Entrainment of Small Particles by a Large Sphere

MANY theoretical and experimental investigations have been carried out on collisions between a single sphere and one or more smaller ones as the former moves through a field of the latter. Pertinent physical phenomena are the growth of raindrops by coalescence and the scavenging on non-liquid particulates from the atmosphere. An index of the efficiency of these processes is given by the concept of collision efficiency. A large drop moving through the atmosphere under gravitational forces sweeps out a cylindrical volume equal in cross-section to that of the advancing drop.

The collision efficiency is usually defined as the ratio of the number of droplets that actually make contact with the drop to the number in the volume swept by the sphere. Theoretical values for the collision efficiency range from zero to unity depending on the relative values of the inertial and fluid forces acting on the smaller particles. Collision efficiencies corresponding to zero values for either fluid or inertial forces can be established, but when both forces have non-zero values the problem is less amenable to mathematical formulation. Langmuir[1] established an empirical equation for interpolating between the efficiencies of unity and zero. More recent results have been summarized by Herne[2] and Englemann[3]. This concept of collision efficiency more or less disregards events that take place at or near the downstream surface of the drop. The terms collection and retention efficiencies are used in the literature to indicate the ratio of the particles retained by the drop to the number of physical contacts made.

The experimental evidence suggests that many small particles are trapped in the region immediately behind the drop and are dragged for a considerable distance before escaping. Oakes[4] carried out a series of experiments with drops falling through smoke and observed smoke particles being dragged behind drops 3·5 mm in diameter. In these laboratories experiments have been carried out in which drops of various sizes were allowed to fall through a smoke cell. The smoke particles were trapped and held in the wake of the drop as it passsed through a layer of smoke 10 cm in thickness.

Fig. 2 shows the first 20 cm of the trail as a drop equivalent to 5 mm in diameter emerges from the 10 cm layer of smoke. The capture of the smoke particles and their subsequent escape from the near wake region support the theory that for large drops there is an exchange of air between this region and the ambient air. The experimental evidence suggests that the exchange is greatest for drops in which the wake is characterized by a periodic or an aperiodic shedding of vortex elements. There is no evidence to suggest an exchange for single trail wakes. This wake geometry is shown in Fig. 1. From smoke density considerations it is estimated that smoke particles are carried an average distance of 40–60 cm at the velocity of the advancing drop.

The large drops were produced by a drop generator of the type described by Magarvey and Curry[5], and a shutter at either end of the smoke cell was synchronized to the drop selector.

Phenomena associated with the entrainment of small particles by falling drops have relevance in theories of scavenging by rain and may well be a factor in the separation of electrical charges in electrical storms.

This work was supported in part by the Defence Research Board of Canada and the Nova Scotia Research Foundation.

R. H. MAGARVEY
J. HOSKINS

Department of Physics,
Acadia University,
Wolfville, Nova Scotia,
Canada.

Received February 12; revised March 25, 1968.

1 Langmuir, I., *J. Meteorol.*, **5**, 175 (1948).
2 Herne, H., *Aerodynamic Capture of Particles* (Pergamon Press, 1960).
3 Englemann, R. J., *AEC Research and Development Report*, *HW*–79382 (1963).
4 Oakes, B., *Aerodynamic Capture of Particles* (Pergamon Press, 1960).
5 Magarvey, R. H., and Curry, M. J., *J. Sci. Instrum.*, **43**, 482 (1966).

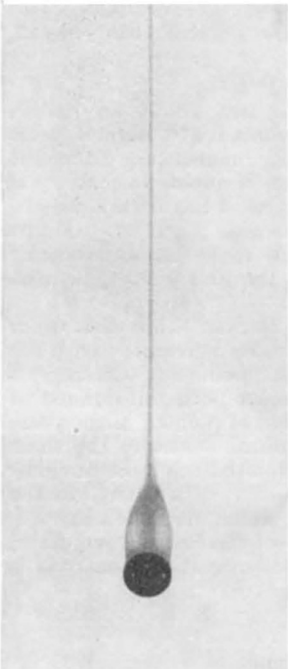

Fig. 1.

Fig. 2.

Fig. 1. The stable wake configuration behind a drop of organic liquid falling through water. Reynolds No. 190.

Fig. 2. Smoke particles dragged behind a drop of milk 5 mm equivalent diameter falling at velocity approaching the terminal value.

Photo-dimerization of Solid Anthracene

THE photo-dimerization of solid anthracene by ultraviolet irradiation has been reported[1] and denied[2]. It has also been suggested[2] that oxygen plays an essential part in photo-reactions of anthracene. We have proved by X-ray diffraction studies of single crystals of anthracene irradiated by ultraviolet light under various conditions: (1) that when radiation of wavelengths less than about 3000 Å is excluded, dimerization does take place; (2) that the presence of oxygen is not necessary; and (3) that the phenomenon is not wholly a surface effect.

Ultraviolet radiation from a Mazda (*ME/D*-250 W) Hg discharge lamp was filtered by a piece of ordinary 'Pyrex' glass and focused by a quartz lens. Photographs of the filtered and unfiltered ultraviolet spectra showed that the 'Pyrex' transmits radiation of wavelengths above 3000 Å. Single crystals of anthracene of maximum dimension 1 to 10 mm were grown from amyl acetate solution. These crystals, originally transparent, turned first pale yellow and then opaque white after a few hours' irradiation, but with no change of external shape.

Crystals irradiated for 50 h with the whole ultraviolet spectrum, unfiltered, remained unchanged. As soon as the 'Pyrex' filter was inserted they began to dimerize.