When end milling cutters break in the region of the welding seam, a defect is found which in the literature is called "bright ring" [1, 2]. The cause of this defect is ascribed to incomplete fusion, and the defect is also called incomplete fusion [1, 2]. To eliminate the defect "bright ring," the All-Union Tool Research Institute recommends raising the temperature and pressure in welding.

At the Pavlodar plant making special tools and technological equipment, friction welding of end milling cutters is used, and the defect "bright ring" is fairly widespread. Acting on the recommendations of the Tool Research Institute did not yield any positive results.

The object of the present work is to study the nature of the defect "bright ring" and to find ways of eliminating it.

We investigated welding seams on tool blanks of steel R6M5 welded to steel 45 on a machine MST-35. Fractures in the region of the welding seam were investigated on a scanning electron microscope REM-200 with magnification up to ×4000, the microstructure in the region of the welding seam was investigated on a transmission microscope and on a scanning electron microscope. We investigated tools both in the annealed state and after final heat treatment. From the blank in the region of welding we cut out a cylindrical specimen. Part of the cylinder was cut off in such a way that a plane perpendicular to the welding seam formed. On it we made a microsection on which we investigated the microstructure both without etching and after etching in 2% solution of HNO₃. By scratching or making indents on a PMT-3 instrument we marked the parts where the appearance of "bright rings" was expected in case of fracture. Fracture of the specimens was carried out by bending without damage to the microsection. The kind of fracture and the microstructure were compared.

Fig. 1. "Bright rings" in the fracture of a tool blank.
Fig. 2. Microstructure of an annealed blank (a) and a carbide band (b) in the region of the welding seam: a) light microscope, etched microsection, ×400; b) scanning electron microscope REM-200, unetched microsection, ×1025.

Fig. 3. Carbide band near the welding seam in an annealed blank (a) and part of the profile of the fracture with remains of the carbide band (bounded by arrows in Fig. 3a) (b): a) light microscope, etched microsection, ×400; b) ×5.

Fig. 4. Fractogram of an annealed blank of high speed steel (REM-200): a, b) outside and in the region of the "bright ring," respectively; a) ×4300; b) ×4500.