The amenability of aluminum and its alloys to roll compaction opens up wide possibilities for the production of aluminum and heat-resisting aluminum alloy sheets containing a high proportion of components which are sparingly soluble in aluminum. Because of the simplicity and flexibility of the technological process, such alloys may become serious competitors of SAP material, which is used for such applications, but is very expensive and has a number of other disadvantages preventing its wide employment in industry.

At the present time, development work is in progress on the production of aluminum and aluminum-alloys sheets by the technique of roiling granules obtained by atomizing liquid metal through a rotating cylinder with orifices (the so-called centrifuging technique) [1]. Various mixtures of such granules, ranging in size from 2 to 8 mm [2] or from 0.28 to 1.5 mm [3], are hot-rolled into dense, high-quality strip. It has been demonstrated that this process is more productive than the manufacture of dense semifinished products from powder of less than 0.07 mm particle size, obtained by atomizing molten aluminum with a jet of air [4].

Although the aluminum used in this process covers a particle-size range from 8 to 0.07 mm, no comparative evaluation has been made as yet of the thermomechanical parameters of the rolling operation and the properties of strip from aluminum materials of various particle-size distributions. A knowledge of the anisotropy of such rolled material would be extremely valuable.

The first attempts to determine qualitatively the optimum rolling conditions for Al aluminum 2–4 mm in size and examine the properties of the resulting strip after consolidation-rolling operations were made by Severdenko and co-workers [5]. However, no analysis was carried out by those authors of the kinetics of property variation for prerolled stock as a function of rolling temperature. Some data on thermomechanical rolling conditions and properties for strip rolled from aluminum and its alloys with a particle size greater than 0.07 mm have been reported by Daugherty [4].

All studies of the properties of roll-compacted aluminum have invariably been conducted on specimens machined in the direction of rolling. However, bearing in mind the specific characteristics of this material, whose structure consists of individual particles (granules) extended in the direction of rolling, it would be expected that the properties of rolled strip would sometimes exhibit substantial differences depending on the direction of rolling.

The present authors investigated the properties of prerolled stock intended for subsequent densification rolling, obtained by hot-rolling aluminum granules which had passed through a sieve with 5-mm apertures and aluminum powder with particles from 0.09 to 0.43 mm in size. Both the granules and the powder were prepared from Al aluminum (99.5% purity). Properties were investigated on specimens machined in the direction of rolling and at right angles to it. Before rolling, the granules and the powder were preheated to temperatures of 100, 200, 300, 350, 400, 500, and 600°C. The time for transferring the heated material to the mill did not exceed 2 sec.
Fig. 2. Micrographs of unannealed prerolled stock from granules preheated before rolling to 500°C, ×60: a) in direction of rolling; b) across direction of rolling.

The mill-roll diameter was 300 mm, the rolling speed 17.5 m/min, and the rolled-strip width 100 mm. The roll clearance was constant throughout the whole investigation.

The resulting prerolled stock, of 1.8-2.0 mm thickness, was tested in tension on an RM-500 machine, and its density, hardness, and electrical resistivity were measured both after rolling and after annealing for 30 min at a temperature of 350°C. The electrical resistivity of specimens was determined by means of double resistance bridge. The density of the prerolled stock lay in the range 2.69-2.72 g/cm³.

As can be seen from Fig. 1, the tensile strength of aluminum rolled from granules initially increases with rise in rolling temperature until it attains a level corresponding to the tensile strength of work-hardened aluminum. The maximum strength characteristics are exhibited by material rolled from granules preheated to 350°C. Up to this temperature, the strip properties are characterized by a strong directionality, which is preserved even after annealing. The directionality of strength completely vanishes as rolling temperature is raised. An entirely different picture is obtained when the ductility characteristics of the prerolled stock are examined. Over the whole rolling-temperature range, the elongation of the material is higher for specimens machined in the direction of rolling. The absolute difference in elongation between specimens machined in the direction of rolling and at right angles to it increases after the annealing of strip.

The anisotropy of prerolled granule stock is a logical consequence of structural heterogeneity (Fig. 2). The microstructure of prerolled strip in the direction of rolling consists of granules (pseudograins) arranged side by side and extended longitudinally as a result of directional plastic deformation. The anisotropy exhibited by a metal can be mechanical or crystalline. The appearance of deformation texture is observed at reductions of ~50%, the texture becoming more and more perfect with increasing reduction.

The material under investigation exhibits a specific characteristic which is linked with the method of its manufacture. Metallographic examination and study of the behavior of specimens in tensile tests reveal that, under certain rolling conditions, the mechanical and crystalline anisotropy of individually deformed granules is supplemented by an anisotropy resulting from the directional deformation of all granules during rolling. Under some favorable conditions, this anisotropy becomes predominant. Such favorable conditions may prevail when there is little or no seizure between the granules being deformed, for instance, during the rolling of granules at low temperatures. In our experiments, in the rolling of granules preheated to temperatures below 350°C (Fig. 1), the strength of prerolled stock at right angles to the rolling direction was lower than in the direction of rolling. On the other hand, in granule rolling at temperatures corresponding to granule preheating to 350°C or higher, the strength values in the direction of rolling and at right angles to it are identical.

The variation in strength properties depending on the direction of testing of strip rolled from granules preheated to temperatures below 350°C must be ascribed to the presence of intense directional granule