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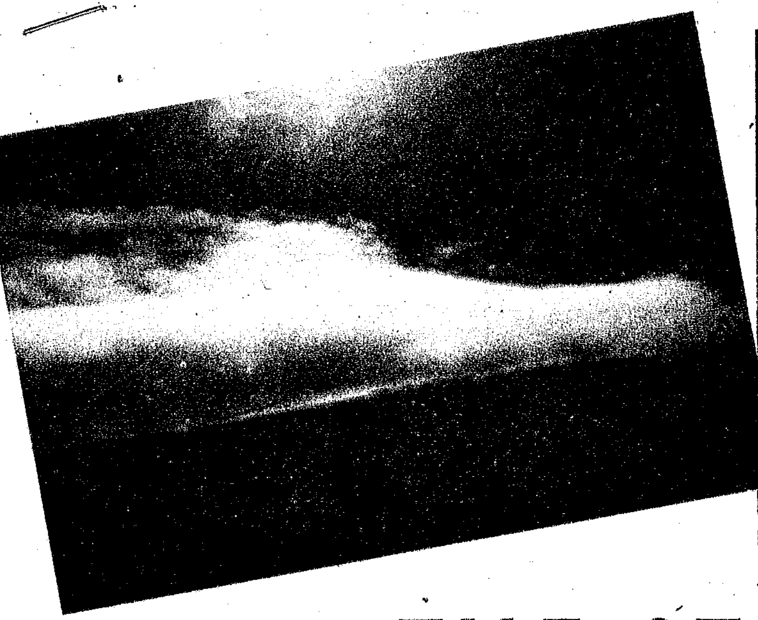

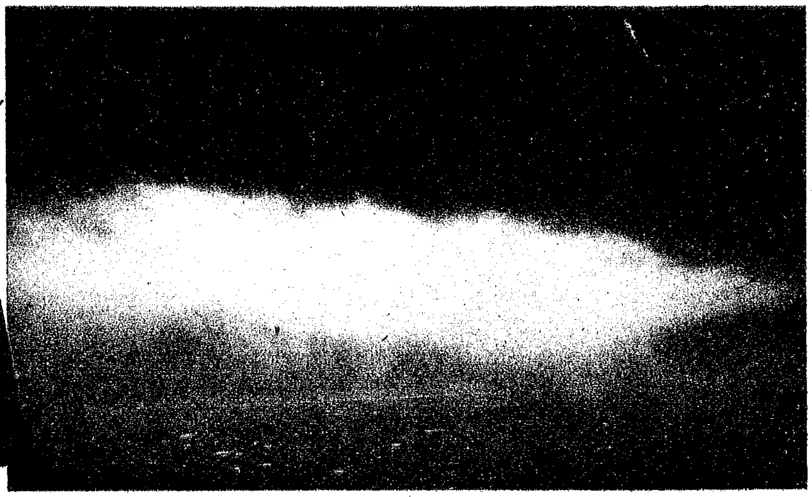

Left—First cloud from which scientists made snow.

Above—First man-made snow falling from "seeded" cloud.

THE STORY OF MAN-MADE WEATHER

By VINCENT J. SCHAEFER

SINCE THE TIME that some of our ancestors first found that a rude shelter and a campfire afforded a degree of protection from snow, cold air, wind, rain and lightning, man has sought ways to overcome the discomforts of "bad" weather. Slowly, he has discovered ways to surround himself and his family with controlled "weather" in the form of warm homes, air-conditioned stores, heated water, well-lighted rooms, and hosts of other things which make life less rigorous.

While these conveniences tend to make us less dependent on the sort of weather doled out by Mother Nature, the farmer, in particular, has always been at the mercy of the weather. Ice storms, drought, torrential rains, lightning, high winds, floods, erosion, dust storms, hail, frost, and excessive heat or cold combine singly, or sometimes in rapid succession, to complicate and sometimes completely ruin the results of a season of hard work.

Considering these factors, it is little wonder that soon after man emerged from his primitive existence and started to recognize the uncertainties of weather, he tried to discover ways to manipulate the weather to better satisfy his needs. Long before recorded history, he learned that when rain failed to come it was sometimes possible to irrigate, and thus use precipitation, which occurred earlier in the season, to help mature his crops. He sometimes resorted to less direct methods which often led to a considerable abuse of logic and reason. Thus, the medicine man, the rainmaker, and similar types of individuals appeared on the scene, flourished while lucky, and then faded from the picture as less credulous critics raised pointed questions about their activities and the results. How then, with such a background of uncertainty, prejudice, skepticism and ambiguity, can we properly evaluate the last year's activity in the realm of rain and snow making?

