The most widely used methods of increasing the wear resistance of materials are based on various forms of chemicothermal treatment, which enable surfaces to be subjected to thermal diffusion impregnation with one or more elements or coated with other metals [1, 2].

Surfaces processed in this manner exhibit high hardness (attaining 2000–3000 units) and brittleness, which depend on many factors, such as the chemical composition and degree of homogeneity of the surface layer, treatment temperature and duration, etc. Materials subjected to chemicothermal treatment, whose wear resistance is increased several times by this method, are extensively used, particularly in high-precision units containing moving parts, where the load is distributed fairly uniformly and the initial fit geometry must be preserved as far as possible.

In heavy-duty operation under boundary- or dry-friction conditions, it is very often undesirable that the surface layer should exhibit high hardness or brittleness, because, as has been established by many authors [3, 4], owing to the specific character of contact loading, maximum shear stresses are concentrated at some distance from the surface. This increases the probability that particles (flakes) will be torn out of the surface and subsequently give rise to abrasive wear in the friction zone.

It would seem much more sensible to choose for friction units materials combining good strength and elastic-plastic properties. An optimum combination of such properties can ensure that the running-in process is completed within a reasonably short time and a high degree of work-hardening is imparted to a thin surface layer under the action of friction loading.

Recent investigations [5, 6] have demonstrated that the friction of metals leads to a marked comminution of coherent scattering regions and substantially increases both second-type distortions and the density of dislocations. All such changes in fine structure manifest themselves particularly strongly in the presence in the friction zone of adsorbed surface-active substances, which produce an additional plasticizing effect [7, 8]. Increasing the number of defects capable of raising the resistance to migration of dislocations would be expected to enhance still further the work-hardening effect produced by friction, thereby improving wear resistance. Such structural changes may be induced by employing special forms of chemicothermal treatment, evolved on the basis of the following considerations.

One of the most effective methods of increasing the yield strength of materials is to introduce dispersed particles uniformly distributed in a plastic matrix. Such structures can be generated by utilizing the phenomenon of limited solid-state solubility during temperature variation and solid-phase transformations. A typical example is provided by the precipitation processes of Guinier–Preston zones or other phases. Precipitated phases with a particle shape close to spherical restrict the migration of dislocations, forcing them to climb in relatively narrow channels. The principal drawback of this idea is the low thermal stability of precipitated phases, which is closely linked with dissolution or coagulation of the strengthening particles, resulting in a reduction in the strength properties of the material. Strength characteristics can be markedly improved by increasing the density, dispersion, and thermal stability of strengthening particles.
A new method for the chemicothermal treatment of surface layers has been proposed and described [9-11], consisting basically in producing a highly dispersed composite system composed of a relatively ductile matrix with uniformly distributed hard chemical or intermetallic compounds. Such a composite layer has been obtained by impregnating a steel matrix with boron in a process involving raising the temperature to achieve incipient melting of an active layer and formation of a liquid eutectic, followed by rapid cooling (quenching).

In contrast to phase precipitation in the solid state, in the technique proposed it is possible to attain a high density of strengthening phase particles (because of the unlimited solubility of the components in the liquid state), and also a high degree of dispersion after quenching. A comparison with the wear resistance of diffusion-type boride coatings demonstrated that the new method of surface hardening can be extremely effective for parts intended for heavy-duty operation under the conditions of boundary and dry friction, as well as friction in a vacuum or at elevated temperatures.

Further researches in this direction [11] established the possibility of generating on friction surfaces a coarsely heterogeneous structure consisting of a ductile matrix with relatively large hardening inclusions, which also exhibits a high resistance to failure under the action of friction. During contact loading, the load in this case is distributed over the hard particles, which ensure a low coefficient of friction and high seizure resistance. The relatively ductile matrix enables the system rapidly to assume an optimum contact geometry, which lessens the risk of formation of local high-pressure zones likely to lead to splintering or seizure.

As a logical extension of these researches, attempts have been made to develop a technique of modifying the surface layer which would result in a structure with individual elongated crystals suitably oriented relative to the working surface. In the case of surface quenching of a liquid-eutectic coating, the wear resistance of the latter depends on the ability of dispersed particles to inhibit the migration of dislocations in