panying photograph (Fig. 1) clearly depicts the spiral growth of crystals. This specimen was made in Sir Henry Miers' laboratory at Manchester in 1924 by allowing a thin film of potassium dichromate solution to evaporate on a warm microscope slide. The structure differs from that of the specimen of sulphur in Hughes's illustration and from most of my specimens, in that crystallisation started from the periphery of the drop and travelled inwards, instead of beginning

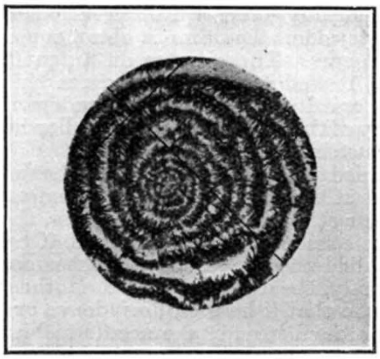

Fig. 1.—Spiral crystal growth. ×25 diameters.

at a central nucleus and radiating outwards. The specimen of carborundum described by Menzies and Sloat may have crystallised in this way.

Where crystallisation starts from a central nucleus, I have not observed among the specimens an example of the immediate development of a spiral, but I have a specimen of camphorsulphonic acid, crystallised from ethyl acetate solution, in which a true spiral succeeds two concentric rings surrounding the nucleus of crystallisation. Moreover, examination shows that a disturbance has been caused at the point where the spiral begins by the presence of another nucleus in the vicinity.

There appears to be no doubt, therefore, that crystallisation does sometimes follow a spiral course to give a variety of periodic structure, and it seems probable that the markings on carborundum are to be explained in this way. Ernest S. Hedges.

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The Atomic Weight of Phosphorus.

In a recent issue of Nature (Mar. 9, p. 390) mention is made of the fact that the English Commission on Atomic Weights adopts for the atomic weight of phosphorus the value 30·98(2), this being based on Aston's results with the mass-spectrograph; whereas the German Commission adheres to the older and higher value 31·02, derived mainly from gravimetric analysis.

The following results, obtained by the physico-chemical method of density and compressibility as applied to phosphine gas, may therefore be of interest:

Density L_0^{760} at one atmosphere, 1·5317.

Density L_0^{760} at one-half atmosphere, 1·5243.

Assuming the compressibility factor to be a linear one, the value for $(1+\lambda)$ so obtained is 1·0097, which, in conjunction with the values for oxygen of 1·4290 for the normal density and 1·0009 for $(1+\lambda)$, leads to the molecular weight of 34·00(2) for phosphine and to 30·97(9) for the atomic weight of phosphorus.

Further experiments are being carried out at the pressures of three-quarters and one-quarter atmosphere, to ascertain whether the compressibility can be taken as a linear function of the pressure. Such results as have been obtained at one-quarter atmosphere give the value $L_0^{760}=1{\cdot}5208$ for which $(1+\lambda)=1{\cdot}0096$ and P = 30·98(2). Mowbray Ritchie.

Department of Chemistry,
University of Edinburgh,
April 30.

The Atomic Weight of Copper.

With reference to the Research item in Nature of April 27, p. 660, that Messrs. Richards and Phillips have recently found the atomic weight of copper to be 63·557 (Ag = 107·88), it may be interesting to note that the spectroscopic value given in my "Analysis of Spectra" (p. 127) is 63·5569 ± 0·060, the 0·06 referring to maximum possible errors. The probable error is much less. The value obtained on spectroscopic data depends on the doublet separation and the $p(1)$ term. These are known with very great accuracy in both silver and copper.

W. M. Hicks.

Quantum Geometry.

Dirac's wave equation for the electron involves a Hamiltonian linear in the momenta p_k. This fact seems to be of geometrical nature and suggests the introduction of a linear fundamental differential form

$$ds = \sum_k \gamma_k dx_k$$

with matrix coefficients γ_k in geometrical considerations.

This linear ds is connected with Dirac's wave equation in the same way as the Riemannian ds^2 with the relativistic wave equation of the older theory.

The matrix vector γ_k may be interpreted as an operator corresponding to the fundamental velocity, namely, that of light, and is connected with the Einsteinian $h_{\nu a}$ by the relation $\gamma_\nu = \sum_a h_{\nu a}\gamma_a^o$ where γ_a^o are Dirac's constant matrices.

Possibly other tensors of the second rank, like the energy tensor T_{ik}, or R_{ik} are to be replaced in the proposed 'linear geometry' by matrix vectors in the same way as g_{ik} is replaced by γ_k.

The linear geometry seems to furnish a basis on which a uniform theory of gravitation, radiation, and quantum phenomena is to be constructed. More detailed considerations on this subject will appear in the *Zeit. f. Physik.* V. Fock.
D. Iwanenko.

Physical Institute of the University,
Leningrad, Mar. 21.

Early Use of Iron.

The early history of iron outlined in the address by Prof. Louis (Nature, May 18, p. 762) has been carried much further back by discoveries in South Palestine, published in *Gerar* last year. Furnaces were found dated to 1100 and 1175 B.C.; the earlier was 67 in. × 36 in. At the side of the furnace lay great hoes, 11 in. × 5 in., plough socks, and a pick of 6 pounds weight, showing that iron was as commonly used then as now. The earliest example was a knife of 1350 B.C., and this accords with the date of the polished steel dagger of Tutankhamen. This year another steel dagger, with cast bronze handle, has been found, of about 1300 B.C.; as it was snapped in two anciently without any bending, it could not be soft iron. Flinders Petrie.

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