

search on condensation and ice nuclei climatology, mechanisms of heterogeneous nucleation, cloud system characteristics, diffusion, and effects of particle charges and charge distribution on precipitation. Intensified research and development is required on seeding agents and delivery systems; on specialized instrumentation such as airborne rain gages, nuclei counters, vapor density indicators, doppler radars for vertical velocity measurement, and precipitation rate sensors; on data collection systems; and on real-time analysis and display systems.

Because of past and current research programs, orographic cloud seeding techniques for augmenting the winter snowpack in the western mountains have been developed to where pilot-type operations are now warranted. Techniques for increasing precipitation from convective- and stratus-type clouds and from frontal storms are still in the development stages and additional years of intensive effort will be required before major application can be tested through pilot operations.

The important last phase is the establishment of large experimental field operations or pilot projects for testing feasibility and solving the problems of widespread application. Comprehensive monitoring and evaluation will be included in these projects.

Most program activity will be performed by university and private firms, with Government agencies generally furnishing the specialized support and management. Research conducted through universities will be administered not only with a view toward producing specific results, but also for strengthening academic research and educational capabilities in general, especially in smaller colleges.

As a result of the Atmospheric Water Resources Program, additional fresh water is anticipated to be producible for \$1 to \$1.50 an acre-foot in the Upper Colorado River Basin. In a society and economy highly dependent on water for continued growth, the benefit of this water will be far reaching. Support necessary for this program must expand from the current \$3.8 million to \$50 million by 1972 with continuing support thereafter.

BASIC AND APPLIED RESEARCH IN DESALINATION

How does water dissolve a salt crystal?

What is a water molecule? What is a salt ion? What occurs at the interface between a water molecule and a salt ion? These may sound like rather simple questions in an era of sophisticated research, but they are but a few of the many questions scientists still must answer and these answers will be of utmost importance to our search for low-cost desalting processes.

In discussing the desalting of the ocean and other natural saline waters, it is appropriate first to outline what is meant by these terms. Sea water is a homogeneous mixture of water molecules and salt particles, predominantly rock salt (sodium chloride) with smaller amounts of more than 40 other minerals. These minerals can remain in a dissolved state only because the pulling forces between the charge-bearing salt particles (ions) and water molecules are not very different from the forces between water molecules themselves, yet there are distinct differences in behavior between the saline and aqueous components. We must take advantage of these differences in order to separate them.

Fortunately, though we cannot explain fully, the aqueous component is sensitive to both the addition and withdrawal of heat, while salt is not. The application of voltage will move the salt, but have no direct effect on the water. These and other observable differences have been known for many years and used in various desalting methods. It is certain, however, that subtle molecular-scale events cause and control observed differences. It is reasonable to assume that there are molecular-scale events that are not yet recognized and practical to expect that basic research into these fundamental phenomena will provide more efficient means for exploiting distinctions between salts and water.

The more we know about aqueous solutions and saline solutions in particular, the better we can manipulate them to effect a separation between the salts and the water. Known desalination processes have reduced the cost of conversion, but they are not presently efficient enough to produce fresh water at very low cost. Thus, we have no more reason to be satisfied with known desalting technology than Shockley had to be satisfied with vacuum tubes, or Salk with iron lungs or Fleming with salvarsan.

Why are saline solutions so complicated? That question may be answered as follows: The particles comprising these solutions are so tiny that if each salt