Freezing of Supercooled Water-droplets (I)*

— Preliminary Report —

by

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(Received December 15, 1955)

Abstract

An experiment was conducted in which a water droplet was frozen to find the effects of artificial rain-making. Taking a distilled water drop, a drop of silver iodide suspension in pure water and further a rain drop, their freezing temperature was observed. As the variance of the temperature was great in each case, some improvement was found necessary for practical use.

1. Introduction

When the temperature falls, a water droplet is supercooled and then frozen. The study of the freezing temperature was taken up by SCHAEFER [1], MASON [2], BIGG [3], CWILONG [4], FOURNIER D'ALBE [5], etc. [6]. The present experiment on the freezing of water-droplets was conducted for the purpose of finding the effects of artificial rain-making. The effects of cloud seeding has been found by handling statistically the amount of precipitation.

The purpose of this experiment is to capture rain drops directly, to freeze them in an apparatus and to find, by their freezing temperature, whether they might be due to seeding or not.

2. Experiment apparatus and method

The whole of the apparatus is shown in Fig. 1. The cooling chamber is shown in Figs. 2, 3 and 4. It is a cylinder, the diameter and height of which is 7 cm and 5 cm respectively, and it has three openings into which a microscope, a light source and a brass rod can be put. Through another oblique opening, the brass plate can be exchanged, with a pincette, which is on the top of the brass rod.

The diameter of the brass rod is 7

Fig. 1. Measurement apparatus.

* Research sponsored in part by the Central Research Institute of Electric Power Industry.

Fig. 2. Cooling chamber installed in Dewar's vessel.

Fig. 3. Cooling chamber and microscope.

Fig. 4. Cooling chamber.

Fig. 5. Cooling brass rod.

Fig. 6. Upper part of cooling rod.

mm and its length 10 cm (Figs. 5 and 6). Through the rubber stopper the rod is inserted, the lower end of which is soaked in alcohol refrigerated by dry ice. A brass plate is fixed on its upper end, and a heater is coiled around it to raise temperature. The thermo-junction made of Cu-Constantan is fixed, to read the temperature.

As shown in Figs. 7 and 8, the brass plate has a handle at its base and the plate fits to the rod. Designing to fix the thermo-junction nearest to the bottom of the plate, the projection is made on the top of the rod as given in the illustration and the thermo-junction is fixed through the opening of the projection. The base of the plate is dented into which the projection is fitted. The distance between the tip of the thermo-junction and the bottom of the plate is nearly 0.2 mm. The inside of the

Fig. 7. Cooling brass plate.

Fig. 8. Brass plate.

brass plate is so cautiously painted with bakelite as not to bare brass and the brass plate coated with silicone vanish (McFarlane DC) is also used. Liquid paraffin is poured into the plate submerging a water-droplet. Its size is measured with the micrometer syringe, and its freezing is observed with the microscope.

3. Explanation of the phenomenon

A water-droplet is supercooled in the liquid paraffin and frozen. The clear water-droplet (Fig. 9), with freezing, turns opal for a moment (Fig. 10), and later opaque producing foams (Fig. 11). Further lowering of the temperature produced frost on the surface of the liquid paraffin without any change in an ice-ball (Figs. 12 and 13).

The cooling chamber is filled with fog of several to scores of microns in size, which change into ice-fog with the temperature falling. The instant ice-fog runs against the supercooled water drop, it will be frozen, and therefore the water drop will never be exposed out of the liquid paraffin.

If we cool the plate further, frost is produced around it, and the frost is generally crevasse hore, depth hore and ice-flower etc. (Fig. 14).

The ice ball heated with the heater begins to melt at 0°C , and while foaming, it melts away changing into a liquid water drop.

4. Result of observation

The waters used for this experiment were distilled, double-distilled and thrice-distilled ones, aqua destillata proinjection, well water, city water, rain drop, silver iodide suspension in pure water, etc.

Fig. 15. Relation between freezing temperature and diameter of distilled water-droplet.

Fig. 16. Relation between freezing temperature and diameter of rain drops.

Fig. 17. Relation between freezing temperature and droplet diameter of silver iodide suspension in pure water.

a) distilled water

The result obtained from distilled water is shown in Fig. 15 where every mark indicates the freezing temperature at the first trial. No definite result can be obtained because the variance is great. Generally speaking, however, the larger a water drop is, the higher the freezing temperature is, and the smaller the drop, the lower the freezing temperature.

b) a rain drop

The result obtained from a rain drop is shown in Fig. 16. Rain drops are received on Petri dishes containing liquid paraffin, and one drop of them is put into the apparatus, to read the freezing temperature. On investigating the rain drops on October 19th, 20th, 24th and 28th, 1955 each rain turned out to be from stratiform clouds. As a general trend, the freezing temperature was a little lower than that obtained from distilled water.

c) silver iodide suspension in pure water

To suspend silver iodide smoke in distilled water, pure silver iodide is smoked with the heater in the triangle flask, into which a fixed quantity of distilled water is poured.

The values in Fig. 17 take no account of the variation of the concentration of silver iodide, and also the variance is great. Generally, the freezing temperature is higher than that obtained from distilled water. The relation between the concentration of silver iodide and the freezing temperature is shown in Fig. 18. The con-

Fig. 12.
Frozen water-droplet
(temperature -30°C).

Fig. 13.
Frozen water-droplet
(temperature -35°C).

Fig. 14.
Ice-flower in cold chamber
(temperature -35°C).

Fig. 9. Supercooled water-droplet under microscope (diameter 1.5 mm)

Fig. 10.
Frozen water-droplet
(temperature -15°C).

Fig. 11.
Frozen water-droplet
(temperature -20°C).

centration is expressed at an arbitrary unit, and when it is 10^{-19} , the temperature is close to the value obtained from distilled water.

d) repetition of observing freezing temperature

In Fig. 19 is shown the result of the experiment in which freezing and melting of a water droplet was tried over and over again. Fig. 20 shows the result obtained from silver iodide. Nevertheless, no definite conclusion was drawn in any case.

Fig. 18. Relation between freezing temperature and silver iodide concentration in suspension.

Fig. 19. Temperature of repetition freezing of distilled water-droplet.

Fig. 20. Temperature of repetition freezing of silver iodide suspension in pure water.

5. Some considerations

The results of this experiment can hardly be applied, exactly as they are, to find the effects of artificial rain-making. It is necessary to narrow the variance and to increase the accuracy. The matters of concerned are the relation of the dispersion with temperature gradient near the brass plate, the variance of the

viscosity of the liquid paraffin and cooling power. The result will be helpful to find the effects of artificial rain-making when we have managed to increase the accuracy of these elements.

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