This article describes an attempt at further investigation of the mechanism of radiation creep in polymers and the causes of the decrease in their lifetimes in a radiation field under load. So far, four different mechanisms have been proposed for radiation acceleration of creep in polymers [1-5]. The mechanism of radiation acceleration of the kinetic processes involving formation of severe local overheating at the ends of the paths of fast electrons [1] conflicts with a number of experimental facts and has incurred adverse criticism [2, 4, 5]. Bell et al. [2] proposed a mechanism of radiation acceleration of creep in polymers involving plasticization by the products of gas emission, which, however, is not consistent with a number of experimental results in their work, or with the results of other authors [4, 5], including those which we shall give below. A mechanism involving accelerated rupture of stressed chemical bonds in regions of local overheating with some effective temperature $T_{	ext{eff}}$, arising when electron excitation of a molecule undergoes transition to vibrational excitation [3], was used to explain the action of ultraviolet (UV) light on polymers; but it does not explain the action of ionizing radiation, because in this mechanism the rate of radiation creep $v_j$ should be proportional to the intensity of irradiation $j$, which conflicts with our data [4, 5]. Below we give additional data on radiation processes in loaded polymers, corresponding to the hypothesis of rupture of stressed bonds owing to interaction with thermal electrons [4, 5].

The experimental method was described in [4]; this time we also used a transducer to measure the dose rate in the irradiated specimen, which enabled us to measure, vary, and control the dose rate $j$ in the specimen very precisely. The action of the transducer was based on measurement of the current density of the electron beam beyond the test specimen. The transducer was calibrated calorimetrically and with the aid of film dosimetry; the results were the same.

Calculations and measurements of the temperature in the irradiated specimen revealed that the stationary temperature difference $\Delta T$ between the blown-through gas and the irradiated specimen is proportional to the dose rate $j$ and the specimen thickness $\delta$; if the irradiation intensity is 0.5 Mrad/sec and the specimen thickness is 100 $\mu$, then $\Delta T = 1.8$ deg C. This temperature difference is established when the beam is switched on for 2-3 sec at the 90% stationary level. The irradiation was by electrons with energies of about 1 meV.

Despite their varied proposed mechanisms of radiation acceleration of creep in polymers, different authors give an additive formula for the creep rate,

$$v = v_0 + v_j, \quad (1)$$

where $v_0$ is the creep rate without irradiation and $v_j$ is the radiation component of the creep rate; in different conditions either term may predominate. It was of interest to verify formula (1) experimentally for comparable values of $v_0$ and $v_j$, and by comparing them to obtain additional data on the nature of $v_j$. For this purpose we performed experiments on two materials—standard Kapron threads (relative stretch 5.2, stabilizer content 0.5%) and polymethyl meth-
acrylate (PMMA, 5% dibutyl phthalate). The specimen was loaded to constant stress for several seconds and the deformation relaxation curve was recorded. If the load was removed after about ten minutes and then the load reinstalled, the relaxation curve could be completely reproduced as many times as desired; it was only observed to shift a little by the amount of the irreversible deformation (~0.04%). A similar relaxation curve was recorded in a field of radiation and compared with the graph obtained without relaxation. The data for Kapron are shown in Fig. 1. Curve 2 illustrates the relaxation process of the deformation under load without radiation; only the upper part of the curve, without elastic deformation, equal to about 14%, is shown.

Curve 1 represents the same process for the same specimen under irradiation, which after approximately 10 min is practically a straight line characterizing the radiation creep. The difference between curves 1 and 2 (line 3) characterizes the radiation component of the creep in the initial period, including the relaxation process of deformation, and, as we see from Fig. 1, is a straight line. This shows that irradiation has no effect on the initial relaxation process, i.e., that the rate of the radiation component of the creep does not have an appreciable relaxation period. The rate of radiation creep, determined from the slope of line 3, is numerically close to the values of $v_1$ obtained for Kapron threads in the case in which irradiation begins after the occurrence of marked deformation relaxation, i.e., 10-20 min after loading of the specimen. The slight deviation of line 3 from the origin is due to some irreversible deformation developed during the process described by curve 2, and also to some increase of temperature and additional dose in irradiation before loading.

On cessation of irradiation, the deformation represented by curve 1 rapidly reaches its stationary level [4]. If immediately after this the load is removed from the specimen and after a time (about 5 min) reapplied, the deformation very rapidly (after about 10 min) reaches the same value which had accumulated under irradiation; consequently, the deformation due to the radiation component is irreversible.

Similar data were obtained for PMMA (polymethyl methacrylate) films. The irreversibility of radiation deformation and its independence of the relaxation processes shows that it is due to rupture of chemical bonds and not to reversible relaxation processes involving regrouping of polymer molecules. If we suppose that radiation deformation is due to acceleration of relaxation creep processes as a result of irradiation by the mechanism of thermal flares or as a result of plasticization by gas emission products without rupture of chemical bonds, as assumed by Mokul'skii [1] and Bell et al. [2], then according to general considerations this should lead to gradual decrease in the radiation component of the creep as the accelerated relaxation deformation process takes place.

We also performed experiments to verify the constancy of the rate of radiation creep throughout the time until failure of the specimen. In all these experiments, and also in later experiments on radiation creep, in contrast to the previously-described experiments, irradiation began after complete cessation of the relaxation process, when the nonradiation component of the creep rate in our conditions had become negligible in comparison with the radiation component (the beginning of radiation was taken as the time origin).