startling 15 to 18 percent, had almost no impact. About the only major development was a congressional mandate for NASA to study the ozone problem and issue a report every two years. "That became the action item—to make a report rather than have regulatory control," Rowland says wryly.

He kept plugging away at the issue, except for a five-month interruption that tells a lot about the man. The Rowlands' son was seriously hurt in an auto accident in San Diego toward the end of 1978. The parents moved there to be with him; Sherry Rowland worked as a hospital orderly for five months, until his son recovered enough to come home.

When Rowland went back to the laboratory, he started on a different line of study, looking at the atmospheric distribution and fate of a chemical called methyl chloroform. Rowland picked it as a model for the CFC replacements he knew would be necessary sooner or later. It has the carbon-hydrogen bonds that are essential if a molecule is to be destroyed in the lower atmosphere, before it can affect the ozone layer. Among other things, Rowland started a program in which air samples are gathered every three months across the Pacific Ocean to measure trace gases released by human activity.

But the sense of urgency had evaporated for the CFC industry. It formed something called the Alliance for Responsible CFC Policy, which solicited money from companies in the business and began hinting broadly that controls needn't be so tight.

Hole over the pole

What turned everything around was a report from a rather obscure group called the British Antarctic Survey. The group had been using an instrument called the Dobson spectrophotometer to measure ozone concentrations over its South Pole stations, adding its numbers to records maintained since the International Geophysical Year in 1957. Early in the 1980s the numbers began to look odd. The Survey was recording a massive depletion of stratospheric ozone in the Antarctic spring.

The first reaction was disbelief. The spectrophotometer was shipped back to Britain for recalibration, and a new machine was brought in. Experts flew in from England to check the findings. But by 1985 the data showing existence of an Antarctic ozone "hole" were firm enough to be published in the journal *Nature*.

"Not too many of us took it seriously," says Cicerone. "There were two reasons. First, have you ever heard of the British Antarctic Survey? And second, these were point measurements, so all you could say was that something was happening locally at two stations in the Antarctic."

There was another reason for disbelief. Two instruments aboard a U.S. satellite, the Nimbus-7, had been monitoring Antarctic ozone. Their data, which were processed by a computer program, showed no excessive ozone depletion. A group including Richard Stolarski, now at NASA, began a reexamination of the original data, stored on tape. What the members found as-

[*Continued on page 102*]

The man who knew too much [Continued from page 65]

tonished them. The satellites had recorded essentially the same huge ozone loss detected by the British. But the hole hadn't shown up in the processed version of the data because the computer had been programmed to throw out any obviously absurd readings.

News about the Antarctic ozone hole started things moving as never before. The United States organized two expeditions to the Antarctic to make detailed measurements from ground stations and aircraft. They confirmed the worst fears: The ozone hole over the Antarctic not only was there every spring, but depletion was getting worse. On March 15, 1988, an Ozone Trends Panel assembled by NASA issued a somber report, saying that the Antarctic ozone loss was caused by CFCs and that ozone loss could be seen at all latitudes.

By then, the world's governments had acted. For several years, the United States had been arguing for a global agreement to limit CFC production. It had gotten frosty lip service and total inaction for several reasons. The Japanese, for example, couldn't see how their electronics industry could get along without CFC-113 as a solvent. Europeans suspected a plot by American chemical companies to monopolize the market in CFC substitutes.

The ozone hole changed all that. "It takes it out of the time scale of what might happen in the year 2075 to the time scale of what might happen in the year 1987," says Rowland. "It didn't creep up on you for a century. It happened in a decade."

Freon freeze

Toward the end of 1987, 24 nations signed the Montreal Protocol, designed to reduce CFC consumption by 50 percent by 1999. The nations agreed first to freeze the production of specific CFCs—11, 12, 113, 114, 115—and some related compounds, then to reduce consumption starting in 1993.

And less than two weeks after the Ozone Trends Panel issued its report, Du Pont swallowed hard and redeemed a pledge it made more than a decade ago in full-page advertisements. If CFCs were shown to be an environmental danger, Du Pont said back then, it would stop their production. On March 24, 1988, the company said it had set a goal of "an orderly transition to the total phase-out of fully halogenated CFC production." Du Pont stressed the difficulty of developing substitutes, but the statement spoke for itself.

Back in the laboratories, scientists were figuring out what happens over the Antarctic.

In the winter months air in the stratosphere over the Antarctic moves round and round in a circle, getting much colder than stratospheric air anywhere else. The water and ice droplets in the clouds that form there provide surfaces that promote the breakup of such molecules as chlorine nitrate and hydrogen chloride, releasing chlorine atoms. When the sun appears after the long winter, the warming increases the rate of chemical reactions, and the chlorine runs wild, destroying ozone at a fantastic rate. It's a seasonal effect that stops either when there's no more ozone left to destroy, or when the sun evaporates the clouds and stops the reactions.

More atmospheric chemistry research—using instruments like the $5-million ozone sensor carried by the recently launched NOAA-II weather satellite—is needed to get the complete picture, as many complex things are happening in the upper atmosphere.

The warning of global atmospheric change is obvious—so obvious that Rowland and others are saying the Montreal Protocol doesn't go nearly far enough. "It does very little to protect the atmosphere," Rowland says. "Very little for a decade and then not enough."

"We really need details," Cicerone says. "Will the phenomenon spread? Will there be ozone holes popping out elsewhere? In the last few months there has been a progression of understanding that makes us concerned that the atmosphere is more sensitive than we thought."

Sherry Rowland, meanwhile, maintains his equilibrium. His warning fulfilled, he's something of a media attraction now, a position that has undone other scientists.

Industry has had a somewhat tougher time coming to terms with Sherry Rowland. He says he has a good working relationship with Mack McFarland, Du Pont's representative on the Ozone Trends Panel. But as recently as 1987 industry people had said they wouldn't attend a meeting in California if Rowland was there. A compromise was reached. Rowland was allowed to deliver his paper, but not to take part in the meeting.

But he treasures one moment that revealed a different attitude among some industrial scientists. It was in September 1976, just after the National Academy of Sciences released its first report. Rowland was at a meeting in Logan, Utah, of a group that included industry scientists. After a formal session, the group went out for a volleyball game that continued as the sun set.

"It became very dark," Rowland recalls. "I had what seemed to me a surreal experience of unidentified figures coming up in the dark and congratulating me, under conditions where no one could tell they were doing it." PS