The disintegration of a molten metal jet by a gas stream involves the formation, at the instant of jet breakup, of primary ligaments of molten metal [1], which may be in a variety of shapes other than spherical. Subsequently, under surface tension forces, these metallic ligaments tend to form spheroidal droplets; at the same time, individual droplets are under the influence of the gas stream over a wide range of sizes and shapes.

Let us examine the character of the influence exerted by a gas stream on individual droplets of various sizes. Droplet comminution takes place in two stages. When the stream attains a certain critical velocity with respect to the droplet size, \( W_{cr} \), the droplet comminution process begins; the higher the stream velocity \( W_s \) with respect to \( W_{cr} \), the more intense is the comminution process. When the stream reaches its second critical velocity \( W_{cr} = W_{crit} \), drop comminution occurs instantaneously in the form of an explosion, with the formation of a wide range of particles of smaller sizes [2, 3]. According to Volynskii [2], the range of velocities establishing conditions under which a drop of size \( d \) will be comminuted is determined by the dimensionless number \( D \):

\[
D = \frac{\rho \cdot W_s^2 \cdot d}{\sigma},
\]

where \( \rho \) is the gas density, g-sec/cm\(^4\); \( W_s \) the velocity of the gas stream relative to that of the metal drop, cm/sec; \( d \) the metal drop size, cm; \( \sigma \) the surface tension of the metal, dynes/cm.

The comminution process is limited by numerical values of the dimensionless number \( D \): At \( D = 10 \), \( W_s = W_{cr} \); at \( D = 14 \), \( W_s = W_{crit} \) [2]. Let us consider the process of comminution of molten copper drops by an air stream. From Eq. (1) we obtain:

\[
W_{cr} = \left( \frac{10 \cdot \sigma}{d \cdot \rho} \right)^{1/2},
\]

\[
W_{crit} = \left( \frac{14 \cdot \sigma}{d \cdot \rho} \right)^{1/2}.
\]

Calculation is performed for particles of the most characteristic sizes, ranging from 50 to 500 \( \mu \). The numerical values of the physical parameters of the gas and the metal are as follows: \( \sigma_{Cu} = 1120 \) dynes/cm [4], \( \gamma_{air} = 0.0013 \) g-sec/cm\(^4\) [5].

The character of emission of an air jet from an annular nozzle orifice can be evaluated with the aid of the Reynolds number:

\[
Re = \frac{W_{air} \cdot d_e}{\nu_{air}},
\]

where \( d_e \) is the equivalent diameter of the nozzle slot, m; \( \nu_{air} \) is the kinematic viscosity of air, m/sec.

The value of the equivalent slow diameter may be calculated from the formula:

\[
d_e = \sqrt{\frac{4 f_{sl}}{\pi}},
\]

where \( f_{sl} \) is the area of a circle whose surface is equal to the cross-sectional area of the annular slot (for our nozzle, \( d_e = 14.8 \times 10^{-3} \)). To allow for the influence of nozzle geometry, the relationship between the intensity of drop comminution and blast velocity may be expressed in the form of the dimensionless equation

\[
\frac{d}{d_e} = f(Re_{cr}).
\]
Determining from Eqs. (2) and (3) the values of the critical velocities for any gas or metal temperature, we can evaluate, with the aid of Eq. (5), the influence of the parameters indicated on the drop comminution process. By comparing the values obtained for the velocities $w_{cr}$ and $w^s_{cr}$ with the velocity of sound under the design conditions, it is possible to arrive at a decision regarding the choice between a converging and a supersonic nozzle in order to obtain drops of the required size.

For calculation, the following data were chosen: air preheating temperatures ranging from 0 to 750°C at intervals of 50°C, and metal preheating temperatures ranging from 1100° to 1450°C also at intervals of 50°C. The calculated data were tabulated and employed for plotting the graphs in Figs. 1-5.

Examination of the graphs leads to the following conclusions. As blast temperature rises (Figs. 1 and 2), the curves are displaced toward higher velocities, i.e., the comminution of a particle of a given size requires a higher blast velocity with rise in the temperature. This is due to the fact that, as the gas is heated to a higher temperature, its density decreases, while its kinetic energy remains constant. This becomes quite apparent when the values of the velocity of sound at the corresponding temperatures are plotted in Fig. 1 and particularly, Fig. 2: within the range of subsonic velocities, intensive comminution takes place for particles $\sim$ 100 μ in size at all temperatures. This provides a basis for the choice of various nozzle designs. To obtain particles less than 100 μ in size, it is necessary to employ atomizing units with a supersonic gas outlet velocity, i.e., units provided with a Laval nozzle, while in other cases atomizing units with the usual converging nozzle are adequate. Figure 3 shows $d$ plotted against $w_{cr}$ for the case of overheating of the metal. Raising the temperature of copper from 1100° to 1450°C only negligibly changes comminution

* In practice, atomization temperatures should be in the range 1140-1350°C.