A series of works [1-4] have been devoted to a study of the deformative and strength characteristics of fiber-glass material, including orientation properties. Most of the indicated papers discuss results of tests on glass-fiber material under conditions of normal temperature and, chiefly, under tension at an angle $\varphi = 0^\circ$ to the direction of the main bulk of reinforcing elements.

The aspects of deformation and strength of fiber-glass material at high temperatures with consideration of the anisotropic properties have been very inadequately studied. Existing experimental data are a subject of debate [6-8].

In the present work we have examined several aspects of deformation and strength of anisotropic glass-fiber material, giving proper consideration to temperature and anisotropy. The choice of the given material for investigation was due to the fact that it is most typical of oriented fiber-glass materials. Uniform anisotropic fiber-glass material was manufactured at the Leningrad Factory of Laminated Plastics in the form of sheets $500 \times 50 \times 3$ mm. The relative content of phenol-epoxy resin in the material was 20-21 percent by weight.

Specimens for testing, of rectangular prismatic form $3 \times 15 \times 235$ mm, were obtained by mechanical processing of the sheets.

The specimens were cut at angles of $\varphi = 45$ and $90^\circ$ relative to the axis of elastic symmetry of the fiber-glass material (for the uniform anisotropic fiber-glass material used, the properties in the directions $\varphi = 0$ and $90^\circ$ are practically identical).

To avoid the effect of high temperatures on subsequent changes in the physical-mechanical properties of the specimens, as observed by many investigators [20, 21, 17], the specimens were subjected to heat treatment before the tests, according to a special temperature regime to insure complete polymerization of the material.

In view of the anisotropy of the properties of the investigated glass-fiber material, considerable attention was given to the precision of applying load relative to the symmetry axis of the specimen. A special adaptation was worked out for this purpose, ensuring precise coincidence of the symmetry axes of the specimen and the holding device, and, consequently, providing for strict centering of the specimen relative to the active load.

The experimental part of the operation was carried out basically according to the known method [10], with one exception: for making the test at constant deforming rate and at high temperatures, a 5-ton Shopper tensile testing machine was equipped with a heat chamber of a type indicated in the above reference and with a reducing gear. The latter permitted the strain rate to be varied within the limits of five orders.

Measurement and recording of deformation were effected chiefly by means of a mechanical strain gauge. An electric-wire strain gauge and a KM-6 cathetometer were also used for the same purpose. For
rapid strain rate, motion-picture photography was employed, using paired cameras, one to record the readings of the mechanical strain gauge, the other to make simultaneous readings of a pendulum dynamometer. In some tests, for precise maintenance of constant strain rate, the pendulum dynamometer was replaced by a rigid strain-gauge type of dynamometer, the rigidity of which was several orders higher than the rigidity of the test sample.

A graph of relative deformation versus time was plotted for determining strain rate of specimens. The strain rate was determined from the slope of the straight-line curves thus obtained. For accurate determination of the shape of the tension curve on a particular specimen, deformation was simultaneously measured by means of the mechanical strain gauge (1), the cathetometer (2), and the electric-wire strain gauge (3) (Fig. 1).

As seen in Fig. 1, the experimental points form practically coincident curves. This coincidence of curves was observed for numerous repeated tests.

The curve obtained by means of the electric-wire gauge could not be extended to the time of specimen failure, since the sensing elements were ruptured at ε = 1.2-1.5%.

It may be seen from the figure that the experimental curves consist of two almost rectilinear segments, differing in slope. The first, a comparatively short segment, corresponds practically to elastic deformation alone, as indicated by the coincidence of elastic-moduli values determined by dynamic and quasistatic methods [11]. The second segment of the curve, practically rectilinear, describes nonelastic deformation, as will be shown below.

In Fig. 2 we have shown the tension curves for specimens at three different strain rates, differing from each other by one order. From this figure we see that the tension curves for specimens of a particular shape are identical. The slope of the initial segment is practically independent of strain rate of the specimen and actually defines the elastic modulus of the material. The second segment of the curve is asymptotic, more clearly seen for specimens with θ = 45°. The results of experimental measurements during unloading [13] show that the second segment of the tension curve represents rubbery elastic deformation. This may be confirmed by theoretical analysis.

As noted in [9, 14], the strain and stress states of oriented glass-fiber material are satisfactorily defined by a nonlinear equation derived from the generalized Maxwell equation [12] with consideration of