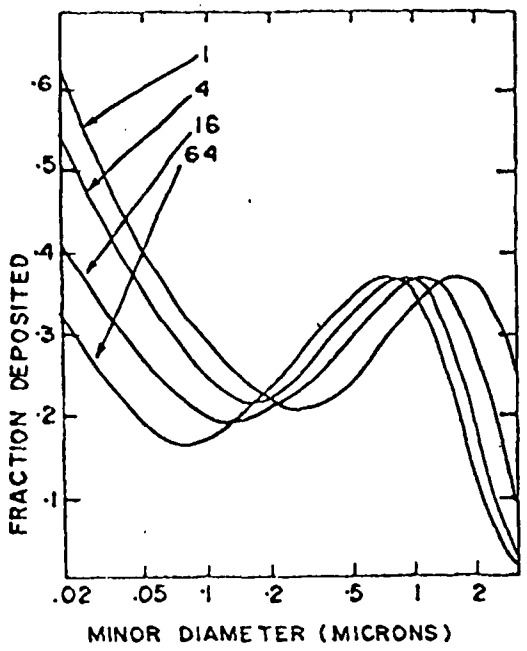

FIGURE 2 Fraction of inhaled particles deposited in the lower (alveolated) region of the respiratory tract, vs equatorial diameter of the particle, for various values of β.

lung was taken as 2000 cm³. The total and alveolar deposition curves for β values of 1, 4, 16, and 64 are shown in Figures 1 and 2. The abscissa represents the equatorial diameter of the ellipsoidal particles, in microns.

These results are perhaps most easily understood by considering the effect of increasing β on the particle mobility. It is easily shown, using equations (1) and (2), that

$$\lim_{\beta \to \infty} B = \frac{3C\ln(\beta)}{20\pi\mu^2\beta} \qquad (8)$$

Thus as β is increased indefinitely, B tends to zero. This accounts for the reduced deposition of the elongated ellipsoids in the particle size range 0.02 μ to approximately 0.2 μ, because diffusion is the predominant mechanism for deposition in this region, and the diffusion coefficient of a particle is proportional to its mobility. Thus the exponential factor in Eq. (3) will tend to zero as β increases indefinitely, and consequently D_1' will also tend to zero.

In the particle-size region above 0.2 μ sedimentation and impaction are more important mechanisms than diffusion. The exponential factor in the sedimentation equation (Eq. 4) is proportional to the sedimentation velocity of the particle, which in turn is proportional to βB. This product becomes proportional to ln β as β increases indefinitely. Consequently increasing β increases the sedimentation velocity, and increases the rate of deposition due to sedimentation. A similar argument for impaction shows that the stopping distance becomes proportional to ln β as β increases indefinitely, and consequently the factor I_1' approaches unity. Now the equations for impaction and sedimentation both contain the factor $\rho\beta B$; consequently an increase in β at fixed ρ can be simulated as far as these two mechanisms are concerned by an appropriate increase in ρ at fixed β. In other words, the deposition behaviour of ellipsoids of a given density and of a given equatorial diameter is equal to that of spheres of equal diamater, but having a greater density such that ($\rho\beta B$) is equal for both classes of particles. This is true only in the particle size region where diffusion is insignificant. Landahl[2, 3] and Beeckmans[4, 5] had shown that as the density of spherical particles is increased, the total and alveolar deposition curves are shifted towards the left, and the same can be seen in the results presented here as β is increased.

Finally, it is pertinent to ask if interception might not play a role in deposition for very elongated particles. Interception might be expected to be of significance when the polar diameter of the particle approaches the dimensions of the smaller airways. The respiratory tract model used in this study is due to Weibel,[9] who calculated a value of 0.041 cm for the diameter of the alveolar sacs, at a functional residual capacity of 4.8 liters. In the present study, the functional residual capacity was 2 liters, and the tidal volume was 1 liter. Consequently the mean lung volume during the breathing cycle was 2.5 liters, and the corresponding alveolar diameter was $0.041 \times \sqrt[3]{(2.5/4.8)}$ cm, or 349 μ. The longest particle for which calculations are reported here had a β value of 64 and an equatorial diameter of 3μ. Consequently its length was 192 μ. Moreover, as can be seen from the figures, this type of particle is virtually completely deposited in the upper respiratory tract, and consequently interception in the lower respiratory tract, if it were to occur, would not be of significance.