

ignition. By correlating flame diameter with pressure rise the mean gas temperature in the burnt portion could be deduced at different instants during the explosion (up to a limiting diameter of 10 in.).

The results obtained with a 10 per cent oxygen plus 90 per cent carbon monoxide mixture are shown in the accompanying graph. Also indicated is the pre-pressure flame temperature measured by means of a platinum resistance thermometer (which in the case of very over-rich mixtures registers the same temperature as a quartz-coated platinum resistance thermometer<sup>1</sup>) and the maximum mean gas temperature obtained from the maximum explosion pressure<sup>2</sup>.

It will be noted that the mean temperature rises from a value very much in line with the platinum wire temperature at a diameter of 6 in. up to a value, at 10 in. diameter, approaching the mean temperature inferred from the maximum pressure. This shows that the latent energy<sup>3</sup> in the flame gases diminishes as the flame travels outwards from the spark.

Direct experimental confirmation of David's postulate<sup>4</sup> that the latent energy diminishes with distance of flame travel from the igniting source is thus furnished by the experiment.

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<sup>1</sup> David, Leah and Pugh, *Phil. Mag.*, (7), **31**, 156 (1941).

<sup>2</sup> David and Leah, *Phil. Mag.*, (7), **22**, 513 (1936).

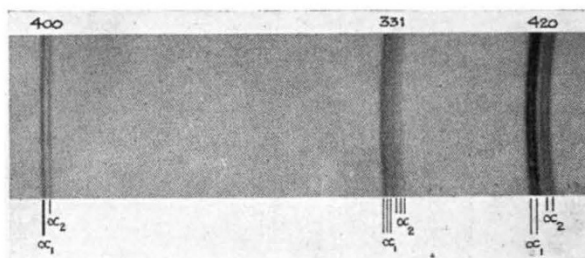
<sup>3</sup> David, "The Abnormality of Flame Gases", *Proc. Inst. Mech. Eng.* (in the press).

<sup>4</sup> *Phil. Mag.*, (7), **23**, 345 (1937).

## Structure of Nickel Oxide

THE development of modern X-ray powder photographic methods has opened up new possibilities for the examination of the fine structure of crystalline substances. The high resolution and definition of the reflexions, particularly in the high-order lines, which is obtainable with such circular cameras as that described by Bradley, Lipson and Petch<sup>1</sup>, has not only meant an increase in accuracy of lattice parameter measurements, but has also enabled interesting phenomena in alloys to be observed<sup>2</sup>. The detection of extra reflexions in powder photographs of graphite<sup>3</sup> has led to the description of a second crystalline form<sup>4</sup>, which apparently co-exists with the structure established by Bernal.

Another instance, which depends upon the observation of the fine structure of powder lines, has been noticed during an examination of nickel oxides from various sources. The structure for nickel oxide determined by Cairns and Ott<sup>5</sup> is face-centred cubic with  $a_0 = 4.1684$  kX., the atomic arrangement being of the sodium chloride type; the lines on a powder photograph taken on a small-diameter camera are distributed in the usual way for a face-centred cubic substance. Photographs of well-crystallized specimens taken on a 19-cm. diameter camera giving highly resolved reflexions show, however, that many of the lines are not simple  $\alpha$ -doublets, but are doubled or in some instances tripled. The type of reflexion obtained is shown in the accompanying illustration,



PART OF X-RAY POWDER PHOTOGRAPH (CALCIUM  $K\alpha$ -RADIATION, 19 CM. CAMERA) OF NICKEL OXIDE.  $\times 2$ .

which is a reproduction of the high-order end of the pattern with cobalt  $K\alpha$ -radiation.

Photographs taken with various radiations, to enable a sufficient number of ( $hkl$ ) reflexions to be analysed, indicate that all lines are doubled or have more than one  $\alpha$ -doublet component except those with indices ( $h00$ ).

If the structure of nickel oxide departs very slightly from cubic symmetry in a manner that makes it rhombohedral, the observed modifications of the reflexions can be explained. The distortion is so small that it is difficult to ascertain with complete certainty whether the angle of the unit rhomb is greater or less than the theoretical for cubic symmetry, but a larger value seems most probable when the intensities and separations of the components of all the observable reflexions are taken into account. On this assumption the most probable values for the lattice parameters of the rhombohedral unit cell are, at 20° C.,  $a_0 = 2.9459$  kX.,  $\alpha = 60^\circ 4.2'$ .

The effect has been observed for nickel oxides of widely different origins, including a variety commonly known as 'black nickel oxide', and is noticeable with feebly crystallized specimens in spite of some broadening of the reflexions owing to small crystal size. It is not obtained with monoxides of the other transition elements iron and cobalt, and indeed the solution of relatively small percentages of these oxides in nickel oxide causes a reduction in separation of the components of the complex reflexions. The asymmetry of the structural unit of nickel oxide may therefore be associated with the slightly smaller effective size of the nickel atom as compared with iron and cobalt; the atomic packing is affected in such a way that there is the equivalent of a small compression of the cubic lattice along a triad axis.

There may well be other crystals, that to a first approximation appear to conform to the isometric system, but would in fact on precision examination be found to possess a less simple structure. Latest refinements in powder photographic technique which permit the fine structure of the reflexion lines to be studied may yield interesting results in this connexion.

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Aug. 3.

<sup>1</sup> Bradley, A. J., Lipson H. and Petch, N. J., *J. Sci. Instr.*, **18**, 216 (1941).

<sup>2</sup> Bradley, A. J., *Proc. Phys. Soc.*, **52**, 80 (1940).

<sup>3</sup> Taylor, A., and Laidler, D., *NATURE*, **146**, 130 (1940).

<sup>4</sup> Lipson, H., and Stokes, A. R., *Proc. Roy. Soc., A*, **181**, 101 (1942).

<sup>5</sup> Cairns, R. W., and Ott, E., *J. Amer. Chem. Soc.*, **55**, 527 (1933).