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PROJECT FOG DROPS

INVESTIGATION OF WARM FOG PROPERTIES AND FOG MODIFICATION CONCEPTS

QUARTERLY PROGRESS REPORT
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I. INTRODUCTION

The Office of Aeronautical Research of the National Aeronautics and Space Administration has authorized this Laboratory, under Contract No. NASr-156, to investigate warm fog properties and possible fog modification concepts. The program to date has emphasized analytical and experimental work on:

1. Models of the micro- and macroscopic properties of warm fogs.

2. The characteristics of aerosol droplets and means of favorably altering these properties.

3. The construction of apparatus for simulating certain fog conditions.

4. The design and construction of apparatus for measuring certain fog parameters.

5. Observations in natural fog to gather more detailed information about the properties of natural fog.

6. Experimental alteration of the growth and evaporation rate of otherwise stable aerosol droplets.

7. Formulation of fog modification concepts based on the above findings, as well as a review of other possible techniques.

8. Assessment of the supercooled fog problem in the United States and specification of the geographic areas where an operational seeding program might be practical.

This report briefly describes accomplishments of the third quarter of the third contract year. Plans for the next quarter are outlined.

II. DISCUSSION

A. Investigation of a Possible Technique for Preventing Dense Radiation Fog

In previous reports (Fog Drops Report Nos. RM-1788-P-9 and RM-1788-P-12) we have suggested that dense radiation fog might be prevented if extremely hygroscopic, large nuclei are introduced into the atmosphere before the fog begins to form. During the past reporting period we have designed and constructed apparatus for testing this hypothesis and have begun laboratory experiments. Results to date have been very encouraging.

In the experiments now being conducted we first produce a fog on natural condensation nuclei drawn into the test chamber from outside of the laboratory. Moisture is supplied by wet blotting paper that lines the test chamber walls. The transmissivity of the natural fog is measured as a function of time, and the extinction coefficient and visibility are computed. The natural fog is then flushed from the chamber and a new sample of outside air, into which nuclei of controlled size have been introduced, is placed in the chamber. The visibility of the fog forming in the seeded air is then determined and compared with that previously determined for the unseeded fog. To the extent that the two air samples are the same, the experiment provides a measure of the effectiveness of our seeding procedure in limiting the degradation of visibility due to fog.

In all experiments conducted thus far visibility in the seeded fog has been greater than in the unseeded fog except in one case when visibility of the natural fog was approximately 1.5 miles. In this case no difference was observed. Maximum improvement observed to date has been 95%.

To overcome the difficulties of producing hygroscopic nuclei of the proper size distribution we designed the apparatus shown schematically in Figure 1. This apparatus permits both gravitational separation of nuclei according to

