We investigated the kinetics* of the isothermal $\alpha \rightarrow \gamma$ transformation in alloys YuNDK24, YuND35T5, and YuNDK40T7 (Table 1), the chemical composition of $\alpha_7$ phase, and the variation of the magnetic properties with the treatment conditions and the amount of $\alpha_7$ phase.

We tested samples 12 $\times$ 12 $\times$ 60 mm with an equiaxed polyhedral structure, which were obtained by casting in molds prepared by investment casting. Metallographic analysis was conducted on transverse sections at a distance of 15 mm from the end of the sample. The amount of $\alpha_7$ phase was determined by Glagolev's method [1] (1600 points on the sample) with the PMT-3 apparatus. The magnetic properties of the ground samples were measured in the Magnit-2 apparatus with automatic recording of hysteresis loops. The chemical composition† of the $\alpha_7$ phase was determined by microprobe analysis with the CAMECA MS-46 analyzer.

Control samples of each alloy were subjected to thermomagnetic treatment in sets of four and tempered by the technique commonly used. These samples contained no $\alpha_7$ phase, and the magnetic properties of each alloy were optima (Table 2 and Fig. 1a). All other samples were subjected to isothermal holding between the operations of homogenizing and thermomagnetic treatment in order to obtain different amounts of $\alpha_7$ phase (Table 2 and Fig. 1a).

Alloy YuNDK24. The maximum formation rate of $\gamma$ phase in alloy YuNDK24 was observed at 1050-1150°C. The transformation practically ceases after holding for 60 min (Fig. 2a). The transformation practically ceases after holding for 60 min (Fig. 2a). At 900-850°C the transformation rate decreases sharply. The $\alpha$ solid solution is least stable at 1150°C — the $\alpha \rightarrow \gamma$ transformation begins after 3 min. With decreasing temperatures the incubation period increases, and at 850-900°C amounts to hours. The temperature limits of the two-phase region can be taken as 850 and 1200°C. At these temperatures the amount of $\gamma$ phase is less than 1% after holding for 60 min and is $\sim$2% after 100 h. The temperature range of 1100-1050°C corresponds to the maximum quantity of $\gamma$ phase, which reaches $\sim$42% in the YuNDK24 alloy investigated.

The distribution of $\alpha_7$ phase in the microstructure is due to the amount of phase located in the grain boundaries in the initial period in the form of a narrow band or needles forming a dense Christmas tree or fringe on one side of the boundary. With increasing holding times the amount of $\alpha_7$ phase increases due to elongation of the needles (Fig. 3a). Larger amounts of $\alpha_7$ phase lead to the appearance of isolated

*V. B. Patt, T. I. Nosova, and A. S. Chernov assisted with the experiments.
† Determined under the direction of G. N. Ronami.

TABLE 1

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Co</th>
<th>Ni</th>
<th>Al</th>
<th>Cu</th>
<th>Ti</th>
<th>Si</th>
<th>S</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>YuNDK24</td>
<td>28.3</td>
<td>13.5</td>
<td>7.8</td>
<td>9.4</td>
<td>0.4</td>
<td>0.12</td>
<td>0.021</td>
<td>0.014</td>
</tr>
<tr>
<td>YuNDK35T5</td>
<td>34.6</td>
<td>14.5</td>
<td>7.1</td>
<td>3.96</td>
<td>5.1</td>
<td>0.09</td>
<td>0.023</td>
<td>0.018</td>
</tr>
<tr>
<td>YuNDK40T7</td>
<td>38.7</td>
<td>12.2</td>
<td>6.9</td>
<td>2.92</td>
<td>0.7</td>
<td>0.10</td>
<td>0.012</td>
<td>0.016</td>
</tr>
</tbody>
</table>

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precipitates within the grains, but the distribution of the phase through the bulk remains uneven for a long time. Only a large quantity of $\alpha$ phase fills the bulk more evenly.

The chemical composition of $\alpha$ phase differed from that of the matrix (Fig. 4). As compared with the matrix, the $\alpha$ phase is enriched in iron and impoverished in aluminum, nickel, and cobalt. The lower the temperature at which the $\gamma$ phase was formed, the greater the difference in composition. The isothermal holding time has almost no effect on the composition of $\alpha$ phase.

Fig. 1. Variation of magnetic properties of alloy YuNDK40T7 with isothermal holding temperature and time (a) and amount of $\alpha$ phase formed at different temperatures in alloy YuNDK24 (b). ■ properties of control samples.

Fig. 2. Diagrams of isothermal $\alpha \rightarrow \gamma$ transformations in alloys YuNDK24 (a), YuNDK35T5 (b), and YuNDK40T7 (c). The numbers on the curves indicate the degree of transformation (%). The dashed lines are extrapolations to points of 0% phase and cooling times of control samples down to the temperatures of the isotherms.