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BRIEF COMMUNICATION

SPOUTS IN A BED OF SILICA POWDER ASSOCIATED WITH FLUIDIZATION BY OUTGASSING OF ADSORBED WATER

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INTRODUCTION

In the course of freeze-drying silica powder for chromatography we noticed that a high rate of evacuation of water vapor was sometimes sufficient to fluidize the powder for a period of several seconds. Immediately before the onset of fluidization, and again after its subsidence through evaporative cooling, transient spout-like structures appeared (figure 1), and often continued to erupt for several minutes. While the spouts usually originated at the vessel walls and could be induced by local heating, they frequently wandered from their points of origin over the surface of the bed, indicating that they were not essentially an edge effect. Because these structures appeared to provide a unique experimental model of hydrodynamic instability, we determined the conditions under which they could be reproducibly observed.

EXPERIMENTAL

Silica gel (Davison grade 15, 250–840 μm; or grade 923, 70–150 μm) was refluxed 8 hr with 12 N HCl, then washed until the filtrate was free of acid. It was dried to the free-flowing stage by filtration, then further dried in an oven at 100° for 12 hr. Shortly before use the silica was mixed with water, 20% by weight, and shaken until it was a homogeneous, free-flowing powder. This was placed in a chamber (figure 2). A vacuum was applied by a rotary oil pump. The only essential features of the apparatus were that the pump be able to attain rapidly a pressure of 10 Torr, and that the trap be able to handle the volume of water vapor outgassed.

RESULTS AND DISCUSSION

Figures 1 (a)–(c) are sequential photographs of spouts in a bed of 250–840 μm silica at intervals of a few seconds. The chamber pressure was about 14 Torr, and the depth of the bed was 2 cm. When the 70-150 μm silica was used instead, the individual spouts were more persistent, sometimes lasting a minute or more. Viewed from above the plane of the bed the spouts were circular with no apparent angular motion. Those spouts which came in contact with the window allowed observation of the internal structure in vertical section. Movement was up in the center in a region of relatively low particle density and down at the edges. Viewed with the naked eye, which involved a degree of time averaging not present in the photographs, the structures appeared to have a high degree of radial symmetry.

Refluxing with HCl was essential. With the 70–150 μm silica not so treated, spouts occurred but were less persistent. With the 250–840 μm silica spouts did not develop at all when the HCl treatment was omitted. Such treatment is known to convert Si–O–Si surface groups to SiOH groups (Aue & Hastings 1969). We cannot explain the effect of the treatment on the behavior of the bed. We have observed, however, that the HCl-treated silica squeaks when shaken in a bottle, indicating that the adhesive forces between the particles are changed by the treatment.

By decreasing the rate of pumping it was sometimes possible to observe spouts under conditions where fluidization of the whole bed did not occur. That is, full fluidization was apparently a manifestation of greater disequilibrium than were isolated spouts. Further, we

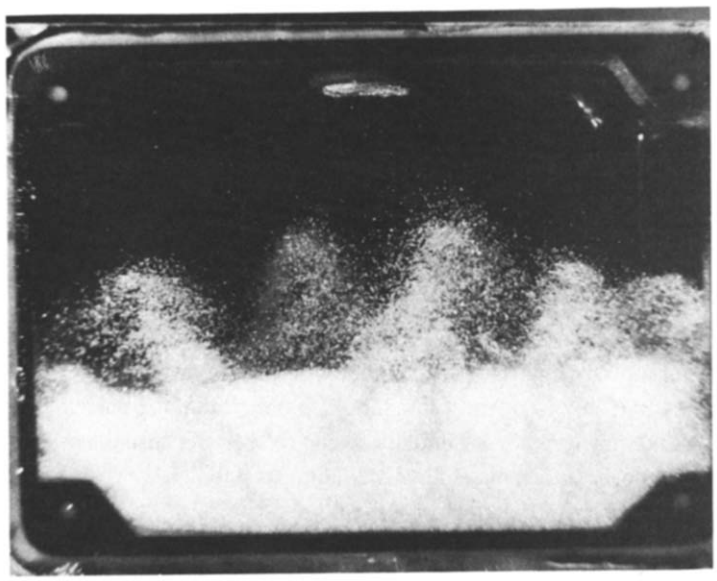

Figure 1(a)

