As is known, sintered alloy materials may be produced by the following methods: 1) mixing of charge components; 2) using prealloyed powders.

In the former case, alloys are produced as a result of diffusional processes accompanying sintering, the extent to which these processes develop being governed by sintering conditions (temperature, holding time, sintering environment, etc.). However, the method of direct mixing of alloying additions with the alloy base before sintering fails to secure a uniform distribution of alloying components in the base metal. The latter method of preparation of sintered materials secures uniform alloying with the required elements and enables the duration of sintering to be substantially reduced.

The use of prealloyed powders for the production of sintered chromium steels is particularly promising, since synthetic chromium steels cannot be obtained by the direct introduction of chromium powder into the charge in view of the very slow diffusion of chromium [2].

Various methods of preparation of prealloyed powders are known, including the atomization of molten metal, eddy mill grinding, simultaneous reduction of oxides, and diffusional saturation. The first three methods have a number of drawbacks which prevent them from being widely employed [1]. Reduction of chromium oxides by means of gaseous reducing agents is impossible because chromium forms sparingly reducible oxides. The Central Scientific Research Institute of Ferrous Metallurgy (TsNIICHERMET) has developed a method of preparation of iron-chromium powders, based on the reduction of chromium oxides by calcium hydride. However, this method is very laborious, because it calls for special hydrometallurgical treatment for the preparation of chemically pure alloy.

In the present investigation, the method of diffusional saturation of freely poured powder from solid chromium-containing packing materials was selected for the manufacture of iron powder alloyed with chromium. Diffusional chromizing in solid packing materials is relatively simple, does not require special equipment, can readily be carried out under any production conditions, and yields sufficiently reliable results. The method of diffusional saturation of freely poured iron powder with chromium from solid packing materials was briefly described in [1], but the optimum conditions for producing powder with a given chromium content were not stated.

The object of the present investigation was to obtain powders with a given amount of chromium (between 5 and 30%), which would be uniformly distributed over the cross section of chromized sponge. In preliminary experiments, a study was made of the effect of the composition of chromizing packing material, chromizing temperature, holding duration, and gas permeability and layer thickness of powder on the mean concentration of chromium and uniformity of its distribution over the cross section of chromized sponge.

The powder was chromized in metal boxes provided with tightly fitting covers with a refractory coating, as used for carburizing. It was poured into a box placed vertically; the distance from the powder to the box walls and bottom, as well as between the individual portions of the powder, was 12-15 mm. In this way, suitable conditions were established for a uniform flow of gaseous chromium compounds over the surface of the iron powder. The chromizing packing materials employed consisted of a mixture of a chromium powder with a particle size of less than 0.25 mm, alumina initially roasted at 1523-1573°K, and ammonium chloride dried at 363°K. During chromizing, the powder was sintered to form a more or less rigid sponge, which could readily be broken up by milling.
In the first experiments, the aim was to find ways of increasing the gas permeability of a powder layer, which would permit a uniform distribution of chromium over the cross section of chromized sponge. The experiments were performed for 2 h at 1373°K, in a packing material containing 47.5% chromium powder, 47.5% alumina, and 5% ammonium chloride. The extent of chromium distribution over the cross section was determined by the method of layer-by-layer analysis of the sponge. Initially, a powder layer 40 mm thick was selected. At this thickness, the chromium content varied from 0.13% in the sponge core to 32% on the external sponge surface. When the layer thickness was decreased to 15 mm, the distribution of chromium over the cross section of chromized sponge became somewhat more uniform, ranging from 7.4% in the core to 30.86% on the outside surface. However, even at this small thickness, it was not possible to obtain a uniform distribution of chromium over the cross section, which was clearly due to the inadequate gas permeability of the powder layer.

For this reason, the subsequent experiments were aimed at improving the gas permeability of the powder layer. For this purpose, the powder was mixed before chromizing the volatile looseners—ammonium chloride or bicarbonate. During heating, the latter decompose at relatively low temperatures and form voids which improve the access of gaseous chromium compounds into the layer.

First, a study was made of the degree of chromium distribution over the cross section of sponge in the case of addition of ammonium chloride or bicarbonate to powder forming a layer 40 mm thick. Both looseners were added in an amount of 25% by weight. The character of chromium distribution over the cross section of sponge with the use of looseners is shown in Fig. 1. Curves 1 and 2 illustrate the degree of chromium distribution over the cross section of sponge when using ammonium chloride and bicarbonate, respectively, as looseners. The mean chromium content of the sponge was 18.2% in the former case and 14.2% in the latter. As can be seen from the graph, the character of chromium distribution with ammonium chloride and bicarbonate is approximately the same, but the former loosener permits a higher mean chromium content to be attained in the powder.

However, even with the use of volatile looseners, it was found impossible to obtain a uniform distribution of chromium at a powder layer thickness of 40 mm. Consequently, the subsequent studies were made at a layer thickness of 15 mm. Ammonium chloride was used as the loosener. Together with the determination of the uniformity of chromium distribution over the cross section of sponge, a study was made of the effect of the amount of loosener in the powder on the character of chromium distribution. The loosener was added in amounts of 5, 10, and 25%. The most uniform distribution of chromium over the sponge cross section was observed on addition of 25% of the loosener (Fig. 2, curves 1, 3, and 4). The mean chromium contents of the powder with 25, 10, and 5% of the loosener were 33.8, 25.6, and 22.9%, respectively.

Thus, by using ammonium chloride as the loosener, it is possible, on the one hand, to control the uniformity of chromium distribution over the cross section and, on the other, to secure different mean chromium contents of the