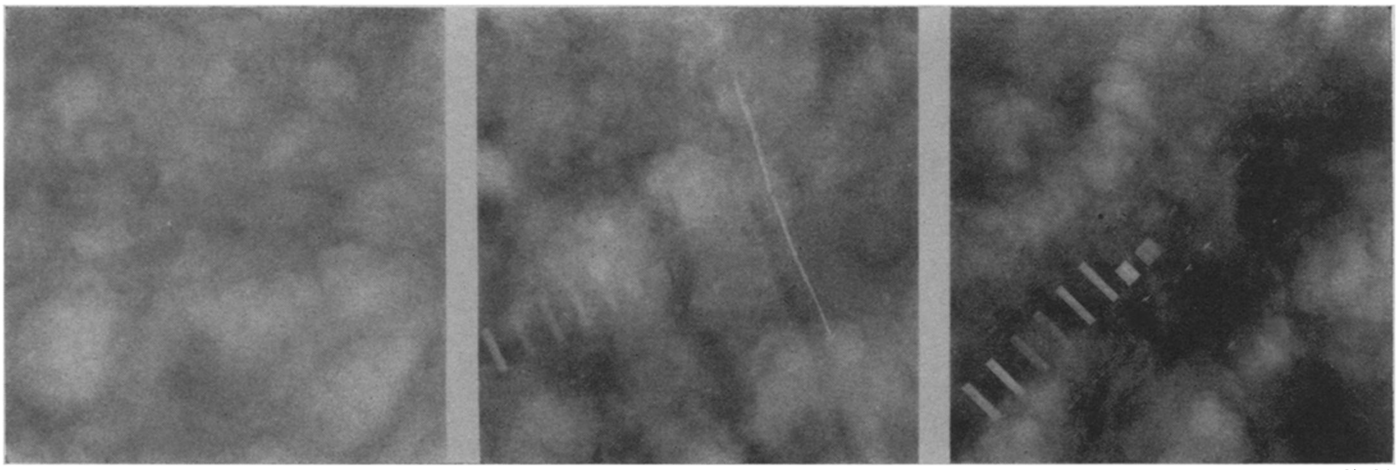


NASA

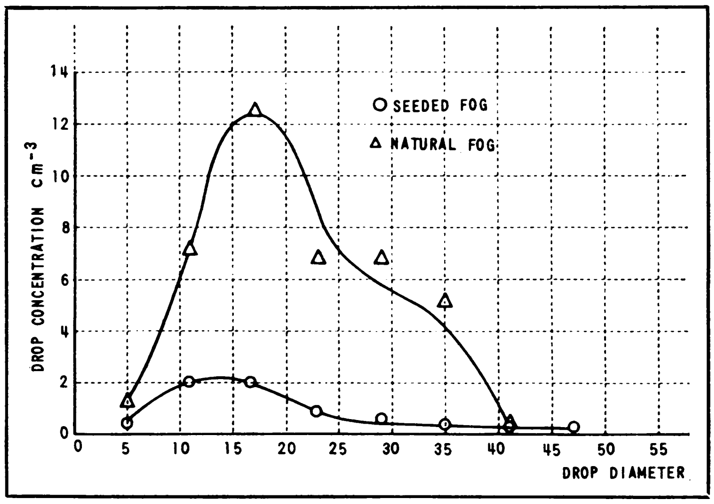
After successful seeding experiment, fog thins out, revealing runway at Chemung County Airport, Elmira, N.Y.

METEOROLOGY

Assault on fogs

The goal is to develop a fully operational fog dissipation method

by Edward Gross



CAL

Fog seeding results in fewer but larger droplets.

Carl Sandburg thought that "the fog comes on little cat feet . . . sits looking over the harbor and city on silent haunches and then moves on." But fogs don't move on quickly enough, and researchers are now making a concerted effort to kick them along faster.

The reason for the increased concern is that fogs cost airlines $75 million a year, contribute to highway deaths and tie up major seaports. The problem is not a new one.

The first real effort to dispel fogs came in World War II, when the British developed FIDO (Fog Investigation and Dispersal Operation). This crude method consisted of setting up oil burners around airfields to burn off the fog. Although the system was able to clear a large field up to a height of 100 feet, a good breeze could undo the work in a few seconds. High installation and operating costs also make it economically impractical.

