a random manner until the composition approaches that of Fe_2N. At this point, rearrangement of nitrogen atoms occurs until they are once more completely ordered, each occupied interstice having an unoccupied 'hole' directly above and below it. The anisotropic distortion of the ε-hexagonal lattice of iron atoms to give the base-centred orthorhombic lattice of the ζ-phase is explained by, and is a result of, this rearrangement of nitrogen atoms ; in the ε-phase the nitrogen atoms of each layer plane are uniformly distributed, but in the ζ-phase they are packed more closely in the direction of the b-axis than in that of the a-axis, resulting in b becoming greater than $\sqrt{3}.a$.

Iron-carbon-nitrogen system. By the action of carbon monoxide on iron nitrides below 500° C., nitrogen is gradually replaced by carbon with the formation of *iron carbonitrides*—a series of new ternary interstitial compounds containing iron, carbon and nitrogen. *ζ-phase carbonitrides* have a range of homogeneity 33·3–36·0 atomic per cent nitrogen plus carbon, extending approximately from Fe_8N_4 to Fe_8C_3N, with a maximum carbon concentration c. 25 atomic per cent. They have distorted 'normal' 12b6 structures essentially the same as those of ζ-iron nitrides, except that distortion increases with increasing carbon concentration. This distortion is explained by a gradual rearrangement of interstitial atoms, within the approximately close-packed iron atom lattice, from the superlattice structure shown by ζ-nitrides to the type shown by ε-iron nitrides. Annealing of ζ-carbonitrides and reaction of ammonia with iron carbides give *ε-phase carbonitrides*, which have 12b6 structures identical with those of ε-iron nitrides, and a homogeneity range 25–33 atomic per cent nitrogen plus carbon.

ζ-carbonitrides start to decompose slowly *in vacuo* at about 350° C., eliminating nitrogen and giving ε-carbonitrides ; these in turn are unstable at 450° C. and decompose to give, according to their nitrogen and carbon contents, γ'- or ε-nitrides and either *iron percarbide* or cementite.

Iron-carbon system. Prolonged reaction of carbon monoxide with iron nitrides below 500° C. results in complete elimination of nitrogen and formation of *iron percarbide* ; this has a small range of composition, C, 30·5–32·1 atomic per cent, and is identical with an unknown carbide obtained previously by Hägg[5] and assumed to be Fe_2C. It is now found that the unit cell is probably orthorhombic, with dimensions

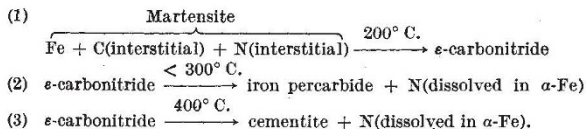$$a, 9\cdot04(3) ; b, \sqrt{3}.a = 15\cdot66(3) ; c, 7\cdot92(1) \text{ kX.,}$$

and contains four $Fe_{20}C_9$ molecules.

Above 500° C., the product of the same reaction is cementite, which is identical with specimens formed below 700° C. in steel[6] and obtained by the action of carbon monoxide on ferric oxide[7].

Both iron carbides appear to be metastable ; iron percarbide decomposes *in vacuo* giving cementite and carbon, and cementite breaks down less rapidly to give α-iron and carbon. Below about 350° C. rates of decomposition are negligible.

Examples of X-ray powder photographs (cobalt $K\alpha$ radiation ; 19-cm. diameter camera) of iron nitrides, carbonitrides and carbides are reproduced herewith.

It is obvious that the hexagonal phase reported by Heidenreich *et al.*[1] as "Fe_8N" is an ε-carbonitride. In steel, the presence of other elements or of large excess of iron may reduce the decomposition temperature of this phase from 450° C. to 350° C. Probable reactions in the tempering of martensite are thus :

(1)   Martensite
$$\overline{Fe + C(interstitial) + N(interstitial)} \xrightarrow{200° C.} \text{ε-carbonitride}$$

(2)   ε-carbonitride $\xrightarrow{< 300° C.}$ iron percarbide + N(dissolved in α-Fe)

(3)   ε-carbonitride $\xrightarrow{400° C.}$ cementite + N(dissolved in α-Fe).

Preliminary experiments indicate that in carburizing mild steel at 750° C., with carbon monoxide, the penetration of carbon is greatly facilitated by previously nitriding the surface ; reactions similar to those described above occur. It is very probable that carbonitrides are also formed in the case-hardening of steel by the dry-cyaniding process.

K. H. JACK

Department of Chemistry, King's College,
Newcastle-upon-Tyne, 1.   June 12.

