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A new X-ray effect

It is a remarkable but as yet imperfectly understood fact that crystalline graphite has a diamagnetic susceptibility many times greater than that of carbon in other forms, either by itself or in combination. In the hope of elucidating this phenomenon, we were led to make a careful study of the X-ray diffraction patterns of purified graphite, using a narrow pencil of the *K* radiation of copper, and taking special pains to avoid fogging of the plate in the vicinity of the primary beam, either by stray radiation or by photographic halation. The diffraction photographs obtained with powdered graphite in this way show a new and hitherto overlooked phenomenon (figure 1). We find a notable amount of scattered radiation in the area surrounding the primary beam, terminating sharply at the first diffraction ring, and reappearing with a much smaller though quite sensible intensity in the area between the first and second diffraction rings.

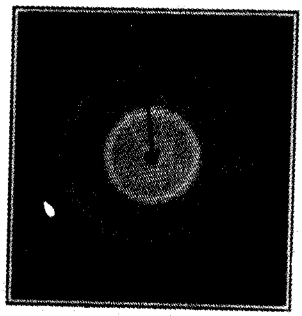

Figure 1

These observations contradict the general belief that crystals or coarsely crystalline powders do not show any appreciable X-ray scattering at small angles with the primary beam.(Hewlett, *Phys. Rev.*, 1922, **20**, 688). Our experiments show the effect to become distinctly more noticeable when graphites of increasing degrees of fineness obtained by sedimentation were used. Blank exposures taken without the graphite, and powder patterns taken with other organic crystals (for e.g. hexamethylene tetramine), do not exhibit the phenomenon; it cannot therefore be ascribed to the presence of white radiation or to stray X-rays. The peculiar distribution of the scattering, and especially its relation to the position of the diffraction rings, appear to us definitely to exclude the possibility of the effect being due to any admixture of adsorbed impurities or of amorphous carbon with the graphite.

We are inclined to attribute the effects noticed by us to the fact that more or less loosely associated with the crystal lattice of graphite there are also certain mobile electrons which endow the substance with its high electrical conductivity. The success of Pauli, Sommerfeld and others in developing the electron theory of paramagnetism and of metallic conduction on the basis of the Fermi–Dirac statistics suggests that even though graphite is strongly diamagnetic, certain electrons in it must possess large velocities, and hence cannot be regarded as an integral part of the lattice in respect of X-ray diffraction. They would therefore necessarily give rise to a scattering at small angles with the primary beam. The influence of particle size presumably depends on the magnitude of the free path of the electrons. We may interpret the increased intensity of the scattering with the finer powders as due to the distribution of the conduction electrons in the crystals becoming more and more completely chaotic with diminishing particle size. Such an interpretation is at least rendered plausible by the fact, discovered in a subsidiary investigation by Raman and Vaidyanathan, that the diamagnetic susceptibility of graphite is markedly a function of particle size, diminishing steadily to a small fraction of its full value with increasing subdivision of the substance.

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