The data obtained in tension or bending tests are inadequate for calculating the structural strength of steels. Data are needed on the properties of the steel in the stressed condition that is characteristic during operation of the part.

It was shown in [1] that when parts operate under cyclic loading conditions it is expedient to increase the carbon content above the level for structural steels, since the fatigue limit increases with the carbon concentration. At hardnesses of HB 350 and 450 the fatigue limit of steel containing 1.0% Mn, 1.0% Cr, and 0.08% V increases with the carbon content up to 0.70–0.75%. In notched samples of the same steels the fatigue limit increases with the carbon content up to 0.6%. In purely manganese steels with 1.4% Mn the fatigue limit is highest for a carbon concentration of 0.6–0.65%.

In this work we studied the variation of the contact strength with the carbon content of structural carbon steel containing ~1.0% Mn. The nominal fatigue limit (N = 7·10^6) was determined under contact loading without slip. The carbon content was varied within limits of 0.46–0.82%. Samples quenched to martensite were tempered at 270–390°C, depending on the carbon content, to the same hardness – HB 450. The troostite structure obtained in samples with various carbon concentrations had the same lamellar shape and differed mainly in the amount of carbide phase. At these tempering temperatures, as is well known [2], the solid solution retains a certain amount of carbon, which decreases with increasing tempering temperatures. This is characterized by the reduced width of interference lines (110) and (211) in x-ray analysis, which may be due also to the reduction of second-order deformation in the solid solution.

Thus, the same hardness or resistance to large plastic deformation in the samples investigated is determined by the total effect of two factors – the small amount of carbide phase and substantial hardening of...
the solid solution in the steel with a low carbon concentration (0.46%), and the substantial amount of carbide phase and low hardening of the solid solution in the steel with the highest carbon concentration (0.82%).

Despite the identical hardness, the contact fatigue limit increases with the carbon concentration (Fig. 1) up to the highest carbon concentration investigated. The increase of the amount of highly dispersed carbide phase of lamellar form, and consequently the interphase surface, with the carbon concentration raises the contact fatigue strength even when the static strength remains the same. The increase of the fatigue limit shown in Fig. 1 corresponds to a multiple increase in the working life of parts under given working conditions.

It should be noted that an increase of the carbon concentration does not have identical effects on the cyclic strength under different stress conditions (Fig. 2).

The deformation mechanism in connection with the structure for different types of stress conditions requires special consideration. In considering the structural strength it is necessary to take into account the stress condition under which the part operates. With comparatively smooth contact cyclic loads the steel with the higher carbon content close to the eutectoid (0.6–0.7%) has the advantage. With impact loading the amount of carbon must be reduced, since the impact strength decreases with increasing carbon concentrations [1].

The increase of the structural strength of steels with a high carbon content during cyclic loading depends primarily on the method of heat treatment, i.e., on the structure obtained. The optimal heat treatment may differ for different levels of structural strength.

Comparison of ordinary quenching to martensite followed by tempering with the so-called single heat treatment in which the decomposition of austenite occurs in the lower pearlitic region, resulting in temper sorbite in the first case and quenching sorbite in the second, with a strength of 110–140 kg/mm$^2$ and HB 300-400 (and in some cases 160 kg/mm$^2$ and HB 450) has shown that in a number of cases the single heat treatment has the advantage [3].

The greatest advantage of quenching sorbite was manifest in the increase of the wear resistance. The wear resistance $Q^{-1}$ (reciprocal of weight loss) under identical testing conditions is shown in Fig. 3.

In steel 70Kh with a structure of quenching sorbite the ratio of the ultimate strength to yield strength in the hardness range of HB 320–400 was 13–15% higher than for a structure of temper sorbite. The higher value of this ratio is favorable for the structural strength of parts and indicates the higher capacity of the quenching sorbite structure for stress redistribution and lower sensitivity to stress concentrations than the temper sorbite structure.

The fatigue limit in cyclic bending of samples with a quenching sorbite structure is higher than that of samples with a temper sorbite structure. At carbon concentrations of 0.4–0.7% in steel with 1% Cr the