there can be no "skipping" or "wild plusses," a phenomenon often seen when aliquot amounts are subcultured.

2. When a diluted bacterial suspension is filtered through a membrane, the organisms form an even, thin layer over its surface and they cannot be removed by washing as from stainless steel carriers. This distribution more closely resembles the spread of bacteria on human skin, mucosa, and contaminated surfaces. The problem of cell clumping which often occurs with bacteria suspended in solutions of quaternary ammonium compounds is eliminated completely.

3. There is no possibility of any carry-over of PVP-iodine activity, since available iodine is neutralized and thoroughly rinsed from the organism prior to culturing. The effectiveness of the neutralization can easily be determined without delay. Since the neutralizer is also removed by washing, the possibility of any interference with the growth of the test organism is eliminated.

REFERENCES

(1) Lawrence, C. A., and Block, S. S., "Disinfection, Sterilization, and Preservation," Lea & Febiger, Philadelphia, 1968, pp. 132–193.
(2) "Official Methods of Analysis of the A.O.A.C.," 10th ed., Association of Official Agricultural Chemists, Washington, D. C., 1965, 5.001–5.014.
(3) *Ibid.*, 5.023–5.032.
(4) Ortenzio, L. F., and Stuart, L. S., *J. Assoc. Offic. Agr. Chemists*, **44**, 416(1961).
(5) Chambers, C. W., *J. Milk Food Technol.*, **19**, 183 (1956).
(6) Cade, A. R., and Halvorsen, H. O., *Soap*, **10**, No. 8, 17; *Soap*, **10**, No. 9, 25(1934).
(7) Kayser, A., and van der Ploeg, G., *J. Appl. Bacteriol.*, **28**, 286(1965).

Keyphrases

Iodophors—bactericidal activity testing
Membrane filter technique—bactericidal activity test
Bactericidal activity—povidone-iodine solutions

Communications

Mechanism of Flow Improvement by the Addition of Fine Particles to Bulk Solids

Sir:

The flowability of a bulk particulate solid may be improved by the addition of a small proportion of fine particles. These fine particles, or glidants, may be chemically similar or dissimilar to the material with which they are admixed (1). In the former case the term "fines" may be used to describe the glidant particles.

Gold *et al.* (2) suggest that fine particles may act as glidants by filling the void spaces between particles, in addition to reducing interparticulate cohesive forces and reducing surface rugosity (3).

Now it can be shown that the voidage of a random array of spheres is 0.38 and 0.26 for a close packed array (4). Provided the size ratio of fine:coarse particles is less than 0.4 → 0.6, fine particles percolate into the interstitial void spaces. Thus, increasing the percentage of fines in a granulation should increase the bulk density until the void spaces are full.

Figure 1 is representative of a number of binary mixtures of magnesia and shows that the bulk density [determined by the British Standard Method (5)] increases as the intergranular voids are filled and then decreases due to bed expansion by the fine component.

If the flowing bulk solid is considered as a continuum, then it should follow that the higher the bulk density the greater the mass flow rate since more material can flow through the orifice due to a closer packing.

The flowability of the binaries outlined in Fig. 1 have been determined (3) and it can be seen

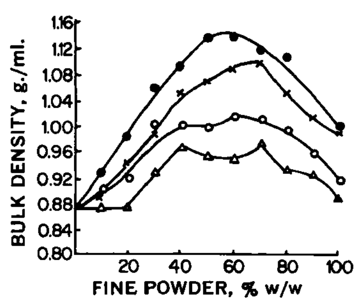

Fig. 1—The changes in bulk density in binary mixtures consisting of coarse granules (0.0561 cm.) with increasing concentrations of fine powders. Arithmetic mean diameter of fine powders. Key: △, *0.0158 cm.;* ○, *0.0090 cm.;* ×, *0.0059 cm.;* ●, *0.0048 cm.*

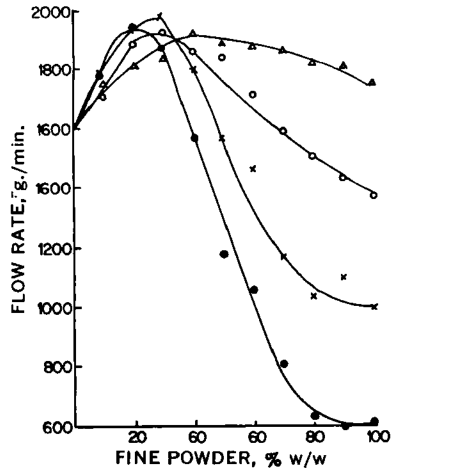

Fig. 2—The effect of fine powders on the flow rate of a coarse granulation (0.0561 cm.) from a horizontal-based hopper through an orifice of diameter 1.353 cm. Arithemetic mean diameter of fine powders. Key: △, *0.0158;* ○, *0.0090 cm.;* ×, *0.0059 cm.;* ●, *0.0048 cm.*

(Fig. 2) that the maxima in the two sets of graphs do not correspond, *i.e.*, improvement in flow rate cannot simply be due to void space filling.

Adopting a particulate approach to the kinematics of flow, it may be shown that particles in the bulk flow downwards and inwards towards an arch situated above the orifice from which they are discharged under the influence of gravity (6). This arch continuously forms and collapses producing a fluctuating voidage at the orifice. The stability of the arch and hence the rate of flow depends upon the number of particle components in its structure, *i.e.*, particle size.

Now the interposition of fine particles between the coarse components of an arch will increase the points of interparticulate slippage due to a displacement of their centers of mass. In addition, the frictional characteristics of the fine component will affect the coefficient of rolling friction of the constituent particles of the arch. Clearly, a limiting concentration of fine particles must be reached above which cohesive bridging will occur and thus a maximum is obtained in the relationship of flow rate to percentage fine component (2, 3).

Gold *et al.* (2) show that the flowability of fine lactose particles is increased by the addition of silica, talc, and magnesium stearate. On the basis of the theory that flow rate depends upon the stability of the natural free fall arch, these additives may act in two ways. First, it is likely that the frictional characteristics of the glidant lead to a reduction in particle-particle interaction within the arch and this may explain the behavior of the silica and talc glidants. However, it is unusual for magnesium stearate to produce glidant action (1) due to its long hydrocarbon tail increasing particle-particle interaction; it is, of course, a useful lubricant within the tablet die. Thus it is possible that a second mechanism of action applies in that the glidant may be of sufficiently large particle size to physically separate the fine particles of the granulation and thereby reduce the influence of cohesive bridging.

(1) Strickland, W. A., Jr., *Drug Cosmetic Ind.*, **85**, 318, 406, 410(1959).
(2) Gold, G., Duvall, R. N., Palermo, B. T., and Slater, J. G., *J. Pharm. Sci.*, **57**, 667(1968).
(3) Jones, T. M., and Pilpel, N., *J. Pharm. Pharmacol.*, **18**, 429(1966).
(4) Ridgway, K., and Tarbuck, K. J., *Chem. Process Eng.*, **49**, 103(1968).
(5) "British Standard," 1948, p. 1460.
(6) Brown, R. L., and Richards, J. C., *Rheol. Acta*, **4**, 153(1965).

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Keyphrases

Glidant action—bulk solid flow
Flow rate, solids—glidant effect
Particle size—flow-rate effect