Letters

Water: Can Cloud-Seeding Help?

Desalination is now believed to be the most promising way to forestall drought disasters. Practical methods for increasing the water supply are so vital that present research and development programs for desalination, and more, are well justified. But while this may be the best approach to increasing the water supply of coastal regions, the delivery of desalinated water to the interior and to localities high above sea level is likely to be prohibitively costly. What are the prospects for such areas?

A short decade ago there was much enthusiasm about artificial cloud nucleation (ACN) as a means of augmenting natural precipitation. Now much less is heard about it. Its possibilities are given relatively little consideration at high levels of authority and planning for the world's water supplies. But it is possible that ACN could be the best means of augmenting water in certain interior regions, especially mountainous parts.

Theoretically, the seeding of supercooled cloud droplets associated with up-slope winds which provide moisture for condensation more or less continuously should yield more precipitation than has in general been obtained in field experiments on mountainous coasts. The reasons for the difference between theoretical and actual yields are not fully known. Research meteorologists have not neglected this field. Its importance is too great and its identity with basic phenomena which must be understood for the advancement of weather prediction are too obvious for meteorologists to overlook. Since 1946 many excellent and productive studies have been pursued in cloud physics and related problems of condensation and precipitation in the free air. Thousands of field tests have been made. But the possibilities and results of ACN in its several techniques are still unknown quantitatively. While much knowledge has been acquired of many of the individual features of precipitation processes, comparatively little is known about the yield from the seeding of clouds in particular cases. Clearly this question would soon be answered if a practical method were found for identifying rainfall or snowfall caused by artificially introduced nuclei and distinguishing it from the precipitation due to natural causes operating at the same time. It would then be relatively simple to run field tests in various favorable regions and obtain a basis for estimating how much ACN might contribute to the world's water supply. But of course the problem is *not* "simple"; quite the contrary.

Much time has been lost and many efforts misdirected. As long ago as 1950 competent research scientists showed the need for basic research in the physics of condensation and precipitation of water vapor in the atmosphere and demonstrated beyond doubt the careful design and conduct of experiments necessary if invalid conclusions were to be avoided in "rain-making" tests. [See *Amer. Meteorol. Bull.* **29**, 266 (1948); **30**, 289 (1949), and other sources for reviews of the classic work by Gunn *et al.* in cloud-seeding tests.] But commercial rain-making operators and others claimed great successes. Scientists who advocated basic research to resolve the many unknowns before releasing the techniques of cloud-seeding for practical applications were put off with the argument, "We can't wait for fundamental studies—we need rain now!" But we *have* waited, in a sense, and now the basic researches are generally recognized as prerequisite to sound practical use of ACN.

There has been progress. Extremists on both sides are less extreme. The public is less credulous when exaggerated claims of having "made rain" are published. The universities and other research institutions, including government agencies, have conducted research which has contributed much to scientific knowledge of particular features of the precipitation cycle. But a comprehensive and concerted program is needed to fill the wide gaps in knowledge. Several such programs have been proposed, among the earliest those of Hall and Kline of the U.S. Weather Bureau, in 1950–55. The National Academy of Sciences, the World Meteorological Organization, and the International Council of Scientific Unions (International Union of Geodosy and Geophysics) are among the organizations that have sponsored committees to review the possibilities and problems of the atmospheric sciences and to include in their recommendations related plans for research in weather modification. The probability that advanced ACN techniques will yield worthwhile increments of precipitation from orographic clouds over certain mountain ranges, and the possibility of increasing yields from cumulo-nimbus clouds and in other favorable situations, should be thoroughly explored. Perhaps, as was suggested many years ago, the complexity of the phenomena may necessitate an examination or "diagnosis" for each individual synoptic situation or cloud system to make sure of maximum yields of precipitation and to settle uncertainties about overseeding and unintentional reduction in coalescence of droplets; but the benefits not only to the understanding of the possibilities of weather modification but also to the advancement of weather prediction and the solution of other atmospheric problems are ample justification for giving very high priority to such research.

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That Seventh Veil

J. K. Mackenzie (Letters, 1 Oct., p. 7) observes that scientists have no aptitude for designing television "science programs" for the general public, and proposes that the education in science of "the tens of millions who are not responding to our present efforts" be entrusted to quite different hands. His criticism and proposal are impressive, but in his preoccupation with the cure he may not have fully analyzed the disease. One symptom can be found, appropriately enough, in Galen, in the often quoted close of the Hippocratic Law: