NOSE RING (MIT 3458)

COMPOSITION: Copper-gold alloy [*tumbaga*]; (analysis unavailable); thin surface gilding overlays copper-colored alloy

MICROSTRUCTURE

SECTION A: Longitudinal section through an end cap and a short length of the shaft

Photomicrographs

A1 -The polished section reveals metal that is highly porous. The pores are large and are aligned parallel to the longitudinal axis of the shaft and end cap. Their orientation changes abruptly within approximately 0.1 cm of the surface of the end cap. In this zone the pores are smaller and are aligned perpendicular to the longitudinal axis of the sample.

The section exhibits a long and wide shrinkage cavity, located at the mid-line of the section and oriented parallel to its longitudinal axis. The shrinkage cavity formed during solidification of the molten alloy. A wide, brittle fracture runs perpendicular to the shrinkage cavity, extending the full width of the end cap.

Metal that originally was located at the ultimate surface of the end cap has been displaced, through plastic deformation, and bent down onto the shaft to form a snug "collar" that encircles the shaft [x15; as-polished].

A2 -Detail of the rim of the end cap, where a thin flange of metal has been bent down onto the shaft of the nose ring. The pores in the flange metal are thin, elongated, and aligned in the direction of metal flow. The thinness and extended nature of the pores indicate the degree to which the flange metal has been compressed. Brittle fractures run across the width of the flange [x50; as-polished].

A3 -Same detail shown in A2, after etching. The metal is highly cored. The shaft exhibits a cast, dendritic microstructure which has been somewhat deformed through plastic deformation. No evidence of the original dendritic microstructure remains in the heavily worked flange metal. The coring appears as banded flow lines oriented in the direction of metal flow [x50; Etchant: KI + KCN]

A4 -Detail of the end cap metal, between the upper terminus of the mid-line shrinkage cavity and the surface of the cap. The dendritic segregation at the center of the section exhibits modest deformation. The large pores to the right and left of the shrinkage cavity are oriented parallel to the longitudinal axis of the section. The microstructure changes abruptly near the surface of the cap. The dendritic coring in the near-surface region exhibits a fine, lamellar-like appearance whose orientation is perpendicular to the longitudinal axis of the sample. The pores are closed, extended, and aligned in the same direction as the remnant dendrites. These microstructural features resulted from severe compression of the metal near the surface of the cap [xl00; Etchant: KI + KCN]

A5 -Detail of the metal in the body of the cap (at the right of the micrograph) and of the flange metal immediately adjacent to it (at the left of the micrograph), with a narrow space between them. The etchant has brought out the equiaxed grain structure of both components. No elongated grains or grains containing deformation lines are present [xl00; Etchant: KI + KCN].

A6 -Detail of the metal near the free end of the flange. Some of the equiaxed grains exhibit annealing twins [x200; Etchant: KI + KCN]

INTERPRETATION OF MICROSTRUCTURE

The nose ring was fashioned from a cast blank, probably in the shape of a cylindrical rod. Upon cooling and solidification, the alloy shrank considerably, forming a long and wide shrinkage cavity along the longitudinal mid-line of the rod. The ends of the rod were worked and annealed in order to shape the end caps through plastic deformation. It may be that during working the ends of the rod developed brittleness, causing the alloy to fracture and weaken at the location of the end caps. This may have been the reason for upsetting the metal at the ends of the rod (i.e., compressing the surface metal back onto itself) sufficiently to produce long, thin flanges that could be bent down onto the shaft, increasing its mechanical strength and lending it integrity. It is also possible that the transverse brittle crack illustrated in A1 may have occurred after the end caps were completely fashioned and the flange was in place. The upsetting of the rod end metal resulted in the formation of a flaring rim around the circumference of each end cap.

Once the end caps were complete, the entire rod was hammered into a roughly circular shape. The nose ring was left in an annealed state, as the equiaxed grains with annealing twins indicate. The thin surface layer of gold probably developed during the hammering and annealing fabrication sequences. Annealing a copper-gold alloy produces a scale of copper oxide on the surface of the metal. The scale is usually dissolved away with a mild pickle before hammering proceeds. After a number of hammering, annealing, and pickling sequences, enough copper is removed from the surface of the metal to leave a pure layer of gold.