down movement of the naked thorax is induced in a way similar to that recorded by Prof. Andrade. It is possible that murderers brought into the presence of the corpse of their victim exposed in a dim light must frequently have seen such movements of the hands especially as they will probably stare fixedly at the body. Any apparent movement will of course be intensified by suggestion. This may account for many old superstitions.

Finally I should like to compliment Prof. Andrade on having described certainly two of the prettiest methods of demonstrating the movements of the visual purple. I find that the phenomena described by him are readily seen by people who have not been told what they are expected to see, an essential point in such experiments.

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London, December 26.

Experiments on Hardness and Penetration.

I AM greatly interested in the letter on "A Curious Feature in the Hardness of Metals," by Mr. Hugh O'Neill and Dr. F. C. Thompson, which appears at p. 773 of NATURE of December 9, for in my paper "Experiments with Clay in its relation to Piles," read before the Society of Engineers on March 10, 1919, will be found an account of the "pressure of fluidity" of clay. Briefly this may be described thus. When a horizontal disc resting on clay is gradually loaded it slowly sinks into the clay, each increment of load producing a corresponding increment of penetration, but when the load on the disc reaches a certain critical value the disc continues to sink at about ten times the speed *without* any further increase of the load. This load divided by the area of the disc I have called the pressure of fluidity of the clay. This quantity has been found, within a considerable range, to be independent of the area of the disc used for its determination. The only factor upon which it depends, in the case of the London clay used, is the percentage of water in the clay, and by this it is very greatly affected, as will be seen from the following equations, which fit the results closely within the ranges stated, and the table below.

From 28 per cent. to 38 per cent. of water; $p' = \frac{1073 \times 10^{10}}{(w')^7}$, where p' is the pressure of fluidity in grams per sq. cm. and w' is the percentage of water in the clay.

The same equation may be used with small error down to $w' = 25{\cdot}7$ per cent., but with values of w' from 25·7 per cent. to 22·0 per cent. the relation is p (kilograms per sq. cm.) $= 39{\cdot}5 - 1{\cdot}48w'$.

I have experimented with spheres in place of discs and have not detected any difference in the values of the pressures of fluidity thus determined. The reason for this is probably due to what other experiments have disclosed, namely, that the descending disc carries down with it the clay which was immediately under it at the start of the experiment, this stagnant clay forming roughly a hemisphere below the disc. Whether a disc or sphere is used, a clean hole is left behind.

Expecting to find a similar phenomenon in the case of metals, a corresponding experiment was made with cast lead. The result was the same. At a certain critical load the disc continued to sink into the lead without further increment of load. The pressure of fluidity of lead was thus found to be 1233 kilos per sq. cm., as recorded at pp. 152-4 of my fourth paper on "The Physical Properties of Clay," read before the Society of Engineers on June 12, 1922. From the rate of penetration (after the pressure of fluidity had been reached) and by a modification of Stokes' Law, the viscosity of the lead at 60° F. was found to be

$$7{\cdot}37 \times 10^{10} \text{ dyne-seconds per sq. cm.}$$

Taking the Brinell formula given by Messrs. O'Neill and Thompson, when the ball is below the surface of the material $d = \mathrm{D}$, and the Brinell formula they give becomes

$$\mathrm{H} = \frac{2\mathrm{L}}{\pi \mathrm{D}^2}. \quad . \quad . \quad . \quad . \quad . \qquad (1)$$

And when $d = \mathrm{D}$ the Meyer formula becomes

$$\mathrm{L} = a\mathrm{D}^n. \quad . \quad . \quad . \quad . \quad . \qquad (2)$$

Substituting (2) in (1) we have

$$\mathrm{H} = \frac{2a\mathrm{D}^n}{\pi \mathrm{D}^2} = \frac{2a}{\pi}\mathrm{D}^{n-2}. \quad . \quad . \quad . \qquad (3)$$

The Brinell hardness number is the stress in kilograms per sq. mm. on the curved surface of the indentation.

The pressure of fluidity, p, is the critical load L divided by the area of the disc (or great circle of the ball). Thus:

$$p = \frac{\mathrm{L}}{\mathrm{A}} = \frac{\mathrm{L}}{\frac{\pi}{4}\mathrm{D}^2} = \frac{a\mathrm{D}^n}{\frac{\pi}{4}\mathrm{D}^2} = \frac{4a}{\pi}\mathrm{D}^{n-2}. \quad . \quad . \qquad (4)$$

Hence p is seen to be equal to 2H, where $\mathrm{H} = \frac{2\mathrm{L}}{\pi \mathrm{D}^2}$ and L is the critical load.

This result also immediately follows from the fact that in the case of the Brinell No. the load is divided by the area of the *curved* surface of the indentation, whereas in the case of the pressure of fluidity the load is divided by the projected area of the sphere, and the ratio of the area of the curved surface of a hemisphere to its flat surface is 2.

$$\text{As } \mathrm{A} = \frac{\pi}{4}\mathrm{D}^2, \quad \therefore \mathrm{D} = 1{\cdot}13\sqrt{\mathrm{A}},$$

Therefore Meyer's formula

$$\mathrm{L} = a\mathrm{D}^n \text{ becomes } \mathrm{L} = a(1{\cdot}13\sqrt{\mathrm{A}})^n$$
$$= a(1{\cdot}13)^n \mathrm{A}^{\frac{n}{2}}.$$

But in the case of clay, $\mathrm{L} \propto \mathrm{A}$, this being one of the most definite and carefully determined results. Consequently, if Meyer's formula is also true for clay, n must be $= 2{\cdot}0$, in which case $\mathrm{L} = a(1{\cdot}13)^2\mathrm{A} = 1{\cdot}275a\mathrm{A}$, and $\mathrm{L}/\mathrm{A} = p = 1{\cdot}275a$ or $a = p/1{\cdot}275$.

Using this relation the following values of a are obtained for London clay:—

Per cent. of Water.	Pressure of Fluidity. Kilos per sq. cm.	*a*.
37·8	0·107	0·083
37·0	0·128	0·100
31·0	0·320	0·251
30·0	0·527	0·414
29·0	0·600	0·471
28·0	0·846	0·663
25·4	1·938	1·521
23·6	4·700	3·69
22·0	7·200	5·65

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