NOTES FROM THE U. S. BUREAU OF STANDARDS.*

PLASTIC FLOW.¹

By Eugene C. Bingham.

EXPERIMENTS by Bingham and Durham² showed that the fluidity of a suspension is a linear function of the concentration. The zero of fluidity is reached at a comparatively low volume-concentration, as is shown in Fig. 1. The concentration which has zero fluidity serves to sharply demarcate viscous from plastic flow. All concentrations of solid less than this are viscous, and any shearing force—no matter how small—will produce permanent deformation, if long enough exerted. Concentrations greater than this are plastic, and it is necessary to use a shearing force of finite magnitude in order to produce a permanent deformation. The laws of plastic flow have never been studied.

The method of attack was to force suspensions of clay and water, under known pressure, through capillaries of different dimensions, and to measure the rate of flow. Some of the values obtained are shown in Fig. 2. For medium pressures the volume of flow per second is given by the formula

$$v = K (P - f)$$

where P is the pressure employed and f is the so-called "friction"; *i.e.*, the force required to start the flow.

Putting $P - f$ in place of P in the ordinary Poiseuille formula for calculating the fluidity, we have a means for calculating the "mobility" of plastic substances, analogous to the fluidity of viscous substances.

The friction increases as a linear function of the concentration of solid present (see Fig. 1). It is independent of the length and diameter of the capillary as well as the viscosity of the medium. It is, however, affected by the presence of alkalies or acids in the medium.

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¹ Scientific Paper No. 278.

² *Am. Chem. Journal*, 46, 278 (1911).

The mobility decreases rapidly as the concentration of solid is increased, as is seen in Fig. 3. The mobility is also enormously sensitive to the presence of alkalies or acids, the mobility of a 50 per cent. by weight clay suspension being increased 330 per cent. by the addition of 0.1 per cent. of potassium carbonate.

At pressures little if any greater than those necessary to overcome the friction there was detected seepage of the medium past the solid particles (see Capillary 6.1 Fig. 2). At high pressures

FIG. 1.

there was sometimes a sudden increase in the rate of flow, which is apparently due to slipping (see Capillary 6.3, Fig. 2).

If the solid material consisted of spheres of equal size, the pore space remaining when the particles were as closely packed as possible would amount to 26 per cent., and quite irrespective of the radius of the spheres. However, due to the friction of the spheres on each other, the pore space may be much larger than this, and this is particularly true if the material is very finely divided. As a matter of fact, it was found that on shaking dry clay into a flask, the pore space remaining amounted to 81.6 per cent. of the

FIG. 2.

The flow (in c.c.) of 50 per cent. clay suspension in water containing 0.1 per cent. of potassium carbonate in solution, for pressures (g. per sq. cm.) as shown, and at 25° C., except one series of experiments with Capillary No. 1, which was made at 40° C. The capillaries had the following dimensions:

Capillary	Radius in cm.	Length in cm.
1	0.02848	2.468
6.1	0.05785	5.011
6.2	0.05811	2.509
6.3	0.05850	9.998

FIG. 3.

total volume. This corresponds closely to the percentage of liquid present in the mixture having zero fluidity, which is 80.5. It is upon this friction that the plasticity depends, and the plasticity is thus closely related to the fineness of subdivision of the material.

FURTHER EXPERIMENTS ON THE VOLATILIZATION OF PLATINUM.*

By G. K. Burgess and R. G. Waltenberg.

THIS is a continuation of an investigation undertaken at the suggestion of the Committee on "Quality of Platinum Utensils" of the American Chemical Society. Seven platinum crucibles of various makes and purity have been subjected to successive heatings at 700, 1000, and 1200° C., followed by determination of iron and other materials soluble in 1 : 4 boiling hydrochloric acid. Among the results obtained are the following:

1. Platinum ware in the form of crucibles of whatever degree of purity behaves, with respect to gain or loss of weight, on heating in air at ordinary atmospheric pressure, in a manner characteristic only of the temperature of heating.

2. Each impurity, as iridium, rhodium, or iron, appears to exert its effect on the volatilization of platinum independently.

3. For platinum crucibles of all degrees of purity containing Ir, Rh, Fe, Si (up to a content of at least 3.0 per cent. Ir) the loss on heating is negligible below about 900° C.

4. Below this temperature there may even be a slight gain in weight on heating platinum, owing to the iron content diffusing to the surface and oxidizing. At higher temperatures the presence of iron will lower the volatilization loss by amounts depending on the quantity of iron present. There appears to be no platinum made which does not contain some iron.

5. The volatilization of platinum containing rhodium is less than that of pure platinum at all temperatures above 900° C.

6. The volatilization of platinum containing iridium is, above 900° C., very much greater than that of pure platinum, and increases with the Ir content and with temperature.

7. It appears to make no material difference in the volatilization results, in the range 700° to 1200° C., what is the order of heating, ascending or descending temperatures.

* Scientific Paper No. 280.