There are several factors which make the present activities exciting, to say the least. For the first time, scientists from many different fields are combining forces in an attempt to wrest from the atmosphere the secrets that Nature, heretofore, has guarded jealousy. Man is probing far into the stratosphere with rockets laden with all kinds of precise instruments; he is discovering, with sensitive radio, fascinating things about the ionized layers which probably have much to do with the weather patterns of the world. With radar he can now plot "contour" maps of precipitation areas in clouds. Supersensitive seismographs let him chart the movements of hurricanes many hundreds of miles away, and by means of elaborate flight programs, he has probed the structures of thunder storms and watched the shift from supercooled clouds to snow and rain areas by precise and quantitative seeding operations.

Astronomers, physicists, chemists, meteorologists, radio engineers, hydrologists, seimologists, mathematicians, and hosts of others are, today, using all sorts of instruments to unravel the mysteries of our planet and its weather. It will be surprising, indeed, if we do not make vast strides within the next few years in reaching a better understanding of the weather, its vagaries, and its trends and patterns.

About The Author

Vincent J. Schaefer is General Electric Company's research scientist who first "seeded" clouds with dry ice from an airplane and produced snow. The startling results of his experiment opened hitherto undreamed opportunities for controlling the weather. In this article, Schaefer gives the facts as they are known today, and also looks into the future regarding this new line of weather research.

In the last year we have acquired a better understanding of clouds and cloud systems. We have learned that profound changes can be produced wherever Nature permits unstabilities to develop. We have advanced our knowledge of some of the phenomena which are part of the natural weather cycle so that we are better able to evaluate results which follow artificial seeding activities. That a profound change can be induced in an unstable cloud system by proper seeding techniques is now well-established.

To illustrate one phase of cloud modification techniques which has been followed with a considerable degree of success during the last year, let us mention the use of dry ice. This is solid carbon dioxide, a common substance having a temperature of —78.5°C, available in most parts of the country, and costing less than five

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cents a pound.

In summarizing the first year of activity in the field of cloud modification, however, it is best to review briefly the basic factors which seem to be of importance if any effect is to follow the introduction of dry ice pellets into a cloud. To start with, at least a part of the cloud must consist of liquid water droplets colder than 0°C. Wherever such supercooled droplets exist, it is a simple matter to produce large numbers of ice crystals in that region. It can be shown quantitatively in the laboratory that a pellet of dry ice the size of a pea is capable of producing at least 10^{16} ice nuclei. Whether all, or only a minute fraction of these, grow to snow crystals when introduced into a cloud depends on such things as the available moisture, the convection in the air, the efficiency of dispersal of the nuclei, and similar factors. To emphasize the tremendous numbers of nuclei which are available when a dry ice pellet is introduced into a supercooled cloud, note that if each of the 10^{16} ice nuclei grew to the size of a small snow crystal, they would amount to 300,000 tons of snow!

If any appreciable precipitation is to fall from a seeded cloud, a number of favorable conditions must be present. For example, unless the humidity of the air below the cloud is fairly high, the precipitation may evaporate before it reaches the ground. It is of even greater importance that there be a continuing supply of moisture flowing into the affected region to continue the precipitation, for there are only about 0.15 inches of condensed moisture in an average cloud which has a vertical thickness of a mile.

A sober realization of the facts emphasizes the point that much work must be done before more than local showers can be produced by man using dry ice or any other material in the clouds of the atmosphere. Unfortunately, when rain is needed to relieve a drought condition, there is often nothing but day after day of cloudless skies over the affected region. However, it should be mentioned that sometimes it should be possible to trigger off a considerable shower from a towering cumulus before the precipitation cycle develops by natural processes. It should be possible, at times, to initiate the development of a snow or rain storm at a specific location when nature permits the development of a large area of

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supercooled clouds.

The following is a list of some of the experiments conducted during the last year which are representative of the general advances made in cloud modification:

November 13, 1946—Initial experiment by the author over Berkshires in Massachusetts, converting a four-mile supercooled strato-cumulus cloud into snow flurries using six pounds of granulated dry ice.

