configuration of the atoms in the structure of tin shows that a diffusing atom will be obstructed by four neighbours if moving in the $a$-direction and by two neighbours if moving in the $c$-direction. Since diffusion in the $c$-direction depends on two atoms being favourably displaced from their equilibrium positions, and diffusion in the $a$-direction requires a favourable displacement of four atoms, jumps parallel to $c$ can occur more frequently. It should be emphasized, however, that this discussion of the temperature-independent factor $A$ leads to difficulties in accounting for the anisotropy of the activation energy for which no explanation can be suggested.

This work forms part of the general programme of research of the Division of Tribophysics, Commonwealth Scientific and Industrial Research Organisation.

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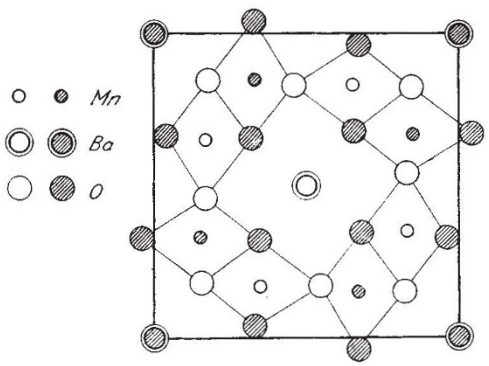
## Crystal Structure of Hollandite

Hollandite, cryptomelane, coronadite and $\alpha$-$MnO_2$ form an isostructural series of the general formula $A_{2-y}B_{8-z}X_{16}$, $A$ being large ions such as $Ba^{2+}$, $Pb^{2+}$ and $K^+$, $B$ small and medium-sized ions such as $Mn^{4+}$, $Fe^{3+}$ and $Mn^{2+}$, and $X$, in the cases investigated, $O^{2-}$ and $OH^-$ ions. The unit cell, which contains one formula unit, is tetragonal or pseudotetragonal, in the latter case monoclinic. Approximate dimensions of the tetragonal unit cell are $a = 9{\cdot}8$ A. and $c = 2{\cdot}86$ A. When deformed, the short axis will be the $b$-axis of the monoclinic cell. The deviation of $\beta$ from 90° is 0·5–1·5°, and the difference $a - c$ is 0·1–0·2 A. The space group of the tetragonal cell is $C_{4h}^5$—$I\ 4/m$ and the atomic positions are:

(000 ; $\frac{1}{2}\frac{1}{2}\frac{1}{2}$)+
$2-y$ $A$ in 2($b$): $00\frac{1}{4}$ ;
$8-z$ $B$ in 8($h$): $x_1y_10$ ; $\bar{x}\bar{y}0$ ; $y\bar{x}0$ ; $\bar{y}x0$ ;
8 $X$ in 8($h$): $x_2y_20$ ;
8 $X$ in 8($h$): $x_3y_30$.




Structure of hollandite projected on (001). Filled circles denote ions at $c = \frac{1}{2}$ and open circles ions at $c = 0$

For a specimen of hollandite the parameters were calculated to be:

| | | |
|---|---|---|
| $x_1 = 0{\cdot}348$ | $x_2 = 0{\cdot}153$ | $x_3 = 0{\cdot}542$ |
| $y_1 = 0{\cdot}167$ | $y_2 = 0{\cdot}180$ | $y_3 = 0{\cdot}167$ |

The $A$ ion is surrounded by eight oxygen ions at a distance of 2·74 A., forming a cube, and at a greater distance (3·31 A.) by four oxygen ions forming a square at the same level as the $A$ ion. The $B$ ion is surrounded by six oxygen ions forming an octahedron, and has a mean distance of $B$—O = 1·97 A. (see diagram).

In the cases investigated, the variable $y$ in the general formula varies from 0·8 to 1·3 and $z$ from 0·1 to 0·5.

A detailed report of the investigation will be published elsewhere.

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## Meyer Analysis of Metals

When a ball is pressed into a plane metal surface, it has been shown[1] that the relation:

$$L = ad^n \qquad (1)$$

holds between the load $L$ (kgm.) and $d$ (mm.) the recovered diameter of the impression in the material. Both $n$ (Meyer index) and $a$ are constants which are dependent upon the material and its condition (annealed, cold-worked, etc.). The constant $a$ also depends upon the size of the ball, whereas $n$ does not.

For different ball diameters ($D$) on a given material in a particular condition, it has been found[2] that

$$aD^{n-2} = \text{constant}. \qquad (2)$$

The Meyer hardness $P_m$ is defined as the load on the ball divided by the projected area of indentation. From equation (1)

$$P_m = \frac{4a}{\pi} d^{n-2}. \qquad (3)$$

This may be written:

$$P_m = \frac{4aD^{n-2}}{\pi}\left(\frac{d}{D}\right)^{n-2}. \qquad (4)$$

From equation (2), $\frac{4aD^{n-2}}{\pi} = \text{constant}$. $P_m$ has the dimension of a stress, and $d/D$ is analogous to a strain.

From equation (4) $P_m$ is seen to be a function of the shape of the impression. To eliminate this dependence, the special value $P_u$ (ultimate ball hardness) which $P_m$ takes when the ball is forced in to its equator has been suggested[2] as the best value to represent the hardness of a metal *in a particular condition*

$$P_u = \frac{4aD^{n-2}}{\pi}. \qquad (5)$$

For materials which do not work-harden, for example, 'Plasticine', $n = 2$. For metals in general $n$ is greater than 2. Previously published work on Meyer analyses has shown that for all metals tested, with the possible exception of magnesium, $P_u$ increases as $n$ decreases, that is, there is a negative correlation ($r$) between $P_u$ and $n$. The correlation