Studies of the properties of high-purity metals (particularly bcc transition metals) have shown that amounts of impurities forming interstitial solid solutions affect the mechanical, physical, and chemical properties [1-3]. The effect of small concentrations of interstitial impurity atoms on the properties is due to the uneven distribution and concentration around dislocations.

We investigated the properties of iron with the minimal concentrations of carbon and nitrogen.

We investigated iron subjected to electron beam zone refining [4]. After refining, the iron was subjected to deformation and annealing to obtain wire samples. Since the iron was contaminated with carbon during reduction, the samples were additionally purified of nitrogen and carbon by the method described in [5]. The samples were treated in a closed loop in an atmosphere of purified hydrogen. A furnace with zirconium hydride was placed in the loop beside the furnace with the iron samples. When heated, zirconium hydride decomposes and the system is filled with hydrogen of high purity. The carbon and nitrogen in the iron react with the hydrogen, forming gaseous compounds which react with zirconium to form zirconium carbide and nitride.

To determine the degree of purification we used blanks of the same chemical composition as the original iron except for radioactive carbon C\textsuperscript{14}. According to the measurements of the radioactivity of the blanks after annealing in hydrogen (850°C, 450 h), the carbon concentration was less than 10\textsuperscript{-7}%\% . It can be assumed that the carbon concentration was the same in the wire samples subjected to further mechanical and other tests.

According to thermodynamic calculations [5], the concentrations of nitrogen and oxygen should be below that of carbon. No metallic impurities were found in spectral analysis.

Cooling from 850°C to room temperature was conducted in vacuum, which makes it possible to consider that hydrogen was completely removed from the wire samples. Thus, it is assumed that the material tested is the purest iron obtainable under present laboratory conditions [6].

Reduction of the carbon and nitrogen concentration from 10\textsuperscript{-3} to 10\textsuperscript{-7}% lowered the yield strength from 12-14 to 2.7-3 kg/mm\textsuperscript{2} (Fig. 1). The sharpest effect on the yield strength corresponded to a change in the impurity concentration from 10\textsuperscript{-7} to 10\textsuperscript{-4}%.

![Fig. 1. Variation of yield strength with holding time in pure hydrogen at 850°C.](image1)

![Fig. 2. Variation of internal friction Q\textsuperscript{-1} with the amplitude of deformation in iron.](image2)

1) Pure iron, < 10\textsuperscript{-7}% C;
2) technical iron, > 0.023% C [8].
At the present time one of the most sensitive methods of revealing the effect of small impurity concentrations on dislocation mobility is measurement of the amplitude dependence of the internal friction (AD-IF).

If the density of impurity atoms at dislocations is small the dislocations are mobile, energy losses are large, and the increase of internal friction is correspondingly large with an increase of deformation amplitude.

The angle of the tangent $\alpha$ to the slope of the curve of the amplitude dependence of internal friction, proportional to the energy dissipated in the movement of dislocations, qualitatively characterizes the density of pinning points of dislocation lines.

The amplitude dependence of internal friction was measured on iron samples 0.8 mm in diameter in a relaxator of the "reversible torsional pendulum" type with a frequency of 0.8 Hz. To eliminate magnetic-elastic scattering, the measurements were made in a longitudinal magnetic field with an intensity of 320 Oe.

Figure 2 shows the ADIF of iron samples purified in an atmosphere of hydrogen for 500 h (curve 1), with $\sigma_T = 3.5$ kg/mm$^2$, deformation rate $5 \times 10^{-4}$ sec$^{-1}$, and ordinary technical iron with 0.025% C in the annealed condition at 20$^\circ$C (curve 2). For the technical iron the internal friction is independent of the amplitude in the range of deformation amplitudes studied. For the pure iron the amplitude-independent portion of the curve of internal friction is absent and a small change in amplitude sharply increases the internal friction. This indicates the absence of dislocation movements during measurements of ADIF in technical iron and also that the density of pinning points of dislocations in high-purity iron is considerably lower than in technical iron. Figure 3 shows the variation of $\alpha$ at 20$^\circ$C with changes in the carbon concentration of the iron in the annealed condition.

For high-purity iron ($10^{-7}$% C) $\alpha \approx 800$, which indicates the low density of impurity atoms at dislocations. An increase of the interstitial impurity concentration to $10^{-4}$% reduces $\alpha$ almost 1000 times; with further increase of the impurity concentration the change in $\alpha$ is negligible.

Thus, an increase of the interstitial impurity concentration from $10^{-7}$ to $10^{-4}$% sharply reduces the mobility of dislocations. With an interstitial impurity concentration of about $3 \times 10^{-4}$% the dislocations are completely pinned in annealed iron. Thus, it can be assumed that a concentration of about $3 \times 10^{-4}$% interstitial impurities is the natural boundary between iron of high purity and technically pure iron.

We also investigated the effect of the interstitial impurity concentration on the increase of the yield strength with an increase of the deformation rate from $10^{-4}$ to $10^{-3}$ sec$^{-1}$. The tests were made in a machine with an inertialess induction strain detector.

Figure 4 shows the variation of the increase in yield strength with the interstitial impurity concentration rate by 10 times. The increase of the yield strength was maximum at a carbon concentration around $3 \times 10^{-4}$%.

With a carbon concentration less than $3 \times 10^{-4}$% the dislocations are weakly pinned and easily break away from pinning points. At carbon concentrations over $3 \times 10^{-4}$% the breakaway of dislocations from