At about the same time, experimenters in the U.S. demonstrated that a fog could be dried out with concentrated solutions of calcium chloride, but the techniques then available were not economically practical.

After FIDO there was a slump in fog dispersal efforts because of the electronics revolution; pilots and controllers alike believed they had whipped the problem.

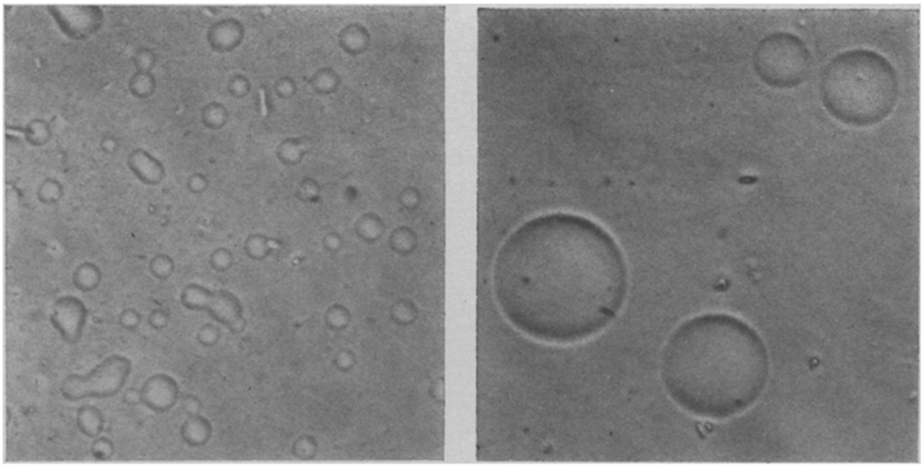
But since 1967 there has been a resurgence of fog dispersal activity as enchantment with electronic landing aids has dimmed.

"The electronics age has reached a plateau," says George P. Ettenheim, manager of the research division of Meteorology Research, Inc., Altadena, Calif. "As the end of the electronics age boom approached, pilots woke up to the fact that there was a gap. . . . They wanted to see the last few seconds before touchdown."

A fog is merely a cloud resting on the earth, but not all fogs are the same. About 95 percent of all fogs are warm, above 32 degrees F. These frequently form at night when the air loses heat to the cooling earth or when warm and cool air masses collide, provided nuclei (dust or pollutants) are present on which water vapor can condense.

Even at temperatures below 32 degrees F. a fog can form on these same nuclei and no ice crystals will be present. Such a fog is called supercooled, and when this fog does form, it is a relatively simple matter to clear a hole in it. The U. S. Air Force proved this in 1962 with its Cloudbuster. This device makes ice pellets by passing liquid carbon dioxide, kept at subzero temperatures and under pressure, through an expansion nozzle. Droplets, relieved of pressure, freeze into dry-ice powder, which is then compacted into different-sized pellets for fog seeding. Once ejected into the air, the pellets grow by crystallizing water vapor in the fog into ice crystals. Eventually, the ice crystals become heavy and fall to earth, carrying moisture from the fog and creating openings.

There are other methods for dispelling supercooled fogs: The French, for example, are spraying liquefied propane from the ground at Orly Airport in Paris. France, however, has few supercooled fogs, and its dispensers are stationary. The U. S. Army at its Cold Regions Research and Engineering Laboratory in Hanover, N.H., is working on the development of a mobile propane dispensing system to provide greater flexibility in dealing with vari-



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Droplets in unseeded fog (left) and those in fog treated with milled salt.

ations in supercooled fogs.

But since 95 percent of all fogs are warm, cold techniques are of marginal interest. And to attack the major fog problem, researchers are now seeking to accomplish chemically what cannot be done physically.

At Cornell Aeronautical Laboratory in Buffalo, N.Y., a center for fog research in the United States, scientists have been testing ordinary table salt, a hygroscopic, or water-attracting, compound. After several years of preliminary testing in a fog chamber, in October 1968, they loaded an airplane with 700 pounds of salt and seeded a fog over Chemung County Airport near Elmira, N.Y. A hole a quarter-mile wide and half-mile long was opened for 15 minutes.

