Brass powders produced by atomization of molten metal with water under high pressure possess excellent processing characteristics, in particular compressibility and sinterability [1]. This enables them to be employed for the manufacture of parts intended for heavy-duty service. The properties of such parts are largely determined by the amount of inclusions trapped in industrial batches of powders during their production. For example, tool blunting and plucking out of fragments of the material of parts have been observed during the machining of hot-forged L62 and L80 brass* blanks [2, 3].

Our microscopical examinations of blanks revealed the presence of hard silica (Fig. 1a), friable zinc oxide (Fig. 1b), and soft graphite inclusions (Fig. 1c), together with films of various thicknesses (Fig. 1a and b). Inclusions in blanks can only originate from starting powders. For example, atomized brass powders have been found [1, 4] to contain oxidized brass particles, particles of zinc oxides, charcoal used for the protection of molten metal, graphite from the crucible material, and refractory materials from the metal receiver and melting furnace linings, and particles of iron (which was particularly plentiful after the chamber had been used for atomizing ferrous alloys) and iron scale (when the metal tubes and containers were not cleaned).

The present work was undertaken with the aim of examining the inclusions present in atomized brass powders from the Baku Experimental Powder Metallurgy Plant and determining their phase compositions and amounts. Samples of L62 and L80 brass powders were obtained from single corresponding batches.

Under an MBS-9 stereoscopic microscope (magnification from 3.3 to 100 diameters) in reflected light, inclusions of five kinds, differing from the brass particles in shape, color, size, and some properties, were separated out of the samples with a steel needle. The particles of the first kind were oxidized brass particles, less branched in shape than the unoxidized ones, in the majority of cases having the appearance of being partially fused, and mainly dark and dark brown, but sometimes also dark gray-brown with a bluish-green hue (Fig. 2). A mixture of these particles with a powder of the polymerizing ACT plastic impregnated with a hardening agent was used for preparing metallographic microsections. At a magnification of 1350 diameters (maximum possible for the MIM-8M microscope with visual observation) no oxide films in sections of the oxidized particles were detected, although the color of the surfaces was indicative of their formation. Hence, the thickness of the oxide films was less than 1 µm (the resolving power of the MIM-8M microscope at a magnification of 1350 diameters). According to [1], the thickness of oxide films on brass particles may vary from less than 1 to 2-3 µm. It can therefore be concluded that from batch to batch of a brass powder produced by the melt atomization method the degree of oxidation of its individual particles varies. An examination of the oxidized surfaces of the brass particles in polarized reflected light (the large multipurpose Nu microscope of the VEB Carl Zeiss company of Jena) at magnification of 32 and more diameters revealed an anisotropy effect with pleochroism — light brown on Nm and brown on Ng. Such pleochroism is exhibited by copper oxide

* L62 and L80 are 38 and 20% Zn brasses, respectively — Publisher.
The main phase in the surface oxide films on brass particles is probably CuO. In ordinary reflected light, however, copper oxide is characterized by a color varying from iron-gray to black. The brownish coloring and bluish-green hue exhibited by the surfaces of the oxidized particles together with the predominant dark or gray color were due to the presence of impurities in the oxide films. From [5] it follows that these may have been Cu₂O (bright red color, isotropic), ZnO (from colorless to dark red, anisotropic, without pleochroism), Cu₃(OH)₂(CO₃)₂ (from pale to dark blue), and Cu₂(OH)₂CO₃ (green with pleochroism from practically colorless to yellowish-green and dark green).

The particles of the second kind were white and brownish-white in color and 0.015-0.5 mm in size (Fig. 3a), and readily disintegrated under pressure of the steel needle. Examination in transmitted light with the MIN-8 microscope showed that they were particles of a transparent material with a refractive index n = 2.056, which was anisotropic and, in polarized light, milky-white in color without pleochroism. These are the characteristics of zinc oxide [5]. X-ray phase analysis revealed the presence of ZnO, ZnO₂, and CuO in these particles (Table I). A loose deposit of material of a white and brownish-white color observed in reflected light on the surface of both the oxidized and unoxidized brass particles had the same composition. In [4] it is shown that dark gray oxide films of thickness less than 1 µm (occasionally up to 10 µm) with a composition close to ZnO have a particularly harmful effect on the properties of pressed specimens from an atomized brass powder. The formation of these films is linked in [4] with the presence of oxidized brass particles in pressed specimens. However, similar broken oxide films were found by us around all brass particles in the microstructure of hot-forged blanks. This leads to the conclusion that the formation of less than 1-µm-thick oxide films is linked with the loose white and brownish-white deposit, and that of thicker films, with individual particles of the same material, composed — according to our data — of the oxides ZnO, ZnO₂, and CuO.

The inclusions of the third kind were irregular-shaped or elongated particles, 0.075-0.5 mm in size (Fig. 3b). The irregular-shaped inclusions were characterized by a metallic