The load--elongation diagrams were obtained for PETP yarns and monofilaments at different deformation temperatures, demonstrating the dependence of the $\sigma(e)$ curves on the testing temperature and the thermomechanical history of the samples. The dependences of the basic strain characteristics determined from the $\sigma(e)$ curves on the temperature can be used to predict the change in the mechanical properties of PETP yarns and fibres at high temperatures. In addition to the fundamental relaxation transition, the $\sigma(e)$ curves can be used to find a new transition in the 180°C region which controls the behavior of PETP yarns and fibres above the transition temperature. The thermomechanical tests and structural studies of the fibres at different temperatures allow correlating the transition found with crystallites and assigning it to an $\alpha_c$ transition based on the characteristic set of properties.

As the studies in [1] showed, the temperature of deformation of fibres and yarns significantly affects the character of the load ($\sigma$)—elongation ($e$) curves. Especially marked changes in the strain characteristic can be observed in the region of relaxation transitions, which makes it possible to use the $\sigma(e)$ curves plotted at different temperatures to reveal the transitions in not only amorphous but also in ordered regions of fibres.

It was shown in [2–5] that in the crystallites in many polymers, there is a transition between the glass transition temperature of amorphous regions and the melting point of crystallites, called the $\alpha_c$-transition, which determines the behavior of the fibres and yarns at high temperatures. The deformation characteristics of poly(ethylene terephthalate) (PETP) fibres and yarns at high temperatures were investigated and the $\alpha_c$-transition was revealed in the crystallites both with mechanical tests and with structural studies. Oriented Lavsan yarns with a linear density of 114 tex (Mogilev Khimvolokno Industrial Association) and PETP monofilament ~254 µm in diameter (experimental setup of the All-Russian Scientific-Research Institute of Synthetic Fibres, Tver') were the samples used for the study.

The stress—strain diagram and thermomechanical curves were obtained with the experimental points on a setup (Ulitka) very similar to the one described in [6] at a constant loading rate of 6.53 mN/sec. The temperature in the tests was maintained with an accuracy of ±1°C with a UVD-2000 attachment which can also be used for x-ray studies. Variations of the loading rate within the limits of three orders of magnitude did not affect the stress—strain diagrams obtained at room temperature, but did affect the deformation with a given load in conditions of high temperatures. The x-ray diffraction studies were conducted on a DRON-2.0 diffractometer with a UVD-2000 temperature attachment. Nickel-filtered CuK$\alpha_1$ radiation was used.

The $\sigma(e)$ curves for PETP yarns and monofilaments obtained at different temperatures are shown in Figs. 1 and 2. The character of the curves shows how the stress—strain diagrams are transformed with an increase in the temperature: the slope of the curves, which determines the instantaneous strain modulus $E = d\sigma/de$, and breaking stress $\sigma_b$ and strain $e_b$ of yarns and monofilaments. The $\sigma_b(t)$, $e_b(t)$, $E_1(t)$ and $E_2(t)$ curves for Lavsan yarns and the $e_0(t)$ for monofilaments are shown in Fig. 3. It should be noted that the curves of the strain characteristics as a function of the temperature for monofilaments are very similar to the curves for yarns, although there are some special features which will be discussed below. The strain modulus $E_1$ for
Fig. 1. Stress—strain curves of Lavsan yarns at different temperatures (in °C): 1) 20; 2) 75; 3) 87.5; 4) 100; 5) 125; 6) 150; 7) 175; 8) 200; 9) 210; 10) 220; curve 11 was obtained at 20°С for yarns previously deformed at 150°С to ε = 10%.

Fig. 2. Stress—strain curves of PETP monofilaments at different temperatures (in °C): 1) 20; 2) 50; 3) 70; 4) 114; 5) 167; 6) 180; 7) 200; 8) 220; 9) 240; curves 10 and 11 were obtained at 20°С for fibres previously deformed at 150°С to ε = 44% and at 240°С to ε = 100%, respectively.

Lavsan yarns was determined in the linear segment of the σ(ε) curve lying in the 1-5% strain range. Modulus $E_s$ was determined with the maximum slope of the σ(ε) curves, i.e., at strains where maximum strengthening of the deformed samples was observed.

As Fig. 3 shows, there are two temperature regions where the strain characteristics of PETP fibres and yarns change relatively sharply.

The first region, which lies between 75 and 100°C, can easily be associated with devitrification of the polymer, which is confirmed by the published data [7, 8] and by the results of the experiments shown in Fig. 4. Note that the shrinkage strains in the initial Lavsan yarns begin to develop intensively in this temperature range. The initial PETP monofilaments were sufficiently thermostabilized and did not give rise to shrinkage strains (Fig. 4, curve 2).