Experience in operating equipment at low climatic temperatures shows that there is a sharp increase in the number of sudden failures in structures and machine components as the operating temperature falls. This is due to insufficient cold resistance in the materials used for the manufacture of equipment designed to operate under these conditions.

The present work gives the results of research on the patterns of fatigue-crack development in steel 15G2AFDps, which is used in structures which operate under the conditions mentioned.

The installation and method for studying the kinetics of fatigue-crack development are described in [1].

Ferrito-pearlitic class steel 15G2AFDps, semikilled and normalized, has a grain reading of not less than 10. The temperature of transition to brittle fracture is below $-95^\circ C$.

Brittle fracture means the spontaneous propagation of a crack due solely to the available reserve of elastic energy in the test piece — machine system or in the structure.

The nature of the fracture was determined by reference to the speed of crack propagation at the instant of static final fracture of the test piece, the results of electron fractography of sectors of test-piece static final fractures, and other criteria described in [2].

The kinetics of fatigue-crack development were studied at temperatures of $+20$, $-26$, $-56$, $-95$, $-120$, $-140$, and $-180^\circ C$ and at stresses equal to $1.08 \sigma_{-1}$ at the appropriate test temperature. These stresses corresponded to $(0.8-1) \times 10^6$ cycles in the life of the test piece.

To study the kinetics of crack development at low temperatures, cracks were produced in the test piece under cyclic harmonic loading and $\sigma = 30.5$ kgf/mm$^2$, which corresponded to a life of $(0.5-0.6) \times 10^6$ cycles at room temperature.

This stress was chosen because at a greater stress several cracks appeared immediately on the test-piece working surface, while at stresses corresponding to a life in excess of $1 \times 10^6$ there was a great variation in the number of cycles to the instant of crack appearance, which made it much more difficult to record that instant.

When the crack had developed, the test pieces were cooled to the prescribed temperature and tested under harmonic loading.

The data obtained on the duration of the crack-development period were related to the total life of pieces tested at the corresponding temperature and stresses. The length of the crack from which the reading was taken was 0.6 mm.

The relationship of crack length to the number of loading cycles at various test-piece cooling temperatures is given in Fig.1.*

* Each curve in this and all subsequent figures is plotted as the mean value of test results from two to four test pieces at the same temperature and the same stress level.
Fig. 1. Relationship of crack length to the number of loading cycles.

Fig. 2. Temperature dependence of ratio of crack-development period duration (solid line) and duration of periods up to crack generation (dashed line) to total life of test piece.

Fig. 3. Relationship of crack length L to depth H.

Fig. 4. Relationship of speed of crack advance per cycle to crack length.

The temperature dependence of the ratio of the duration of crack-development periods and of periods up to crack generation to the total life of the test piece is shown in Fig. 2.

It is apparent from Fig. 2 that the relative duration of the fatigue-crack development periods remains practically constant and equal to 13.6-15.7% as test temperature is reduced from +20 to −95°C at $\sigma_a = 1.08 \sigma_T$. When the test temperature is reduced to −180°C the duration of the crack-development periods is sharply curtailed, and at −180°C the duration from a size of 0.2–0.4 mm to the sudden fracture of the whole