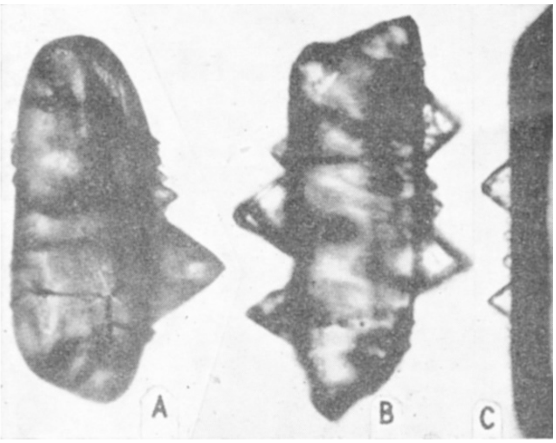

Fig. 1. Photomicrographs taken by the Kellner-eyepiece method. Outgrowths on grains of zircon. Magnifications: *A*, × 220; *B*, × 645; *C*, × 880. Objectives: *A*, × 43; *B* and *C*, × 95 oil immersion

but in general a faster (bromide) lantern plate was preferred with exposures of 1–30 sec. for 40-watt illumination. The objectives were achromatic and a tricolour blue filter between lamp and mirror appeared to improve the result.

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Bursting of Bubbles at an Air–Water Interface

IN a recent communication[1], we presented a series of high-speed photographs of bursting bubbles at an air–water interface. These photographs demonstrate the manner in which small airborne droplets evolve from the vertical water jet which forms upon collapse of the bubble cavity. These studies were carried out as a contribution to the understanding of the role of bursting bubbles in the production of atmospheric sea-salt nuclei[2]. It was stated that our study was confined to bubbles of 0·2–0·02 cm. diameter. In this region the jet mechanism appears to be the only one responsible for the production of airborne nuclei. We did not imply that the production of airborne salt was entirely via the jet mechanism. For example, in a study of foam patches, it may turn out that the production of droplets is predominantly from the collapse of the bubble film[3].

The more recent communication of Knelman *et al.*[4] states "that two separate mechanisms are involved in the bursting of a bubble—one producing a cloud of droplets of diameter about 60 microns, and the other a few comparatively large drops of diameter approximately 1 mm.". Inasmuch as the authors give no reference to the size of bubble used in their work, the implication is that these two mechanisms can be applied to all cases of bubble bursting. Intuitively this is not plausible and experimentally it can be shown not to hold true. An examination of the photograph in this communication[4] indicates that the bubble is probably greater than 0·3 cm. and possibly as large as 0·6 cm. in diameter. This was determined by noting the degree to which the bubble penetrated the surface film while at rest at the surface. The larger a bubble, the larger is the ratio of the buoyant to the surface tension forces; these forces being dependent upon volume and surface respectively. This ratio can be used to provide a measure of the tendency of the bubble to rise above the surface. The bubbles studied in our work, as compared to those illustrated in the communication by Knelman *et al.*, had a much greater percentage of their volume beneath the surface. It is thus reasonable to conclude that the investigation was confined to bubbles greater than 0·3 cm. in diameter; this is further confirmed by the statement that the jet produces droplets of approximately 1 mm. diameter. This certainly would require bubbles greater than 0·3 cm. If their conclusion regarding the two separate mechanisms was based on observations of such large bubbles it would scarcely seem correct to infer that phenomena associated with these bubbles should also be found in the bursting of much smaller bubbles.

I have observed the bursting of bubbles of less than 50 microns diameter and find the jet mechanism producing droplets of 2–20 microns diameter; but can see no evidence as to any cloud produced by the bursting of a protuberance on the bubble film. If such a cloud is present, its droplets must be far less than 1 micron in diameter.

Thus we must be very cautious before we can accept any single mechanism to explain the production of airborne droplets from the bursting of bubbles. It is possible that the mechanisms proposed by Knelman *et al.* are important in the production of droplets from a collection of large bubbles in the form of a foam patch. In any event, it would be useful if Knelman and his co-workers could present more detailed information in regard to the extent of the size-range of bubbles used in their investigation. Their high-speed photography has demonstrated the existence of an interesting and possibly important phenomenon. A knowledge of the range of bubble-sizes encompassed by this mechanism has sufficient interest to warrant further investigation.

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[2] Woodcock, A. H., *J. Met.*, **10**, 362 (1953).

[3] Facy, L., *J. Sci. de la Met.*, **3**, (11), 86 (1951).

[4] Knelman, F., Dombrowski, N., and Newitt, D. M., *Nature*, **173**, 261 (1954).

MR. BLANCHARD is correct in inferring that the photographs of bubble bursts accompanying the communication by Knelman, Dombrowski and Newitt (*loc. cit.*) relate to bubbles in the size range 0·3–0·6 cm. Although our experiments did not extend to the smaller sizes to which he refers, there is no reason for supposing that the two separate mechanisms disclosed in the photographs are confined to narrow size-limits; nor can we agree that "intuitively it is not plausible" for such mechanisms to operate with smaller bubbles.

We have examined photographically the break-up of thin films of a large number of liquids under conditions in which viscosity, surface tension and thickness were varied over a wide range and, in every instance, including that of mercury films, the mechanism of break up was as shown in Fig. 2 of our communication. A detailed account of this work is in course of publication.

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