

# UNITED STATES PATENT OFFICE

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## COPPER-INDIUM ALLOY

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This invention relates to metallic mixtures and alloys.

We have discovered that the metal element, indium, can be mixed or alloyed with the metal element, copper, and that the resulting mixture or alloy is permanent and stable and has certain advantageous properties.

An advantageous property imparted to copper by indium is resistance to tarnish and corrosion. For example, a body having a base or core of copper with indium diffused into the surface provides a product which will resist tarnishing to an extent substantially depending on the percentage of indium present in the surface metal. In this respect, the indium acts as a preventive against the formation of surface tarnishing copper compounds. These compounds which are probably oxides, sulphates, carbonates, etc. of copper form quickly on an exposed copper surface, usually giving the surface a crust of brown or green color. My invention involves the discovery that the introduction of indium into the surface of the copper, even in small percentages, retards and inhibits the formation of such tarnishing compounds and provides a tarnish-resisting surface alloy.

An advantageous effect of the addition of indium to copper is the modification of the copper color. Pure copper has an objectional red color which renders the use of copper undesirable for a number of purposes, for example, for kitchen utensils, spoons, etc. This objectional red color is changed by the addition of the indium. The red color is diluted and lightened by adding even small percentages of indium, for example, 10% and is changed to a gray as higher percentages are added, for example, 45% indium.

Our invention also involves the discovery that, while copper and indium are each relatively ductile metals, certain mixtures or alloys of these metals are relatively stiff and hard. For example, a copper-indium alloy with 10% indium has nearly twice the hardness of pure copper, while an alloy with 33 1/3% indium has about twice the hardness of the 10% alloy. These estimations are based on Brinnell and Rockwell hardness measurements of the alloys. The hardness of the alloy appears to increase at a rapid rate with small percentages of indium added to copper, this rate of increase decreasing with higher percentages of indium until about 50% indium, which seems to be about the maximum point of hardness. With further increase of indium, the hardness drops off.

The addition of indium, even in small per-

centages, to copper has consequently the effect of producing an alloy of a hardness materially greater than pure copper. The ductility of copper is advantageous in many instances as the copper can be drawn or otherwise worked conveniently into a desired product. On the other hand, this ductility may be disadvantageous in some cases because of the relative softness of the final product. By my invention, the shaped product of copper may be hardened or stiffened by diffusing indium into the copper surface. The final product then has a core of copper with copper softness and a shell of stiffer nature. This shell may be made of varying degrees of stiffness to meet the requirements by varying the amount of indium in the surface alloy.

My invention is capable of many applications in practice. For example, it may be applied to kitchen utensils, and similar articles which may be formed of a copper core and a shell of the copper-indium mixture or alloy. Brushes, commutators, wire conductors, etc. may be similarly formed. The surface would then have a tarnish-resisting shell with a stiffness that may be adjusted by regulation of the amount of indium. The addition of indium to copper also varies the conductivity which can also be regulated by the amount of indium to meet given requirements.

An intimate mixture or alloy of copper and indium may be obtained in the usual metallurgical ways, for example, by melting and mixing the two elements. One advantageous method of producing the mixture or alloy is by diffusing the indium into the copper. In such method, copper in any desired form is first coated with the desired or required quantity of indium, by electro-deposition, for example, and then subjected to a heat treatment to drive the indium into the copper.

A suitable coating bath is as follows:

|                              | Ounces per gallon |
|------------------------------|-------------------|
| Indium.....                  | 5                 |
| Dextrose.....                | 3                 |
| Potassium cyanide, free..... | 8                 |
| Potassium chloride.....      | 5                 |

In the electrolytic process, the copper article to be coated is the cathode. The anode may be an insoluble anode, such as platinum, or it may be an indium anode. The difference in potential between anode and cathode must be sufficient to deposit indium. The current should be such as to give a density at the cathode of about 0.2 ampere per square inch.

The copper thus coated is then heated at a

temperature at which the indium will diffuse into the copper, the height of this temperature depending on the thickness of the coating and the speed desired or required for the diffusing operation. Preferably the minimum temperature is about the melting point of the indium but to accelerate the diffusing operation, it is desirable to employ higher temperatures. This diffusing operation is conducted in a suitable oven from which the alloy or intimate mixture is then withdrawn and allowed to cool. In the final product, particularly where the product is thick, the indium content decreases from the surface towards the center, that is, the product has a core of substantially pure copper or relatively low indium content and a shell of relatively high indium content.

What is claimed is:

1. A metallic mixture or alloy composed of copper and indium, the copper ranging from 50 to 90% of the alloy, the indium from 10 to 50%.
2. A metallic mixture or alloy composed of copper and indium, the copper constituting sub-

stantially 90% of the alloy and the indium about 10% thereof.

3. A metallic mixture or alloy composed of copper and indium, the copper constituting 66 $\frac{2}{3}$ % of the alloy and the indium about 33 $\frac{1}{3}$ % thereof. 80

4. A metallic mixture or alloy composed of copper and indium, the copper constituting from 66 $\frac{2}{3}$ % to 90% of the composition, the remainder, to make 100%, being indium, except for impurities, if any. 85

5. A metallic mixture or alloy composed of copper and indium, the indium constituting 10% to about 50% of the composition, the remainder, to make 100%, being copper, except for impurities, if any. 90

6. A metallic mixture or alloy composed of copper and indium, the indium constituting from 10% to 45% of the composition, the remainder to make 100%, being copper except for impurities, if any. 95

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