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# GRAIN REFINEMENT PROCESS FOR COPPER-BISMUTH ALLOYS

Arthur George Knapton, Sale, and Thomas Raine, Bramhall, England, assignors to Associated Electrical Industries Limited, London, England, a British company

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U.S. Cl. 148—2 4 Claims

## ABSTRACT OF THE DISCLOSURE

Copper-bismuth alloys with a refined grain structure are prepared by casting the alloys, which contain from 0.05% to 1% of bismuth, into the form of ingots, heating the ingots to temperatures in the range of 300° C. to 950° C., and extruding the heated ingots at an extrusion ratio such that the alloy is maintained in a state of hydrostatic compression during deformation, and that tensile forces are absent, a preferred extrusion ratio being 4:1.

This invention is concerned with a method of improving the properties of copper-bismuth alloys intended for use in electrical devices, and is particularly concerned with a process for preparing such alloys with a refined grain structure.

An alloy with anti-welding properties is required at the contact faces of vacuum switches. A copper-bismuth alloy is favoured for this purpose, the alloy usually being produced in the cast state by melting processes. A drawback of the cast material is the inherently large grain size which may lead to the plucking of pieces of material, corresponding to the large grains, from the contact faces. Such pieces of material may cause restriking, or obstruct reclosure of the switch. This difficulty may be overcome by reducing the grain size of the alloy. The usual methods of grain refinement by forging or rolling are not possible with copper-bismuth alloys due to the brittle nature of the material.

This invention consists in a method of preparing a copper-bismuth alloy with a refined grain structure, which comprises subjecting the alloy to an extrusion process at a temperature in the range 300°–950° C., the extrusion ratio being typically 4:1. It is preferable to extrude at a temperature in the lower part of the range.

An important feature of the extrusion process is that the alloy is maintained in a state of hydrostatic compression during deformation, and that tensile forces are absent. Intergranular cracking which normally takes place via the bismuth phase in the alloy is thereby avoided.

The invention is put into practice in the following way. Copper-bismuth alloys in the range 0.05–1% bismuth by weight are melted and cast into ingots by a suitable technique. One such technique, which has been employed for vacuum switch alloy production, involves high frequency melting in a graphite crucible in a vacuum. In this technique it is necessary to alloy for any loss of the more

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volatile element bismuth that occurs, to ensure that the desired alloy composition is obtained. The ingots from the casting operation are machined to produce billets appropriate for extrusion. Typical billets would be cylindrical, 4" diameter x 6" long. At this stage and before extrusion it may be desirable to enclose the alloy billet in a ductile can. The can serves a dual purpose, firstly to give support to the alloy during the extrusion process and also to prevent the pick up of gaseous or other contaminants which are deleterious to the satisfactory functioning of a vacuum switch. It has been found that copper tube forms a suitable canning material for the alloy billet, the ends of the tube being sealed by welded-in copper plugs. The pick-up of gaseous contaminants can be further reduced by evacuating the can before sealing.

For extrusion, the billet is heated by any appropriate means to the extrusion temperature, which for copper-bismuth alloys lies in the range 300°–950° C. The heated billet is extruded through a die of the required dimensions. If a cylindrical rod is required, this may be produced by extrusion through a circular die. Alternatively, strip may be obtained by extrusion through a die of rectangular cross section. Various other shapes of extruded product are also possible.

The canning material extrudes simultaneously with the alloy, maintaining a gas tight sheath on the alloy. The sheath is removed by machining.

The magnitude of the grain refining effect is shown by the following examples.

### Example 1

An alloy cast from copper with 0.5% added bismuth was machined to give a 2" diameter extrusion billets. This was heated to 850° C. and extruded to 1" diameter, i.e., with 4:1 extrusion ratio. The cast grain size of 2–3 mm. was reduced to a fine equiaxed structure with grains 1/10 mm. diameter by this method.

### Example 2

An alloy of copper with 0.5% bismuth by weight was extruded at 500° C. with a 4:1 extrusion ratio, viz. from a 2" diameter billet to 1" diameter. After extrusion the structure showed elongated grains of copper interspersed with bismuth, demonstrating that at this extrusion temperature the copper retains a worked structure. On annealing the alloy at 800° C. for 1 hour to simulate processing on a vacuum switch the copper phase was annealed and an equiaxed grain structure was produced with grain size 0.2–0.3 mm. compared with the cast grain size of 2–3 mm.

What we claim is:

**1.** A method of manufacturing a copper-bismuth alloy with a refined grain structure, which includes the steps of casting a copper-bismuth alloy containing 0.05% to 1% bismuth into the form of an ingot, heating the ingot to a temperature in the range of 300° C. to 950° C., and extruding the heated ingot at an extrusion ratio such that the alloy is maintained in a state of hydrostatic compression during deformation and that tensile forces are absent.

**2.** A method according to claim **1**, in which the ingot is machined to the form of a cylindrical billet which is then enclosed in a copper tube, the ends of the tube being sealed by welded copper plugs, and the billet is then subjected to the extrusion process, the copper covering being later removed by machining.

**3.** A method according to claim **1**, in which a copper-bismuth alloy containing 0.5% bismuth is extruded at a temperature of 850° C., the extrusion ratio being 4:1.

**4.** A method according to claim **1**, in which a copper-bismuth alloy containing 0.5% bismuth is extruded at 500° C., the extrusion ratio being 4:1, and the extruded alloy is thereafter subjected to annealing by being heated to 800° C. for one hour.




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CHARLES N. LOVELL, *Primary Examiner.*

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