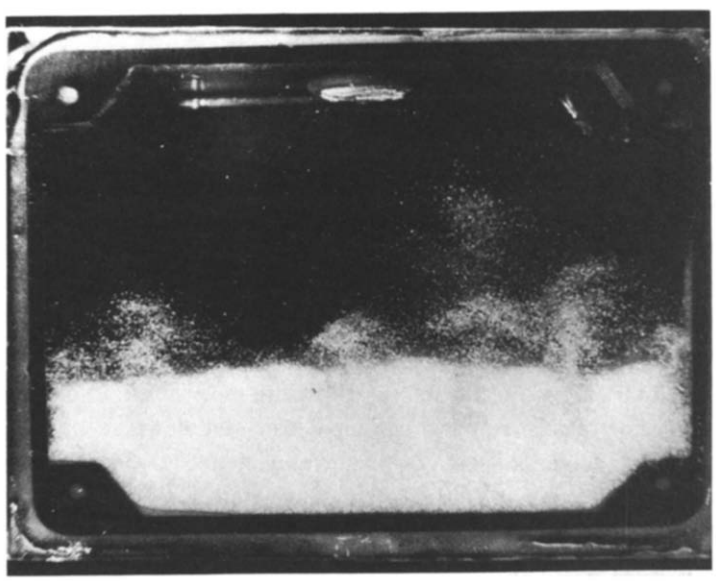

Figure 1(b).

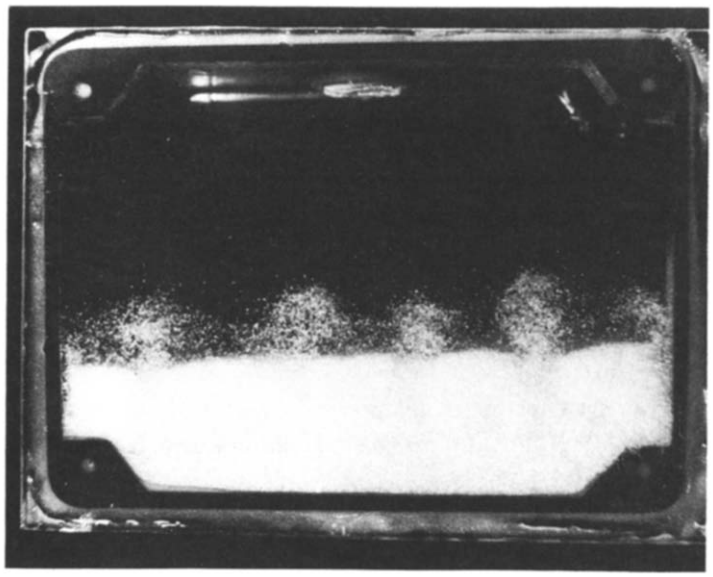

Figure 1(c).

Figure 1 (a)–(c). Still photographs, at intervals of a few seconds, of spouts in a bed of 250–840 μm silica powder.

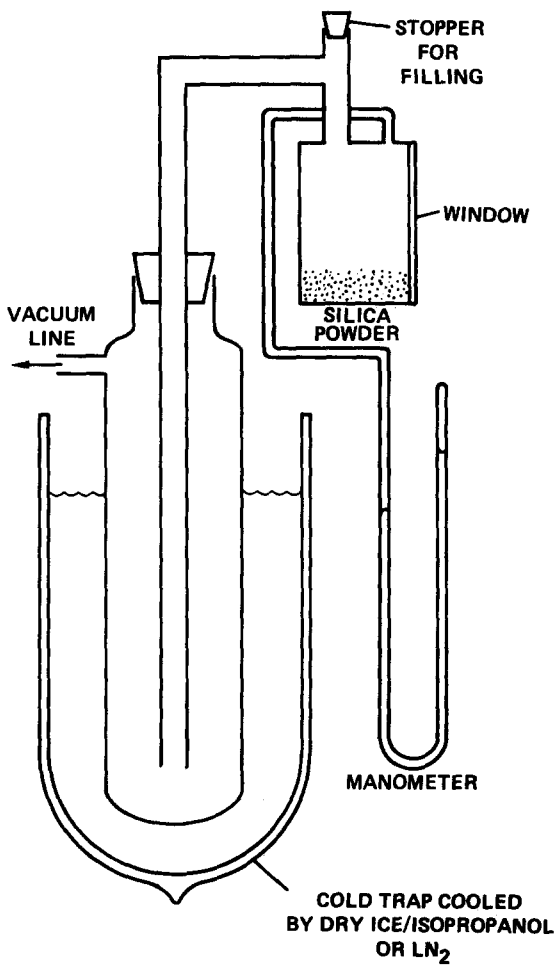

Figure 2. Apparatus for observing spouts in silica powder.

could detect no abrupt transition between isolated spouts and a fully fluidized bed. Rather, it was our impression that the latter could be viewed as a case of closely-packed spouts. If this is true, the mechanism that sustains the isolated spouts may be the same as that which gives rise, in general, to structure in fluidized beds (see, e.g. El-Kaissy & Homsy *et al.* 1980; Anderson & Jackson 1969).

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