related to the rheological breakdown and consequent disturbance in the dispersing medium, induced by the rotation of elongated elements of the magnetic particle structure. It can thus be used as a highly sensitive method for the study of such structures, and in the field of general rheology. A machine which automatically measures the Dorf effect and which is suitable for the routine checking of dispersions during manufacture is currently in use.

Dorf values of dispersions range widely depending on the formulation of the medium, the concentration of the magnetic particles and their saturation magnetization. Particle size, intrinsic coercivity and the level of initial orientation are not important, while preparation methods, standing time and temperature influence the results to some extent. From experiments with many dispersions of different magnetic particles, and mixtures with non-magnetic powders, it has invariably been found that the Dorf value of a dispersion varies linearly with the concentration of magnetic particles over a very wide range. Broader experience, however, is required to understand the significance of the many slopes and intercepts of these curves.

An orientated magnetic dispersion consists of a mesh structure of "particle strings" immersed in a structured fluid medium. From Fig. 1 it is seen that the application of a reverse field has little effect until a threshold or yield value is reached at which, it is thought, the torque imparted to certain "strings" is not only sufficient to detach them from the magnetic forces of the mesh, but also to cause disruption in the surrounding medium structure, so enabling them to rotate. As the field is increased, other "strings" become involved and the process continues to the Dorf value and beyond where re-orientation of the oppositely disposed structure takes place. The Dorf condition is one of balanced moments between those particles which have been rotated and the unaffected ones.

Many interesting phenomena have been observed during the course of this work which will be fully reported elsewhere.

R. R. PEARCE

Research Laboratories of
Electric and Musical Industries, Ltd.,
Hayes, Middlesex.

Received September 1, revised November 18, 1966.

THE SOLID STATE

Shear Compliance of Hot-worked Pyrolytic Graphite

WHEN hot-worked at temperatures above 2,500° C, pyrolytic graphite is transformed into a material with characteristics which approach those of single crystals of natural graphite. For example, the density is greater than 2·2 g/cm³ (compared with an X-ray density of 2·26), while the two coefficients of thermal expansion are identical to those of single crystals. Such a material has been made for the Centre d'Études Nucléaires de Saclay (France) by Carbone Lorraine. It has a high lustre and cleaves extremely easily along the basal plane albeit with a certain amount of corrugation (see Fig. 1). Transmission electron microscopy shows that many areas extending over 1000 Å along the *a*-axis are free of tilt boundaries. The concentration of dislocations is very variable but it appears to be somewhat greater overall than that of natural graphite.

The S_{44} compliance of such a material, that is, the compliance governing the shear of the basal plane, has been measured before and after hot-working. The only published measurement of S_{44} until now is that of Baker and Kelly[1], who found values of $1 \pm 1 \times 10^{-9}$ cm²/dyne, using crystals of natural graphite. They measured the frequency of cantilevered specimens vibrating perpendicular to the basal plane. The contribution of the S_{44} compliance in such a system is particularly difficult to estimate. It was decided, therefore, to use a new more direct method.

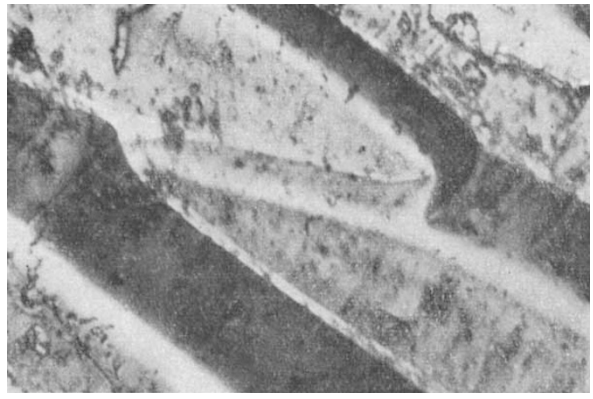

Fig. 1. A typical area of hot-worked graphite showing basal cleavage × *c.* 265).

A compound specimen was made from two lengths of pure aluminium (≃ 5 cm long) of square cross-section (≃ 7 mm side), and a graphite specimen (≃ 5 mm thick perpendicular to the basal plane) with the same cross-section. The parts were joined, using thin layers of epoxide resin, with the graphite sandwiched between the two metal rods so that a common axis ran through the centre of the square cross-section. Measurements were made of the resonant frequency of the compound rods in torsion with and without the graphite specimen using a Förster 'Elastomat'. It can be shown that the S_{44} of the graphite is given, approximately, by

$$S_{44} = \frac{1}{G_A} \times \frac{L_A}{L_G} \times \left[\left(\frac{f_A}{f}\right)^2 - 1\right]$$

where G_A = shear modulus of aluminium, L_A = length of one metal rod, L_G = half the thickness of the graphite specimen, f_A = resonance frequency of the metal rods bonded together without graphite, and f = resonance frequency of the compound specimen.

Great care needs to be taken with the hot-worked graphite because it cleaves very easily, but typical results are as follows: f_A = 14,200 c/s, f (for a typical high temperature pyrographite) = 8,640 c/s, and f (for three specimens of hot-worked graphite) = 4,188, 2,494, 4,194 c/s.

From this the compliance of a high temperature graphite can be calculated as $0{\cdot}13 \times 10^{-9}$ cm²/dyne which, when hot-worked, increases to 0·60, 0·80, $2{\cdot}40 \times 10^{-9}$ cm²/dyne. This approaches the values quoted[1] for single crystals of natural graphite.

It should be noted, however, that the internal friction of the hot-worked graphite is extremely large and the resonance peak is quite asymmetric (presumably as a result of damping which is highly dependent on amplitude), so that the values quoted above need to be corrected.

G. M. JENKINS

Department of Metallurgy,
University College of Swansea.

G. JOUQUET

Commissariat à l'Énergie Atomique,
Centre d'Études Nucléaires de Saclay.

Received October 14, 1966.

[1] Baker, C., and Kelly, A., *Phil. Mag.*, **9**, 927 (1964).