Fig. 2

Table 1

Shell radii from centroid	0-8	8-10	10-12	12-14
Average co-ordination No.	2.39	2.09	2.24	2.02
Porosity	0.80	0.83	0.81	0.83

close- and open-packed solids⁵. Not unexpectedly, random solids are denser than geometrical ones of the same average co-ordination number. Our calculations may be correlated with the experimental observations on random close-packed solids in the form:

$$N_{av} = 1.3 \exp(3.0\phi)$$

where ϕ is the volume fraction ($1 - \text{porosity}$) of the solid. The correlation:

$$N_{av} = 2.0 \exp(2.4\phi)$$

has been proposed⁶ for geometrical solids.

We are not intending to carry this investigation further: the co-ordinates of the spheres in the 1800 floc exist in punched card form, and could be made available for further analysis of the structure.

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Contrast in Electron Micrographs using Two Opposed Electron Beams

TRANSMISSION electron microscopy and electron-probe X-ray microanalysis are two well-established methods of micro-investigation. The two functions may be combined in one instrument by using two electron guns connected to a single high-voltage source and with beams in opposition. One electron gun is used to illuminate the specimen and further lenses produce a magnified image on a fluorescent screen. The second electron gun produces a beam that emerges through a hole in the fluorescent screen and passes through the electron lenses in the opposite direction so that the electron source is demagnified by the same amount that the image of the specimen is magnified. Further details are given elsewhere^{1,2}.

When both beams are on together and an insulating specimen is used, it is possible to see the position of the electron probe with respect to the specimen in the image of the specimen seen on the fluorescent screen. The

Fig. 1. *a*, Over-focused electron probe image using two electron beams; *b*, under-focused image ($\times c. 500$)

electron probe appears to charge up the area of the insulating specimen that is struck and this region forms a micro-lens that affects the imaging electron beam. The region is positively charged due to an excess of secondary electrons which leave the surface over the number of high-energy primaries that remain in the specimen, usually a collodion film a few hundred Å thick for 35-kV accelerating voltage. The illuminating electron beam then converges at this micro-lens and a through focal series shows a dark spot in the under-focused condition and a light spot in the over-focused case, that is, more lens current than at focus. At focus the spot is too small to observe. The contrast is given as dark or light with respect to the background and not with respect to clear space where no film is present. The charging effect fades immediately the beam conditions are changed, and the size, shape and position of the beam may be observed by this method. Astigmatism correction and alignment are both aided by observing the electron probe image while moving the controls. No effect is seen with metal films where the charge is not retained. If the beam remains at one place for 2-3 min a deposit of contamination is built up and this is visible even with the second electron beam cut-off³. The contrast effect is not due to contamination. The beam cross-sectional current density is reflected in the density of the dark or light spot as seen on the fluorescent screen. In particular the dark spots are surrounded by a bright ring and vice-versa, which may be due to maximum deflexion of the electrons at the edge of the charged area. Two such spots are shown in Fig. 1*a* and *b*, where (*a*) is the over-focused and (*b*) the under-focused condition. The quality of the prints is low because the fluorescent screen had to be photographed from outside the vacuum, as internal photography was impossible with both beams in operation at once.

An anomalous contrast effect has been reported by Muller and Meyerhoff⁴ using phosphotungstate negative stained specimens in a normal electron microscope. A through focal series of this type of standard biological specimen should show whether these two effects are similar. If so, the micro-lens could lead to incorrect application of magnification calibrations, obtained with a conducting specimen such as a diffraction grating replica, to insulating specimens such as collodion and phosphotungstate. Image contrast of a similar nature, but using the single gun of a normal electron microscope, has been reported in thin carbon films⁵.

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