The problem of determining the creep and long-term strength characteristics of materials under conditions of nonstationary thermal loading is greatly complicated by the indeterminate effect on them of a number of parameters, the simultaneous variation of which during loading leads to such a degree of uncertainty about the behavior of the material that theoretical prediction of the deformation process under conditions of nonisothermal creep becomes practically impossible.

Most important among the parameters concerned are the stress under which creep of the material takes place, the extent of instantaneous plastic deformation and creep deformation up to the time of the temperature level and the amount it falls during nonisothermal loading, the total time and the time at the given temperature level (particularly in the case of aging materials), the rate of heating and cooling, the type of heat treatment, etc.

Hence we have to devise a new approach to this problem which would enable us to estimate the extent of the effect of each of the parameters concerned on the deviation of the deformation process from that predicted by the various theories of creep.

The present article reports the results of theoretical and experimental studies carried out with the object of developing such an approach on the basis of the temperature-aftereffect hypothesis [1].

According to this hypothesis, at each temperature level a new structural state, stable at that temperature, is gradually established; consequently the creep rate corresponding to the new temperature will not be attained immediately but over a certain period of time, which it has been agreed to call the stabilization time. Clearly the stabilization time may become the quantitative criterion by means of which it would be possible to determine the effect of all the factors enumerated and to predict theoretically with an adequate accuracy the course of the deformation curve during nonisothermal creep. A graphical representation of the temperature-aftereffect hypothesis is shown in Fig. 1.

To simplify matters, we will assume that the increase in elastic deformation due to the transition to a new temperature level (from $T_i$ to $T_{i+1}$), and also the increase in size of the test specimen resulting from thermal expansion, can always be calculated, and hence we will confine ourselves to a consideration of the deformation processes in the coordinates $p-\tau$, where $p$ is the creep deformation and $\tau$ is the time.

If, at the moment $\tau_i$ the temperature assumes the value $T_{i+1}$, the deformation does not follow the curve FKM corresponding to one of the theories of creep (the hardening theory is taken in this figure), but follows the curve FLN, so that at a certain time $\tau_{i+1}$ the creep curves may with reasonable accuracy be taken as equidistant and that, beginning at the point L, the structure of the material may be assumed to

†In some articles the time in question is called the aftereffect time.
pass into the state corresponding to the given temperature. The time $t_\ast$ is the time required for the stabilization of the properties on the transition from temperature $T_i$ to temperature $T_i+1$ for the given material, degree of creep deformation $P_1$, stress $\sigma$, and all the other parameters as indicated above. Thus, after one change in temperature conditions, there is a deviation of the value of the accumulated deformation from that predicted by the hardening theory by an amount $\Delta p = \bar{P}_{i+1} - P_{i+1}$, which must accordingly be taken into account in calculating the nonisothermal creep of isothermal elements working in a range of fairly high temperatures.

Hence the problem is reduced to one of determining the correction $\Delta p$ for each change of temperature conditions, from the initial isothermal creep curve at temperature $T_i + 1$ and the experimental value of the stabilization time $t_\ast$. For this purpose it is first necessary to determine the effect of the principal factors concerned with the creep of the material on the stabilization time. This enables us, on the one hand, to determine $\Delta p$ and, on the other — which is evidently the most important at present — to show clearly the extent of the effect of each of the factors on the deviation of the nonisothermal deformation from creep under constant-temperature conditions.

Among the group of factors indicated above, we have investigated those which, in our opinion, should play an important part in the change of $t_\ast$, viz., the sum of the plastic deformation and the creep deformation up to the moment when the temperature changes, the absolute temperature level, the magnitude of the acting stress, and the deformation time at the initial temperature.