The Kazan compressor plant has mastered the manufacture of two new articles from titanium alloys: the ATKA-545-5000 turbocompressor aggregate and the TsKS-390/0.1-1.15m hydrogen sulfide vacuum-compressor. The rotors of the ATKA-545-5000 were made from the titanium alloy AT-6, developed by the Institute of Metallurgy of the Academy of Sciences of the USSR; those of the hydrogen sulfide compressor were made from the titanium alloy VTZ-1. The mechanical properties of these alloys conform to prevailing industrial specifications.

The turbocompressor aggregate ATKA-545-5000 which was developed by the All-Union Scientific-Research Institute of Refrigeration Machinery (VNIIkholadmash) and mastered in production by the Kazan compressor plant, is intended for the generation of cooling. The refrigerating agent in this aggregate is ammonia. The design conditions of aggregate operation are as follows; vaporization and condensation temperatures, -17 and +38°C, respectively; cooling capacity, 5 million kcal/h; power required, 2400 kW; rate of rotor rotation, 15,000 rpm.

The TsKS-390/0.1-1.15m hydrogen sulfide vacuum-compressor, which was developed by the SKBK, is intended for pumping out hydrogen sulfide gas. The working agent in this vacuum-compressor is hydrogen sulfide + carbon dioxide + hydrogen cyanide + air + water vapor. The operation parameters of the compressor are these; productivity with respect to intake conditions, 440 m³/min; initial and final pressures of 0.109 and 1.15 kgf/cm², respectively; power required, 320 kW; rate of rotor rotation, 9154 rpm; greatest rotor diameter, 560 mm; number of stages, 8.

In using the titanium alloy AT-6 in the ATKA-545-5000 aggregate, account was taken of its high strength properties. It is known that, as compared with alloy steel, titanium alloys have higher specific strength (σₚ/γ for alloy AT-6 is 1.7 times as large as that of 40KhNMA steel). This made it possible to increase the peripheral velocity with respect to the outer rotor diameter up to 350 m/sec, which afforded the opportunity to raise the rotor pressure head and decrease the number of rotors. The peripheral speed with respect to the outer diameter of the rotor of the TsKS-390 compressor was increased to 266 m/sec. The choice of titanium alloy VTZ-1 was also occasioned by its high resistance to hydrogen sulfide medium. Before the use of the titanium alloy, refrigerating machines having similar parameters were put out in a 10-stage model, made in two bodies with autonomous drive motors and oil systems. The decrease in number of stages to 5 and the one-body fabrication of the compressor made it possible to reduce the size and weight of the machine, cut down on the laboriousness of its manufacture, and cut in half the number of parts.

The compressor rotor (Fig. 1) consists of a main disk with entirely milled blades and a cover disk made of AT-6 alloy. Connection of the main disk with the cover disk in vacuum-compressor TsKS-390/0.1-1.15m is made with rivets made of 1Kh18N9T steel; in the ATKA-545-5000 aggregate, of 13N5A steel.

Because titanium alloy AT-6 was first used as a material for fabricating rotors of disks with large dynamic loads operating in ammonia medium and intended for machines which had a long service life,
the following experimental work was carried out by the A. A. Baikov Institute of Metallurgy in conjunction with VNIIkholodmash and the Kazan compressor plant: tests of the mechanical properties of the alloy under active loading \( (\sigma_y, \sigma_b, \delta, \psi) \); determination of the cyclic strength of the alloy at room temperature; resistance capacity to creep and long-term strength; corrosion tests of AT-6 alloy joined with rivets of 1Kh18N9T steel in ammonia medium contaminated with lubricating oil; tests of the strength of disks under test stand conditions under dynamic loads to failure; a study of the structure and phase transitions of the alloy during a process of long-term testing; and performance of control tests on a prototype batch of disks.

The study of disk strength under test stand conditions under dynamic loads was carried out in four stages at the following rates of rotation: 15,000, 18,000; and 21200 rpm, and acceleration of the rotor to destroying rotation rates. Failure of the rotor took place at 22,750 rpm. During the testing period, after each stage the rotor was subjected to inspection and measurement. The tests showed that rotor failure began with deformation of the blades; extraction of the rivets from the seats, which caused separation of the main disk from the cover disk. Data from the studies performed showed that rotors of AT-6 titanium alloy ensure safe operation at a short-term safety factor with respect to breakdown rpm of 1.52.

It should be noted that the high strength and low specific heat-conductivity of titanium alloys cause definite difficulties in their mechanical processing. Therefore successful treatment of rotors of centrifugal compressors which are made of titanium alloy depends on a correct selection of the brand of material and the geometry of the cutting instrument in conjunction with optimum cutting regimes.

The technological process of manufacturing compressor rotors which was developed in the plant consists of the following basic operations: lathe treatment (rough and finish turning of disks), milling (formation of blades in main disk), boring of the holes under the rivets in the main disk and cover disk, and riveting (connecting the main disk and cover disk with the aid of rivets). The mechanical treatment of disk from titanium alloy was performed in attachments with increased rigidity, with liberal and continuous cooling of the part being processed. A 5% emulsion or 10% sulfured emulsion served as the lubricating and cooling liquid in lathe turning, milling, and drilling.

For the rough and finish turning and boring, cutting holes of alloys R9K5 or R9K10 were used, with a lead angle of 8-12° and a back angle of 8-10°. At a feed rate equal to 0.2 mm/rotation, the cutting rate was 12 m/min. Milling of the disks was performed with cutters made of type R9K5 steel. The characteristic feature of the instrument geometry was the absence of margins and the low magnitude of the lead cutting angle (0-5°). The cutting rate at such a cutter geometry was 12-15 m/min.

Drilling of holes in the disks was carried out on a drill-press without directing the bit along a conductor sleeve, with manual feed, liberal cooling, and frequent withdrawal of the bit from the drilling zone. The drill bit, of fast-cutting steel brand R18, was made with a reduced spiral section length and with an increased angle at the tip (up to 140°) and with a minimum width of the directing margin of the drill (0.25-0.4 mm).

The process of riveting was performed on a special electrical riveting press (Fig. 2). A special feature of riveting the rotors on this press consisted in the fact that, to ensure the needed quality of the riveted connection, the process of forming the rivet heads was carried out simultaneously from two sides by fast electrical contact heating of the projecting parts of the rivet stem while under the action of the stress generated by the press. A uniform clinching of the rivet heads from both sides was ensured due to the presence of a system of rods and levers which served to effect a kinematic connection of the mobile plunger of the press with the motion of the part being riveted in the same direction.

The process of riveting the rotor was performed as follows. The rivet blank, which had the form of a straight rod (without a rivet head), was set in the rivet hole provided for in the rotor, and the rivet axis