away on either side. If the grains have different lattice spacings as Müller suggests, the maxima of these smears should be staggered. If, on the other hand, they have the same spacing, the maxima should all fall into place below each other.

Fig. 2 shows the result of such a micro-rotation. The same specimen (a copper wire) was used for all three photographs, the lines being the K_a doublet of cobalt radiation, reflected in the 400 order ($\theta \sim 82°$ for α_1, 83° for α_2). Fig. 2*a* shows the spots produced by individual grains when the specimen is stationary, and it is indeed surprising how much the spots are staggered. Fig. 2*b* shows the ordinary Debye-Scherrer lines when the specimen is completely rotated so that numerous grains pass through the reflecting positions. Fig. 2*c* shows the effect of extending spots similar to those of Fig. 2*a* into smears by a rotation of 3°. It will be seen that their maxima appear in the same positions as the lines in Fig. 2*b*; in other words, the *crystal grains have identical spacings*.

Two suggestions may be offered to explain the striking spread of the spots in a case such as that of Fig. 2*a*. In the first place, though the smooth α doublet lines of Fig. 2*b* appear to be well resolved, examination with a microphotometer shows that they are actually so wide that they overlap, showing that $\delta\theta$ is greater than the separation of α_1 and α_2. Thus there may be a complete overlap of the spots due to α_1 and α_2 when the crystal is stationary.

In the second place, if the incident radiation is not monochromatized, Laue spots due to white radiation appear all over the film. Some of these spots may be near the K_a lines, and seem to belong to them, thus increasing the apparent spread.

We wish to stress, however, that it is still an open question whether all the features of Dr. Müller's photographs can be explained in this way; further investigation is required.

Dr. Müller's experiment suggests an elegant way of examining individual crystal grains, for we gain more information about their dimensions from the individual smears of Fig. 2*c* than from the complete rotation illustrated in Fig. 2*b*, which merely gives the average size.

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[1] NATURE, 140, 1012 (Dec. 11, 1937).
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Cooling Curves and the Laws of Radiation

I WISH to record a method of treating the radiation between a body and a surrounding enclosure which has been applied to the study of the heating and cooling curve techniques so much used by metallurgists, and may have other uses.

If the time-temperature relationship of such a body is obtained from the Stefan-Boltzmann law, the resultant expression and equations derived from it, if the case is even slightly complicated, are too difficult to be handled by workers of ordinary mathematical attainments. The use of Newton's law of cooling gives simpler expressions, but leaves an uncertainty as to their validity, particularly for theoretical work. By equating a Newtonian expression of radiation such as $k(T-T_e)$ to the corresponding Stefan expression, the 'constant' may be evaluated: and it is found that in many interesting cases the approximation $k = 4C\sigma T_g^3$ (where C is the area-emissivity coefficient between body and enclosure, σ is the absolute emissivity of a black body, and T_g is a fixed temperature chosen by rules which are often very simple) is a very good one, and that equations based on it are easy to handle. For the case of a thermally simple body in an enclosure the temperature of which is a linear function of time, for example, there is, when t is large, an important temperature difference between specimen and furnace (unsuspected or ignored by many previous workers) given by $\rho = -\frac{ms}{4C\sigma T_g^3}\cdot\frac{dT_e}{dt}$ and the temperature difference at all values of t is given by $\frac{\varphi-\rho}{\varphi_0-\rho_0} = e^{-4C\sigma T_g^3 t/ms}$ where s is specific heat of the specimen, and φ is $T - T_e$.

This manageable form can be modified to allow for heat transfer other than by radiation, and permits, among other things, the existing thermal curve techniques to be examined in a critical manner. In the course of this it was found that if the enclosure temperature as well as the temperature of the specimen were observed, these techniques would be improved in that certain difficulties of interpretation would be removed, and enriched in that the heat quantities involved in a physical change could be assessed and curves of dH/dT (H is the heat contents of the specimen) obtained, not in many cases with the accuracy of Sykes's method[1], but with complication and labour little greater than that of an ordinary thermal curve, and with the ability to work with both rising and falling temperatures.

Two techniques so suggested appear particularly promising. The first is a modified inverse rate curve method. The values of $\delta t/\delta T$ usually observed, when multiplied by the appropriate values of φ, enable a curve of relative dH/dT to be plotted, and absolute values may be obtained if a suitable constant or constants are determined. Mr. W. S. Walker, formerly demonstrator here, has during the last three years developed the practical side of this method and used it to measure the heat changes in carbon steels over the allotropic range, but publication is delayed owing to an unforeseen experimental error. The second technique involves the concurrent plotting of $T-t$ and T_e-t curves by a semi-automatic device permitting a very open scale to be used. The taking of these curves should be less mentally exacting than obtaining a high-grade inverse-rate curve; they will be fairly sensitive and very easy to interpret, and curves of dH/dT are obtainable by measuring areas between the pair of curves. Mr. E. A. Fowler, assistant lecturer here, is collaborating with me in developing this method.

A critical examination of Plato's[2] and Rosenhain's[3] heat evaluation techniques has been made, and it is hoped to publish this shortly.

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[1] Sykes, C., *Proc. Roy. Soc.*, A, 148, 422 (1935).
[2] Plato, *Z. phys. Chem.*, 55, 721 (1906); 58, 350 (1907); 63, 447 (1908).
[3] Rosenhain, W., *Proc. Phys. Soc.*, 21, 180 (1908).