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High-frequency Discharge as an Ion Source

IT has been found possible to draw a 10-milliampere current of positive hydrogen ions from a high-frequency discharge maintained at a pressure of about 10^{-3} mm. A self-sustained discharge cannot be maintained at this pressure with constant potentials even up to 20 kilovolts, and it is thus possible to use constant potentials of this order to extract positive ions from the discharge and to focus them into a beam. The arrangement is shown in the accompanying diagram.

The discharge was maintained in a two-litre 'Pyrex' flask by two ring electrodes A and B excited by a 5-metre oscillator. Approximately 200 watts could be dissipated in the bulb. The ionized gas was held at a high potential (between 0 and 20 kV.) by means of the electrode E_1. The ions were drawn out of the discharge by the hollow cylindrical electrode E_2 held at earth potential.

As the high tension was increased from zero the discharge, which initially projected a small distance into the neck of the flask, retreated from the neck until at 20 kV. the dark space was about 5 cm. deep. The boundary of the dark space resembled a spherical cap with the
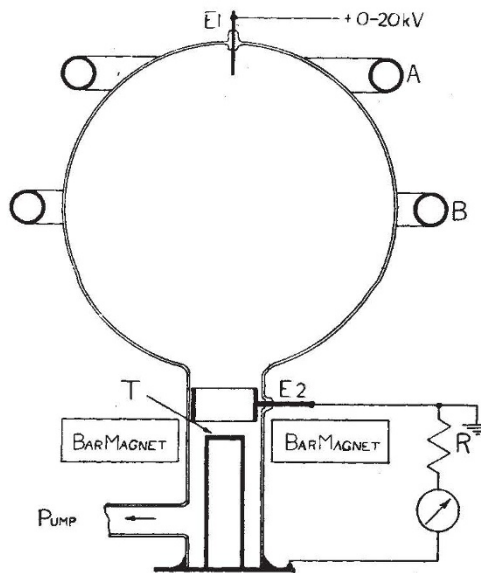
centre near the copper target T. A luminous red cone with its apex on the target and its base on the discharge boundary indicated the envelope of the ion beam. The fluorescent spot on the target was estimated visually to be about 2 mm. in diameter. The distance between the beam focus and the target increased as the high tension was increased.

In order to prevent the influence of secondary electrons on the target current, the target potential was maintained at about 700 volts higher than that of E_2 by means of the resistance R. In addition, two Alnico bar magnets near the target produced a strong magnetic field parallel to its surface.

The ion current to the target increased from 10 milliamperes at 10 kilovolts to 12 milliamperes at 20 kilovolts.

It is proposed to make a magnetic analysis of the beam and to see whether the ion currents can be increased by the use of a magnetic field.

P. C. THONEMANN

School of Physics,
University of Sydney.   May 27.

A Particle-size Distribution Function for Air-borne Dusts

THE following function has been found useful in problems involving the sedimentation or transport of air-borne bacteria-carrying dusts in inhabited rooms.

$$Y_S = CS^n \exp - \alpha S, \quad . \quad . \quad (1)$$

where S is the settling-rate of a particle in still air (proportional to the square of the diameter (d) for spheres obeying Stokes's law), Y is the frequency of occurrence of particles with settling-rate S, C is a normalizing coefficient ($C = 100 \frac{\alpha^{n+1}}{\Gamma(n+1)}$ for a total of 100 particles) and n and α are constants.

For values of n greater than zero, this leads to a skew distribution with Y_0 zero. The mean value of S is given by $(n + 1)/\alpha$ and the modal value by n/α.

The equation may be rewritten in terms of the fraction, S', of the modal value as

$$Y_S' = C' . S'^n. \exp - nS', \quad . \quad (2)$$

from which it is clear that the constant α represents a scale factor only while the 'spread' of the distribution is determined by the value of n.

This distribution has the important property of persisting without change of form during sedimentation of the dust from a continuously mixed atmosphere (that is, an atmosphere in which turbulence is sufficient to maintain a uniform distribution of particles, but the air velocities are not so high as to redisperse sedimented material). For after a time t,

$$Y_S = CS^n \exp - \alpha S \exp - bSt,$$

where b is a constant (equal to A/V when sedimentation is taking place in a room of volume V on to surfaces of area A). Hence

$$Y_S = CS^n \exp - (\alpha + bt)S,$$

and the distribution is altered only in the value of the constant α.

There will, then, be a tendency for any suspended material to approximate to this form of distribution as sedimentation proceeds (within the limitation of the original particle-size distribution of the material).

The accompanying graph shows a number of distribution functions plotted as cumulative percentage under size on logarithmic probability paper. It will be seen that the distribution discussed here lies between the logarithmic probability function (the divergence from the logarithmic probability function becomes less as n increases, being only