In view of the fact that in practically all other cases of diffuse bands published so far[2] they are temperature-dependent, it was worth while to make such photographs anew, now conditions for obtaining liquid air are again more favourable. These photographs show clearly that with silver chloride also the bands are of thermal nature, as they disappear practically completely at low temperatures. The apparently opposite effect obtained in the former experiment was probably due to insufficient cooling of the crystals. Diffuse bands due to lattice distortions of the type discussed in our note are thus, so far as known to us, not observed with certainty in any case[3]. The remarkable etching effect shown by the irradiated crystals remains, however, an indication that actually deviations parallel to cube planes are present in the crystals.

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March 21.

[1] Burgers, W. G., and Tan Koen Hiok, *Physica*, **11**, 353 (1946); *Nature*, **157**, 19 (1946).
[2] Lonsdale, K., *Proc. Phys. Soc.*, **54**, 314 (1942).
[3] We are not discussing here such effects as are observed on photographs of age-hardening crystals (Preston, G. D., *J. Sci. Instr.*, **18**, 155 (1941)), of asbestos crystals and the like (cf. Guinier, A. J., *Proc. Phys. Soc.*, **57**, 310; 1945) and also the 'extra reflexions', observed with special diamonds, the exact nature of which seems not to be precisely known (Lonsdale, K., *loc. cit.*; Lonsdale, K., and Smith, H., *Nature*, **148**, 112, 257 (1941); also Guinier, A. J., *loc. cit.*).

X-Ray Diffraction Studies of Yielding in Mild Steel

The distribution of plastic deformation in a cold-stretched mild steel bar has been studied by X-ray diffraction methods. Using the back-reflexion technique with cobalt radiation, two spotty rings were obtained by reflexion of the $K\alpha$ doublet from the (310) plane of iron. Plastic deformation in the specimen was indicated by a blurring of the spots of the diffraction pattern as the individual crystals, which gave the reflexions, became distorted. An X-ray beam of about 1 mm. diameter was used to explore the distribution of the deformation.

A normalized, 0·26 per cent carbon steel bar was stretched in a tensile testing machine until the so-called 'Lüders lines' or 'Hartmann bands' appeared over part of its length. These Lüders lines are parallel strain bands, inclined at approximately 45° to the bar axis, and made visible by the flaking-off, along the bands, of the oxide scale produced by the normalizing process. The average plastic extension within the region showing Lüders lines was found from gauge marks to be about 1·5 per cent.

Fig. 1 represents a section of the bar including part of a region of strain markings. Figs. 2 *a–d* show portions of X-ray patterns obtained from the particular areas of the bar indicated in Fig. 1. In each case the chosen area was first etched with nitric acid to remove the oxide layer.

The pattern, Fig. 2 *a*, was obtained from an area within a region showing no strain markings. The sharpness of all but a few of the spots indicates that only slight plastic deformation occurred in this region. In the pattern, Fig. 2 *b*, obtained by directing the X-ray beam on a Lüders line (that is, on a band from which scale had peeled) almost all spots are diffuse, indicating marked plastic deformation.

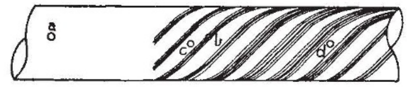

Fig. 1. Portion of a stretched steel bar, showing part of a region of Luders lines

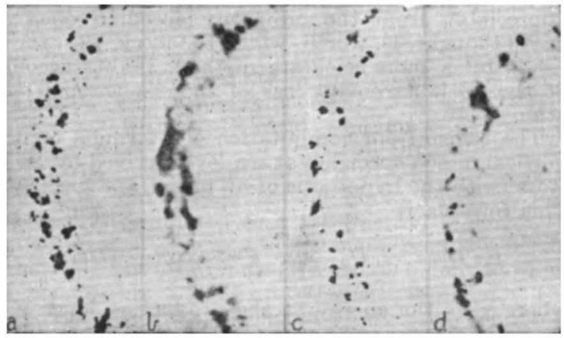

Fig. 2. X-ray diffraction rings obtained by back-reflexion from points *a*, *b*, *c*, *d* of Fig. 1

Figs. 2 *c* and *d* illustrate patterns obtained from areas lying between two Lüders lines. For such areas chosen near the boundary of a region showing the strain bands, only a few of the spot reflexions are blurred, as in Fig. 2 *c*. However, in patterns such as Fig. 2 *d*, from such areas chosen near the centre of a region of Lüders lines, a greater proportion of the spots are blurred, although the blurring is still less extensive than in Fig. 2 *b*.

Since the region of Lüders lines grows as a bar is stretched, these results show that the amount of plastic deformation is much greater between Lüders lines formed at an early stage of the stretching than between those formed later, and is very slight between the most recently formed lines. These observations lead to a picture of the mode of yielding in mild steel similar to that proposed by Jevons[1]. At first a narrow band of material at about 45° to the axis of the bar undergoes plastic strain of the order of 2 per cent. With increased stress, other such bands, separated by regions of very little deformation, appear at successive intervals along the bar. As the region of strain-bands grows by the formation of new bands, the earlier formed lines grow laterally by an increase in plastic distortion on either side. Thus the distribution of plastic deformation becomes more uniform, and eventually the whole bar undergoes plastic strain of the order of 2 per cent.

The variation of deformation across a set of Lüders lines may be demonstrated readily by the use of an X-ray beam diverging from a point source through a long slit. A strip of the specimen at right-angles to the lines is irradiated, and gives diffraction rings broadened along their diameter parallel to the strip. Across the broadened portion of the rings, the spots are alternately sharp and diffuse, corresponding to the alternation of plastically deformed and underformed regions along the irradiated strip. Good resolution may be obtained by a suitable choice of radiation.

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[1] Jevons, J. D., "The Metallurgy of Deep Drawing and Pressing", Chapter 7 (1940).