The resulting figure represents the diameter of uniform spherical particles which, for a similar weight of dust, samples have very closely the same equivalent surface area as the original particles. The formula used in finding the surface mean diameter is as follows :—

$$\text{Surface mean diameter} = \frac{\Sigma\, d^3}{\Sigma\, d^2}$$

This figure is always a larger value than the arithmetical mean and is a measure of the specific surface of the dust.

The specific surface is the factor which determines the ability of the particles to remain suspended. It also has an important influence on its chemical activity and in the case of dusts of carbonaceous and various other substances has a direct bearing on its explosive possibilities.

Characteristic Dimensions

Volume Mean Diameter.—Maintaining the foregoing procedure, this figure is arrived at in a similar manner to the surface mean diameter. The formula in this case is :—

$$\text{Volume mean diameter} = \frac{\Sigma\, d^4}{\Sigma\, d^3}$$

The volume mean diameter gives us a single value specifying spherical particles with an equivalent volume to that of the original dust particles for an equal weight of dust sample.

Particle Specific Surface.—Consider a mass of identical particles having a characteristic dimension (side, diameter, etc.), L. Calling the total weight of all the particles ΔW and density S_1, the total surface $\Delta A'$ is the number of particles $\frac{\Delta W}{S_1 kL^3}$ multipled by the surface area of each KL^2.

$$\Delta A' = \frac{K \Delta W}{k S_1 L}$$

the constants K and k depending on the shape of the particles.

For any given material $\frac{K}{k}$ often remains approximately constant over a wide range of size ; hence $\frac{K}{k}$ need not be known to compare the specific surface of different grades of division. Let ΔW be the weight of material passed by a sieve of mesh width L_1, and retained on a smaller sieve having a mesh width L_2. If the ratio $\frac{L_1}{L_2}$ does not exceed 2, little discrepancy can be introduced by using the arithmetic mean giving :—

$$\Delta A' = \frac{K \Delta W}{k S_1 \frac{(L_1 + L_2)}{2}}$$

$$= \frac{K \Delta W}{k S_1 L_{\text{av.}}}.$$

Where $\Delta A'$ is the surface of the fraction of the weight ΔW. One should use a series of screens so that ΔW for *each screen is only a small fraction of the original sample.* The total surface is readily estimated by graphical integration, *i.e.*, by plotting $\frac{1}{L_{\text{av.}}}$ as ordinates against W as abscissæ, the area under the curve, multiplied by $\frac{K}{kS_1}$ is the total surface.

If the particles have the shape of a cube or sphere the shape factor $\frac{K}{k}$ is 6. This is frequently used for all shapes, but $\frac{K}{k}$ is 7 to 8 for powered coal. For flat particles, *e.g.*, mica basing, L on the average diameter of the large face $\frac{K}{k}$ is 55.

If, however, a large fraction passes the finest sieve, the summation will not be accurate, since the specific surface varies rapidly with diameter at small diameters. In a great many cases in dust control work it is required to make size analysis of a sample, giving, for instance, the percentage of a lesser range than the 10-20 micron range. As the British standard sieve of 300 mesh and the American screen of 325 mesh have openings of 53 microns and 44 microns respectively, it is not possible to study the problem by this means as often less than 10 per cent. of dust samples will be retained by them, and the rest of the sample, which is of the most vital range of size, will not be entrained and so cannot be differentiated. This is most important, as size is the factor which perhaps influences health and well-being more than any other. The size causing lung damage is from 0·5 to 8 microns. To enable the required separation to be made, the process of elutriation is employed, using either air or water at the medium. By feeding the sample into a rising current of water or water at constant velocity, certain particles fall to form a residue, whilst smaller ones are carried over according to Stokes' law. By running the apparatus at a series of velocities, the sample may be divided into a number of fractions far beyond the range of mechanical sieving. Study of these fractions gives most important information as to the behaviour of a dust in filtration, precipitation and health.

With air-borne matter in the free atmosphere, the dust sample is somewhat difficult to obtain and is, therefore, small. The measurement of this is usually done by direct optical means by microscopic projection.

In the case of smoke and fume particles where the size becomes extremely small, and at which stage the optical microscope becomes inadequate, we have to resort to the ultra-microscope which renders particles down to 0·001 microns visible. Even with this instrument no definite outline of the object can be seen, the larger particles showing up brighter than the smaller ones. Perhaps the electron microscope which has been developed in this country and in Germany will open up new fields of study in this direction. With this instrument it is possible to obtain useful magnifications of the order of 30,000 diameters as compared with 2,000 diameters which is the limit for the optical microscope.

Sizes of Some Industrial and Other Particles

	Microns
Cement dust	40
Talc dust	10
Sprayed zinc dust	15
Silica dust	5
Coal dust	5
Flour mill	15
Alkali fume	1 to 5
Ammonium chloride fume	0·01 to 1
Zinc oxide fume	0·05
Condensed zinc dust	2
Tobacco smoke (tar mist)	0·25

Laws of Behaviour of Air-Borne Matter

When studying air-borne matter it is usual to group it into three general categories, but the limits of demarcation are not definite, one category merging gradually into the next. This classifying into groups, though not strictly scientific, is very convenient by virtue of its being descriptive of their mode of behaviour and also because it refers to their origin and to the process by which they were generated. These groups are : dusts, fumes and smokes.

Dusts

Dusts are particles which are heavy enough to fall in still air with a velocity due to gravity varying from constant to increasing, depending on their size and form. The general laws of Newton referring to gravity fall are usually not applicable for objects less than $\frac{1}{4}$ in. (7,000 microns) in