Results are shown of an experimental study concerning the development of a laminar sublayer in a turbulent boundary layer under large negative longitudinal pressure gradients.

Many studies were made of the reversal in a turbulent boundary layer, i.e., of the transition from a turbulent boundary layer to a laminar one under large negative pressure gradients [1-4].

The mechanism of this transition has hardly been explored, however. Here the results will be shown of a study concerning the characteristics of a laminar sublayer in a turbulent boundary layer under large negative pressure gradients, the occurrence of such a transition being hypothetically related to a situation

![Graph](image-url)
Fig. 2. (a) Fluctuations of the longitudinal velocity component across the thickness of a boundary layer under a negative pressure gradient. (b) Typical trend in the development of a boundary layer under large negative pressure gradients. \( F = 0 \) (1), \(-1.79 \cdot 10^{-6} \) (2), \(-3.02 \cdot 10^{-6} \) (3), \(-6.3 \cdot 10^{-6} \) (4), laminar boundary layer (I), laminar sublayer of a turbulent boundary layer (II) turbulent core of a boundary layer (III).

where the flow in the sublayer is nearly laminar even while the gas stream is fully turbulent. Measurements in a 1 m long boundary layer at a flat plate were made with a model ETAM-3A thermoanemometer and with total-pressure Pitot microtubes. In the latter case, the pressure drop \( P' = P_0 - P_S \) was picked off a precision alcohol manometer and read out automatically with photodiodes, optical lenses, and a relay, accurately within 0.01 mm H2O. A longitudinal pressure gradient along the plate was produced by placing into the active zone of an aerodynamic tunnel (Fig. 4) special inserts designed so as to eliminate the effect of previous history on the development of the boundary layer [5]. The tests were performed at either almost constant or quite variable gradients \( \frac{dP}{dx} \) along the plate. Upstream before the insert a velocity profile of a fully turbulent boundary layer was always attained by means of a turbulizer at the front edge.

The velocity profile of the turbulent boundary layer in our test is shown in Fig. 1 as a power function of the negative longitudinal pressure gradient (absolute value):

\[
\frac{U}{U_\infty} = (y/\delta)^{1/n}.
\]

Power laws describe the measured velocity profile in the outer region of a boundary layer at all test values of the pressure gradient. At large pressure gradients, however, not only the exponent \( n \) in (1) increases but also the relative sublayer thickness increases sharply. While \( \delta_1/\delta = 0.02 \) at \( F = 0 \) in our test, for example, the relative thickness of the laminar sublayer increased by an order of magnitude to \( \delta_1/\delta = 0.2 \) at \( F = -10.38 \cdot 10^{-6} \). The edge of the laminar sublayer, with a longitudinal pressure gradient present in the boundary layer, was related to the maximum fluctuation of the longitudinal velocity component (Fig. 1c). It has been established that, under moderate longitudinal pressure gradients, the maximum velocity fluctuations in the boundary layer correspond to the intersection points of two straight lines describing the measured velocity profile \( u/u_\infty = f(y/\delta) \) (to a logarithmic scale) of the laminar sublayer and of the turbulent core respectively.

Distortions of the measured velocity profile at the wall and at the outer edge of the boundary layer