November 21, 1946—Conversion by the author of supercooled ground fog to snow crystals by seeding with dry ice. Schenectady, New York.

December 20, 1946—Production of snow by R. Smith-Johannsen in supercooled orographic cloud on summit of Mt. Washington, New Hampshire. Seeding with liquid CO_2 from tower of Mt. Washington Observatory.

December 20, 1946—Production of extensive snow area by the author in supercooled stratus cloud by seeding in base of supercooled overcast with dry ice and liquid CO_2 in region north of Mohawk Valley in New York.

February 5, 1947—E. B. Kraus and P. Squires. Production of rain in stratocumulus by seeding supercooled cloud at 23,000 feet with dry ice and detection of effect by radar 100 miles east of Sydney, Australia.

February 6, 1947—Production of snow by R. E. Falconer and V. F. Clark in supercooled orographic cloud at 6,200 feet using silver iodide flare. Mt. Washington, New Hampshire.

PRODUCING FIGS IN ILLINOIS

In a climate which is normally too severe for raising figs, Charles Pirrera of Springfield, Illinois produced a successful crop of figs. He did this by burying the tree tops in a shallow ditch as soon as they shed their leaves. To accomplish this he cut off half the roots and bent the trees over. Pirrera began his hobby four years ago and now has four trees, the tallest of which is seven feet. Shown in the photo above is the last of this season's fig crop being admired by Michael Foley, Pirrera's grandson.

April 4, 1947—Colonel E. S. Ellison and L. R. Richards. Production of rain in supercooled stratus cloud at 10,000 feet in Oregon.

April 7, 1947—Personnel of Project CIRRUS. Joint Army-Navy-Air Forces-General Electric project produced 45-square-mile geometric hole in supercooled stratus cloud, over Adirondack Mountains in New York to obtain quantitative information on effect of dry ice seeding methods.

July 16, 1947—A. Hoff and H. L. Mott. Production of rain from cumulus cloud near Phoenix, Arizona, by seeding cloud at 20,000 feet with dry ice.

September 23, 1947—Production of rain at 9,500 feet by L. B. Leopold and M. Halstead in above-freezing cumulus cloud using dry ice over island of Molokai in Hawaiian Islands. Results interpreted by Dr. Irving Langmuir as start of chain reaction in new precipitation theory advanced in paper delivered before the National Academy of Sciences, November 17, 1947.

October 13, 1947—Personnel of Project CIRRUS in dry ice seeding flight and cloud study of hurricane

"King" 350 miles east of Jacksonville, Florida, at 25,000 feet.

September-October, 1947—Production of snow and rain by C. L. Chipman and G. G. Sampson in vicinity of Prosser, Washington, in series of flights.

October-November, 1947—Series of experimental flights over western Kansas by C. Barhydt and J. Berkeley, producing snow and rain areas.

Many other experiments might be listed, but it is believed that the above examples illustrate some of the significant advances in techniques and materials during the last year. The list indicates the widespread and active interest that has developed in the general subject. Many experiments have been carried out in other countries which have not yet been reported in sufficient detail to permit analysis.

What the future holds is not easy to predict. Caution must be exercised in analyzing experiments of this kind. It should be remembered that natural processes generally produce precipitation when suitable cloud systems occur. Much careful study of naturally occurring precipitation must be made to differentiate properly between natural and artificial effects that develop in the free atmosphere. Because of the vast areas involved, new observational techniques must be developed and mastered if a worthwhile evaluation is to be realized.

The elimination of hail storms, the modification of thunder storms, the removal of icing conditions in supercooled clouds, and the possible increase in precipitation under certain unstabilities of the atmosphere seem to be some of the benefits that may result from the present activity in the field of experimental meteorology. This activity is rapidly spreading throughout this country and into many other parts of the world.

It is very likely that the next year or two will disclose the limitations of the present techniques involving the use of dry ice, silver iodide, water, or "wet" ice. As is always the case, however, when careful research is conducted, all sorts of unexpected occurrences will be observed, which if properly recognized, evaluated, and exploited will lead to newer techniques which will undoubtedly lead to a better understanding and quite likely a certain limited control of the weather. Whether this greater knowledge of weather will be for the benefit or further confusion of mankind will depend to a great extent on man's willingness and readiness to cooperate in making the whole world, as well as his own local region, a better place for living.