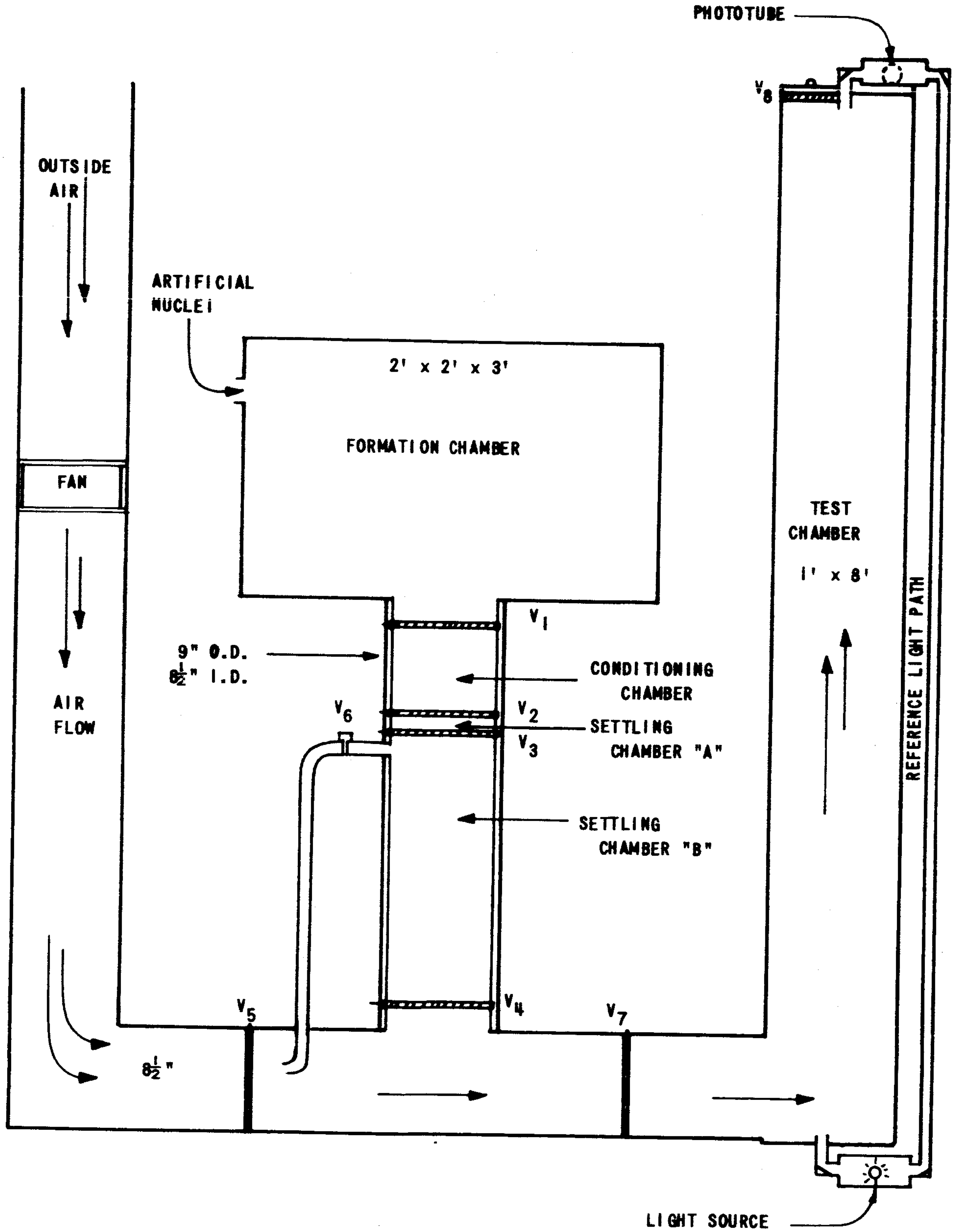

Figure 1 APPARATUS FOR TESTING FOG SEEDING TECHNIQUE

size and the insertion of only those nuclei of proper size into the test chamber. Nuclei are produced by spraying a saturated salt solution into a 12 ft^3 formation chamber which is heated by an infra-red lamp. The solution drops quickly evaporate in the dry atmosphere, leaving very high concentrations of dry salt crystals. Since drops of varying size are created by the aerosol spray, the resulting nuclei range in size from $< 1\mu$ diameter to $> 30\mu$ diameter. Once inside the formation chamber the nuclei are kept in constant motion by a small fan. The problem is to separate those particles that have diameters of approximately 4 to 10μ from the others and insert the desired particles into the atmosphere in which the fog will be formed. For reasons given in the last quarterly report all other nuclei are considered either too large or too small to be useful in the experiment.

To prepare the nuclei for separation, circular disk V_1 in Figure 1 is first removed to permit the nuclei to circulate into the conditioning chamber. Disk V_1 is then heated to approximately 80°C and replaced. A temperature inversion is thus established in the conditioning chamber and the air quickly stabilizes. Disks V_2 and V_3 are next removed to permit the nuclei to settle at their terminal fall velocities into settling chambers A and B. The settling chambers' dimensions were selected so that in approximately 100 seconds all nuclei of radius larger than 5μ settle onto disk V_4 and those smaller than 2μ radius remain in or above chamber A. After 100 seconds disk V_3 is replaced and, ideally, only artificial nuclei between 2 and 5μ radius remain in settling chamber B.

During this time, V_5, V_7 and V_8 are open so that the test chamber is flushed with clear outside air. V_6 and V_4 are now removed so that the artificial nuclei in settling chamber B are forced into the main air stream. Disks V_7 and V_8 are then replaced and the seeded fog is allowed to mature. Light transmission through the seeded fog is recorded on a Sanborn chart recorder for comparison with measurements made previously in unseeded fog.

To date we have run 7 experiments. In three of these experiments the seeded atmosphere produced fog in which visibility was 70 to 95 percent greater than in the corresponding control fog. In three different cases calibration difficulties prevented quantitative estimate of visibility, but substantial improvement in light transmission was observed as a result of prior seeding. In one case no difference in visibility was noted between the two fog types; however, on this occasion fog visibility in the natural case was approximately 7800 ft and little improvement was expected.

These results, while very encouraging, must be interpreted with care for they represent the data from just a few trials. Only after developing substantially better control of experimental parameters and conducting many additional experiments can results be interpreted as being significant. We already recognize several refinements both in the operating procedure and the experimental technique that will be incorporated in the experiments. In particular we must determine the number of hygroscopic nuclei that are admitted into the test chamber on each experiment in order to estimate the number required to produce optimum results. To make these measurements we will photograph the droplets in a small sensitive volume within the test chamber in the same way as we have been doing in the thermal diffusion chamber. We will also attempt to determine the size distribution and the concentration of nuclei that are initially trapped in settling chamber B and then forced into the test chamber. Because the existing chamber is only eight feet tall the droplets formed on artificial nuclei settle out of the fog in approximately ten minutes. While this is a desirable result for operations in the field, it limits our evaluation of the concept to unrealistically short times. Even though a substantial amount of work remains to be done in this short interval, we are now considering procedures for extending the experimental period. These, and other experimental improvements will be incorporated during the final quarter of this year's effort.

B. Electrical Means of Fog Dispersal

As part of this project we have been investigating the feasibility of promoting droplet coalescence in a fog by charging alternate adjacent regions positively and negatively. Calculations presented in our proposal for this years effort indicated that if an average 2×10^{-5} esu (4×10^{4} electronic charges) could be placed on each droplet, significant changes in coalescence rate could be anticipated. These changes would be brought about by increased mixing within the fog and mutual attraction of oppositely charged particles.

Detailed laboratory measurements completed during the last report period indicate that the maximum average charge that can be placed on typical fog droplets using practical equipment is approximately 2×10^{-7} esu/drop (400 electronic charges) or two orders of magnitude less than assumed earlier. Calculations indicate that with such small charges per droplet no significant increase in mixing or mutual attraction between droplets can be expected. These calculations were verified by producing adjacent positively and negatively charged fogs in the laboratory and observing the interaction.

As a result of these experiments we have concluded that the concept for suppressing fog by treating adjacent regions of the fog with charge of opposite polarity is not practical. Details of the experiments will be presented in the annual report to be submitted at the end of the next report period.

III. FUTURE PLANS

1. Refine experimental technique and incorporate necessary improvements in the fog seeding apparatus as outlined in Section A of this report.
2. Perform additional experiments with the present seeding apparatus to quantitatively determine effectiveness of the seeding technique.
3. Make suggestions regarding the feasibility of using the proposed fog dispersal technique in larger scale operations.
4. Continue 'cloud' nuclei measurements with the thermal diffusion chamber and correlate this years data with the results of measurements taken last year.