The important point of the experiment was not that salt could clear a fog—that had been demonstrated before—but that the effectiveness of the seeding depended on the size of the salt particles.

The Cornell researchers found that grains of table salt are 100 times too large for effective fog dispersal. They determined that the optimum size for the particles is between 5 and 30 microns. Smaller particles take longer to clear a fog because they fall out of the atmosphere more slowly. Extremely small particles (0.1 micron) may even act as condensation nuclei and aggravate a fog condition.

The theory behind the seeding is that once in the atmosphere, the salt grains combine with water vapor to form drops of brine. This reaction reduces the water vapor content of the air, causing nearby fog droplets to evaporate into the air to replace the missing vapor. The drops of brine continue to grow, becoming heavier and more dilute as they do. As they descend through the air, they leave behind a wake of drier air which evaporating fog droplets fill in at the expense of the fog. Eventually, the brine drops become so dilute that the salt in them no longer attracts water vapor, or else they hit the ground. In this way, the fog is thinned out, and sunlight completes the job.

Actual seeding operations are still being refined to cope with special problems.

For example, although seeding from the top of a fog is effective for shallow fogs (300 to 400 feet high), it doesn't work as well for drying out deep fogs because the descending brine droplets progressively lose their ability to attract and hold water vapor as they reach the fog's lower regions. In addition, salt is corrosive to metal, so it cannot be used extensively over airfields.

For reasons like these, with the principle established, substitute chemicals are being sought; CAL is presently engaged in this work.

Under consideration are such chemical compounds as urea, disodium phosphate and arabinogalactan, some of which are already in use. The lab has tested 30 to 40 compounds and eliminated all but a dozen. Present experiments will determine which of these are best suited for fog dispersal.

Two major types of chemicals now in use are polyelectrolytes and surfactants. Polyelectrolytes are high-molecular-weight compounds containing electrically charged groups. They work by attracting oppositely charged water droplets, clumping together with them until they are too heavy to stay in the air. Surfactants achieve the same result by reducing the surface tension of the droplets, enabling them to unite easily.

A combination of polyelectrolytes and surfactants, tried from November 1967 to March 1968 at Sacramento, was 70 percent successful (SN: 12/2/67, p. 551) as was the same test a year later at Portland, Ore. When salt alone was used at Sacramento and Los Angeles from January to March of this year, the results were more than 75 percent successful.

Critics of the polyelectrolyte and surfactant approach point out that the electrical forces on polyelectrolytes are too small to affect droplet movement significantly, while surfactants require a force to push the droplets together; natural air turbulence, which only mixes the droplets, is not sufficient.

Turbulence itself is another problem. Stationary fog is simpler to disperse than fog moved by the wind, which can blow away the seeding material, close over a hole formed in the fog and pose a mathematical problem in determining where to seed and at what rate so that the fog's cleared area will drift over the airport.

Olin Mathieson Chemical Corp., because it feels that aerial seeding is costly and hazardous, is trying to revive the FIDO method. The company is experimenting with burning solid chemicals in a ground dispensing equipment to produce enough heat to dry out fogs.

One thing is clear about fogs: All the answers aren't in yet. Although fogs can be temporarily abated, the techniques can't be considered fully proved.

"We don't know enough to be operational now," says Cornell's Roland J. Pilié. "We're still on the fringes of research. It will really be operational when an operator in a tower can feed data into a computer, which will then direct a pilot to seed at a particular location, say, 2.7 miles up the runway at an altitude of 400 feet. That kind of operation could be done in about five years."

But not only airports are involved. Highway authorities are also interested in fog dispersal, particularly officials of the New Jersey Turnpike. The job here is usually easier because heights of only 30 to 40 feet are involved. For this purpose, a ground dispensing system is being pushed and one is presently in the works.

The Air Force has worked out its own technique for dispersing fogs less than 300 feet high. The Air Force Cambridge Research Laboratories in Bedford, Mass., conducted tests in April and November of last year over the Gulf of Mexico near Elgin Air Force Base and at Smith Mountain Airport, near Roanoke, Va., in which helicopters successfully cut holes in fogs 200 feet high. The choppers worked by forcing warm dry air from above into the moist layer below through rotor action. The subsequent evaporation created large holes. The method has been used in Vietnam in the rescue of several downed pilots. ◇