As new processing techniques are adopted in industry and, at the same time, production of fine powders grows, powders are expected to fulfill increasingly severe particle size requirements. In this connection, there is now an urgent need to develop effective methods for the fractionation of powders whose maximum particle size may not exceed 40-60 μ. The classification methods and apparatus currently used in industry with such powders are incapable of meeting normal separation accuracy, reliability, and power consumption requirements.

In the separation of fine fractions, difficulties arise when their particles and the working elements of separating apparatus become charged, since this leads to particle agglomeration and adversely affects separation accuracy. Particle charge removal is virtually impossible to achieve in practice, and it is therefore logical to explore ways of utilizing particle charges for the fractionation of powders. The existing electrostatic, corona, and corona-electrostatic separators [1] suffer from a number of disadvantages, the most serious of which is that the accuracy of separation ensured by them depends on their throughput rates.

In this article an examination is made of the possibility of separating powder fractions in the electrode gap of a plane capacitor supplied with an alternating voltage. The powder separation method described utilizes the dynamics of charged particles in a nonuniform variable field of a plane capacitor. The process of contact particle charging on the lower electrode of the apparatus results in the particles (including those forming agglomerates) receiving a unipolar charge. As a result, further agglomeration is prevented, and moreover - as is confirmed by experiment - some of the lumps already present in the powder break up.

When a sample of a powder is placed on the lower electrode of a plane air capacitor, at certain values of field strength $E_0$, amplitude and frequency $f$, the powder particles begin to float, forming in the electrode gap an aerosol with a specific structure. The character of the structure of each particle depends on its equivalent dimensions $d$, $a$, and $b$, random quantities $a$ and $b$, and random functions $a(t)$ and $b(t)$. Here $d$, $a$, and $b$ are, respectively, the particle diameters equivalent in volume, surface area, and area of projection on a selected plane; $a$ and $b$ are coefficients depending on the particle shape and which are determined by the expressions $a = a/d$ and $b = b/d$; $a(t)$ is a function of the specific surface charge of the particle (the magnitude of the specific surface charge varies in a random manner as the particle interacts with a charged electrode and other charged particles); $X(t)$ is a function characterizing the fluctuation of the field strength and which depends on the total charge of all the particles floating in the electrode gap.

The stochastic movement of a particle of density $p$ in the electrode gap of a plane capacitor, in a medium of dynamic viscosity $\eta$, can be expressed by the formula

$$m \frac{dz^2}{dt^2} = na^2a(t)[E_0\sin(\omega t - \varphi) + X(t)] - k\eta \frac{ab^2}{4} \frac{dz}{dt} - mg,$$

where $m = \pi/6 \cdot d^3 p$ is the mass of the particle, $\varphi$ the phase of the detachment of the particle from the lower electrode, $k$ a coefficient of proportionality, and $z$ the coordinate of the height to which the particle has ascended.

Simple transformations reduce Eq. (1) to

$$
\rho \frac{d}{dt} \frac{d^2 z}{dt^2} + \frac{3\eta}{2} \frac{dz}{dt} = \alpha^2 \sigma(t)[E_0 \sin(\omega t - \varphi) + X(t)] - \frac{\rho d}{6} \cdot g.
$$

(2)

For a random quantity

$$
\theta = \frac{3\eta k}{2} \beta^2
$$

and a random process

$$
Y(t) = 6\alpha^2 \sigma(t)[E_0 \sin(\omega t - \varphi) + X(t)],
$$

Eq. (2) becomes

$$
\rho d \frac{d^2 z}{dt^2} + \theta \frac{dz}{dt} = Y(t) - g.
$$

(3)

From Eq. (3) it follows that the random function $z(t)$ depends on the particle size $d$, the particle density $\rho$, the distribution parameters of the random quantity $\sigma$, and the statistical characteristics of the process $Y(t)$. Thus, the parameters of the process $Y(t)$ can in principle be varied so that at the output of the dynamic system described by Eq. (3) a steady-state, in a wide sense, process $z(t)$ is obtained characterized [2] by stability of values of the mean process ordinate $M[z(t)]$ and of its standard deviation $D[z(t)]$,

$$
M[z(t)] = \text{const}; \quad D[z(t)] = \text{const}.
$$

(4)

Satisfaction of the conditions (4) provides a basis for designing an apparatus for the separation of powders in a variable electric field. In such a device, classification of powders according to particle size involves extracting particles of different sizes on different levels in the aerosol cloud.

Using an apparatus with a 20-mm electrode gap (Fig. 1), fraction separation experiments were carried out on alumina ($\text{Al}_2\text{O}_3$) powder. In this apparatus, the two electrodes 1 are of sheet stainless steel, the surface of the lower electrode having a Class 7 finish. The electrodes are held at the required distance from each other by the Perspex walls 2 and 3. The openings 4 and 5 in these walls enable powder fractions to be removed at different heights above the lower electrode. The powder is introduced into the space between the electrodes through the charger 6. The separated fractions are collected in the containers 7 and 8. The coarsest fraction, moving along the lower electrode toward its end, is collected in the container 9.

In our experiments, a variable voltage was applied by means of a special device to the electrodes and then the alumina powder was introduced into the space between the electrodes. After coming into contact with the lower electrode, the powder particles began to rise. The aerosol forming in the electrode gap was extracted from it on different levels with the aid of separating screens. From each fraction of extracted particles, an average sample was obtained and subjected to microscopical analysis. Results for such samples, containing more than 1000 particles each, enables histograms to be constructed and distribution parameters to be calculated.