We present results obtained in a study of velocity fields occurring in a turbulent flow of air over a perforated plate with blowing of various gases taking place. We give empirical formulas for obtaining the velocity fields in the boundary layer above permeable walls, and we examine the question as to the generality of our results.

A considerable number of papers [1-6] have been devoted to the study of the flow over porous plates and the cooling of porous walls. In a number of practically important problems, instead of porous materials, expedience has directed the use of perforated sheet materials with hole dimensions on the order of the wall thickness.

A general solution of the problem concerning turbulent flow over a perforated plate and the thermal state of such a flow must depend not only on the mixing flow parameters and the intensity of blowing but also on the geometrical and thermophysical characteristics of the perforated plates. To obtain generalized results a large volume of experimental data is necessary. For the particular case in which the wall temperature is constant this volume may be reduced since fullness of the profiles cannot depend on the longitudinal coordinate. This case is of great importance in practice.

The volume of experimental data required may be substantially curtailed if it can be shown, for certain geometrical characteristics of the perforated plates, that their thermal state and the flow in the boundary layer depend weakly on the number of holes per unit of cooling surface.

The prehistory of the flow may have a noticeable influence on the distribution of the gas parameters in the boundary layer and on the thermal state of the permeable plates; it is therefore expedient that the gas flow over the plate be one with a uniform distribution of parameters for a minimum dynamic boundary layer thickness before the first series of holes of the perforation.

1. Description of the Model and Method of Procedure. The basic experiments were carried out with changeable perforated plates forming the upper wall of the model, placed in a uniform air flow from a rectangular nozzle.

The permeability distribution $c$ along the length of the plate was chosen so as to obtain a constant wall temperature. We note that for small blowing intensities $(\rho u)_1/(\rho u)_0$ [where $(\rho u)_1$ is the mass outflow rate of coolant per unit of cooling surface and $(\rho u)_0$ is the flow density in the flow of gas carried away] the temperature of the wall over which the turbulent flow passes must obviously be constant when

$$(\rho u)_1/(\rho u)_0 \approx x^{-0.5}$$

However for perforated plates with small hydraulic resistance the distribution $(\rho u)_1/(\rho u)_0$ along the length of the plate may not coincide with the plate permeability distribution $c$.

By choosing a distribution of holes and hole sizes to yield a total plate permeability $c = 3\%$ with 4 holes per $1 \text{ cm}^2$, we ensured a plate temperature which was practically constant over a wide range of variation of the blowing intensity.
The study of flow uniformities in the boundary layer was carried out using plates for which \( c = 3\% \) and \( m = 4 \) holes/cm\(^2\). The study of the influence of permeability and the number of holes per unit of cooling surface was conducted with plates for which the permeability distribution was the same as that for plates with \( c = 3\% \) and \( m = 4 \) holes/cm\(^2\).

We show that the thermal state of plates with \( c \approx 1 \) to \( 4\% \) and \( m \approx 1 \) to \( 7 \) holes/cm\(^2\) is practically independent of \( x \). For these plates we may assume that the blowing intensity

\[
\frac{(\rho u)_1}{(\rho u)_0} \sim x^{-0.2}
\]

and, consequently, the blowing parameter

\[
f_o = \frac{(\rho u)_1}{(\rho u)_0} Re_o^{0.4} = 0.8 \frac{(\rho u)_1}{(\rho u)_0} Re_\infty^{0.4} = \text{const}(x)
\]

(1.1)

Here \( L \) is the length of the surface being cooled, \( (\rho u)_w \) is the mean mass outflow rate of coolant per unit of cooled surface.

For turbulent gas flow over a plate the blowing parameter \( f_0 \) is connected with the widely used parameter

\[
B_o = \frac{[(\rho u)_1/ (\rho u)_0] St_o^{-1}}{(\rho u)_0}
\]

in the following way:

\[
f_o = 0.037 Pr^{0.37} B_o
\]

(1.2)

A boundary layer study in which blowing was absent was carried out for both perforated and non-perforated plates; it showed that the relative velocity profiles for both cases are practically coincident and that with good accuracy they may be described by the known power-law relation

\[
u / u_o = (y / \delta)^{n/3}
\]

(1.3)