of molecules "rigidly" attached to each other as in a solid, and in part of molecules which are relatively mobile as in the gaseous state (NATURE, April 21, p. 532).

That the supposition made regarding the constitution of liquids is *prima facie* a reasonable one is, I think, clear from thermodynamical considerations. The liquid stands midway between the solid and the gas and has affinities to both. The volume of a liquid at temperatures slightly higher than the melting point is only moderately different from that of the solid, and hence the probability that many of the molecules are at any instant at the same distance from each other as in a solid is considerable. This probability may indeed be found from the latent heat of fusion of the substance. If W be the heat of fusion in ergs per mol, the number of molecules in the "rigid" and "mobile" states should be approximately in the ratio $e^{W/KT}$.

The mechanism of viscous flow of a liquid is perhaps clearest if we consider the case of a thin layer enclosed between two parallel plates, one of which slides over the other. When a steady state is reached, the "rigid" parts of the liquid move practically as complete wholes, and hence the effect of their existence is to diminish the thickness of the layer through which momentum has to be transported by the "mobile" molecules, and thus to increase the viscosity. As a rough approximation, this increase is in the proportion of the numbers of the two types of molecules. A more exact theory should take into account also the volumes occupied by the two types of aggregation and their changes with temperature.

The effect of pressure on viscosity of liquids would arise in two distinct ways. In the first place, we have a change of volume on fusion, and hence, by the Le Chatelier-Braun principle, the assumed dissociation from the "solid" to the "mobile" aggregation would be retarded by pressure, so that the viscosity should be increased. With substances such as ice which contract on melting, we have the opposite effect. In the second place, pressure diminishes the volume occupied by the "mobile" molecules, and therefore also the distance through which they have to transport momentum. This would increase the viscosity. At temperatures not much higher than the melting point, the first effect would preponderate. This is strikingly illustrated in the case of water, the pressure-coefficient of viscosity of which is negative up to 32°C , that is, even at temperatures much higher than that of maximum density.

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Calcutta, March 15.

Green and Colourless Hydra.

IN NATURE of April 7 a short account is given of the interesting experiments made by Goetsch on the conversion of the green Hydra into a pale Hydra. Some years ago I observed what may be called a natural experiment of the same kind. At the south end of the tunnel that conducts the water supply of Manchester from Lake Thirlmere under Dunmail Raise to the Grasmere valley there is a small settling tank, and on the walls of this tank I found a very large assembly of milk-white Hydras. An examination with a pocket lens led me to the conclusion that they were only a white variety of the common *Hydra viridis*, and were probably the offspring of parents living in the tunnel. These white Hydras were evidently enjoying the full vigour of life.

SYDNEY J. HICKSON.

The University, Manchester, April 11.

Single Crystals of Aluminium and other Metals.

WITH reference to Prof. Porter's letter in NATURE of March 17, p. 362, the accompanying photographs (Figs. 1 and 2) may be of interest. They illustrate at a magnification of 100 diameters the type of fracture obtained when a drawn tungsten wire consisting of a single crystal is broken in tension. The fracture is

FIG. 1.—0.05 mm. single crystal tungsten wire broken in tension, showing reduction in diameter. ($\times 100$.)

FIG. 2.—Same specimen photographed in a plane at right angles to that of Fig. 1, showing no reduction in diameter in this plane.

always of the wedge type, the wire being very greatly reduced in diameter in one plane while it suffers no appreciable reduction in the plane at right angles. The photographs show the same specimen after fracture taken from two planes at right angles. The diameter of the wire was 0.05 mm.

C. J. SMITHELLS.

Research Laboratories,
General Electric Co., Ltd.,
Wembley, March 20.

Stirling's Theorem.

A SMALL modification of the proof given by Mr. Strachan in NATURE of March 24, p. 397, leads to an asymptotic series for $n!$ rather more convergent than Stirling's. The symbol $n!$ standing, generally, for $\Gamma(n+1)$, we have

$$\log(n + \frac{1}{2})! - \log(n - \frac{1}{2})! = \log(n + \frac{1}{2}).$$

Hence, by Taylor's theorem,

$$\left(D - \frac{D^3}{2^2 \cdot 3!} + \frac{D^5}{2^4 \cdot 5!} - \dots\right) \log n! = \log(n + \frac{1}{2}).$$

$$\therefore \log n! = \left(\frac{1}{D} - \frac{D}{2^4} + \frac{7D^3}{5760} - \dots\right) \log(n + \frac{1}{2}).$$

$$\therefore n! = \sqrt{2\pi} \left(\frac{n + \frac{1}{2}}{e}\right)^{n+\frac{1}{2}} \times \exp. \left(-\frac{1}{24(n + \frac{1}{2})} + \frac{7}{2880(n + \frac{1}{2})^3} - \dots\right),$$

the constant in the integration being determined as before.

Stirling's first approximation, $\sqrt{2\pi n} n^n e^{-n}$, makes $1! = 0.922$, whilst $\sqrt{2\pi} \{(n + \frac{1}{2})/e\}^{n+\frac{1}{2}}$ makes $1! = 1.028$ and so is a little closer.

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