A note on concentrated ferro-magnetic amalgams

1941 Proc. Phys. Soc. 53 113

(http://iopscience.iop.org/0959-5309/53/2/302)

A NOTE ON CONCENTRATED FERROMAGNETIC AMALGAMS

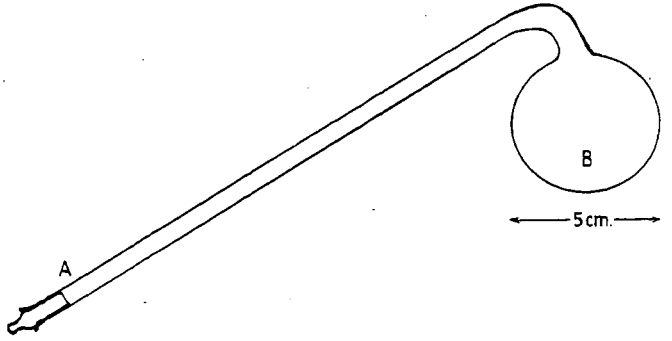
By L. F. BATES, D.Sc.,
University College, Nottingham

Received 4 *November* 1940

ABSTRACT. Attempts to obtain concentrated fluid amalgams of nickel and mercury are described. Concentrated amalgams formed by low-temperature distillation become ferromagnetic when their constitution reaches 3 atoms of mercury to 1 of nickel.

§ 1. DESCRIPTION OF EXPERIMENTS

As it was recently shown (Bates and Baker, 1940) that dilute amalgams of nickel in mercury exhibit ferromagnetism when once they have been heated to a temperature above 225° C., it was thought worth while to find if such amalgams could be concentrated to make, as it were, a kind of ferromagnetic liquid. It is not convenient to prepare by electrolysis amalgams



Distillation apparatus.

containing much more than 2 per cent. of nickel by weight, as they tend to become increasingly solid with rise in nickel content, and consequently, amalgams so prepared were concentrated by removal of mercury by distillation *in vacuo*.

The freshly prepared amalgam was carefully washed in distilled water, roughly dried and placed in the bulb B of an apparatus, of the form shown in the figure, which was evacuated by a Hyvac pump, B being placed in boiling water during the final stages of the evacuation. In this way the amalgam was denuded of any remaining traces of water, and the apparatus was sealed by the simple

device described by Bates, Baker and Meakin (1940). B was then placed in a vessel containing oil which was heated on a sand bath, while the remote end of A was placed in ice. The oil was kept at a chosen temperature for long intervals of time, and the mercury driven off from the amalgam was collected in A. The latter was of fairly uniform bore, so that the volume of mercury driven off could be periodically measured by the length of the column in A, and, accordingly, the composition of the amalgam left in B could be determined from time to time.

The chosen temperatures in these experiments, in each of which a fresh amalgam was used, were 170, 195, 215 and 223° c., all below the temperature 225° c. at which the liquid amalgams become ferromagnetic. At each of these temperatures, and while it still continued to lose mercury, the amalgam in B became a hard matt grey solid at the same composition, viz. 10 atoms of mercury to 1 of nickel. The strange feature about this solid was that it became plastic, one might say fluid, at lower temperatures. It was possible to heat an amalgam of this composition to a temperature at least as high as that at which it was formed and then cool it many times without change in its properties becoming apparent. When maintained for long periods at any one of the above temperatures, the solid amalgam lost more mercury and became increasingly hard and difficult to break up by shaking against the walls of the bulb, and, eventually, a black ferromagnetic powder formed on the surface. The powder was easily shaken from the surface of the amalgam, and its formation coincided with the appearance of traces of ferromagnetism in the main body of the amalgam, whose constitution was then found, in all cases, to be 3 atoms of mercury to 1 of nickel. Thereafter, on further loss of mercury the solid became increasingly ferromagnetic, until all the mercury was removed and black powdered nickel remained. The latter readily soaked up liquid mercury *in vacuo*; it would not soak up mercury after being in contact with air.

Attempts were also made to distil mercury from an amalgam *in vacuo* when B was kept at 240° c., i.e. well above 225° c., but with the above design of apparatus the mercury came off so quickly that it condensed and ran back on to the amalgam before it could be collected in A, and it was impossible to know the actual temperature of the amalgam. An inert gas at a pressure of about 10 cm. of mercury at 240° c. was therefore placed in the apparatus. A non-homogeneous ferromagnetic fluid amalgam was then formed. On evacuation at 240° c. mercury distilled over, leaving first a matt grey ferromagnetic solid and later black powdered nickel.

Nickel powder prepared in these experiments was found to have a specific magnetization of approximately 36 c.g.s. units per gm. in a field of 10,000 oersteds, and a remanent magnetization of approximately 11 c.g.s. units per gm. after it had been in contact with air. The corresponding data for pure solid nickel (hard-drawn) are 57·6 and 33 c.g.s. units per gm. respectively. It was not possible to measure the ferromagnetic properties of a fluid or plastic specimen obtained on cooling to room temperature an amalgam of concentration 10 atoms of mercury

to 1 of nickel, without the use of special apparatus, but we can readily estimate the saturation magnetic moment of the material. One gm. of the fluid contains 0·0286 gm. nickel, so that its saturation intensity of magnetization, taken to be equal to that of the black powder, would be about 14 c.g.s. units per c.c. of fluid, compared with 500 for pure solid nickel. Naturally, its initial susceptibility is low.

§ 2. ACKNOWLEDGEMENTS

It is with much pleasure that I record my thanks to Mr. E. J. Adamson for his valuable help with the experiments.

REFERENCES

BATES L. F. and BAKER C. J. W., 1940. *Proc. Phys. Soc.* **52**, 536.
BATES L. F., BAKER C. J. W. and MEAKIN, R., 1940. *Proc. Phys. Soc.* **52**, 429.