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METALLIC COMPOSITIONS CONTAINING BISMUTH

Franz R. Hensel, Indianapolis, Ind., assignor to P. R. Mallory & Co., Inc., Indianapolis, Ind., a corporation of Delaware

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1 Claim. (Cl. 174—126)

The present invention relates to metal compositions and articles made therefrom and more particularly to compositions and articles of manufacture containing bismuth.

It is known that bismuth does not appreciably alloy with metals such as copper or aluminum in any substantial proportion. The degree of solubility of solid bismuth in either copper or aluminum is less than 0.1%. All copper-bismuth alloys containing more than 0.2% of copper consist of crystals of substantially pure copper surrounded by an envelope of substantially pure bismuth, which explains why many alloys containing bismuth within or adjacent to their grain boundaries are so brittle as to be useless for practically all industrial applications.

An object of this invention is to provide useful metallic compositions containing bismuth.

A further object of the invention is to provide metal compositions having improved properties which make them particularly advantageous for use as bearing materials, resistor materials, electric contact alloys and rectifying discs.

Another object of the invention is to provide articles of the type mentioned having increased efficiency of operation, an increased useful life, at a greatly reduced cost of production thereof.

More specific objects and advantages of the invention will appear from the following description thereof.

Broadly, the present invention contemplates the use of bismuth as an impregnating material for a number of metals, or mixtures thereof, selected from the group having a relatively high electrical conductivity and a relatively low affinity or alloy-forming tendency with bismuth, such group including copper and silver. Bismuth has a number of outstanding properties. One of these properties is that it changes its electrical resistance when subjected to a magnetic field. The resistance of bismuth increases in a transverse magnetic field. For a given field strength the percentage change increases with a decrease in temperature. At a given temperature the percentage change in resistance increases with an increase in field strength; for example, at a constant temperature of 18° C., the percentage change in resistance is 12% at 4000 gausses, 32% at 8000 gausses and 104% at 20,000 gausses.

For a number of electrical control applications, the high resistivity of pure bismuth (about 119 microhms-cm.) interferes with satisfactory operation. It therefore becomes a problem to provide a material which retains the special electrical properties when inserted into a magnetic field, and at the same time have an overall electrical conductivity considerably higher than that of bismuth. The special resistivity characteristics of bismuth can be readily destroyed by slight impurities or other foreign matter which may enter into the space lattice of the bismuth crystals. The fact that bismuth has a rhombohedral hexagonal crystal lattice further complicates matters because the resistivity becomes partly a function of crystal orientation.

According to one preferred embodiment of the invention the metal or metals whose properties are to be improved is comminuted to powder of conventional grain size. The powdered metal is then pressed into the desired shape and heated at a temperature and for a time sufficient to produce sintering of the powder. In the case of copper this temperature is in the vicinity of about 975° C. and the time is about 30 minutes. Preferably the heating is effected in a reducing atmosphere, such as hydrogen, for example. After satisfactory sintering of the powder, metallic bismuth is brought into contact with the mass and the heating is continued at a somewhat lower temperature, e. g., about 625° C., also preferably in a hydrogen atmosphere, until the sintered mass has been sufficiently permeated or impregnated by the bismuth. While the bismuth may be in the solid form, we prefer the powdered form.

In the impregnation process it is possible to use fairly high temperatures and thereby improve both fluidity and wettability because of the wide spread that exists between the melting point of bismuth (271.3° C.) and the boiling point (1450° C.).

It is possible to produce rather dense composite structures when using bismuth because the latter expands during solidification while other metals usually contract during such a phase change. The amount of expansion can be calculated from the density in the solid state (9.781 g./cc.) and the density in the liquid state which is 10.04 g./cc. at the melting point. The volume change in melting therefore amounts to about 3.4% expressed in percent of the liquid metal.

In an alternative embodiment of the invention, both the metal or metals whose properties are to be improved and the bismuth may be mixed, in powder form, e. g., in a ball mill, for about three hours, the mixture pressed into shape and sintered as described above, for about one hour. A suitable proportion of the mixture is about 40% to 60% bismuth, the balance being the metal to be improved, but obviously this ratio may be varied, as desired, and the sintering of the bar or

article may be effected in contact with additional bismuth material, either powdered or solid. Most of the useful compositions contain between 5 and 60% bismuth. The fact that the compacts made by the present procedure will result in a structure of two distinct and separate phases, one being the bismuth and the other being a soft matrix such as copper or silver provides a structure which has excellent possibilities for bearing applications. Although bismuth has a brittle structure at room temperature, at slightly elevated temperature it is quite plastic and ductile. At a temperature of about 100° C., for instance, the metal can be readily extruded into fine wires or other shapes. In bearings we have operating temperatures which raise the ductility and plasticity of bismuth to a point where it becomes well suited for antifriction purposes. Furthermore, the complete insolubility of iron and bismuth will prevent any cold welding of the bearing to the shaft.

If the new compacts are to be used for rectifying discs it is possible to subject them to chemical treatment in order to form oxides, sulfides, selenides or tellurides, bismuth forming stable compounds of all of the above mentioned combinations.

While a preferred embodiment of the invention has been described herein, it is understood that considerable variation may be made in the method of procedure and the combination of elements without departing from the spirit of the invention as indicated in the appended claim.

I claim:

An operative element of an electrical control system which element is characterized by a relatively high but variable overall electrical conductivity, this conductivity varying in use in response to varying applied magnetic fields, said element comprising a sintered component of the group consisting of copper and silver, and a bismuth component dispersed in said sintered component, said bismuth component comprising 5 to 60% of said element.

FRANZ R. HENSEL.