We have established an isothermal section of the phase diagram for the V-Al-B system at 870 K (for ≤0.60 at. % boron) and at 1070 K (for larger amounts of boron) using x-ray phase analysis. We did not find significant regions of solid solutions based on binary compounds or ternary compounds.

The V-Al-B system has not been systematically studied [1]. It has been partially studied on samples pre-pressed from powders of the starting components after sintering at 1270 K. Such phase fields have been established as: a solid solution based on vanadium combined with V₃B₂—VB or VB—V₃Al₈; VB—VAI₃—V₅Al₈; the melt combined with VB—VAI₃ or V₃B₄—VB₂, VB₂—AlB₁₂. The mutual solubility of AlB₂ and VB₂ is no greater than 0.03 mole fraction [2]. Considering the important changes in the phase diagrams of the binary systems on the boundary of V-Al-B, we thought we should investigate this system more completely with the objective of plotting the phase equilibrium diagram.

The most reliable variant of the phase diagram for the system Al—B is plotted using the data in [1]. The compound AlB₂ is formed by a peritectic reaction at 1770-1820 K; it is found in equilibrium with the boride AlB₁₂ for which a synthesis method and a formation temperature have not been established. According to the phase diagram for the system V—B [3], we can be sure that the following borides exist: VB₂ (formed congruently), V₃B₂, VB, V₃B₄, V₂B₃ (formed by peritectic reactions) and V₂B₆ (formed by a peritectoid reaction). All these compounds are stable below 2000 K. The phase diagram of the V—Al system is shown in [4]. At 870 K, vanadium dissolves up to 0.40 mole fraction Al. The compound V₅Al₈ is formed by a peritectic reaction at 1873 K; it has a broad homogeneity region, narrowing at 870 K to 0.385-0.400 mole fraction V. Other intermetallics in this system have a constant composition and are formed by peritectic reactions; their composition is described by the formulae V₄Al₂₃, V₇Al₄₅, and V₁₀Al₁₀ [4].

To prepare the samples we used powders of aluminum (purity 0.9999 mass fraction), boron (0.994 mass fraction), and vanadium cuttings (0.995 mass fraction). Premixed and pre-pressed components were melted in an electric arc furnace with a tungsten electrode on a copper water-cooled hearth under a purified argon atmosphere. Homogenization of the samples containing less than 0.60 mole fraction B was done at 870 K; the rest of the samples were homogenized at 1070 K. These temperatures were selected based on the phase diagrams of the binary systems. Annealing was done in evacuated quartz ampuls for at least 800 h, followed by quenching in cold water. The phase composition was determined from powder x-ray diffraction patterns taken in CrK radiation in cameras of diameter 57.3 mm. We have studied the phase composition of 12 two-component and 28 three-component samples (Fig. 1).

In the V—Al binary system, we confirmed the formation of the following compounds: V₅Al₈ (experimentally established parameter a = 0.9241(1) nm), VAI₃ (a = 0.3783(2), c = 0.8326(8) nm), V₄Al₂₃ (a = 0.7628(6), c = 1.7040(2) nm), and VAI₁₀ (a = 1.4686(3) nm). The lattice parameters of all the compounds agree well with literature data [4]. We obtained the compound V₇Al₄₅ in a two-phase sample in equilibrium with VB. All the binary compounds we confirmed are shown in Fig. 1.

In the system V—Al—B, no ternary compounds were found. Between the isostructural borides VB₂ and AlB₂ we might have expected formation of continuous or limited solid solutions; but all the samples in this part of the system proved to be three-phase (VB₂+AlB₁₂+Al). The boride VB₂, found in equilibrium with aluminum, has lattice parameters (a = 0.3004(7), c = 0.3079(8) nm) close to the parameters of pure VB₂ (a = 0.2999, c = 0.3051 nm), which suggests insignificant solubility of aluminum in VB₂. In the three-phase samples, the lattice parameters of the borides V₃B₆ (a = 0.3056(1), b = 2.124(1), c = 0.2974(2) nm) and V₂B₃ (a = 0.3056(1), b = 1.838(1), c = 0.2985(2) nm) also agree well with literature data (a = 0.3058, b = 2.125, c = 0.2974 nm and a = 0.3061, b = 1.840, c = 0.2984 nm, respectively [1]). This suggests that the borides V₃B₆ and V₂B₃ also do not dissolve significant amounts of Al. The lack of solubility of Al in the borides V₃B₄, VB, and V₂B₂ is indicated in [2]. Thus the solubility of aluminum is not high in any of the vanadium borides. For a favorable size factor, the lack of solubility of aluminum in vanadium borides is connected with the effect of the chemical factor, i.e., it is due to the different structures of the electronic shells of these atoms (p and d elements).

Our investigation has shown that in the V—Al—B system, in contrast to {Cr, Mn, Fe}—Al—B [1], ternary compounds M₂AlB₂ with a structure of the Mn₂AlB₂ type are not formed. This is apparently because of the increase in the atomic radius of vanadium (rᵥ = 0.134 nm) compared with the radii of transition metals (r₉ = 0.127, rₘ₉ = 0.130, and r₉fft₉ = 0.126 nm).